CH2M HILL ENGINEERING CHANGE NOTICE	1a. ECN 722904 R 1
Page 1 of 2 ☒ DM ☐ FM ☐ TM	1b. Proj. ECN - - R

2. Simple Modification ☒ Yes ☐ No	3. Design Inputs – For full ECNs, record information on the ECN-1 Form (not required for Simple Modifications)		4. Date September 7, 2005
5. Originator's Name, Organization, MSIN, & Phone No. S. D. Kozlowski, Waste Feed Nuclear Safety, R3-86, 373-1360		6. USQ Number No. - - - R - ☒ N/A	7. Related ECNs N/A
8. Title Technical Basis Document for the Aboveground Tank Failure Representative Accident	9. Bldg. / Facility No. Tank Farms	10. Equipment / Component ID N/A	11. Approval Designator N/A
12. Engineering Documents/Drawings to be Changed (Incl. Sheet & Rev. Nos.) RPP-13175, Rev. 1		13. Safety Designation ☐ SC ☐ SS ☐ GS ☒ N/A	14. Expedited/Off-Shift ECN? ☐ Yes ☒ No
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17. Description of the Change (Use ECN Continuation pages as needed)

RPP-13175 is being updated to provide analyses of aboveground tank failure accident scenarios applicable to the Contact-Handled Transuranic/Mixed (CH-TRUM) Waste Packaging Unit (WPU).

Changes were made to Chapter 2 and Appendices A, B, and C. Appendix G was added in its entirely to Rev. 2.

18. Justification of the Change (Use ECN Continuation pages as needed)

The CH-TRUM WPU is a supplemental treatment technology being developed to receive, dry, and package low-activity, contact-handled transuanic/mixed waste from Tank Farm single-shell tank (SST) systems. The updated document provides the radiological and toxicological consequences for a range of aboveground tank failure accident scenarios to determine the representative accident for CH-TRUM.

The change supports a preliminary documented safety analysis (PDSA) for the CH-TRUM WPU. However, the project has been placed on hold. The PDSA will be submitted, but will not be approved by DOE at this time. With the project deferred, there can be no impact on the tank farms safety basis. Therefore, a USQ evaluation is not required. Note that the PDSA will undergo formal DOE/ORP review and approval when the project is restarted.

19. ECN Category

☒ Direct Revision
☐ Supplemental
☐ Void/Cancel

ECN Type

☐ Supercedure
☐ Revision

20. Distribution

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L. J. Kripps	S7-90		

Release Stamp

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 ☒ DM ☐ FM ☐ TM

1a. **ECN** 722904 **R** 1

1b. **Proj. ECN** - - R

21. Revisions Planned (Include a brief description of the contents of each revision)
N/A

Note: All revisions shall have the approvals of the affected organizations as identified in block 11 "Approval Designator," on page 1 of this ECN.

22. Design Basis Documents
☐ Yes ☒ No

23. Commercial Grade Item Dedication Numbers (associated with this design change)
N/A

24. Engineering Data Transmittal Numbers (associated with this design change, e.g., new drawings, new documents)
N/A

25. Other Non Engineering (not in HDCS) documents that need to be modified due to this change

Type of Document	Document Number	Update Completed On	Responsible Engineer (print/sign and date)
Alarm Response Procedure	N/A		
Operations Procedure	N/A		
Maintenance Procedure	N/A		

Type of Document	Document Number	Type of Document	Document Number
None			

26. Field Change Notice(s) Used?
☐ Yes ☒ No
If Yes, Record Information on the ECN-2 Form, attach form(s), include a description of the interim resolution on ECN Page 1, block 17, and identify permanent changes.

NOTE: ECNs are required to record and approve all FCNs issued. If the FCNs have not changed the original design media then they are just incorporated into the design media via an ECN. If the FCN did change the original design media then the ECN will include the necessary engineering changes to the original design media.

27. Design Verification Required?
☐ Yes ☒ No
If Yes, as a minimum attach the one page checklist from TFC-ENG-DESIGN-P-17.

28. Approvals

Facility/Project Signatures		Date	A/E Signatures		Date
Design Authority			Originator/Design Agent		
Resp. Engineer	S.D. Kozlowski [signature]	9/22/05	Professional Engineer		
Resp. Manager	J. M. Grigsby [signature]	9/22/05	Project Engineer		
Quality Assurance			Quality Assurance		
IS&H Engineer			Safety		
NS&L Engineer	S. D. Kozlowski [signature]	9/22/05	Designer		
Environ. Engineer			Environ. Engineer		
Engineering Checker	E. C. Heubach [signature]	09/22/05	Other		
Other			Other		
Other			DEPARTMENT OF ENERGY / OFFICE OF RIVER PROTECTION		
Other			Signature or a Control Number that tracks the Approval Signature		
Other					
Other			ADDITIONAL SIGNATURES		
Other					
Other					

Technical Basis Document for the Aboveground Tank Failure Representative Accident and Associated Represented Hazardous Conditions

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U.S. Department of Energy Contract DE-AC27-99RL14047

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Key Words: radiological, toxicological, consequence, tank failure, representative accident, risk binning, controls, DBVS, CH-TRUM

Abstract: This document analyzes aboveground tank failure accident scenarios. The radiological and toxicological consequences are determined for a range of aboveground tank failure accident scenarios to determine the representative accident. Based on the consequence results and accident frequency evaluations, risk bins are determined and control decisions are made. This revision deals with aboveground tank failure accidents during CH-TRUM operations.

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Tank Farm Contractor (TFC) RECORD OF REVISION	(1) Document Number RPP-13175	Page 1

(2) Title

Technical Basis Document for the Aboveground Tank Failure Representative Accident and Associated Represented Hazardous Conditions

Change Control Record

(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release	
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RPP-13175
Revision 2

Technical Basis Document for the Aboveground Tank Failure Representative Accident and Associated Represented Hazardous Conditions

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

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

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Date

CONTENTS

APPENDICES

TABLES

LIST OF TERMS

AA	analysis assumptions
ARF	airborne release fraction
ARR	airborne release rate
AC	administrative control
CH-TRUM	Contact-Handled Transuranic Mixed (Waste)
DBVS	Demonstration Bulk Vitrification System
DSA	documented safety analysis (RPP-13033, *Tank Farms Documented Safety Analysis*)
DST	double-shell tank
DWS	dewatering system
ERPG	Emergency Response Planning Guideline
FRPS	Feed Receipt Processing System
HEPA	high-efficiency particulate air (filter)
ISO	International Organization for Standardization
ID	internal diameter
L	low
M	moderate
MAR	material at risk
NA	not applicable
RF	respirable fraction
SMP	safety management program
SSC	structures, systems, and components
SST	single-shell tank
SOF	sum of fractions
TEEL	Temporary Emergency Exposure Limit
TSR	technical safety requirement
U	unlikely
ULD	unit-liter dose
USOF	unitless sum of fractions
WIPP	Waste Isolation Pilot Plant
WPU	Waste Packaging Unit

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1.0 INTRODUCTION

1.1 PURPOSE

This technical basis document was developed to support RPP-13033, *Tank Farms Documented Safety Analysis* (DSA), and describes the risk binning process and the technical basis for assigning risk bins for the aboveground tank failure representative accident and associated represented hazardous conditions. The purpose of the risk binning process is to determine the need for safety-significant structures, systems, and components (SSC) and 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 Documented Safety Analyses*, as described below.

1.2 BACKGROUND INFORMATION

1.2.1 Representative Accident

Aboveground structures may fail from one of several possible causes (e.g., seismic event, high winds, structural degradation) and fall on the equipment contained inside, leading to failure of that equipment. The 242-T Evaporator was built in the 1950's and is susceptible to failure and the waste assumed to remain in the 242-T Evaporator could be released to the environment. Specifically, in the unlikely event of either a high wind or a seismic event, or the anticipated continued degradation of the structure, roof panels may fall on the 242-T Evaporator vessel, which is assumed to contain up to 300 gal of waste remaining from its previous function of reducing waste volume through the evaporation process.

A review of unusual occurrences involving building failures was performed and none were found to be significant. A review of other tank farm facilities during DSA development did not identify any other facility that stores waste in an aboveground tank, although there are aboveground facilities that contain contaminants. The 242-S Evaporator is an abandoned evaporator. However, it was flushed when it was shutdown so that modifications (which were not subsequently activated) could be performed. While the 242-A Evaporator is an active evaporator, it is not subject to the Tank Farms DSA. The 204-AR Waste Unloading Facility is addressed separately. The In-Tank Solidification System 1 and the 241-A-431 ventilation building both have de-entrainers. The de-entrainers may retain contaminants aboveground, but do not retain liquid or solid tank waste.

1.2.2 Bounding Offsite Accident

An aboveground tank failure is a moderate energy, atmospheric vapor/gas/aerosol release event that is bounded by the dome collapse 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 dome collapse accident is documented in RPP-12395, *Offsite Radiological Consequences of Waste Tank Dome Collapse*, 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 numerical evaluation guidelines (i.e., evaluation guidelines are not provided for offsite toxicological, onsite radiological and toxicological, or facility worker exposures). These exposures were evaluated for the aboveground tank failure 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 hazard evaluation database lists numerous hazardous conditions that are represented by the aboveground tank failure accident. Some of these hazardous conditions are similar to the representative accident, although the initiators and aerosol release paths may be different. They were assigned to the aboveground tank failure representative accident because these events all involve moderate energy, atmospheric releases of vapors and aerosols.

1.3 RISK BINNING METHODOLOGY

Direction on risk binning was 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 consequences of the representative accident. Frequency is qualitatively estimated as "anticipated," "unlikely," "extremely unlikely," or "beyond extremely unlikely." Consequences are evaluated for the following receptors and exposures: offsite toxicological, onsite radiological, and onsite toxicological. These consequences are assigned to one of three levels: high, moderate, or low. Based on the frequency and consequence, risk bins (ranging from I to IV) are assigned. Tables 1-1 and 1-2 show the criteria for assigning the frequency and consequence levels, 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.

In accordance with the control selection guidelines in Klein and Schepens (2003), Risk Bin I events require safety-significant SSCs or TSRs, and Risk Bin II events must consider safety-significant SSCs and TSRs. Risk Bin III events are generally protected by the safety management programs (SMP), and Risk Bin IV events do not require additional measures.

Table 1-1. Offsite (Toxicological Only) Risk Bins.

Consequence level (toxicological only[a])	Event frequency			
	$<10^{-6}$/yr Beyond extremely unlikely	**10^{-4} to 10^{-6}/yr Extremely unlikely**	**10^{-2} to 10^{-4}/yr Unlikely**	**$>10^{-2}$ to $\leq10^{-1}$/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

Notes:

[a] Radiological consequences for the offsite receptor are evaluated in accordance with DOE-STD-3009-94, 2002, *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. TEEL = Temporary Emergency Exposure Limit.

Table 1-2. Onsite (100 m) Risk Bins.

Consequence level (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**	**$>10^{-2}$ to $\leq10^{-1}$/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

Notes:

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

Environmental consequences are also assigned during the risk binning process. There are four levels of environmental consequences (E0, E1, E2, and E3, in order of increasing severity) and these levels are defined in Table 1-3.

Table 1-3. Environmental Consequence Levels.

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

2.0 RISK BINNING RESULTS

A risk binning team meeting was held July 22, 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. (Note the attendance list is labeled "above grade structure failure." However, the list was used for two meetings as noted at the bottom of the page.) After the meeting, the risk binning results were distributed to the Technical Working Group for review and concurrence. With some minor clarifications, the Technical Working Group concurred with the final risk bin results, which are shown in Table 2-1.

A subsequent meeting was held on September 14, 2004, to assign risk bins and controls for aboveground tank failure conditions that were identified during the design and hazards analysis of the Demonstration Bulk Vitrification System (DBVS). The results are discussed in Sections 2.3.1 and 3.1.

Another meeting was held on January 27, 2005, to assign risk bins and controls for aboveground tank failure conditions that were identified during the design and hazards analysis of the Contact-Handled Transuranic Mixed (Waste) (CH-TRUM) Facility. The results are also discussed in Sections 2.3.2 and 3.2.

Table 2-1. Summary of Results for Representative Scenarios.

Postulated accident/ hazardous condition	Frequency	Consequences				Risk bin		
		Onsite radiological	Offsite toxicological	Onsite toxicological	Environmental	Onsite radiological	Offsite toxicological	Onsite toxicological
Release of radioactive and hazardous material from 242-T Evaporator due to facility degradation.	A	L	L	L	E1	III	III	III

Notes:

A = anticipated.

L = low.

2.1 ABOVEGROUND TANK FAILURE REPRESENTATIVE ACCIDENT WITHOUT CONTROLS

2.1.1 Accident Scenario

The 242-T Evaporator was constructed in the early 1950s and has been idle since the 1970s. The structure was not designed to current standards and has not been maintained. This establishes the scenario in which the building fails due either to degradation or natural phenomena. The roof panels collapse on the evaporator vessel and it splits open, spilling the contents, which are then picked up by the wind and dispersed. The potential initiators of this accident are structural failure of the roof or wall collapse because of aging or corrosion, roof overload because of snow or ash, high winds, or a seismic event. Documentation of the facility shut down is limited, so it is unclear what contents remain in the 242-T Evaporator.

Adding to the waste in the evaporator is material assumed to be on the high-efficiency particulate air (HEPA) filters. This material is assumed to blow out during the pressure pulse through the ventilation system when the roof panels fall.

2.1.2 Frequency Determination

The initiator for the scenario is the collapse of the roof panels and then falling on the evaporator vessel. The evaporator vessel is the largest component in the evaporator system and contains the most waste (based on radiation surveys). There are no other initiators with the potential energy to cause the vessel to rupture and create a release to the environment that is essentially unrestricted. The causes of a roof panel falling on the evaporator vessel, which creates hazardous conditions with the greatest consequences, were then addressed.

A frequency of "unlikely" was qualitatively assigned to this accident based on natural phenomena initiators. RPP-4780, *Calculation Notes with Structural Analysis for the 242-T Evaporator*, Appendix B, contains a failure mode analysis for the 242-T Building to estimate the frequency of roof collapse scenarios caused by snow or volcanic ash fall, wind loading, or seismic events. The frequency of roof collapse from these natural phenomena loads was approximately 2.9×10^{-3} per year, placing this event in the "unlikely" frequency class (10^{-2} to 10^{-4}/yr).

A frequency of "anticipated" was qualitatively assigned to this accident based on degradation of the structure, which has received minimal maintenance. There is a 10^{-2} or greater likelihood that the building may fall down on its own if no maintenance is performed.

2.1.3 Consequence Determination

After the building collapses, the postulated release results from splash/splatter and wind entrainment.

The calculations presented in Appendix B provide input into the qualitative assessment of consequences, using conservative modeling assumptions documented in Table 2-2. The analysis assumes that the waste remaining in the evaporator is released to the environment when the evaporator fails due to the roof panels falling on it.

It is important to note that the analysis assumptions listed in Table 2-2 were selected to maximize the calculated consequences of the aboveground tank failure accident. It is the combination of conservative assumptions that truly drives the accident consequences. Because a combination of conservative analysis assumptions was used and because of the large difference between the calculated radiological and toxicological consequences, sensitivity studies were not conducted on each of the individual input parameters. However, Table 2-2 provides information on each of the assumptions, the potential effect of changes in the assumption on the frequency or consequence level (qualitatively evaluated), and the need to protect the assumptions.

Table 2-2. Qualitative Evaluation of Analysis Assumptions for Representative Accident. (4 sheets)

Analysis assumptions (AA) with references/basis	Assumption type	Sensitivity (consequence)	Need to protect AA	Protection Basis
The released waste is equivalent to SST waste that is 78% liquids and 22% solids based on RPP-7277 analysis. Evaporator operation was to process salt slurries, not sludge. 242-T received its feed from 241-TX-118, which received feed from the T farm complex, all SSTs. The feed material had to be liquid to be pumped to the evaporator and drain (not pumped) from the evaporator to a diversion box.	Conservative based on the physical configuration.	The SST waste characteristics (ULD and SOF) are either higher than other waste types, or are relatively close; assuming the highest value would not cause the consequences to change risk bins. ULD would increase 50% if the waste were assumed to be 100% solids. SOFs would change (either increase or decrease, depending on the TEEL) approximately 20%.	No	NA
The maximum volume of waste in the evaporator vessel for the analysis = 300 gal of SST waste. (The volume documented in RPP-7277 in the evaporator vessel is 212 gal. This is based on field measurements of radiation levels at the bottom of the evaporator of 15 rem/h and calculating the contents.) Because of the uncertainty in the best estimate, it was increased by approximately 50%. There is no connection to add more waste to the evaporator.	Reasonably conservative based on evaporator design, field surveys, and operational practices.	The entire inventory is assumed to be in the evaporator vessel based on radiation surveys in the facility. This consolidates the inventory making it more probable that it would be affected by falling roof panels than if it is spread throughout the building. To challenge the threshold for the "moderate" consequence category, the material in the vessel would have to be increased from the conservative 300 gal by another 40% with the same ULD and SOF.	No	NA
The amount of waste assumed on each HEPA filter is such that the dose from each is 200 mrem/h. Based on 22% solids and 78% liquid, the amount of waste is 0.311 L per filter. Appendix B assumed that all eight HEPA filters were contaminated with 242-T waste to the point where they read 200 mrem/h. Then the equivalent of one more filter was included for contaminants in the duct.	Reasonably conservative based on operational practices (As Low as Reasonably Achievable).	Increasing the MAR by two orders of magnitude would not cause the results to change. Both filter banks would have to be on line to produce the full release, even though one bank normally will be isolated by manually operated dampers.	No	NA
The ARF and RF for splash/splatter were selected from DOE-HDBK-3010-94. The approximation in DOE-HDBK-3010-94 is for the free-fall of a concentrated heavy metal solution for fall distances of 9.8 ft or less to a hard, unyielding surface. The fall distance for 242-T is approximately 3 ft or less. DOE-HDBK-3010-94's correlation for ARF with a conservatively low viscosity is a valid approach. RF = 0.7 is considered reasonable. (DOE-HDBK-3010-94, Section 3.2.3.1).	Reasonably conservative based on the physical configuration and use of DOE-HDBK-3010-94.	If the viscosity is higher than the low value, the ARF decreases by the rate of the inverse square. If the spill is more than 3 ft, the ARF increases by the inverse square.	No	NA

Table 2-2. Qualitative Evaluation of Analysis Assumptions for Representative Accident. (4 sheets)

Analysis assumptions (AA) with references/basis	Assumption type	Sensitivity (consequence)	Need to protect AA	Protection Basis
A breathing rate of 3.33×10^{-4} m^3/s was used to estimate the radiological consequences. This is the breathing rate associated with light activity (i.e., it is an 8-hr average, which assumes 2.5 hr of sitting and 5.5 hr of light exercise) as derived by the International Commission on Radiological Protection. (RPP-5924.)	Reasonably conservative.	This is a standard analysis assumption.	No	NA
Onsite exposure of 2 hr. The normal work shift for tank farm personnel is longer than 2 hr. However, this accident would be quite obvious and 2 hr is a reasonable time for normal protective actions to occur.	Reasonably conservative.	Increased exposure time will cause an almost linear increase in wind entrainment consequences with the caveat that the released MAR will decrease with time as the pool is depleted. Maximum exposure time for the wind entrainment consequences would be a factor of 6 higher than calculated, which would not change the risk bin.	No	NA
Inhalation ULD for SST waste of 7.7×10^3 Sv/L. This is a composite of ULDs in RPP-5924 based on waste type and liquid/solids content (78%/22%).	Bounding of current liquid and solids ULDs.	No anticipated effect on consequence bin. Relationship with consequences is linear. The specific radioactivity of SST solids is higher than that of DST solids and the difference between the liquids is nominal. Therefore, the SST waste is a conservative choice.	No	NA
For the purpose of estimating toxicological consequences, the released waste is assumed to be SST liquids and solids. Toxicological consequences are calculated per the methodology established in RPP-8369. The values used are composites of numbers in RPP-8369 based on waste type and liquid/solids content (78%/22%). The onsite USOF for anticipated events is 5.8×10^8; the offsite USOF for anticipated events is 3.4×10^9.	Bounding of current SST liquid and solids SOFs.	No anticipated effect on consequence bin.	No	NA

Table 2-2. Qualitative Evaluation of Analysis Assumptions for Representative Accident. (4 sheets)

Analysis assumptions (AA) with references/basis	Assumption type	Sensitivity (consequence)	Need to protect AA	Protection Basis
Consideration for the assumptions of meteorological conditions include the following. Accident duration is less than 1 hr for the HEPA filter release and the splash/splatter from the evaporator vessel. For toxicological consequences, atmospheric dispersion coefficients of 3.28×10^{-2} s/m^3 (onsite) and 2.22×10^{-5} s/m^3 (offsite) were used to estimate consequences. For onsite radiological consequences, 3.28×10^{-2} s/m^3 (HEPA filter), 3.28×10^{-2} s/m^3 (splash/splatter), and 9.4×10^{-3} s/m^3 (wind entrainment) were used (RPP-13482).	Reasonably conservative. These atmospheric dispersion coefficients are based on 95% meteorology, which is recommended for conservative analysis.	No anticipated effect on consequence bin.	No	NA
The entrainment rate for the material after the initial building collapse and waste spill was selected from DOE-HDBK-3010-94 for the aerodynamic entrainment and suspension of the waste from the floor. DOE-HDBK-3010-94, Section 3.2.4.5 provides a bounding value for large pools in high winds (e.g., 30 mi/h). For the 242-T situation, the entrainment rate is 4×10^{-6}/hr.	Bounding value.	For a smaller pool or winds with a lower velocity, the entrainment rate is lower.	No	NA
No credit is taken for the HEPA filters from an aerosol removal standpoint. The scenario assumption is that the building collapses, exposing the MAR to the elements.	Bounding (physically limited).	No anticipated effect on consequence bin. If the HEPA filters are credited with particulate removal then the accident consequences would be reduced.	No	NA
For the HEPA filter overpressurization, the ARF is developed from DOE-HDBK-3010-94, Section 5.4 for shocking, blasting, or impacting a HEPA filter in an unconfined or a confined space providing a limiting ARF of 2.0×10^{-6} and RF = 1.	Bounding value.	In this case, this release fraction is highly conservative because a relatively mild pressure pulse is the initiator rather than a blast or explosion.	No	NA

Table 2-2. Qualitative Evaluation of Analysis Assumptions for Representative Accident. (4 sheets)

Analysis assumptions (AA) with references/basis	Assumption type	Sensitivity (consequence)	Need to protect AA	Protection Basis

Notes:

DOE-HDBK-3010-94, 1994, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, U.S. Department of Energy, Washington, D.C.

RPP-5924, 2005, *Radiological Source Terms for Tank Farms Safety Analysis*, Rev. 4A, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-7277, 2003, *Evaluation of Radionuclide Inventory at 242-T Evaporator*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-8369, 2003, *Chemical Source Terms for Tank Farms Safety Analyses*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-13482, 2005, *Atmospheric Dispersion Coefficients and Radiological and Toxicological Exposure Methodology for Use in Tank Farms*, Rev. 5, CH2M HILL Hanford Group, Inc., Richland, Washington.

AA = analysis assumptions.
ARF = aerosol release fraction.
DST = double-shell tank.
HEPA = high-efficiency particulate air (filter).
MAR = material at risk.
NA = not applicable.
RF = respirable fraction.
SOF = sum of fractions.
SST = single-shell tank.
TEEL = Temporary Emergency Exposure Limit.
ULD = unit-liter dose.
USOF = unitless sum of fractions.

2.2 CALCULATION RESULTS

2.2.1 Assignment of Consequence Bins for the Onsite Receptors

The maximum effects calculated in Appendix B (including HEPA filter effects) produced estimated onsite radiological consequences of 3.3×10^{-2} rem, onsite toxicological consequences (sum of fractions [SOF]) of 9.7×10^{-1} (emergency response planning guide [ERPG]-2) and offsite toxicological consequences (SOFs) of 2.7×10^{-3} (ERPG-1).

In determining the offsite toxicological and onsite radiological and toxicological consequences bins, the meeting participants considered 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 <25 rem and the onsite and offsite toxicological consequences (SOFs) of <1 ERPG-2/Temporary Emergency Exposure Limit (TEEL)-2 and <1 ERPG-1/TEEL-1, respectively). Therefore, a consequence bin of "low" was assigned to the onsite radiological and the onsite and offsite toxicological exposures.

2.2.2 Assignment of Environmental Consequences

The hot side of the evaporator building (i.e., where the evaporator vessel is located) has a dike at its only door. The height of the dike is sized to retain the operating volume of the evaporator (i.e., 4,000 gal). The analysis in Appendix B conservatively assumes 300 gal of solids and supernatant, which would be easily retained by the dike. If the evaporator vessel were at the operating level (4,000 gal) with an undetected 3,700 gal layer of contaminated water over the 300 gal of waste, the contents would still be retained in the building. The total collapse of the south wall, or the south part of the east and/or west wall, to the point where the waste would be released directly to the ground is not likely.

The aerosol release would be 4.1×10^{-2} L from splash/splatter and 1.2×10^{-1} L from the entrainment. 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 aboveground tank failure accident.

2.2.3 Assignment of Risk Bins

As discussed previously, the frequency of the aboveground tank failure due to facility degradation was considered to be in the "anticipated" range, and the offsite toxicological and the onsite radiological and toxicological were assigned a consequence bin of "low." Each exposure category for the aboveground tank failure accident was assigned to Risk Bin III based on Tables 1-1 and 1-2.

2.3 ABOVEGROUND TANK FAILURE - ASSOCIATED HAZARDOUS CONDITIONS

There are numerous additional hazardous conditions represented by the aboveground tank failure representative accident. (Note that the specific number of hazardous conditions may change based on changes in field configurations or operations.) The results of the risk binning process for these hazardous conditions are shown in the hazard evaluation database under representative accident (Rep Acc) 34. Included in these hazard evaluation database entries is a basis for each consequence and frequency. Most of the related hazardous conditions consider the failure of other components in the 242-T Evaporator building. As noted previously, the evaporator vessel is the largest component in the building and has the largest inventory of waste (based on radiation surveys). The initiators for the failure of the other components would be the same as for the evaporator vessel.

2.3.1 Demonstration Bulk Vitrification System Associated Hazardous Conditions

Additional hazardous conditions related to the aboveground tank failure accident were identified during the design and hazards analysis of the aboveground tanks associated with the DBVS project. These hazardous conditions were identified to potentially not be bounded by the existing aboveground failure representative accident. Analysis is presented here to support the stand alone preliminary documented safety analysis (RPP-23429, *Preliminary Documented Safety Analysis for the Demonstration Bulk Vitrification System*) used to support construction of the DBVS.

The DBVS project, which is part of the Hanford Supplemental Treatment Project, is intended to supplement the Waste Treatment Plant low activity waste plant capacity. The project will determine the feasibility of using bulk vitrification technology to safely and economically produce an immobilized low activity waste borosilicate glass product that is comparable to Waste Treatment Plant immobilized low activity waste glass. The Supplemental Treatment Project performs tests using full scale bulk vitrification equipment and actual Hanford tank waste. The Supplemental Treatment Project has two major systems:

- The Waste Retrieval System will retrieve salt waste, pretreat the waste through selective dissolution and solid/liquid separation, and delivers the waste salt solution to the DBVS.

- The DBVS will combine the waste salt solution with glass formers, vitrify the salt/former mixture, and produce a vitrified waste package suitable for disposal in an onsite licensed disposal facility.

The major DBVS subsystems/components, and their functions, include:

- Retrieval – Retrieve salt waste solution from single-shell tank (SST) 241-S-109 using proven retrieval technology, sample and store for analytical verification.

- Feed/Receipt – Receive, sample and store for analytical verification, and feed salt waste solution.

- Waste Dryer Module – Mix salt waste solution with soil and small amounts of zirconia and boria, dry and transfer the mixture to the melt station.

- Melt Station – Using joule heating, melt the mixture to produce borosilicate glass, and confine and direct the off gas.

- Off-Gas Treatment – Treat off gas generated during the drying and melting process to remove radionuclides and toxic gases.

- Liquid Effluent – Collect, store and transfer liquid waste to tankers for shipment to Effluent Treatment Facility.

- Package Interim Storage – Sample finished packages and store until shipment to the disposal facility.

As part of the feed/receipt function, there are three 18,000 gal waste staging tanks, which are aboveground. The aboveground tanks associated with the DBVS are subject to failure from one of several possible causes (e.g., seismic event, high winds, structural degradation, manufacturing defects, vehicle collisions). The primary structures of concern from a material at risk (MAR) standpoint are the three large waste staging tanks. During system operations, those tanks could contain a maximum of 18,000 gal of waste each (which bounds the other aboveground tanks present in the system and exceeds the volume of MAR in the aboveground tank failure representative accident discussed above). Scoping calculations were performed to aid in the assignment of risk bins. The scoping calculations are documented in Appendix C. The results are summarized in Table 2-3 and a qualitative evaluation of the sensitivity of the analysis assumptions is documented in Table 2-4.

The calculations for the aboveground failure of the small (1,100 gal) 241-S-109 staging tank, which will be used during the Phase I demonstration of the bulk vitrification process, are presented in Appendix D along with a qualitative evaluation of the sensitivity of the analysis assumptions.

It should be noted that the simultaneous failure of the three large waste staging tanks bounds the consequences of all other failures of aboveground tanks that are part of DBVS, such as the failure of a single waste staging tank, failure of the waste dryer, failure of the 241-S-109 Phase I staging tank (see Appendix D), and failure of secondary waste tanks. This is a result of the combination of quantity of MAR available, the type of waste, and the spill height.

Table 2-3. Summary of Results for Demonstration Bulk Vitrification System Associated Conditions.

Postulated accident/ hazardous condition	Frequency	Consequences				Risk bin		
		Onsite radiological	Offsite toxicological	Onsite toxicological	Environmental	Onsite radiological	Offsite toxicological	Onsite toxicological
Catastrophic failure of three tanks due to a seismic event with rapid draining of the contents	U	L	L	M	E2	III	III	II
Failure of a single tank with drainage through a broken penetration	U	L	L	L	E1	III	III	III

Notes:

The frequency determination of "anticipated" in Section 2.1.2 above for the 242-T Evaporator vessel (old and not maintained) does not apply to the new tanks in DBVS.

DBVS = Demonstration Bulk Vitrification System.
L = low.
M = moderate.
U = unlikely. (Note: the frequency range of 1 x 10^{-2} to 1 x 10^{-4}/yr is judged to be applicable for DBVS because the tanks are new, are located in a new enclosure, and will be subjected to startup testing, and will operate for limited time. Also, the recurrence period of a performance category 2 seismic event is consistent with this frequency range. Additionally, the tanks are assumed to fail at the worst possible location to maximize the splash/splatter component of the release.

Table 2-4. Qualitative Evaluation of Analysis Assumptions for an Aboveground Tank Failure During Demonstration Bulk Vitrification System Operations. (5 sheets)

Analysis assumptions (AA) with references/basis	Assumption type	Sensitivity (frequency/consequence)	Need to protect AA	Protection/evaluation basis
Catastrophic failure of three tanks with rapid draining of the contents				
All three tanks were assumed to be completely full (54,000 gal or 204,000 L).	Bounding value.	No anticipated effect on consequence bin. This is the bounding MAR that could be present. The MAR would have to be increased by almost a factor of 500 to change a consequence bin, which is physically impossible.	No	NA
An airborne release fraction and respirable fraction for splash/splatter were specifically calculated to maximize the release using the equation found in DOE-HDBK-3010-94, Section 3.2.3.1. The ARF and RF used were 1.99×10^{-6} and 0.8, respectively.	Reasonably conservative.	No anticipated effect on risk bin. The spill height would have to be increased significantly (about a factor of 40) beyond the physical height of the waste staging for the consequence bin to be affected. While the tank will be elevated slightly (40 cm) above grade, current plans do not require it to be elevated such a significant height above grade.	No	NA
All three tanks (54,000 gal) are assumed to drain within 60 sec due to large simultaneous breaches in each tank.	Reasonably conservative.	No anticipated effect on consequence bin. The entire release is compressed into 60 sec to maximize the toxicological consequences. Even if the release were assumed to be a puff release, consequences would not be exceeded.	No	NA
For radiological consequence calculations, the three tanks are assumed to consist of 95% liquid and 5% sludge from SST 241-S-109. The onsite ULD that was calculated for this mixture is 2.3×10^{2} Sv/L.	Bounding value.	No anticipated effect on consequence bin. The sludge ULD and the liquid ULD bounds the saltcake ULD from SST 241-S-109. Even if 100% sludge were assumed the consequence bin would not change.	No	NA

Table 2-4. Qualitative Evaluation of Analysis Assumptions for an Aboveground Tank Failure During Demonstration Bulk Vitrification System Operations. (5 sheets)

Analysis assumptions (AA) with references/basis	Assumption type	Sensitivity (frequency/consequence)	Need to protect AA	Protection/evaluation basis
For toxicological consequence calculations, the three tanks are assumed to contain 95% liquid and 5% solids from SST 241-S-109. The SOFs that were calculated for this mixture are 8.7×10^8 (TEEL-1), 1.3×10^8 (TEEL-2), and 7.8×10^6 (TEEL-3).	Bounding value.	No anticipated effect on consequence bin. If 100% solids are assumed, the onsite consequence bin would change from moderate to high, and the offsite consequence bin would remain low, even though 100% solids could not physically be transferred into the tanks. It would take an increase in solids content from 5% to about 15% for the onsite consequence bin to change from moderate to high, assuming no viscosity effect. The expected solids content is 3%. Therefore, this amount of solids (15%) is five times the expected value, and therefore, is considered extremely unlikely.	No	NA
The specific gravity of the slurry in the tanks is assumed to be ~1.2 to maximize the splash and splatter.	Reasonably conservative.	No anticipated effect on consequence bin. As the specific gravity increases the viscosity increases thus minimizing the splash/splatter component. The specific gravity is assumed to be 1.2 even though the solution is saturated with salts and some solids are assumed to be present, both of which would tend to increase the specific gravity beyond the value assumed.	No	NA
The duration of exposure to entrainment and resuspension is assumed to be 8 h.	Reasonably conservative.	No anticipated effect on consequence bin. This is a standard assumption for resuspension. Resuspension is a small contributor to the overall dose. The duration of exposure would have to increase by a factor of about 2,000 for the consequence bin to be affected.	No	NA
A breathing rate of 3.33×10^{-4} m^3/s was used to determine the radiological consequences. This is the breathing rate associated with light activity (i.e., it is an 8-hr average which assumes 2.5 hr of sitting and 5.5 hr of light exercise) as derived by the International Commission on Radiological Protection (documented in RPP-5924).	Reasonably conservative.	No anticipated effect on consequence bin. This is a standard analysis assumption.	No	NA

Table 2-4. Qualitative Evaluation of Analysis Assumptions for an Aboveground Tank Failure During Demonstration Bulk Vitrification System Operations. (5 sheets)

Analysis assumptions (AA) with references/basis	Assumption type	Sensitivity (frequency/consequence)	Need to protect AA	Protection/evaluation basis
An atmospheric dispersion coefficient of 2.22 x 10^{-5} s/m^3 was used for offsite consequences and an atmospheric dispersion coefficient of 3.28 x 10^{-2} s/m^3 was used for onsite consequences.	Reasonably conservative.	No anticipated effect on consequence bin. The atmospheric dispersion coefficients are from RPP-13482 and represent the 95th percent overall value for accidents less than 1 hr with an assumed ground level release point. No credit is taken for plume meander, building wake effects, or deposition.	No	NA
An airborne release rate for entrainment of 4 x 10^{-7} /hr was used for a liquid pool exposed to small external wind speeds due to localized damage to the surrounding concrete radiation shield wall structure (DOE-HDBK-3010-94, Section 3.2.4.5).	Reasonably conservative.	No anticipated effect on consequence bin. The airborne release rate for entrainment would have to be increased by a factor of nearly 200 for the onsite toxicological consequence bin to change from moderate to high.	No	NA
Failure of a single tank with drainage through a broken penetration				
The tank was assumed to be completely full (18,000 gal or 68,000 L).	Bounding value.	No anticipated effect on consequence bin. This is the bounding MAR that could be present. The MAR would have to be increased by a factor of almost 2,000 to change a consequence bin, which is physically impossible.	No	NA

Table 2-4. Qualitative Evaluation of Analysis Assumptions for an Aboveground Tank Failure During Demonstration Bulk Vitrification System Operations. (5 sheets)

Analysis assumptions (AA) with references/basis	Assumption type	Sensitivity (frequency/consequence)	Need to protect AA	Protection/evaluation basis
An airborne release fraction and respirable fraction for splash/splatter were specifically calculated for a spill height of 55 cm) using the equation found in DOE-HDBK-3010-94, Section 3.2.3.1. [The final configuration was not available, so a reasonably conservative drop height of 55 cm is used based on the penetration height shown on drawing DBVS-SK-M104 (see Appendix E).] The ARF and RF used were 2.9×10^{-7} and 0.8, respectively.	Reasonably conservative.	No anticipated effect on risk bin. The spill height would have to be increased significantly (about a factor of 200) beyond the physical height of the waste staging for the consequence bin to be affected. While the tank will be elevated slightly (40 cm) above grade, current plans do not require it to be elevated such a significant height above grade.	No	NA
The tank is assumed to drain through a broken 2-in. ID penetration with 90 in. of head.	Reasonably conservative.	While the 2-in. penetration is the bounding penetration on the standard tank configuration, it is possible that additional penetrations will be added to meet operational needs. If a penetration were to be added that was 17 in. or larger in diameter, the moderate consequence bin would be approached. It is extremely unlikely that a penetration of this size would be added to the tank based on drawing DBVS-SK-M104 (see Appendix E).		NA
For radiological consequence calculations, the tank is assumed to consist of 95% liquid and 5% sludge from SST 241-S-109. The onsite ULD that was calculated for this mixture is 2.3×10^{2} Sv/L.	Bounding value.	No anticipated effect on consequence bin. The sludge ULD and the liquid ULD bounds the saltcake ULD from SST 241-S-109. Even if 100% sludge were assumed the consequence bin would not change.	No	NA

Table 2-4. Qualitative Evaluation of Analysis Assumptions for an Aboveground Tank Failure During Demonstration Bulk Vitrification System Operations. (5 sheets)

Analysis assumptions (AA) with references/basis	Assumption type	Sensitivity (frequency/consequence)	Need to protect AA	Protection/evaluation basis
For toxicological consequence calculations, the tank is assumed to contain 95% liquid and 5% solids from SST 241-S-109. The SOFs that were calculated for this mixture are 8.7×10^8 (TEEL-1), 1.3×10^8 (TEEL-2), and 7.8×10^6 (TEEL-3).	Bounding value.	No anticipated effect on consequence bin. If 100% solids are assumed, the onsite and offsite consequence bin would remain low, even though 100% solids could not physically be transferred into the tanks.	No	NA
The specific gravity of the slurry in the tank is assumed to be ~1.2 to maximize the splash and splatter.	Reasonably conservative.	No anticipated effect on consequence bin. As the specific gravity increases the viscosity increases thus minimizing the splash/splatter component. The specific gravity is assumed to be 1.2 even though the solution is saturated with salts and some solids are assumed to be present, both of which would tend to increase the specific gravity beyond the value assumed.	No	NA
The duration of exposure to entrainment and resuspension is assumed to be 8 h.	Reasonably conservative.	No anticipated effect on consequence bin. This is a standard assumption for resuspension. Resuspension is a small contributor to the overall dose. The duration of exposure would have to increase by a factor of almost 2,700 for the consequence bin to be affected.	No	NA
A breathing rate of 3.33×10^{-4} m^3/s was used to determine the radiological consequences. This is the breathing rate associated with light activity (i.e., it is an 8-hr average which assumes 2.5 hr of sitting and 5.5 hr of light exercise) as derived by the International Commission on Radiological Protection (documented in RPP-5924).	Reasonably conservative.	No anticipated effect on consequence bin. This is a standard analysis assumption.	No	NA

Table 2-4. Qualitative Evaluation of Analysis Assumptions for an Aboveground Tank Failure During Demonstration Bulk Vitrification System Operations. (5 sheets)

Analysis assumptions (AA) with references/basis	Assumption type	Sensitivity (frequency/consequence)	Need to protect AA	Protection/evaluation basis
An atmospheric dispersion coefficient of 2.22×10^{-5} s/m^3 was used for offsite consequences and an atmospheric dispersion coefficient of 3.28×10^{-2} s/m^3 was used for onsite consequences.	Reasonably conservative.	No anticipated effect on consequence bin. The atmospheric dispersion coefficients are from RPP-13482 and represent the 95th percent overall value for accidents less than 1 hr with an assumed ground level release point. No credit is taken for plume meander, building wake effects, or deposition.	No	NA
An airborne release rate for entrainment of 4×10^{-7} /hr was used for a liquid pool exposed to small external wind speeds due to localized damage to the surrounding concrete radiation shield wall structure (DOE-HDBK-3010-94, Section 3.2.4.5).	Reasonably conservative.	No anticipated effect on consequence bin. The airborne release rate for entrainment would have to be increased by more than a factor of 30 for the onsite toxicological consequence bin to change from low to moderate.	No	NA
Tank penetrations are assumed to have sharp edged entrances and exits.	Reasonably conservative.	No anticipated effect on consequence bin. The pipe friction factor is conservatively ignored. Even if the failed pipes are assumed to have polished, well-rounded entrances and exits, the release rate would only increase by 20% which would not affect the consequence bin.	No	NA

Table 2-4. Qualitative Evaluation of Analysis Assumptions for an Aboveground Tank Failure During Demonstration Bulk Vitrification System Operations. (5 sheets)

Analysis assumptions (AA) with references/basis	Assumption type	Sensitivity (frequency/consequence)	Need to protect AA	Protection/evaluation basis

Notes:

DOE-HDBK-3010-94, 2000, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, Change Notice 1, U.S. Department of Energy, Washington, D.C.

RPP-5924, 2005, *Radiological Source Terms for Tank Farms Safety Analysis*, Rev. 4A, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-8369, 2003, *Chemical Source Terms for Tank Farms Safety Analyses*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-13482, 2005, *Atmospheric Dispersion Coefficients and Radiological/Toxicological Exposure Methodology for Use in Tank Farms*, Rev. 5, CH2M HILL Hanford Group, Inc., Richland, Washington.

AA = analysis assumption.
ARF = airborne release fraction.
ID = internal diameter.
MAR = material at risk.
NA = not applicable.
RF = respirable fraction.
SOF = sum of fractions.
SST = single-shell tank.
TEEL = Temporary Emergency Exposure Limit.
ULD = unit-liter dose.

2.3.2 Contact-Handled Transuranic Mixed Waste Associated Hazardous Conditions

Additional hazardous conditions related to the aboveground tank failure accident were identified during the design and hazards analysis of the CH-TRUM facility. These hazardous conditions were also identified to potentially not be bounded by the existing aboveground failure representative accident. Analysis is presented here to support the stand alone preliminary documented safety analysis (RPP-23479, *Preliminary Documented Safety Analysis for the Contact-Handled Transuranic Mixed (CH-TRUM) Waste Facility*) used to support construction of the CH-TRUM waste facility.

The CH-TRUM Waste Packaging Unit (WPU) is a supplemental technology developed by CH2M HILL to receive, dry, and package contact-handled transuranic/mixed waste from Tank Farm SST systems.

Waste from the 241-B and 241-T Tank Farm SSTs will be retrieved using the SST waste retrieval (vacuum retrieval) system and transferred to the CH-TRUM WPU for receipt, drying, packaging, and interim storage prior to being shipped to the Waste Isolation Pilot Plant (WIPP). The dried waste will be packaged in 55-gal drums and moved to interim storage facilities via forklift where it will be temporarily stored prior to shipment to the Hanford Central Waste Complex.

The CH-TRUM WPU is a modular, portable, nuclear processing system designed to receive and package waste retrieved from 11 SSTs located in the 200 East and 200 West Areas. The 11 tanks are 241-B-201, 241-B-202, 241-B-203, 241-B-204, 241-T-201, 241-T-202, 241-T-203, 241-T-204, 241-T-104, 241-T-110, and 241-T-111. The WPU will be set up and operated initially at the 241-B Tank Farm in the 200 East Area. Upon completion of processing at the 241-B Tank Farm, the WPU will be relocated to the 241-T Tank Farm in the 200 West Area.

The WPU is sized to process 1.4 Mgal of undiluted waste retrieved from 11 SSTs. The mission is to complete the packaging of the SST waste in approximately 1 yr, including a 30-day transfer of the WPU from the 241-B Tank Farm to the 241-T Tank Farm. The WPU is available for operation 24 hours per day, 7 days per week, 365 days per year, and is designed to receive up to 7,200 gal of undiluted waste per day (14,400 gal per day total throughput when a nominal 1:1 dilution with water is included). Additives will be used, as necessary, to control the properties of the dried product and insure a flowable material that can be transported in the conveyance chute.

The aboveground tanks/vessels associated with the CH-TRUM system (e.g., waste receipt tanks, dryers) are subject to failure from one of several possible causes (e.g., seismic event, high winds, structural degradation, manufacturing defects, vehicle collisions). The primary structures of concern are the five large feed receipt processing system (FRPS) receipt tanks and the two waste dryers. During system operations each FRPS receipt tank and each dryer could contain a maximum of 30,280 L and 10,200 L, respectively, of waste and dilution water which bounds the other aboveground tanks and vessels present in the CH-TRUM Facility. Scoping calculations were performed to aid in the assignment of risk bins. The scoping calculations are documented in Appendix G. The results are summarized in Table 2-5, and the analysis assumptions are documented in Table 2-6.

Table 2-5. Summary of Results for Contact-Handled Transuranic Mixed Waste Associated Conditions.

Postulated accident/ hazardous condition	Frequency	Consequences				Risk bin		
		Onsite radiological	Offsite toxicological	Onsite toxicological	Environmental	Onsite radiological	Offsite toxicological	Onsite toxicological
Catastrophic failure of five FRPS receipt tanks due to seismic event with rapid draining of the contents	U	L	L	H	E2	III	III	I
Catastrophic failure of one FRPS receipt tank due to seismic event with rapid draining of the contents	U	L	L	H	E2	III	III	I
Catastrophic failure of one waste dryer due to seismic event with rapid draining of the contents	U	L	L	H	E2	III	III	I
Failure of a single FRPS receipt tank with drainage through a broken overflow penetration	U	L	L	L	E1	III	III	III

Notes:

FRPS = feed receipt processing system.
H = high.
L = low.
M = moderate.
U = unlikely.

Table 2-6. Qualitative Evaluation of Analysis Assumptions for Aboveground Tank Failures During Contact-Handled Transuranic Mixed Waste Facility Operations. (13 sheets)

Analysis assumptions (AA) with references/basis	Assumption type	Sensitivity (frequency/consequence)	Need to protect AA	Protection/evaluation basis
Catastrophic failure of five FRPS receipt tanks with rapid draining of the contents				
All five tanks were assumed to be completely full (40,000 gal or 151,400 L).	Bounding value.	No anticipated effect on consequence bin. This is the bounding MAR that could be present. The MAR would have to be increased by a factor on nearly 8 to change a consequence bin, which is physically impossible.	No	NA
An airborne release fraction and respirable fraction for splash/splatter were specifically calculated to maximize the release using the equation found in DOE-HDBK-3010-94, Section 3.2.3.1. The ARF and RF used were 6.34×10^{-6} and 0.8, respectively.	Reasonably conservative.	No anticipated effect on risk bin. The spill height would have to increase significantly by about 860 cm, which is beyond the physical height of the FRPS receipt tank for the consequence bins to be affected. While the tank will be elevated slightly (68 cm) above grade, current plans do not require it to be elevated such a significant height above grade.	No	NA
All five FRPS receipt tanks (151,400 L) are assumed to drain within 60 sec due to large simultaneous breaches in each tank.	Reasonably conservative.	No anticipated effect on consequence bin. The toxicological consequences are based on a release over time and maximum concentrations occurring over a 1 to 15 min interval of exposure are typical. The splash/splatter release is compressed into 60 sec to maximize the toxicological consequences. Even if the release were assumed to be a puff release, the consequence bins would not change.	No	NA
The bounding ULDs and SOFs documented in RPP-5924 and RPP-8369 for the CH-TRUM tanks are used for estimating radiological and toxicological consequences. CH-TRUM waste consists of waste from 241-B-201, 241-B-202, 241-B-203, 241-B-204, 241-T-110, 241-T-111, 241-T-201, 241-T-202, 241-T-203, 241-T-204, and 241-T-104.	Bounding value.	No anticipated effect on consequence bin. The ULDs and SOFs would have to be increased by a factor of about 100 and 8, respectively to change the consequence bins.	No	NA

Table 2-6. Qualitative Evaluation of Analysis Assumptions for Aboveground Tank Failures During Contact-Handled Transuranic Mixed Waste Facility Operations. (13 sheets)

Analysis assumptions (AA) with references/basis	Assumption type	Sensitivity (frequency/consequence)	Need to protect AA	Protection/evaluation basis
For radiological consequence calculations, the five FRPS receipt tanks are assumed to contain slurry consisting of 50% water mixed with the bounding solid CH-TRUM waste. The onsite ULD that was calculated for this mixture is 6.0×10^2 Sv/L.	Bounding value.	No anticipated effect on consequence bin. The ULD would have to be increased by a factor of about 50 above the undiluted waste ULD to change the onsite radiological consequence bin from low to moderate.	No	NA
For toxicological consequence calculations, the five FRPS receipt tanks are assumed to contain slurry consisting of 50% water mixed with the bounding solid CH-TRUM waste. The SOFs that were calculated for this mixture are 8.6×10^8 (TEEL-1), 2.8×10^8 (TEEL-2), and 1.7×10^8 (TEEL-3).	Bounding value.	No anticipated effect on consequence bin. The SOF would have to be increased by a factor of about 4 above the undiluted waste SOF to change the offsite toxicological consequence bin from low to moderate.	No	NA
The FRPS receipt tanks are assumed to contain the minimum amount of dilution water (1:1) to enable the transfer from the source tank. Additionally, the specific gravity of the slurry in the tanks is assumed to be ~1.2 to maximize the splash and splatter.	Reasonably conservative.	No anticipated effect on consequence bin. As the specific gravity increases the viscosity increases thus decreasing the splash/splatter component. Even if the tanks were filled with pure solids, the viscosity of the tank contents would increase sufficiently to lower the ARF for splash and splatter such that the consequences remain unchanged. Additionally, the specific gravity is assumed to be 1.2 even though the solution contains 50% solids, which would increase the specific gravity beyond the value assumed.	No	NA
An airborne release rate for entrainment of 4×10^{-7} /hr was used for a liquid pool exposed to small external wind speeds. (DOE-HDBK-3010-94, Section 3.2.4.5).	Reasonably conservative.	No anticipated effect on consequence bin. The airborne release rate for entrainment would have to be increased by a factor of over 1,000 for the onsite radiological and offsite toxicological consequence bins to change from low to moderate.	No	NA

Table 2-6. Qualitative Evaluation of Analysis Assumptions for Aboveground Tank Failures During Contact-Handled Transuranic Mixed Waste Facility Operations. (13 sheets)

Analysis assumptions (AA) with references/basis	Assumption type	Sensitivity (frequency/consequence)	Need to protect AA	Protection/evaluation basis
The duration of exposure to entrainment and resuspension is assumed to be 8 h.	Reasonably conservative.	No anticipated effect on consequence bin. This is a standard assumption for resuspension. Entrainment is a small contributor to the overall consequences. The duration of exposure would have to increase by a factor of over 1,000 for the onsite radiological consequence bin to change from low to moderate.	No	NA
For the splash/splatter part of the release, an atmospheric dispersion coefficient of 2.22×10^{-5} s/m^3 was used for offsite consequences and an atmospheric dispersion coefficient of 3.28×10^{-2} s/m^3 was used for onsite consequences. For the entrainment part of the release, the 8-hr atmospheric dispersion coefficient of 5.58×10^{-3} s/m^3 was used for onsite radiological consequences.	Reasonably conservative.	No anticipated effect on consequence bin. The atmospheric dispersion coefficients used for the splash/splatter part of the release are from RPP-13482 and represent the 95th percent overall value for accidents less than 1 hr with an assumed ground level release point. The 8-hr atmospheric dispersion coefficient used for radiological entrainment is also from RPP-13482 and represents the 95th percent overall value for accidents of 8-hr duration. None of the values take credit for plume meander, building wake effects, or deposition.	No	NA
A breathing rate of 3.33×10^{-4} m^3/s was used to determine the radiological consequences. This is the breathing rate associated with light activity (i.e., it is an 8-hr average which assumes 2.5 hr of sitting and 5.5 hr of light exercise) as derived by the International Commission on Radiological Protection (documented in RPP-5924).	Reasonably conservative.	No anticipated effect on consequence bin. This is a standard analysis assumption.	No	NA
Catastrophic failure of one FRPS receipt tank with rapid draining of the contents				
Each FRPS receipt tank was assumed to be completely full (8,000 gal or 30,280 L).	Bounding value.	No anticipated effect on consequence bin. This is the bounding MAR that could be present. The MAR would have to be increased by a factor of nearly 40 to change a consequence bin, which is physically impossible.	No	NA

Table 2-6. Qualitative Evaluation of Analysis Assumptions for Aboveground Tank Failures During Contact-Handled Transuranic Mixed Waste Facility Operations. (13 sheets)

Analysis assumptions (AA) with references/basis	Assumption type	Sensitivity (frequency/consequence)	Need to protect AA	Protection/evaluation basis
An airborne release fraction and respirable fraction for splash/splatter were specifically calculated to maximize the release using the equation found in DOE-HDBK-3010-94, Section 3.2.3.1. The ARF and RF used were 6.34×10^{-6} and 0.8, respectively.	Reasonably conservative.	No anticipated effect on risk bin. The spill height would have to be increased significantly by about 2,900 cm, which is beyond the physical height of the FRPS receipt tank for the consequence bins to be affected. While the tank will be elevated slightly (68 cm) above grade, current plans do not require it to be elevated such a significant height above grade.	No	NA
The FRPS receipt tank (30,280 L) is assumed to drain within 60 sec due to a large breach in the tank.	Reasonably conservative.	No anticipated effect on consequence bin. The toxicological consequences are based on a release over time and maximum concentrations occurring over a 1 to 15 min interval of exposure are typical. The splash/splatter release is compressed into 60 sec to maximize the toxicological consequences. Even if the release were assumed to be a puff release, the consequence bins would not change.	No	NA
The bounding ULDs and SOFs documented in RPP-5924 and RPP-8369 for the CH-TRUM tanks are used for estimating radiological and toxicological consequences. CH-TRUM waste consists of waste from 241-B-201, 241-B-202, 241-B-203, 241-B-204, 241-T-110, 241-T-111, 241-T-201, 241-T-202, 241-T-203, 241-T-204, and 241-T-104.	Bounding value.	No anticipated effect on consequence bin. The ULDs and SOFs would have to be increased by a factor of about 500 and 40, respectively, to change the consequence bins.	No	NA

Table 2-6. Qualitative Evaluation of Analysis Assumptions for Aboveground Tank Failures During Contact-Handled Transuranic Mixed Waste Facility Operations. (13 sheets)

Analysis assumptions (AA) with references/basis	Assumption type	Sensitivity (frequency/consequence)	Need to protect AA	Protection/evaluation basis
For radiological consequence calculations, the FRPS receipt tank is assumed to contain slurry consisting of 50% water mixed with the bounding solid CH-TRUM waste. The onsite ULD that was calculated for this mixture is 6.0×10^2 Sv/L.	Bounding value.	No anticipated effect on consequence bin. The ULD would have to be increased by a factor of about 250 above the undiluted waste ULD to change the onsite radiological consequence bin from low to moderate.	No	NA
For toxicological consequence calculations, each FRPS receipt tank is assumed to contain slurry consisting of 50% water mixed with the bounding solid CH-TRUM waste. The SOFs that were calculated for this mixture are 8.6×10^8 (TEEL-1), 2.8×10^8 (TEEL-2), and 1.7×10^8 (TEEL-3).	Bounding value.	No anticipated effect on consequence bin. The SOF would have to be increased by a factor of about 20 above the undiluted waste SOF to change the offsite toxicological consequence bin from low to moderate.	No	NA
Each FRPS receipt tank is assumed to contain the minimum amount of dilution water (1:1) to enable the transfer from the source tank. Additionally, the specific gravity of the slurry in the tank is assumed to be ~1.2 to maximize the splash and splatter.	Reasonably conservative.	No anticipated effect on consequence bin. As the specific gravity increases the viscosity increases thus decreasing the splash/splatter component. Even if the tank was filled with pure solids (sludge), the viscosity of the tank contents would increase sufficiently to lower the ARF for splash and splatter such that the consequences remain unchanged. Additionally, the specific gravity is assumed to be 1.2 even though the solution contains 50% solids, which would increase the specific gravity beyond the value assumed.	No	NA
An airborne release rate for entrainment of 4×10^{-7} /hr was used for a liquid pool exposed to small external wind speeds. (DOE-HDBK-3010-94, Section 3.2.4.5).	Reasonably conservative.	No anticipated effect on consequence bin. The airborne release rate for entrainment would have to be increased by a factor of over 5000 for the onsite radiological and offsite toxicological consequence bins to change from low to moderate.	No	NA

Table 2-6. Qualitative Evaluation of Analysis Assumptions for Aboveground Tank Failures During Contact-Handled Transuranic Mixed Waste Facility Operations. (13 sheets)

Analysis assumptions (AA) with references/basis	Assumption type	Sensitivity (frequency/consequence)	Need to protect AA	Protection/evaluation basis
The duration of exposure to entrainment and resuspension is assumed to be 8 h.	Reasonably conservative.	No anticipated effect on consequence bin. This is a standard assumption for resuspension. Entrainment is a small contributor to the overall consequences. The duration of exposure would have to increase by a factor of over 5,000 for the onsite radiological consequence bin to change from low to moderate.	No	NA
For the splash/splatter part of the release, an atmospheric dispersion coefficient of 2.22×10^{-5} s/m^3 was used for offsite consequences and an atmospheric dispersion coefficient of 3.28×10^{-2} s/m^3 was used for onsite consequences. For the entrainment part of the release, the 8-hr atmospheric dispersion coefficient of 5.58×10^{-3} s/m^3 was used for onsite radiological consequences.	Reasonably conservative.	No anticipated effect on consequence bin. The atmospheric dispersion coefficients used for the splash/splatter part of the release are from RPP-13482 and represent the 95th percent overall value for accidents less than 1 hr with an assumed ground level release point. The 8-hr atmospheric dispersion coefficient used for radiological entrainment is also from RPP-13482 and represents the 95th percent overall value for accidents of 8-hr duration. None of the values take credit for plume meander, building wake effects, or deposition.	No	NA
A breathing rate of 3.33×10^{-4} m^3/s was used to determine the radiological consequences. This is the breathing rate associated with light activity (i.e., it is an 8-hr average which assumes 2.5 hr of sitting and 5.5 hr of light exercise) as derived by the International Commission on Radiological Protection (documented in RPP-5924).	Reasonably conservative.	No anticipated effect on consequence bin. This is a standard analysis assumption.	No	NA
Catastrophic failure of one waste dryer with rapid draining of the contents				
Each waste dryer was assumed to be completely full (10,200 L).	Bounding value.	No anticipated effect on consequence bin. This is the bounding MAR that could be present. The MAR would have to be increased by a factor of over 20 to change a consequence bin, which is physically impossible.	No	NA

Table 2-6. Qualitative Evaluation of Analysis Assumptions for Aboveground Tank Failures During Contact-Handled Transuranic Mixed Waste Facility Operations. (13 sheets)

Analysis assumptions (AA) with references/basis	Assumption type	Sensitivity (frequency/consequence)	Need to protect AA	Protection/evaluation basis
An airborne release fraction and respirable fraction for splash/splatter were specifically calculated to maximize the release using the equation found in DOE-HDBK-3010-94, Section 3.2.3.1. The ARF and RF used were 1.35×10^{-5} and 0.8, respectively.	Reasonably conservative.	No anticipated effect on risk bin. The spill height would have to be increased significantly by about 3,200 cm, which is beyond the physical height of the dryer for the consequence bins to be affected. While the dryer will be elevated (550 cm) above grade, current plans do not require it to be elevated such a significant height above grade.	No	NA
The waste dryer (10,200 L) is assumed to drain within 60 sec due to a large breach in the vessel.	Reasonably conservative.	No anticipated effect on consequence bin. The toxicological consequences are based on a release over time and maximum concentrations occurring over a 1 to 15 min interval of exposure are typical. The splash/splatter release is compressed into 60 sec to maximize the toxicological consequences. Even if the release were assumed to be a puff release, the consequence bins would not change.	No	NA
The bounding ULDs and SOFs documented in RPP-5924 and RPP-8369 for the CH-TRUM tanks are used for estimating radiological and toxicological consequences. CH-TRUM waste consists of waste from 241-B-201, 241-B-202, 241-B-203, 241-B-204, 241-T-110, 241-T-111, 241-T-201, 241-T-202, 241-T-203, 241-T-204, and 241-T-104.	Bounding value.	No anticipated effect on consequence bin. The ULDs and SOFs would have to be increased by a factor of about 300 and 20, respectively to change the consequence bins.	No	NA

Table 2-6. Qualitative Evaluation of Analysis Assumptions for Aboveground Tank Failures During Contact-Handled Transuranic Mixed Waste Facility Operations. (13 sheets)

Analysis assumptions (AA) with references/basis	**Assumption type**	**Sensitivity (frequency/consequence)**	**Need to protect AA**	**Protection/evaluation basis**
For radiological consequence calculations, each waste dryer is assumed to contain slurry consisting of 50% water mixed with the bounding solid CH-TRUM waste. The onsite ULD that was calculated for this mixture is 6.0×10^2 Sv/L.	Bounding value.	No anticipated effect on consequence bin. The ULD would have to be increased by a factor of about 150 above the undiluted waste ULD to change the onsite radiological consequence bin from low to moderate.	No	NA
For toxicological consequence calculations, each waste dryer is assumed to contain slurry consisting of 50% water mixed with the bounding solid CH-TRUM waste. The SOFs that were calculated for this mixture are 8.6×10^8 (TEEL-1), 2.8×10^8 (TEEL-2), and 1.7×10^8 (TEEL-3).	Bounding value.	No anticipated effect on consequence bin. The SOF would have to be increased by a factor of about 10 above the undiluted waste SOF to change the offsite toxicological consequence bin from low to moderate.	No	NA
Each waste dryer is assumed to contain the minimum amount of dilution water (1:1) to enable the transfer from the source tank. Additionally, the specific gravity of the slurry in the tank is assumed to be ~1.2 to maximize the splash and splatter.	Reasonably conservative.	No anticipated effect on consequence bin. As the specific gravity increases the viscosity increases thus decreasing the splash/splatter component. Even if the dryer were filled with pure solids, the viscosity of the dryer contents would increase sufficiently to lower the ARF for splash and splatter such that the consequences remain unchanged. Additionally, the specific gravity is assumed to be 1.2 even though the solution contains 50% solids, which would increase the specific gravity beyond the value assumed.	No	NA
An airborne release rate for entrainment of 4×10^{-7} /hr was used for a liquid pool exposed to small external wind speeds. (DOE-HDBK-3010-94, Section 3.2.4.5).	Reasonably conservative.	No anticipated effect on consequence bin. The airborne release rate for entrainment would have to be increased by a factor of over 7,000 for the onsite radiological and offsite toxicological consequence bins to change from low to moderate.	No	NA

Table 2-6. Qualitative Evaluation of Analysis Assumptions for Aboveground Tank Failures During Contact-Handled Transuranic Mixed Waste Facility Operations. (13 sheets)

Analysis assumptions (AA) with references/basis	Assumption type	Sensitivity (frequency/consequence)	Need to protect AA	Protection/evaluation basis
The duration of exposure to entrainment and resuspension is assumed to be 8 h.	Reasonably conservative.	No anticipated effect on consequence bin. This is a standard assumption for resuspension. Entrainment is a small contributor to the overall consequences. The duration of exposure would have to increase by a factor of over 7,000 for the onsite radiological consequence bin to change from low to moderate.	No	NA
For the splash/splatter part of the release, an atmospheric dispersion coefficient of 2.22×10^{-5} s/m^3 was used for offsite consequences and an atmospheric dispersion coefficient of 3.28×10^{-2} s/m^3 was used for onsite consequences. For the entrainment part of the release, the 8-hr atmospheric dispersion coefficient of 5.58×10^{-3} s/m^3 was used for onsite radiological consequences.	Reasonably conservative.	No anticipated effect on consequence bin. The atmospheric dispersion coefficients used for the splash/splatter part of the release are from RPP-13482 and represent the 95th percent overall value for accidents less than 1 hr with an assumed ground level release point. The 8-hr atmospheric dispersion coefficient used for radiological entrainment is also from RRP-13482 and represents the 95th percent overall value for accidents of 8-hr duration. None of the values take credit for plume meander, building wake effects, or deposition.	No	NA
A breathing rate of 3.33×10^{-4} m^3/s was used to determine the radiological consequences. This is the breathing rate associated with light activity (i.e., it is an 8-hr average which assumes 2.5 hr of sitting and 5.5 hr of light exercise) as derived by the International Commission on Radiological Protection (documented in RPP-5924).	Reasonably conservative.	No anticipated effect on consequence bin. This is a standard analysis assumption.	No	NA

Table 2-6. Qualitative Evaluation of Analysis Assumptions for Aboveground Tank Failures During Contact-Handled Transuranic Mixed Waste Facility Operations. (13 sheets)

Analysis assumptions (AA) with references/basis	Assumption type	Sensitivity (frequency/consequence)	Need to protect AA	Protection/evaluation basis
Failure of a single FRPS receipt tank with drainage through a broken overflow penetration				
The FRPS receipt tank was assumed to be completely full (8,000 gal or 30,280 L).	Bounding value.	No anticipated effect on consequence bin. This is the bounding MAR that could be present. The MAR would have to be increased by nearly a factor of 2 to change the onsite toxicological consequence bin from low to moderate, which is physically impossible.	No	NA
An airborne release fraction and respirable fraction for splash/splatter were specifically calculated for a spill height of 493 cm (height of overflow line penetration) using the equation found in DOE-HDBK-3010-94, Section 3.2.3.1. The ARF and RF used were 1.09×10^{-5} and 0.8, respectively.	Reasonably conservative.	No anticipated effect on risk bin. The spill height would have to be increased significantly (about 64 cm or 2 ft) beyond the physical height of the FRPS receipt tank for the onsite toxicological consequence bin to change from low to moderate. While the tank will be elevated slightly (68 cm) above grade, current plans do not require it to be elevated an additional 2 ft above grade.	No	NA
The tank is assumed to drain through a broken 2-in. ID penetration with 76 cm of head (tank height of 569 cm – spill height of 493 cm).	Reasonably conservative.	While the 2-in. penetration is the bounding penetration on the standard tank configuration, it is possible that additional penetrations will be added to meet operational needs. If a penetration were to be added that was 2.5 in. or larger in diameter and at the same height, the onsite toxicological consequence bin would change from low to moderate. Since the tanks have already been fabricated with a 2-in. ID penetration, this sensitivity is no longer a concern.	No	NA
Tank penetrations are assumed to have sharp edged entrances and exits.	Reasonably conservative.	No anticipated effect on consequence bin. The pipe friction factor is conservatively ignored. Even if the failed pipes are assumed to have polished, well-rounded entrances and exits, the release rate would only increase by 20% which would not affect any consequence bin.	No	NA

Table 2-6. Qualitative Evaluation of Analysis Assumptions for Aboveground Tank Failures During Contact-Handled Transuranic Mixed Waste Facility Operations. (13 sheets)

Analysis assumptions (AA) with references/basis	Assumption type	Sensitivity (frequency/consequence)	Need to protect AA	Protection/evaluation basis
The bounding ULDs and SOFs documented in RPP-5924 and RPP-8369 for the CH-TRUM tanks are used for estimating radiological and toxicological consequences. CH-TRUM waste consists of waste from 241-B-201, 241-B-202, 241-B-203, 241-B-204, 241-T-110, 241-T-111, 241-T-201, 241-T-202, 241-T-203, 241-T-204, and 241-T-104.	Bounding value.	No anticipated effect on consequence bin. The ULDs and SOFs would have to be increased by a factor of about 1,000 and 2, respectively to change the consequence bins.	No	NA
For radiological consequence calculations, each waste dryer is assumed to contain slurry consisting of 50% water mixed with the bounding solid CH-TRUM waste. The onsite ULD that was calculated for this mixture is 6.0×10^2 Sv/L.	Bounding value.	No anticipated effect on consequence bin. The ULD would have to be increased by a factor of about 500 above the undiluted waste ULD to change the onsite radiological consequence bin from low to moderate.	No	NA
For toxicological consequence calculations, each waste dryer is assumed to contain slurry consisting of 50% water mixed with the bounding solid CH-TRUM waste. The SOFs that were calculated for this mixture are 8.6×10^8 (TEEL-1), 2.8×10^8 (TEEL-2), and 1.7×10^8 (TEEL-3).	Bounding value.	No anticipated effect on consequence bin. The SOF would have to be increased by a factor of about 2 to change the onsite toxicological consequence bin from low to moderate. This could only occur if the bounding waste solids were transferred with no dilution water.	No	NA

Table 2-6. Qualitative Evaluation of Analysis Assumptions for Aboveground Tank Failures During Contact-Handled Transuranic Mixed Waste Facility Operations. (13 sheets)

Analysis assumptions (AA) with references/basis	**Assumption type**	**Sensitivity (frequency/consequence)**	**Need to protect AA**	**Protection/evaluation basis**
The FRPS receipt tank is assumed to contain the minimum amount of dilution water (1:1) to enable the transfer from the source tank. Additionally, the specific gravity of the slurry in the tank is assumed to be ~1.2 to maximize the splash and splatter.	Reasonably conservative.	No anticipated effect on consequence bin. As the specific gravity increases the viscosity increases thus decreasing the splash/splatter component. Even if the tank were filled with pure solids, the viscosity of the tank contents would increase sufficiently to lower the ARF for splash and splatter such that the consequences remain unchanged. Additionally, the specific gravity is assumed to be 1.2 even though the solution contains 50% solids, which would increase the specific gravity beyond the value assumed.	No	NA
An airborne release rate for entrainment of 4×10^{-7} /hr was used for a liquid pool exposed to small external wind speeds. (DOE-HDBK-3010-94, Section 3.2.4.5).	Reasonably conservative.	No anticipated effect on consequence bin. The airborne release rate for entrainment would have to be increased by over two orders of magnitude to change the onsite toxicological consequence bin from low to moderate.	No	NA
The duration of exposure to entrainment and resuspension is assumed to be 8 h.	Reasonably conservative.	No anticipated effect on consequence bin. This is a standard assumption for resuspension. Entrainment is a small contributor to the overall consequences. The duration of exposure would have to increase by over four orders of magnitude to change the onsite radiological consequence bin from low to moderate.	No	NA
For the splash/splatter part of the release, an atmospheric dispersion coefficient of 2.22×10^{-5} s/m^3 was used for offsite consequences and an atmospheric dispersion coefficient of 3.28×10^{-2} s/m^3 was used for onsite consequences. For the entrainment part of the release, *the 8-hr atmospheric dispersion* coefficient of 5.58×10^{-3} s/m^3 was used for onsite radiological consequences.	Reasonably conservative.	No anticipated effect on consequence bin. The atmospheric dispersion coefficients used for the splash/splatter part of the release are from RPP-13482 and represent the 95th percent overall value for accidents less than 1 hr with an assumed ground level release point. The 8-hr atmospheric dispersion coefficient used for radiological entrainment is also from RRP-13482 and represents the 95th percent overall value for accidents of 8-hr duration. None of the values take credit *for plume meander, building wake effects, or deposition.*	No	NA

Table 2-6. Qualitative Evaluation of Analysis Assumptions for Aboveground Tank Failures During Contact-Handled Transuranic Mixed Waste Facility Operations. (13 sheets)

Analysis assumptions (AA) with references/basis	**Assumption type**	**Sensitivity (frequency/consequence)**	**Need to protect AA**	**Protection/evaluation basis**
A breathing rate of 3.33×10^{-4} m^3/s was used to determine the radiological consequences. This is the breathing rate associated with light activity (i.e., it is an 8-hr average which assumes 2.5 hr of sitting and 5.5 hr of light exercise) as derived by the International Commission on Radiological Protection (documented in RPP-5924).	Reasonably conservative.	No anticipated effect on consequence bin. This is a standard analysis assumption.	No	NA

Notes:

DOE-HDBK-3010-94, 2000, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, Change Notice 1, U.S. Department of Energy, Washington, D.C.

RPP-5924, 2005, *Radiological Source Terms for Tank Farms Safety Analysis*, Rev. 4A, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-8369, 2003, *Chemical Source Terms for Tank Farms Safety Analyses*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-13482, 2005, *Atmospheric Dispersion Coefficients and Radiological and Toxicological Exposure Methodology for Use in Tank Farms*, Rev. 5, CH2M HILL Hanford Group, Inc., Richland, Washington.

AA = analysis assumption.
ARF = airborne release fraction.
CH-TRUM = Contact-Handled Transuranic Mixed Waste.
FRPS = Feed Recipient Processing System.
ID = internal diameter.
MAR = material at risk.
NA = not applicable.
RF = respirable fraction.
SOF = sum of fractions.
SST = single-shell tank.
TEEL = Temporary Emergency Exposure Limit.
ULD = unit-liter dose.

As shown in Table 2-5, a frequency of "unlikely" (U) is assigned based on several factors; specifically, the recurrence period of a PC-2 seismic event, the FRPS receipt tanks and waste dryers are new, will be subjected to startup testing, and will operate for a limited time of about 1 yr. In addition, the tanks and dryer vessel are assumed to fail at the worst possible location to maximize the splash/splatter component of the release. Therefore, for those reasons, it is judged that the frequency of occurrence of those events presented in Table 2-5 is in the range of 1×10^{-2} to 1×10^{-4}/yr.

It should be noted that the failure of either a single or multiple FRPS receipt tanks, or the failure of one waste dryer, bounds the consequences of all other failures of aboveground tanks/vessels that are part of CH-TRUM, such as the failure of liquid effluent storage tank, process condensate tank, or slurry tank. This is a result of the combination of quantity of MAR available, the type of waste, and the spill height.

3.0 CONTROL SELECTION

For the release of radioactive and hazardous material from the 242-T Evaporator due to facility degradation, Table 2-1 indicates that the representative accident and associated hazardous conditions are assigned to Risk Bin III for all receptors; therefore, safety SSCs and/or TSR-level controls are not required for the aboveground tank failure accident and associated hazardous conditions. However, defense-in-depth features were identified for the evaporator dump accident and associated represented hazardous conditions as described in RPP-14821, *Technical Basis Document for Defense-In-Depth Features*. No safety SSCs or TSR-level controls were selected within the defense-in-depth features identified for the evaporator dump accident and associated represented hazardous conditions. Facility worker hazardous conditions, including those associated with the evaporator dump representative accident, were evaluated for controls as documented in RPP-14286, *Facility Worker Technical Basis Document.*

3.1 DEMONSTRATION BULK VITRIFICATION SYSTEM CONTROLS

For the aboveground failures of multiple and single tanks associated with DBVS, Table 2-3 indicates that the representative accident and associated hazardous conditions are assigned to Risk Bin II and III, respectively for the onsite receptor due to toxicological releases. Therefore, safety-significant SSCs and/or TSR-level controls will be required to prevent or mitigate the releases of hazardous material from the aboveground tank failure accident.

SSCs. Safety-significant SSCs that are selected to prevent aboveground tank failures (i.e., those that result in Risk Bin I or II) during DBVS operations are described as follows:

- Aboveground transfer system vehicle barriers
- Waste staging tanks
- Waste dryer.

The safety function of the aboveground transfer system vehicle barriers is to prevent waste leaks from the waste staging tanks and waste dryer caused by vehicle collision, thus decreasing the frequency of an aboveground tank failure accident. The safety function of the waste staging tanks is to contain waste and to confine waste in the event of primary tank failure, thus decreasing the frequency of an aboveground tank failure accident. The waste dryer has a safety function to contain waste, thus decreasing the frequency of an aboveground tank failure accident.

Safety-significant TSR administrative controls (ACs) and design features that are selected to prevent and/or mitigate aboveground tank failures are described below.

TSRs. The TSR controls selected for the failure of aboveground tanks during DBVS operations are the following ACs:

- DBVS Controls
  - Vehicle barriers

  - Waste dryer "openings" and seals
- Emergency Preparedness
- SMP
  - Hoisting and rigging

The DBVS Controls AC prevents waste leaks from the waste staging tanks and waste dryer caused by vehicle collision, thus decreasing the frequency of an aboveground tank failure accident and ensures waste dryer openings are closed and seals are inspected and tested, thus decreasing the frequency of an aboveground tank failure accident. The Emergency Preparedness AC was selected to decrease the consequences of waste staging tank and waste dryer failures caused by natural phenomena events (i.e., seismic, high wind). The hoisting and rigging SMP was selected to reduce the frequency of load-handling (e.g., load drop) accidents, thus decreasing the frequency of an aboveground tank failure accident.

Design features. The design feature selected to prevent this accident is the waste staging tanks shield wall.

The important attribute of the waste staging tanks shield wall is the structural integrity of the wall (i.e., prevent damage to the waste staging tanks in the event of natural phenomena events, such as seismic or high wind).

Table 3-1 presents the risk bin results with controls for the aboveground tank failure accident scenarios that are shown in Table 2-3, which presents the corresponding results without controls. The selected controls, which are described above, decrease the accident frequency from "unlikely" to "extremely unlikely" (10^{-6} to 10^{-4}/yr). This results in Risk Bin III with controls for the bounding aboveground tank failure accident scenario.

Table 3-1. Summary of Risk Bin Results With Controls for the Demonstration Bulk Vitrification System.

Postulated accident/ hazardous condition	Frequency	Consequences				Risk bin		
		Onsite radiological	Offsite toxicological	Onsite toxicological	Environmental	Onsite radiological	Offsite toxicological	Onsite toxicological
Catastrophic failure of three tanks due to a seismic event with rapid draining of the contents	EU	L	L	M	E2	IV	IV	III
Failure of a single tank with drainage through a broken penetration	EU	L	L	L	E1	IV	IV	IV

Notes:
DBVS = Demonstration Bulk Vitrification System.
EU = extremely unlikely.
L = low.
M = moderate.

Additional non-safety defense-in-depth features that further reduce the risk of aboveground tank failure accident scenarios are identified in RPP-23429 Section 3.3.2.3.2. Other SMPs were allocated to protect the facility worker and are discussed in the RPP-23429, Section 3.3.2.3.3.

3.2 CONTACT-HANDLED TRANSURANIC MIXED WASTE CONTROLS

Table 2-5 summarizes the frequencies, consequences, and risk bins without controls for postulated aboveground tank failure accidents for CH-TRUM. For the catastrophic failure of either one FRPS receipt tank, or one dryer, or the simultaneous failure of all five FRPS receipt tanks, the results without controls are Risk Bin I for the onsite receptor due to toxicological releases. Therefore, safety significant SSCs and/or TSR-level controls will be required for the FRPS receipt tanks and waste dryers to prevent or mitigate the releases of hazardous material from the aboveground tank failure accident.

SSCs. Safety-significant SSCs that are selected to prevent and/or mitigate aboveground tank failures (i.e., those results in Risk Bin I or II) during CH-TRUM operations are described as follows:

- FRPS receipt tanks
- Waste dryers
- Aboveground transfer system vehicle barriers
- Dewatering system (DWS) International Organization for Standardization (ISO) freight container.

The safety function of the FRPS receipt tanks is to contain waste, thus decreasing the frequency of an aboveground tank failure accident. The safety function of the waste dryer is to contain waste, thus decreasing the frequency of an aboveground tank failure accident. The safety function of the aboveground transfer system vehicle barriers is to prevent the waste leaks from the FRPS receipt tanks and waste dryers caused by vehicle collision, thus decreasing the frequency of an aboveground tank failure accident. The safety function of the DWS ISO freight container is to maintain important attributes that decrease the consequences of an aboveground tank failure accident. The important design attribute of the DWS ISO freight container is to limit waste leak splash/splatter releases. The DWS ISO freight containers are not required to be leak tight to mitigate this accident. This attribute is similar to that of the FRPS receipt tank enclosures (Design Features). However, the DWS ISO freight containers were designated as safety-significant because they were selected as safety significant for their mitigative function for the Release of Dried Waste accident scenario.

Safety-significant TSR ACs and design features that are selected to prevent and/or mitigate aboveground tank failures are described below.

TSRs. The TSR controls selected for the failure of aboveground tanks during CH-TRUM operations are the following ACs:

- CH-TRUM WPU Controls
  - Vehicle barriers
  - Waste dryer "openings" and seals
  - DWS ISO freight container doors
  - FRPS receipt tank enclosure access doors
- Emergency Preparedness
- SMP
  - Hoisting and rigging.

The CH-TRUM WPU Control AC for vehicle barriers prevents waste leaks from the FRPS receipt tanks and waste dryers caused by vehicle collision, thus decreasing the frequency of an aboveground tank failure accident. The CH-TRUM WPU Control AC for waste dryer "openings" and seals ensures that waste dryer openings are closed and seals are inspected and tested, thus decreasing the frequency of an aboveground tank failure accident. The CH-TRUM WPU Control AC for DWS ISO freight container doors ensures that the doors are closed and reduces airborne releases from splash/splatter due to waste dryer leaks, thus decreasing the consequences of an aboveground tank failure accident. The CH-TRUM WPU Control AC for FRPS receipt tank enclosure access doors ensures that the doors are closed and reduces airborne releases from splash/splatter due to FRPS receipt tank leaks, thus decreasing the consequences of an aboveground tank failure accident.

Two SMPs, the hoisting and rigging program and the emergency preparedness program, are selected as TSR-level controls to reduce the frequency and consequences, respectively, of potential releases of radioactive and other hazardous material from aboveground tank failure accidents.

The hoisting and rigging program AC was selected to reduce the frequency by imposing design and administrative requirements to prevent load-handling (e.g., load drop) accidents, thus decreasing the frequency of an aboveground tank failure accident. This program provides guidelines for inspection, personnel qualification, training, equipment to be used, and critical lift procedures.

The emergency preparedness program AC was selected to decrease the consequence of FRPS receipt tank and waste dryer failures caused by natural phenomena events (i.e., seismic, high wind) by implementing rapid evacuation or take cover procedures for the facility and collocated workers immediately following the event. A description of the emergency preparedness and hoisting and rigging programs are provided in the PDSA for CH-TRUM (RPP-23479), Chapters 15.0 and 17.0, respectively.

Design features. The design feature selected to mitigate this accident is the FRPS receipt tank enclosure.

The important attribute of the FRPS receipt tank enclosures is to limit waste leak splash/splatter releases. Both the DWS ISO freight container and the FRPS receipt tank enclosures limit the releases by reducing the direct release of aerosol to the atmosphere. Note that the FRPS receipt tank enclosures are considered waste transfer-associated structures to mitigate waste transfer leaks.

Table 3-2 presents the risk bin results with controls for the aboveground tank failure accident scenarios that are shown in Table 2-5, which presents the corresponding results without controls. The selected controls, which are described above, decrease the accident frequency from "unlikely" to "extremely unlikely" (10^{-6} to 10^{-4} per yr) and mitigate the consequences to "moderate." This results in Risk Bin III with controls for the bounding aboveground tank failure accident scenarios.

Table 3-2. Summary of Risk Bin Results With Controls for Contact-Handled Transuranic Mixed Waste.

Postulated accident/ hazardous condition	Frequency	Consequences				Risk bin		
		Onsite radiological	Offsite toxicological	Onsite toxicological	Environmental	Onsite radiological	Offsite toxicological	Onsite toxicological
Catastrophic failure of five FRPS receipt tanks due to seismic event with rapid draining of the contents	EU	L	L	M	E2	IV	IV	III
Catastrophic failure of one FRPS receipt tank due to seismic event with rapid draining of the contents	EU	L	L	M	E2	IV	IV	III
Catastrophic failure of one waste dryer due to seismic event with rapid draining of the contents	EU	L	L	M	E2	IV	IV	III
Failure of a single FRPS receipt tank with drainage through a broken overflow penetration	EU	L	L	L	E1	IV	IV	IV

Notes:
EU = extremely unlikely.
FRPS = feed receipt processing system.
H = high.
L = low.
M = moderate.

Additional defense-in-depth features that further reduce the risk of aboveground tank failure accident scenarios are identified in RPP-23479, Section 3.3.2.3.2. Other SMPs that protect the facility worker from postulated aboveground tank failure accidents are described in the RPP-23479, Section 3.3.2.3.3.

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 Documented Safety Analyses*, Change Notice No. 2, U.S. Department of Energy, Washington, D.C.

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

RPP-4780, 2000, *Calculation Notes with Structural Analysis for the 242-T Evaporator*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-5924, 2005, *Radiological Source Terms for Tank Farms Safety Analysis*, Rev. 4-A, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-7277, 2003, *Evaluation of Radionuclide Inventory at 242-T Evaporator*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-8369, 2003, *Chemical Source Terms for Tank Farms Safety Analyses*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-12395, 2003, *Offsite Radiological Consequences of Waste Tank Dome Collapse*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-13033, *Tank Farms Documented Safety Analysis*, as amended, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-13482, 2005, *Atmospheric Dispersion Coefficients and Radiological and Toxicological Exposure Methodology for Use in Tank Farms*, Rev. 5, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-14286, 2005, *Facility Worker Technical Basis Document*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-14821, 2004, *Technical Basis Document for Defense-In-Depth Features*, Rev. 3, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-23429, 2005, *Preliminary Documented Safety Analysis for the Demonstration Bulk Vitrification System*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-23479, 2005, *Preliminary Documented Safety Analysis for the Contact-Handled Transuranic Mixed (CH-TRUM) Waste Facility*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

APPENDIX A

MEETING ATTENDEES

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APPENDIX A

MEETING ATTENDEES

AUGUST 22, 2002

DSA Accident Risk Binning Attendance Sheet

Meeting Subject: Above grade Structure Failure Date 7/22/02

Name	Organization	Phone	Mail Stop
MILTON V. SHULTZ	CHG-NS&L	372-3740	R1-44
JOSEPH J. BEVELACQUA	ORP	376-8443	H6-60
James J. Zach	CHG-NS&L	373-0670	R1-49
Robert D CARRELL	ORP-support	521-6921	H6-60
Larry J. Julyk	CHG Design Eng	376 4608	R3-83
David Foust	CHG-Rad Eng	376-8215	S7-90
Phil Miller	CHG-ENV	373-1920	R1-51
CLIFF HAMPTON	CHG-OPS	372-0566	R2-50
Geoffrey Gelhaus	ORP support	539-1822	
# Delmar Noyes	ORP	376-5166	H6-60
Craig Caird	CHG NS&L	372-2646	R1-44
Steve Eschetti	ORP Support	528-5007	
Ed Ford	CHG NS&L	373-1296	R1-44
* AL FRIBERG	CHG DES. ENGRG.	376-1190	R3-83

* present for 242-A Evap. only # present for mixer pump only

JANUARY 23, 2003

ABOVE GROUND TANK FAILURE

JIM ZACH

Defense In Depth

Meeting Attendance Sheet January 23, 2003

Name	Knowledge Area(s) Represented (see below)	Organization	Telephone Number
Ed Ford	1, 2, 3, 6, 9, 13	NS&L	373-1296
Lawrence T. Kripps		NSL	376-1061
James Zach	1, 2, 3, 6, 9, 13	NS&L	373-0670
MARK HASTY	5, 9, 13	OPS	373-9378
Rick Hu[illegible]	17	Safety	373-3212
Ralph Broz	12, 11	Rad Con	372-8450
Rich Larson	4, 8, 14, 23	Design Engineering	373-9100

Knowledge Areas:

1 Licensing
2 Safety Analysis
3 Hazard Analysis
4 Engineering
5 Operations
6 Accident Analysis
7 Nuclear Safety
8 Design Authority
9 Technical Safety Requirements
10 Safety Structures, Systems, and Components
11 Emergency Preparedness
12 Radiological Control
13 Regulatory Compliance
14 Environmental Protection
15 Quality Assurance
16 Other - specify
17 Industrial Safety
18 Project Management
19 Industrial Hygiene
20 Maintenance Engineering
21 Reliability Engineering
22 Process Engineering
23 Equipment Engineering

CONTROL DECISION MEETING ATTENDANCE

Meeting Subject: Aboveground Tank Failures during DBVS Operations

Meeting Date: 9/14/04

Name	Knowledge Area(s) Represented (use codes below)	Organization	Telephone
Kevin Sandgren	1, 2, 3, 6, 7, 9, 10	NS&L	372-0374
Mark Hasty	5, 7, 9	Closure Project	373-9378
David Shuford	4, 18, 20, 23	DBVS	372-0703
W. D. White	5, 11, 12, 13	AMEC	531-7662
J. M. Grigsby	1, 2, 3, 6, 7, 9, 10	CH2M NS&L	372-1907
Ray Merriman	8	CH2M – DA	372-1653
John Harris	1, 2, 3, 6, 7, 9, 10	NS&L	372-1237
John A. Hammer	5, 13	AMEC	948-5333
Mark Lucas	5, 18	AMEC	942-1292
Robert Kuespert	5, 18	AMEC	942-1292
Lawrence J. Kripps	1, 2, 3, 6, 7, 9, 10	CH2M HILL	376-1061
Dick Whitehurst	3, 4, 5, 8, 9, 10, 22	DMJM	375-7883
Charles Grenard	4, 5, 10, 21, 22	DMJM	375-7895

Knowledge Areas:

1. Licensing
2. Safety Analysis
3. Hazard Analysis.
4. Engineering
5. Operations
6. Accident Analysis
7. Nuclear Safety
8. Design Authority
9. Technical Safety Requirements
10. Safety Structures, Systems, and Components
11. Emergency Preparedness
12. Radiological Control
13. Regulatory Compliance
14. Environmental Protection
15. Quality Assurance
16. Other – specify
17. Industrial Safety
18. Project Management
19. Industrial Hygiene
20. Maintenance Engineering
21. Reliability Engineering
22. Process Engineering
23. Equipment Engineering
24. Other

CONTROL DECISION MEETING ATTENDANCE

Meeting Subject: CH-TRUM Aboveground Tank Failure Accident Control Decision

Meeting Date: 1/27/05

Name	Organization	Telephone
Steve Kozlowski	CH2M/NS&L	373-1360
Andy Marchese	CH2M/NS&L	373-3759
Matt Landon	CH2M/Engineering	373-1379
Lawrence J. Kripps	CH2M/NS&L	376-1061
Wes Bryan	CH2M	373-9740
Shawn Hailey	DMJM	375-7868
Melissa Holm	CH2M/Eng	373-1098
Rick Tedeschi	CH2M Hill	373-6018
Mark Sautman	DNFSB	373-0101
Curt Reichmuth	CH2M/Ops	376-4796
Rick Heath	CH2M/Systems Eng	376-3152
Mike Grigsby	CH2M/NS&L	372-1907

APPENDIX B

CALCULATIONS FOR ABOVEGROUND TANK FAILURE AT THE 242-T EVAPORATOR FACILITY

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APPENDIX B

CALCULATIONS FOR ABOVEGROUND TANK FAILURE AT THE 242-T EVAPORATOR FACILITY

B1.0 BACKGROUND

B1.1 SCENARIO

This accident corresponds to a hazardous condition identified in HNF-4508, *Hazard Evaluation for 242-T Evaporator Facility*, caused by a tank failure, in turn, caused by a partial building collapse. This accident is somewhat similar to the existing tank failure due to excessive loads representative accident except that the tank involved is aboveground inside a building. It is assumed that the tank in question ruptures after being hit by one or more falling roof panels and/or walls, and that the resulting pressure transient in the building caused by air displacement is sufficient to breach the high-efficiency particulate air (HEPA) filters in the ventilation system. The consequences of the HEPA filter failure caused by high pressure representative accident (Section B3.1) will be added to those of the tank failure accident to obtain the total consequences.

There is a release of aerosols from the vapor space of the evaporator added to the blowout of the HEPA filter, and a time-dependent release of aerosols from liquid dispersed from the rubble of the 242-T Evaporator building. The entire building inventory is assumed to be in the evaporator vessel, which contains most of the inventory based on radiation readings. Some initiator causes one or more concrete roof panels to fall onto the evaporator vessel. The evaporator vessel is assumed to suffer gross failures and to pour its contents out onto the floor of the facility. It should be noted that the vessel and supports were designed to hold more than 4,000 gal of waste with a specific gravity of 1.2 or more. The design of the tank should be able to support the weight of the roof panels from half the building, if the vessel is empty. This does not consider any structural degradation of the vessel and supports or the impact loading of the panel falling a few feet. Because the building is assumed to be open to the environment after the building collapse, aerosol generated during the tank failure and spill can be ejected directly into the air above the facility. In addition, the air displaced during the roof collapse is assumed to breach the HEPA filters and result in a maximum release from the exhaust system.

The HEPA filter component of accident corresponds to an identified hazardous condition that addresses most of the other tank farm facilities. A filter blowout could be caused by air displacement caused by collapse of the building roof, which consists of a series of 20 concrete panels, each of which is 21 ft 5 1/2 in. by 4 ft 2 in. Half of the roof panels are over the "cold side" and half over the "hot side." No calculation was performed to determine how many panels would have to fall to develop a pressure pulse to blow out the HEPA filters. Each panel is approximately 80 ft^2 and each half of the building is approximately 800 ft^2. In this scenario, all the HEPA filters are breached and release a fraction of their contents during an over-pressure condition within the facility. Each of the two filter banks has two parallel branches each composed of two HEPA filters in series, or a total of four HEPA filters per bank, for a total of eight HEPA filters at risk. The system contains no prefilters separate from the HEPA filters. In addition, it is assumed that the venting from the over-pressure condition causes a further release (equal to the release from one HEPA filter) from material deposited in the duct and preheater. Because this facility is assumed to contain no waste outside its tanks and pipes, it is assumed that no appreciable sustained unfiltered release occurs beyond the release from the filters themselves.

In summary, this accident has three primary sources of release:

- The immediate release from the blown filters and exhaust system (Section B3.1)
- The immediate release of the aerosol generated from splash/splatter during the tank failure and agitation of the waste as it pours out onto the floor (Section B3.2)
- A steady release of aerosol entrained by wind from the waste covering the floor of the open building (Section B3.3).

B1.2 ESTIMATED INVENTORY AT RISK

The material at risk (MAR) is the amount of radionuclides available to be acted on by a given physical stress. For tank farm facilities, the MAR is taken to be the maximum quantity of radioactive material present or reasonably anticipated at each accident location.

The contents of the tanks and vessels within the 242-T Evaporator facility process areas are not completely identified. The volume of waste in the 242-T Evaporator facility is contained primarily in the evaporator vessel and associated piping. Radiation surveys, system design, and operating history confirm that other large components (e.g., condensate catch tanks, blend tank,) either are essentially empty, or contain material with little radioactive content (e.g., flush water). The design of the evaporator internals and operating records indicate that the evaporator could have contained between 0 and a maximum 4,000 gal of material when it was shut down.

The tank is 12 ft in diameter and 12 ft tall. It is basically a right circular cylinder with a dished bottom. The straight section of the tank is approximately 4 ft from the floor with the center of the dished bottom being about 2 ft from the floor. The top surface of the operating level of 4,000 gal of waste is 7.5 ft from the floor. The tank is made of 3/8 in. 347 stainless steel.

RPP-7277, *Evaluation of Radionuclide Inventory at 242-T Evaporator*, calculates that the waste inventory present in the 242-T Evaporator vessel is more than 200 gal. The conclusion is that the bounding volume is 47 gal of wetted solids, 165 gal of supernatant, and 16 gal of "crud" residual on the tank wall (solids). The report also says that the 1 rem/h background in the cell would tend to bias the crud in a conservative direction (higher values predicted than likely to exist). In the assumed accident, in which the waste flows out of the evaporator with splash/splatter dynamics and is then entrained by the wind, the 16 gal of crud will be neglected because the likelihood of the crud contributing to and/or affecting the source term would be less than 10%. Therefore, the solids/liquid mix is 22.2%/77.8%. The mix is relatively high in solids compared to the limits imposed on solids concentrations to ensure fluid flow. Because the unit-liter dose (ULD) for solids is almost two orders of magnitude higher than the ULD for corresponding liquid, a high solids concentration is conservative for radiological consequences. For toxicological consequences, there is a small difference between the solid and liquid factors.

The type and quantity of waste are based on the evaporator vessel operating history and radiation surveys, respectively. The entire inventory is assumed to be in the evaporator vessel, based on radiation surveys in the facility. This consolidates the inventory into a single location, making it more probable that it would be affected by falling roof panels than if it is spread throughout the building.

In addition to the MAR in the evaporator vessel, there is also MAR assumed on the HEPA filters. RPP-13437, *Technical Basis Document for Ventilation System Filtration Failures Leading to an Unfiltered Release*, provides dose rate per liter of waste on the filter. For a 2 ft x 2 ft x 1 ft filter with a survey point on the duct 4 in. from the side of the filter, the dose rates are 702 mrem/h per L of single-shell tank (SST) liquids and 435 mrem/h per L of SST solids. A slurry with 78% liquids would have a dose rate of 643 mrem/h per L of slurry. If the assumption is that the reading on the filter is 200 mrem/h, it would then correspond to 0.243 L of liquid (200/702), 0.460 L of solids (200/435) or 0.311 L (200/643) of slurry.

$$0.78_{\text{liquid}}(702 \text{ mrem/hr-L}) + 0.22_{\text{solids}}(435 \text{ mrem/hr-L})$$
$$= 548 \text{ mrem/hr} + 96 \text{ mrem/hr} = 643 \text{ mrem/hr}$$

Confirming the slurry volume that would produce a 200 mrem/h dose:

$$0.311 \text{ L x } [0.78_{\text{liquid}}(702 \text{ mrem/hr-L}) + 0.22_{\text{solids}}(435 \text{ mrem/hr-L})]$$
$$= 170 \text{ mrem/hr} + 30 \text{ mrem/hr}$$
$$= 200 \text{ mrem/hr}$$

The HEPA filter failure accident is assumed to affect all eight HEPA filters in the system even though only four filters normally are online; the other four filters are isolated by manually operated dampers. This conservatism allows for the possibility of inadvertently mispositioning the dampers. The total release is assumed to be the equivalent of nine HEPA filters (eight filters plus contaminants in the duct). It is very conservative to assume that all eight HEPA filters reach the maximum loading without having to replace any filters. In addition, it is unlikely that a downstream HEPA filter would reach 200 mrem/h while the upstream HEPA filter stopped loading at 200 mrem/h.

B1.3 OTHER ASSUMPTIONS

The following are the assumptions for the parameters of the calculation.

- The airborne release fraction (ARF) and airborne release rate (ARR) are used to estimate the amount of radioactive material suspended in air as an aerosol and available for transport due to a physical stress from a specific accident. For discrete events, the ARF is a fraction of the material affected; for ongoing events, the ARR is a fraction of the material affected per unit time. For aboveground tank failure, different ARFs are selected for the different parts of the accident (i.e., HEPA filter failure, splash/splatter, wind entrainment).

For splash/splatter the ARF and respirable fraction (RF) were selected from DOE-HDBK-3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, for the aerodynamic entrainment and suspension of the waste from the ground. The immediate waste release from the evaporator vessel is assumed to be equivalent to a free-fall spill of the entire inventory from a height of 3 ft onto a hard surface. This is conservative because the distance from the bottom of the tank to the floor is approximately 2 ft, and the most likely sources of the spill are ruptures near the tank base caused by the support legs penetrating the base and the bottom drain connection leaking. The waste is largely concentrated within 3 ft of the floor based on radiation readings. DOE-STD-3010-94, Section 3.2.3 provides bounding and median ARFs for alternative waste compositions for spills from 9 ft. Values are provided for two types of solutions: slurries and viscous. A correlation is provided in DOE-STD-3010-94, Section 3.2.3.1 for calculations which "...covers all of the spill data, including slurries and viscous solutions."

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

where:

Arch	=	Archimedes Number.
	=	$(\text{density}_{air})^2 \times (\text{spill height})^3 \times g/(\text{solution viscosity})^2$
Density$_{air}$	=	1.2×10^{-3} g/cc
Spill height	=	100 cm
g	=	981 cm/s^2
Solution viscosity	=	2.6×10^{-2} poise.

$$\text{Arch} = (1.2 \times 10^{-3}\ \text{g/cm}^3)^2 \times (100\ \text{cm})^3 \times 981\ \text{cm/s}^2/(2.6 \times 10^{-2}\ \text{poise})^2 = 2.1 \times 10^6$$

$$\text{ARF} = 8.9 \times 10^{-10} \times (2.1 \times 10^6)^{0.55} = 8.9 \times 10^{-10} \times 3000 = 2.7 \times 10^{-6}$$

The selected viscosity (2.6×10^{-2} poise) corresponds to a value on DOE-HDBK-3010-94, Table 3-9, at the low end of potential values. Higher values decrease the Archimedes Number by the inverse of the square.

Air density for ~21 °C (~70 °F) was taken from *Fluid Mechanics with Engineering Applications* (Franzini, J. B., and E. J. Finnemore, 1997) (see Attachment B1). Decreasing the air temperature to 0 °C (32 °F) increase the density to 0.0013 g/cm^3 and increase the Archimedes Number by 17%. However, in the ARF equation Archimedes Number is taken to the 0.55 power, which means the ARF increases by ~8%.

- The RF is the fraction of airborne material that can be transported through the air and inhaled into the human respiratory system. It is commonly assumed to include particles 10-μm aerodynamic equivalent diameter (AED) and less. The term "10-μm AED" means the particle has the same settling speed in air as a 10-μm unit density sphere. The actual diameter could differ from 10 μm due to differences in density and/or shape. The principal emphasis in this document is directed toward the potential downwind hazard to the populations at some distance from the point of source term generation. Note that the loss from airborne particles attaching to fixed objects such as foliage, buildings, and the ground surface is small due to the small size of the particles. An RF of 0.7 is assumed as a reasonably high value, selected from the bounding values for the various types of waste.

- Onsite and 1 hr offsite breathing rate (BR) is 3.33×10^{-4} m^3/s (light physical activity; i.e., it is an 8-hr average, which assumes 2.5 hr of sitting and 5.5 hr of light exercise). The BR is the rate at which people inhale the contaminated air. The light-activity BR for an adult male (RPP-5924, *Radiological Source Terms for Tank Farms Safety Analysis*) is used to calculate both onsite and offsite receptor inhalation doses for all release scenarios. The adult male inhalation rate is chosen to maximize the intake and resulting dose equivalent.

- Onsite exposure duration is 2 hr. All of the hazardous conditions are initiated by a significant event (e.g., roof collapse), which would be obvious to the co-located worker. If a single roof panel falls due to degradation, it would likely come down partially in pieces (halves). The evaporator would likely not be damaged to the point of failure by such an event. Increased exposure time will cause an almost linear increase in consequences with the caveat that the released MAR will decrease with time as the pool is depleted. If a complete work shift with overtime were assumed, maximum exposure time (12-hr shift) would be a factor of 6 higher than assumed.

- The composite inhalation ULD for SST waste of 7.7×10^3 Sv/L based on Table 4-1 of RPP-5924. The evaporator processed waste from SSTs in the 200 West Area, particularly from the T Tank Farm complex. Its feed tank was SST 241-TX-118. Therefore, the ULDs in RPP-5924, Table B-1, are the values for SST salt cake (SST 241-TX-118 is the tank with the highest value) and SST saltcake liquid (SST 241-U-106 is the bounding tank). The two possible columns that could be selected from RPP-5924, Table 4-1, "Dome Failure All Tanks" and "Balance of Scenarios Bounding Cases," are identical. The mix is 22.2%/77.8% solids/liquid.

Table B-1. Single-Shell Tank 22/78 Solids/Liquid Mix Unit-Liter Doses (Sv/L).

Receptor	Solid	Liquid	Composite
Onsite	3.3×10^4 Saltcake	4.5×10^2 Saltcake or Liquid	$(0.73 + 0.04) \times 10^4$ 7.7×10^3

- Toxicological consequences are calculated per the methodology established in RPP-8369, *Chemical Source Terms for Tank Farms Safety Analyses*. The composite onsite sum of fractions (SOF) for anticipated and unlikely events is listed in Table B-2 with the source of the component values.

Table B-2. Single-Shell Tank 22/78 Solids/Liquid Mix Sum of Fractions.

	RPP-8369 Table	Anticipated and Unlikely
Solids (TEEL-2, onsite)	Table 6-8	6.3×10^8
Liquids (TEEL-2, onsite)	Table 6-20	5.7×10^8
Solids (TEEL-1, offsite)	Table 6-5	2.2×10^9
Liquids (TEEL-1, offsite)	Table 6-17	3.7×10^9
Solids fraction in waste	--	22%
Liquids fraction in waste	--	78%
Composite (TEEL -2, onsite)	--	5.8×10^8
Composite (TEEL -1, offsite)	--	3.4×10^9

Notes:

RPP-8369, 2003, *Chemical Source Terms for Tank Farms Safety Analyses*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

TEEL = Temporary Emergency Exposure Limit.

- Because there are three components of the accident with radiological consequences for the onsite worker and toxicological consequences for both onsite and offsite calculated, selection of the atmospheric dispersion factors (χ/Q') includes different values. Table B-3 is the matrix of the different types of releases. The toxicological consequences from the entrainment are not calculated because the concentrations are low compared to the peak concentrations from the HEPA filters and the splash/splatter.

  Based on the assumptions in RPP-13482, *Atmospheric Dispersion Coefficients and Radiological and Toxicological Exposure Methodology for Use in Tank Farms*, was used to determine which value should be used. Table B-3 lists the source of the χ/Q's from RPP-13482. (Note that the column entitled "Meteorological Condition" is considered Column 1 in the RPP-13482 tables.)

  Table B-3 also provides the χ/Q' values from RPP-13482 that are assumed in the calculations for the aboveground tank failure.

Table B-3. Type of Release Assumed, Information Source, and Atmospheric Dispersion Factor.

Release mechanism	Onsite radiological			Onsite toxicological			Offsite toxicological		
	Model assumed	**Information source in RPP-13482**	**χ/Q' (s/m^3)**	**Model assumed**	**Information source in RPP-13482**	**χ/Q' (s/m^3)**	**Model assumed**	**Information source in RPP-13482**	**χ/Q' (s/m^3)**
Filter release	1 hour (95th %)	Table 2-4, Column 2	3.28×10^{-2}	1 hour (95th %)	Table 2-4, Column 2	3.28×10^{-2}	1 hour (95th %)	Table 2-5, Column 2	2.22×10^{-5}
Splash/splatter	1 hour (95th %)	Table 2-4, Column 2	3.28×10^{-2}	1 hour (95th %)	Table 2-4 Column 2	3.28×10^{-2}	1 hour (95th %)	Table 2-5, Column 2	2.22×10^{-5}
Entrainment	2 hour (95th %)	Table 2-4, Column 3	9.40×10^{-3}	NA	NA	NA	NA	NA	NA

Notes:

RPP-13482, 2005, *Atmospheric Dispersion Coefficients and Radiological and Toxicological Exposure Methodology for Use in Tank Farms*, Rev. 5, CH2M HILL Hanford Group, Inc., Richland, Washington.

NA = not applicable.

- Because the cell (i.e., the roof, door, and possibly portions of the walls) is assumed to be open after the roof collapse, the pool is subject to direct entrainment by wind, which has a much higher velocity than ventilation airflow within a facility. Because this facility is a small, one-story structure and could be only partially collapsed, no credit is taken for any mitigation caused by a sheltering effect of rubble. The entrainment rate for the material after the initial building collapse and waste spill was selected from DOE-HDBK-3010-94, for the aerodynamic entrainment and suspension of the waste from the floor. DOE-HDBK-3010-94, Section 3.2.4.5 provides a bounding value for large pools in high winds (e.g., 30 mi/h). For a smaller pool or winds with a lower velocity, the entrainment rate is lower. The rate of 4×10^{-6}/hr is consistent with the information provided with DOE-HDBK-3010-94, Figure 3-8. It states, "With a fetch of 10 m (~33 ft), a wind speed of 15 m/s (~ 33.6 mi/hr), and an effective active layer (depth of liquid actually involved in drop generation) under these conditions of 1 mm to 1 cm, the airborne suspension rate would range from 4E-6/hr to 4E-8/hr." The fetch is the pool diameter; for the 242-T Evaporator this would be the length of the building (~ 40 ft). Lower air entrainment values are presented for liquids indoors exposed to forced ventilation (4×10^{-7}/hr in Section 3.2.4.5), or for liquid in remnants and debris (4×10^{-8}/hr in Section 3.2.4.5). A conservative value of 4×10^{-6}/hr (1.1×10^{-9}/sec) was selected for the analysis.

- DOE-HDBK-3010-94, Section 5.4, for shocking, blasting, or impacting a HEPA filter in an unconfined or a confined space provides an ARF range from 1.0×10^{-6} to 1.0×10^{-2}. The phenomenon of the roof panel falling and creating a mild pressure pulse is best described as a shock. This analysis assumes the same value, 2.0×10^{-6} as used in RPP-13437 (see Table B-4).

Table B-4. High-Efficiency Particulate Air Filter Airborne Release Fractions for Various Initiators.

Scenario	ARF	RF
Shock	2×10^{-6}	1.0
Blast	1×10^{-2}	1.0
Free-fall or impact	5×10^{-3}	1.0
Enclosed	5×10^{-4}	1.0
Open	1×10^{-2}	1.0

Notes:
ARF = aerosol release fraction.
RF = respirable fraction.

B2.0 CONSEQUENCE CALCULATION METHODS

B2.1 SOURCE TERM

Both radiological and toxicological consequences are estimated using standardized factors to account for the source term, atmospheric dispersion, and hazard index.

The airborne source term is typically estimated via a five-component linear equation. The total released (Equation B1) is used for radiological dose calculations and the release rate (Equation B2) is used for toxicological calculations.

$$Q = MAR \text{ x } DR \text{ x } ARF \text{ x } RF \text{ x } LPF \quad \text{(B1)}$$

$$Q' = MAR \text{ x } DR \text{ x } ARR \text{ x } RF \text{ x } LPF \quad \text{(B2)}$$

where:

Q = quantity released as respirable particles (L)
MAR = material-at-risk (L)
DR = damage ratio (= 1.0 for this analysis = unitless)
ARF = airborne release fraction (unitless)
RF = respirable fraction (unitless)
LPF = leak path factor (= 1.0 for this analysis = unitless)
Q' = respirable release rate (L/s)
ARR = airborne release rate fraction (= ARF/$T_{(REL)}$ = 1/s)
$T_{(REL)}$ = release duration (sec).

$$Q = MAR \text{ x } 1.0 \text{ x } ARF \text{ x } RF \text{ x } 1.0 \quad \text{(B1a)}$$

$$Q' = MAR \text{ x } 1.0 \text{ x } ARF/60 \text{ x } RF \text{ x } 1.0 \quad \text{(B2a)}$$

The factors in Equations B1 and B2 are described in more detail in Section B1.

B2.2 RADIOLOGICAL DOSE CONSEQUENCE METHOD

The total onsite dose can include inhalation and submersion (i.e., immersion in the cloud of radioactive material). Usually the dominant exposure pathway is via inhalation. RPP-5924 describes the individual dose as Equation B3:

$$D = Q \text{ x } \chi/Q' \text{ x } BR \text{ x } ULD \quad \text{(B3)}$$

where:

D = inhalation dose at a downwind location (Sv)
Q = amount released as respirable particles, the source term from Equation B1a (L)
χ/Q' = air transport factor (s/m^3)
BR = breathing rate (m^3/s)
ULD = unit-liter dose (Sv/L).

The source term, Q, is the amount of radioactive material released to the environment as described in Section B2.1 (Equation B1a).

B2.3 TOXICOLOGICAL CONSEQUENCE METHOD

The methodology that is used to calculate the toxicological exposure consequences is documented in RPP-8369. In this method, the source release rate is multiplied by the air transport factor and an appropriate unitless sum of fractions (USOF). The USOF is a sum of the ratios of each mean analyte concentration for the waste type (e.g., SST solids) to its respective Temporary Emergency Exposure Limit (TEEL) or allowable concentration in air. The value of the USOF is dependent on the waste composition and the event frequency (Equation B4).

$$SOF = Q' \text{ x } \chi/Q' \text{ x } USOF \quad \text{(B4)}$$

where:

SOF = sum of fractions
Q' = release rate from Equation B2a (L/s)
χ/Q' = air transport factor for a plume (s/m^3)
$USOF$ = unitless sum of fractions, computed as the sum of the unitless ratios of the analyte concentration divided by its TEEL.

The SOF represents the total fraction of the air concentration guideline that the release caused. The SOF risk guideline for a given release is 1.

The release rate, Q', is computed as shown in Section B2.1, Equation B2a. When using the SOF values from RPP-8369, the calculations require the application of a conversion factor ($1\ m^3/10^3$ L) to convert the release rate from the L/s to release rate values of m^3/s.

B3.0 CONSEQUENCES

B3.1 HIGH-EFFICIENCY PARTICULATE AIR FAILURE CAUSED BY HIGH PRESSURE

Each filter is assumed to contain 3.11×10^{-1} L of SST waste equivalent (Section B1.2): 9 "filters" x material per filter x ARF ($9 \times 3.11 \times 10^{-1}$ L $\times 2.0 \times 10^{-6}$) = 5.60×10^{-6} L. The duration of the release caused by overpressure is expected to be less than 1 min, so the minimum 1-min averaging time for corrosive/irritant agents was used; assuming the entire release to be averaged over a 1-min (60 sec) period produces a release rate of 9.33×10^{-8} L/s. Consistent with the assumption in Section B1.3, RF = 1 for the HEPA filter failure.

The resulting radiological doses and SOFs ("anticipated" frequency class) for the HEPA filter failure caused by the over-pressure accident without controls were calculated as follows:

Radiological Dose = $(Q)(\chi/Q')(BR)(ULD)$

Onsite dose = $(5.60 \times 10^{-6}$ L$)(3.28 \times 10^{-2}$ s/m$^3)(3.33 \times 10^{-4}$ m^3/s$)(7.7 \times 10^3$ Sv/L$)$

= 4.7×10^{-7} Sv (4.7×10^{-5} rem).

Toxicological Dose = $(Q')(\chi/Q')(SOF)(1$ m$^3/10^3$ L$)$

Onsite = $(9.33 \times 10^{-8}$ L/s$)(3.28 \times 10^{-2}$ s/m$^3)(5.8 \times 10^8)(1$ m$^3/10^3$ L$)$ = 1.8×10^{-3}

Offsite = $(9.33 \times 10^{-8}$ L/s$)(2.22 \times 10^{-5}$ s/m$^3)(3.4 \times 10^9)(1$ m$^3/10^3$ L$)$ = 7.0×10^{-6}.

where:

Q = 5.60×10^{-6} (L)
χ/Q' *(radiological)* = 3.28×10^{-2} (s/m^3)
BR = 3.33×10^{-4} (m^3/s)
ULD = 7.7×10^3 (Sv/L)
Q' = 9.33×10^{-8} (L/s)
SOF = 5.8×10^8 (onsite) and 3.4×10^9 (offsite)
χ/Q' *(toxicological)* = 3.28×10^{-2} (s/m^3) onsite and = 2.22×10^{-5} (s/m^3) offsite.

B3.2 INITIAL RELEASE OF SUSPENDED AEROSOLS FROM TANK FAILURE

The initial spill from the evaporator vessel is modeled as a spill of liquid on to a hard surface from some height. To determine the respirable material from the splash/splatter, solve Equation 1a, assuming 300 gal of waste in the evaporator (i.e., 50% more than calculated in RPP-7277):

$$Q = 300 \text{ gal} \times 3.79 \text{ L/gal} \times 2.7 \times 10^{-6} \times 0.7 = 2.1 \times 10^{-3} \text{ L}.$$

This is the amount assumed for the release from splash/splatter including the RF of 0.7. For toxicological consequences, the amount is averaged over 1 min (i.e., divide by 60 sec) and RF is not used ($Q' = 5.1 \times 10^{-5}$ L/s).

The radiological doses and SOFs for the initial release of suspended aerosols component of the tank failure accident without controls were calculated as follows:

Onsite dose: *Inhalation* ➔ $(Q)(\chi/Q')(BR)(ULD_{inh})$

= $(2.1 \times 10^{-3}$ L$)(3.28 \times 10^{-2}$ s/m$^3)(3.33 \times 10^{-4}$ m^3/s$)(7.7 \times 10^3$ Sv/L$)$

= 1.8×10^{-4} Sv (0.018 rem).

Onsite SOF: $SOF = Q' \times (\chi/Q') \times USOF$

➔ $(5.1 \times 10^{-5}$ L/s$)(3.28 \times 10^{-2}$ s/m$^3)(5.8 \times 10^8)$ $(1$ m$^3/10^3$ L$) = 0.97$

Offsite SOF: *SOF = Q'x (χ/Q') x USOF*

➔ $(5.1 \times 10^{-5}$ L/s$)(2.22 \times 10^{-5}$ s/m$^3)(3.4 \times 10^9)$ (1 m^3/10^3 L) $= 3.8 \times 10^{-3}$.

where:

$Q = 2.1 \times 10^{-3}$ (L)
χ/Q' *(radiological)* $= 3.28 \times 10^{-2}$ (s/m^3)
$BR = 3.33 \times 10^{-4}$ (m^3/s)
$ULD = 7.7 \times 10^3$ (Sv/L)
$Q' = 5.1 \times 10^{-5}$ (L/s)
$SOF = 5.8 \times 10^8$ (onsite) and 3.4×10^9 (offsite)
χ/Q' *(toxicological)* $= 3.28 \times 10^{-2}$ (s/m^3) onsite and $= 2.22 \times 10^{-5}$ (s/m^3) offsite.

B3.3 CONTINUOUS RELEASE FROM MATERIAL SPILLED ON FLOOR

After the initial energetic release of aerosol, the release rate from the pool of material inside the facility will fall to a constant level. Applying the release rate 4×10^{-6}/hr to the equivalent evaporator vessel inventory (300 gal) gives the corresponding 2-hr radiological release to the onsite receptor.

$$Q = 300 \text{ gal} \times 3.79 \text{ L/gal} \times 4 \times 10^{-6}/\text{hr} \times 2 \text{ hr} \times 0.7 = 6.4 \times 10^{-3} \text{ L}.$$

Because the toxicological exposure is rate dependent and the highest rate occurs at the beginning of the accident (the first minute), toxicological calculations are not done for the long-term exposure that would result from entrainment.

The resulting radiological doses for the continuous release from the floor-spill component of the tank failure caused by a building or roof collapse accident without controls were calculated as follows:

Onsite dose (2-hr): *Inhalation* ➔ $(Q)(\chi/Q')(BR)(ULD_{inh})$

$= (6.4 \times 10^{-3}$ L$)(9.40 \times 10^{-3}$ s/m$^3)(3.33 \times 10^{-4}$ m^3/s$)(7.7 \times 10^3$ Sv/L$)$

$= 1.5 \times 10^{-4}$ Sv (0.015 rem).

B4.0 SUMMARY

The total consequences for the tank failure caused by a building or roof collapse accident are the sum of the consequences of the three component releases: (1) aerosols suspended by the evaporator vessel rupture (Section B3.2); (2) the continuous release from the material spilled onto the floor of the room (Section B.3.3); and (3) the release from the failed filters in the exhaust system (Section B3.1). Note that the peak release rates from the initial aerosol release and the filter failure occur at the same time in the first minute of the accident and so are directly additive (along with the constant release rate from the spill). The resulting totals are as follows for the tank failure caused by a building or roof collapse without controls:

Onsite dose: *Sections B3.2 + B3.3 + B3.1*

➔ 1.8×10^{-4} Sv + 1.5×10^{-4} Sv + 4.7×10^{-7} Sv

= 3.3×10^{-4} Sv (0.033 rem = 33 mrem).

Onsite SOF: *Sections B3.2 + B3.1*

➔ $9.7 \times 10^{-1} + 1.8 \times 10^{-3} = 9.7 \times 10^{-1}$

Offsite SOF: *Sections B3.2 + B3.1*

➔ $3.8 \times 10^{-3} + 7.0 \times 10^{-6} = 3.8 \times 10^{-3}$.

The following tables give the consequences of the 242-T Evaporator building collapse. Both Tables B-5 and B-6 show that onsite radiological consequences are well below the low consequence evaluation guideline and are classified as "low." In addition, the tables show that the onsite and the offsite toxicological consequences are well below the low consequence evaluation guidelines, and therefore, are also classified as "low."

Table B-5. Consequences of 242-T Evaporator High-Efficiency Particulate Air Filter Failure Caused by High Pressure Without Controls.

Hazard	Receptor	Dose/exposure	Evaluation guideline (anticipated)
Radiological	Onsite	4.7×10^{-7} Sv	0.25 Sv
Toxicological	Onsite	1.8×10^{-3}	1
	Offsite	7.0×10^{-6}	1

Note:
NA = not applicable.

Table B-6. Consequences of 242-T Evaporator Vessel Failure Without Controls.

Hazard	Receptor	Dose/exposure	Evaluation guideline (anticipated)
Radiological	Onsite	3.3×10^{-4} Sv	0.25 Sv
Toxicological	Onsite	9.7×10^{-1}	1
	Offsite	3.8×10^{-3}	1

Note:
NA = not applicable.

B5.0 REFERENCES

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ATTACHMENT B1

Fluid Mechanics with Engineering Applications

NINTH EDITION

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Table A.2
Physical properties of air at standard sea-level atmospheric pressure[a]

Temperature T	Density, ρ	Specific weight, γ	Viscosity,[b] μ	Kinematic viscosity,[b] ν
°F	slug/ft³	lb/ft³	10^{-6} lb·s/ft²	10^{-3} ft²/s
−40°F	0.002 940	0.094 60	0.312	0.106
−20°F	0.002 807	0.090 30	0.325	0.116
0°F	0.002 684	0.086 37	0.338	0.126
10°F	0.002 627	0.084 53	0.345	0.131
20°F	0.002 572	0.082 77	0.350	0.136
30°F	0.002 520	0.081 08	0.358	0.142
40°F	0.002 470	0.079 45	0.362	0.146
50°F	0.002 421	0.077 90	0.368	0.152
60°F	0.002 374	0.076 40	0.374	0.158
70°F	0.002 330	0.074 95	0.382	0.164
80°F	0.002 286	0.073 57	0.385	0.169
90°F	0.002 245	0.072 23	0.390	0.174
100°F	0.002 205	0.070 94	0.396	0.180
120°F	0.002 129	0.068 49	0.407	0.189
140°F	0.002 058	0.066 20	0.414	0.201
160°F	0.001 991	0.064 07	0.422	0.212
180°F	0.001 929	0.062 06	0.434	0.225
200°F	0.001 871	0.060 18	0.449	0.240
250°F	0.001 739	0.055 94	0.487	0.280
°C	kg/m³	N/m³	10^{-6} N·s/m²	10^{-6} m²/s
−40°C	1.515	14.86	14.9	9.8
−20°C	1.395	13.68	16.1	11.5
0°C	1.293	12.68	17.1	13.2
10°C	1.248	12.24	17.6	14.1
20°C	1.205	11.82	18.1	15.0
30°C	1.165	11.43	18.6	16.0
40°C	1.128	11.06	19.0	16.8
60°C	1.060	10.40	20.0	18.7
80°C	1.000	9.81	20.9	20.9
100°C	0.946	9.28	21.8	23.1
200°C	0.747	7.33	25.8	34.5

[a] In these tables, if (for example, at −40°F) μ is given as 0.312 and the units are 10^{-6} lb·s/ft² then $\mu = 0.312 \times 10^{-6}$ lb·s/ft².
[b] For viscosity, see also Figs. 2.3 and 2.4.

APPENDIX C

CALCULATIONS FOR ABOVEGROUND TANK FAILURE DURING DEMONSTRATION BULK VITRIFICATION SYSTEM OPERATION

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APPENDIX C

CALCULATIONS FOR ABOVEGROUND TANK FAILURE DURING DEMONSTRATION BULK VITRIFICATION SYSTEM OPERATION

C1.0 INTRODUCTION

The purpose of this appendix is to provide a basis for the qualitative assessment of consequences to be used for risk binning. Consequences are calculated for the radiological and toxicological exposures resulting from a release of radioactive or hazardous waste materials from the above ground tanks associated with the Demonstration Bulk Vitrification System (DBVS) operations.

C2.0 WASTE RETRIEVAL SYSTEM OPERATIONS HAZARDOUS CONDITIONS

The aboveground tanks associated with the DVBS are subject to failure from one of several possible causes (e.g., seismic event, high winds, structural degradation, manufacturing defects, vehicle collisions). The primary structures of concern are the three large waste staging tanks. During system operations, the three tanks could contain a maximum of 18,000 gal of waste each (which bounds the other aboveground tanks present in the system). Two failures are analyzed here: a catastrophic failure of all three tanks with rapid drainage of the contents (e.g., the shielding wall falling onto all three tanks), and a failure of a single tank with drainage through a broken penetration. The consequences consist of splash and splatter from the spill and entrainment of aerosol by air movement over the pool of released waste.

C3.0 ASSUMPTIONS

The following enabling assumptions are considered for the catastrophic failure of three tanks:

- The top of the tank is assumed to be 283 cm above the floor and the bottom of the tank is assumed to be 40 cm above the floor based on drawing DBVS-SK-M104 (see Appendix E).
- The tanks are assumed to be full to maximize the material at risk (18,000 gal per tank).
- All three tanks are assumed to drain within 60 seconds due to large simultaneous breaches in each tank at the worst possible height.
- For radiological consequence calculations, the three tanks are assumed to consist of 95% liquid and 5% sludge from single-shell tank (SST) 241-S-109.
- For toxicological consequence calculations, the three tanks are assumed to contain 95% liquid and 5% solids from SST 241-S-109.

- The specific gravity of the slurry in the tanks is assumed to be ~1.2 to maximize the splash and splatter.
- The duration of exposure to entrainment and resuspension is assumed to be 8 h.

The following enabling assumptions are considered for the failure of a single tank through a broken penetration:

- The only penetration that is not on the top of the tank is assumed to be 55 cm above the floor based on drawing DBVS-SK-M104 (see Appendix E).
- The tank is assumed to be full of waste to maximize the head and material at risk.
- The tank is assumed to drain through a broken 2-in. ID penetration. (Based on drawing DBVS-SK-M104 (see Appendix E).)
- The tank is assumed to have a maximum head of 90 in. above the penetration. (Based on drawing DBVS-SK-M104 (see Appendix E).)
- The tank penetration is assumed to have a sharp edged entrance and exit.
- For radiological consequence calculations, the tank is assumed to consist of 95% liquid and 5% sludge from SST 241-S-109.
- For toxicological consequence calculations, the tank is assumed to contain 95% liquid and 5% solids from SST 241-S-109.
- The specific gravity of the slurry in the tank is assumed to be ~1.2 to maximize the splash and splatter.
- The duration of exposure to entrainment and resuspension is assumed to be 8 hr.

C4.0 INPUT DATA FOR UNIT LITER DOSES AND SUM OF FRACTIONS

The input data used is as follows:

1. Onsite unit liter doses (ULD) for SST 241-S-109 are taken from RPP-5924, *Radiological Source Terms for Tank Farms Safety Analysis*:

Waste Type	ULD (Sv/L)	Basis Tank
SST Liquid	7.8×10^{1}	241-S-109
SST Sludge	3.1×10^{3}	241-S-109

2. Sum of fractions (SOF) multipliers for each Temporary Emergency Exposure Limit (TEEL) for SST 241-S-109 are taken from RPP-8369, *Chemical Source Terms for Tank Farms Safety Analyses*:

Waste Type	TEEL-1	TEEL-2	TEEL-3	Basis Tank
SST Liquid	7.97×10^8	1.18×10^8	7.03×10^6	241-S-109
SST Solids	2.19×10^9	3.22×10^8	2.30×10^7	241-S-109

C5.0 CALCULATION OF MIXTURE UNIT LITER DOSES AND SUM OF FRACTIONS

C5.1 DEMONSTRATION BULK VITRIFICATION SYSTEM UNIT LITER DOSE MULTIPLIERS

ULDs and SOF multipliers for each TEEL were calculated for consequence calculations.

Since the waste is assumed to be 95% liquid and 5% sludge, the resultant onsite ULD can be found by:

$$[(7.8 \times 10^1 \text{ Sv/L})(0.95) + (3.1 \times 10^3 \text{ Sv/L})(0.05)] = 2.3 \times 10^2 \text{ Sv/L}$$

where:

7.8×10^1 Sv/L = onsite liquid ULD before drying (RPP-5924)

3.1×10^3 Sv/L = onsite sludge ULD before drying (RPP-5924).

C5.2 DEMONSTRATION BULK VITRIFICATION SYSTEM SUMS OF FRACTIONS MULTIPLIERS

As stated in Section C3.0, each tank is assumed to contain 95% liquid and 5% solids from SST 241-S-109 for the toxicological consequences. Calculating the SOF multipliers:

TEEL-1 SOF multiplier = $[(7.97 \times 10^8)(0.95) + (2.19 \times 10^9)(0.05)] = 8.7 \times 10^8$

where:

7.97×10^8 = liquid TEEL-1 SOF multiplier before drying (RPP-8369).
2.19×10^9 = solid TEEL-1 SOF multiplier before drying (RPP-8369).

TEEL-2 SOF multiplier = $[(1.18 \times 10^8)(0.95) + (3.22 \times 10^8)(0.05)] = 1.3 \times 10^8$

where:

1.18×10^8 = liquid TEEL-2 SOF multiplier before drying (RPP-8369).
3.22×10^8 = solid TEEL-2 SOF multiplier before drying (RPP-8369).

TEEL-3 SOF multiplier = $[(7.03 \times 10^6)(0.95) + (2.30 \times 10^7)(0.05)] = 7.8 \times 10^6$

where:

7.03×10^6	= liquid TEEL-3 SOF multiplier before drying (RPP-8369).
2.30×10^7	= solid TEEL-3 SOF multiplier before drying (RPP-8369).

C6.0 ACCIDENT CONSEQUENCE COMPARISON

C6.1 Catastrophic Failure of Three Tanks

The assumed failure is a spill of the entire contents of three large waste staging tanks within a 60 second period. The consequences consist of two components: (1) splash and splatter from the spill and (2) entrainment of aerosol by air movement over the pool of released waste.

Splash and Splatter

The airborne release fraction (ARF) for splash/splatter can be calculated with the following equation from DOE-HDBK-3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, Section 3.2.3.1:

$$ARF = 8.9 \times 10^{-10} \times Arch^{0.55}$$

$$ARF = 8.9 \times 10^{-10} [(1.2 \times 10^{-3} \text{ g/cm}^3)^2 \times (\text{height})^3 \times (981 \text{ cm/s}^2)/(7.9 \times 10^{-2} \text{ poise})^2]^{0.55}$$

where:

Arch	= Archimedes Number
	= $(\text{density}_{air})^2$ x $(\text{spill height})^3$ x (g) / $(\text{solution viscosity})^2$
1.2×10^{-3} g/cm^3	= density of air (*CRC Handbook of Chemistry and Physics* [Weast 1981])
height	= spill height in cm.
981 cm/s^2	= g (acceleration due to gravity)
7.9×10^{-2} poise	= solution viscosity (the selected viscosity corresponds to a value from DOE-HDBK-3010-94, Table 3-9, to conservatively represent the viscosity of the waste).

As the spill height increases the ARF will increase; however, as the spill height increases the amount of material at risk will decrease. The potential spill heights for the tank could be anywhere across the height of the tank from an event such as a wall falling onto the tanks. In order to conservatively calculate the consequences for the release, the point with the maximum airborne release was found. Since the waste tank internal dimensions are 90 in. wide by 508.75 in. long, each tank will leak 198 gal for every inch above the leak point (or 300 l for every centimeter). A series of spill heights are evaluated for the maximum airborne release using the equation above in Section C4-1.

Table C6-1. Evaluation of Maximum Airborne Release as a Function of Spill Height.

Spill height (cm)	Splash/splatter ARF	Material at risk per tank (spill volume in liters)	Airborne release (liters)
280	4.29×10^{-6}	900	3.86×10^{-3}
260	3.80×10^{-6}	6,900	2.62×10^{-2}
240	3.33×10^{-6}	12,900	4.29×10^{-2}
220	2.88×10^{-6}	18,900	5.44×10^{-2}
200	2.46×10^{-6}	24,900	6.13×10^{-2}
180	2.07×10^{-6}	30,900	6.39×10^{-2}
178	2.03×10^{-6}	31,500	6.40×10^{-2}
177	2.01×10^{-6}	31,800	6.40×10^{-2}
176	1.99×10^{-6}	32,100	6.40×10^{-2}
175	1.98×10^{-6}	32,400	6.40×10^{-2}
170	1.88×10^{-6}	33,900	6.38×10^{-2}
160	1.70×10^{-6}	36,900	6.29×10^{-2}
40 (bottom of the tank)	1.73×10^{-7}	68,000	1.18×10^{-2}

The onsite radiological consequences for the splash/splatter can now be calculated using the ARF found above:

Onsite Radiological Dose$_{splash/splatter}$ =

$$(32{,}100 \text{ L/tank})(3 \text{ tanks})(1.99 \times 10^{-6})(0.8)(2.3 \times 10^{2} \text{ Sv/L})(3.28 \times 10^{-2} \text{ s/m}^3)(3.33 \times 10^{-4} \text{ m}^3\text{/s})$$
$$= 4.0 \times 10^{-4} \text{ Sv}$$
$$= 4.0 \times 10^{-2} \text{ rem}$$

where:

32,100 L	= material at risk (volume of each large waste staging tank)
1.99×10^{-6}	= ARF for splash/splatter
0.8	= respirable fraction for a viscosity of 7.9×10^{-2} poise (DOE-HDBK-3010-94)
2.3×10^{2} Sv/L	= ULD for 95% liquid/5% solids for SST 241-S-109 (calculated above, Section C5.1)
3.28×10^{-2} s/m^3	= onsite 1-hr atmospheric dispersion coefficient (χ/Q) from (RPP-13482, *Atmospheric Dispersion Coefficients and Radiological and Toxicological Exposure Methodology for Use in Tank Farms*)
3.33×10^{-4} m^3/s	= breathing rate for light activity (RPP-5924).

The toxicological consequences are based on a release over time. Since the release is assumed to take place within 60 seconds:

Release Rate = (32,100 L/tank) (3 tanks) / (60 s) = 1.61×10^{3} L/s

The onsite toxicological consequences can now be calculated:

Onsite Moderate Toxicological $SOF_{splash/splatter}$ =
$(1.61 \times 10^3 \text{ L/s})(1.99 \times 10^{-6})(3.28 \times 10^{-2} \text{ s/m}^3)(1.3 \times 10^8)/(1{,}000 \text{ L/m}^3) = 1.4 \times 10^{+1}$

where:

1.3×10^8 = Temporary Emergency Exposure Limit (TEEL)-2 unitless SOF for 95% liquid/5% solids for SST 241-S-109 (calculated above, Section C5.2)
$1{,}000 \text{ L/m}^3$ = conversion factor.

Onsite High Toxicological $SOF_{splash/splatter}$ =
$(1.61 \times 10^3 \text{ L/s})(1.99 \times 10^{-6})(3.28 \times 10^{-2} \text{ s/m}^3)(7.8 \times 10^6)/(1{,}000 \text{ L/m}^3) = 8.2 \times 10^{-1}$

where:

7.8×10^6 = TEEL-3 unitless SOF for 95% liquid/5% solids for SST 241-S-109 (calculated above, Section C5.2).

The offsite toxicological consequences can be calculated similarly:

Offsite Moderate Toxicological $SOF_{splash/splatter}$ =
$(1.61 \times 10^3 \text{ L/s})(1.99 \times 10^{-6})(2.22 \times 10^{-5} \text{ s/m}^3)(8.7 \times 10^8)/(1{,}000 \text{ L/m}^3) = 6.3 \times 10^{-2}$

where:

$2.22 \times 10^{-5} \text{ s/m}^3$ = offsite 1-hr atmospheric dispersion coefficient (RPP-13482)
8.7×10^8 = TEEL-1 unitless SOF for 95% liquid/5% solids for SST 241-S-109 (calculated above, Section 5.2).

Entrainment of Aerosol

The entrainment of aerosol by air is based on an airborne release rate for a liquid pool exposed to small external wind speeds due to localized damage to the surrounding concrete radiation shield wall structure. An eight hour exposure to entrainment is assumed for radiological consequences.

The onsite radiological consequences for the entrainment can be calculated from:

Onsite Radiological $Dose_{entrainment}$ =
$(32{,}100 \text{ L/tank})(3 \text{ tanks})(4 \times 10^{-7}/\text{hr})(8 \text{ hr})(2.3 \times 10^2 \text{ Sv/L})(5.58 \times 10^{-3} \text{ s/m}^3)(3.33 \times 10^{-4} \text{ m}^3/\text{s})$
$= 1.3 \times 10^{-4} \text{ Sv}$
$= 1.3 \times 10^{-2} \text{ rem}$

where:

$4 \times 10^{-7}/\text{hr}$ = airborne release rate for entrainment (DOE-HDBK-3010-94, Section 3.2.4.5)

2.3×10^{2} Sv/L	= ULD for 95% liquid/5% solids for SST 241-S-109 (calculated above, Section C5.1)
5.58×10^{-3} s/m^3	= onsite 8-hr atmospheric dispersion coefficient (RPP-13482).

Toxicological consequences can also be calculated:

Onsite Moderate Toxicological $SOF_{entrainment}$ =

$$(32{,}100 \text{ L/tank})(3 \text{ tanks})(4 \times 10^{-7}/\text{hr})(3.28 \times 10^{-2} \text{ s/m}^3)(1.3 \times 10^{8})/(3{,}600 \text{ s/hr})(1{,}000 \text{ L/m}^3) = 4.6 \times 10^{-2}$$

where:

1.3×10^{8}	= TEEL-2 unitless SOF for 95% liquid/5% solids for SST 241-S-109 (calculated above, Section 5.2)
3,600 s/hr	= conversion factor.

Onsite High Toxicological $SOF_{entrainment}$ =

$$(32{,}100 \text{ L/tank})(3 \text{ tanks})(4 \times 10^{-7}/\text{hr})(3.28 \times 10^{-2} \text{ s/m}^3)(7.8 \times 10^{6})/(3{,}600 \text{ s/hr})(1{,}000 \text{ L/m}^3) = 2.8 \times 10^{-3}$$

where:

7.8×10^{6}	= TEEL-3 unitless SOF for 95% liquid/5% solids for SST 241-S-109 (calculated above, Section 5.2).

Offsite Moderate Toxicological $SOF_{entrainment}$ =

$$(32{,}100 \text{ L/tank})(3 \text{ tanks})(4 \times 10^{-7}/\text{hr})(2.22 \times 10^{-5} \text{ s/m}^3)(8.7 \times 10^{8})/(3{,}600 \text{ s/hr})(1{,}000 \text{ L/m}^3) = 2.1 \times 10^{-4}$$

where:

8.7×10^{8}	= TEEL-1 unitless SOF for 95% liquid/5% solids for SST 241-S-109 (calculated above, Section 5.2).

Total Consequences

The total consequences for the aboveground tank failure during DBVS operations are the sum of the contributions from splash/splatter and entrainment:

Onsite radiological consequences	$= 4.0 \times 10^{-2}$ rem + 1.3×10^{-2} rem	$= 5.3 \times 10^{-2}$ rem
Onsite moderate toxicological consequences	$= 1.4 \times 10^{+1} + 4.6 \times 10^{-2}$	$= 1.4 \times 10^{+1}$
Onsite high toxicological consequences	$= 8.2 \times 10^{-1} + 2.8 \times 10^{-3}$	$= 8.2 \times 10^{-1}$
Offsite moderate toxicological consequences	$= 6.3 \times 10^{-2} + 2.1 \times 10^{-4}$	$= 6.3 \times 10^{-2}$

C6.2 Single Tank Failure

The assumed failure is a spill of the entire contents of a single large waste staging tank through a broken 2-in penetration. The consequences consist of two components: (1) splash and splatter from the spill and (2) entrainment of aerosol by air movement over the pool of released waste.

Splash and Splatter

The ARF for splash/splatter can be calculated with the following equation from DOE-HDBK-3010-94:

$$ARF = 8.9 \times 10^{-10} \times Arch^{0.55}$$
$$ARF = 8.9 \times 10^{-10} [(1.2 \times 10^{-3} \text{ g/cm}^3)^2 \times (55 \text{ cm})^3 \times (981 \text{ cm/s}^2)/(7.9 \times 10^{-2} \text{ poise})^2]^{0.55}$$
$$ARF = 2.9 \times 10^{-7}$$

where:

Arch	= Archimedes Number = $(\text{density}_{air})^2$ x (spill height)^3 x (g) / (solution viscosity)^2
1.2×10^{-3} g/cm^3	= density of air (Weast 1981)
55 cm	= spill height.
981 cm/s^2	= g (acceleration due to gravity)
7.9×10^{-2} poise	= solution viscosity (the selected viscosity corresponds to a value from DOE-HDBK-3010-94, Table 3-9 to conservatively represent the viscosity of the waste).

The onsite radiological consequences for the splash/splatter can now be calculated using the ARF found above:

Onsite Radiological $\text{Dose}_{splash/splatter}$ =

$$(68{,}000 \text{ L})(2.9 \times 10^{-7})(0.8)(2.3 \times 10^{2} \text{ Sv/L})(3.28 \times 10^{-2} \text{ s/m}^3)(3.33 \times 10^{-4} \text{ m}^3\text{/s})$$
$$= 4.0 \times 10^{-5} \text{ Sv}$$
$$= 4.0 \times 10^{-3} \text{ rem}$$

where:

68,000 L	= material at risk (volume of one large waste staging tank) = (18,000 gal) (3.785 L/gal)
2.9×10^{-7}	= ARF for splash/splatter
0.8	= respirable fraction for a viscosity of 7.9×10^{-2} poise (DOE-HDBK-3010-94)
2.3×10^{2} Sv/L	= ULD for 95% liquid/5% solids for SST 241-S-109 (calculated above, Section C5.1)
3.28×10^{-2} s/m^3	= onsite 1-hr atmospheric dispersion coefficient (χ/Q) from (RPP-13482)
3.33×10^{-4} m^3/s	= breathing rate (RPP-5924).

The toxicological consequences are based on a release over time. The flow rate out of the penetration is a function of head which decreases as the spill height increases. The flow rate can be found using $h_L = K (v^2/2g)$ (Crane 1988, *Flow of Fluids Through Valves, Fittings, and Pipe*). The estimated flow rate is based on a sharp edged 2-inch pipe entrance and exit and conservatively assumes the fluid being released has the viscosity of pure water instead of the viscosity of SST waste solids.

A head of 90 in. (229 cm) is used based on drawing DBVS-SK-M104 (see Appendix E):

$$229 \text{ cm} = 1.5 (v^2/[(2)(981 \text{ cm/s}^2)])$$
$$v = 547 \text{ cm/s}$$

where:

229 cm	= head
1.5	= a constant (K) for a sharp edged pipe entrance and exit (Crane, 1988)
981 cm/s^2	= g (the acceleration due to gravity).

The velocity can be converted into a flow rate:

$$\text{Velocity x cross-sectional area} = (547 \text{ cm/s})[(\pi)(2.54 \text{ cm})^2] = 1.11 \times 10^4 \text{ cm}^3\text{/s} = 1.11 \times 10^1 \text{ L/s.}$$

where:

2.54 cm	= radius of the 2-in. penetration.

The onsite toxicological consequences can now be calculated:

Onsite Moderate Toxicological $SOF_{splash/splatter}$ =
$$(1.11 \times 10^1 \text{ L/s})(2.9 \times 10^{-7})(3.28 \times 10^{-2} \text{ s/m}^3)(1.3 \times 10^8)/(1{,}000 \text{ L/m}^3) = 1.4 \times 10^{-2}$$

where:

1.3×10^8	= Temporary Emergency Exposure Limit (TEEL)-2 unitless SOF for 95% liquid/5% solids for SST 241-S-109 (calculated above, Section C5.2)
1,000 L/m^3	= conversion factor.

The offsite toxicological consequences can be calculated similarly:

Offsite Moderate Toxicological $SOF_{splash/splatter}$ =
$$(1.11 \times 10^1 \text{ L/s})(2.9 \times 10^{-7})(2.22 \times 10^{-5} \text{ s/m}^3)(8.7 \times 10^8)/(1{,}000 \text{ L/m}^3) = 6.2 \times 10^{-5}$$

where:

2.22×10^{-5} s/m^3	= offsite 1-hr atmospheric dispersion coefficient (RPP-13482)
8.7×10^8	= TEEL-1 unitless SOF for 95% liquid/5% solids for SST 241-S-109 (calculated above, Section 5.2).

Entrainment of Aerosol

The entrainment of aerosol by air is based on an airborne release rate for a liquid pool exposed to small external wind speeds due to localized damage to the surrounding concrete radiation shield wall structure. An eight hour exposure to entrainment is assumed for radiological consequences.

The onsite radiological consequences for the entrainment can be calculated from:

Onsite Radiological $Dose_{entrainment}$ =
(68,000 L)(4 x 10^{-7}/hr)(8 hr)(2.3 x 10^{2} Sv/L)(5.58 x 10^{-3} s/m^3)(3.33 x 10^{-4} m^3/s)
= 9.3 x 10^{-5} Sv
= 9.3 x 10^{-3} rem

where:

4 x 10^{-7}/hr	= airborne release rate for entrainment (DOE-HDBK-3010-94, Section 3.2.4.5)
2.3 x 10^{2} Sv/L	= ULD for 95% liquid/5% solids for SST 241-S-109 (calculated above, Section C5.1)
5.58 x 10^{-3} s/m^3	= onsite 8-hr atmospheric dispersion coefficient (RPP-13482).

Toxicological consequences can also be calculated:

Onsite Moderate Toxicological $SOF_{entrainment}$ =
(68,000 L)(4 x 10^{-7}/hr)(3.28 x 10^{-2} s/m^3)(1.3 x 10^{8})/(3,600 s/hr)(1,000 L/m^3)= 3.2 x 10^{-2}

where:

1.3 x 10^{8}	= Temporary Emergency Exposure Limit (TEEL)-2 unitless SOF for 95% liquid/5% solids for SST 241-S-109 (calculated above, Section C5.2)
3,600 s/hr	= conversion factor.

Offsite Moderate Toxicological $SOF_{entrainment}$ =
(68,000 L)(4 x 10^{-7}/hr)(2.22 x 10^{-5} s/m^3)(8.7 x 10^{8})/(3,600 s/hr)(1,000 L/m^3)= 1.5 x 10^{-4}

where:

8.7 x 10^{8}	= TEEL-1 unitless SOF for 95% liquid/5% solids for SST 241-S-109 (calculated above, Section 5.2).

Total Consequences

The total consequences for the aboveground tank failure during DBVS operations are the sum of the contributions from splash/splatter and entrainment:

Onsite radiological consequences = 4.0 x 10^{-3} rem + 9.3 x 10^{-3} rem = 1.3 x 10^{-2} rem

Onsite moderate toxicological consequences = $1.4 \times 10^{-2} + 3.2 \times 10^{-2}$ $= 4.6 \times 10^{-2}$

Offsite moderate toxicological consequences= $6.2 \times 10^{-5} + 1.5 \times 10^{-4}$ $= 2.1 \times 10^{-4}$

C7.0 RESULTS

The total consequences are compared to evaluation guidelines in Tables C7-1 and C7-2.

Table C7-1. Summary of Onsite Radiological Consequences Without Controls for the Aboveground Tank Failure During Demonstration Bulk Vitrification System Operations.

Case	**Onsite radiological consequences**	
	Calculated dose (rem)	**Moderate consequence guideline (rem)**
Catastrophic failure of three tanks due to a seismic event with rapid draining of the contents	5.3×10^{-2}	$2.5 \times 10^{+1}$
Failure of a single tank with drainage through a broken penetration	1.3×10^{-2}	$2.5 \times 10^{+1}$

Table C7-2. Summary of Toxicological Consequences Without Controls for the Aboveground Tank Failure During Demonstration Bulk Vitrification System Operations.

Case	**Toxicological consequences**					
	Onsite				**Offsite**	
	Moderate consequence		**High Consequence**		**Moderate consequence**	
	SOF	**Guideline**	**SOF**	**Guideline**	**SOF**	**Guideline**
Catastrophic failure of three tanks due to a seismic event with rapid draining of the contents	$1.4 \times 10^{+1}$	1	8.2×10^{-1}	1	6.3×10^{-2}	1
Failure of a single tank with drainage through a broken penetration	4.6×10^{-2}	1	--	1	2.1×10^{-4}	1

Note:

SOF = sum of fractions.

The consequence bin associated with the aboveground failure of either one or three Waste Feed Receipt Tanks with regard to onsite radiological and offsite toxicological consequences is "low" because the scoping calculations show that the consequences are below the "moderate" consequence evaluation guidelines. The onsite toxicological consequence bin is also "low" for the failure of a single tank. However, if three tanks fail, the onsite toxicological consequence bin is above the "moderate" consequence evaluation guideline value and is therefore classified as "moderate".

C8.0 REFERENCES

Crane, 1988, *Flow of Fluids Through Valves, Fittings, and Pipe*, Crane Co., Joliet, Illinois.

DOE-HDBK-3010-94, 2000, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, Change Notice 1, U.S. Department of Energy, Washington, D.C.

RPP-5924, 2005, *Radiological Source Terms for Tank Farm Safety Analysis*, Rev. 4-A, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-8369, 2003, *Chemical Source Terms for Tank Farm Safety Analyses*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-13482, 2005, *Atmospheric Dispersion Coefficients and Radiological and Toxicological Exposure Methodology for Use in Tank Farms*, Rev. 5, CH2M HILL Hanford Group, Inc., Richland, Washington.

Weast, R. C., 1981, *CRC Handbook of Chemistry and Physics*, 61st Ed., CRC Press, Inc., Boca Raton, Florida.

APPENDIX D

CALCULATIONS FOR ABOVEGROUND TANK 241-S-109 PHASE I STAGING TANK FAILURE DURING DEMONSTRATION BULK VITRIFICATION SYSTEM OPERATION

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APPENDIX D

CALCULATIONS FOR ABOVEGROUND TANK 241-S-109 PHASE I STAGING TANK FAILURE DURING DEMONSTRATION BULK VITRIFICATION SYSTEM OPERATION

D1.0 INTRODUCTION

The purpose of this appendix is to provide a basis for the qualitative assessment of consequences to be used for risk binning. Consequences are calculated for the radiological and toxicological exposures resulting from a release of radioactive or hazardous waste materials from the above ground tanks associated with the Demonstration Bulk Vitrification System (DBVS) operations.

D2.0 WASTE RETRIEVAL SYSTEM OPERATIONS HAZARDOUS CONDITIONS

The aboveground tanks associated with the DVBS are subject to failure from one of several possible causes (e.g., seismic event, high winds, structural degradation, manufacturing defects, vehicle collisions). The primary structure of concern in this appendix is the 241-S-109 staging tank, which will be used during the Phase I demonstration of the bulk vitrification process. The staging tank will be an upright, double wall, flat bottom storage tank containing mixed radioactive waste. The 241-S-109 Phase I staging tank is constructed of polyethylene (plastic) with a nominal working volume of 1,100 gal; however, the actual volume of stored waste will be less than 1,100 gal. The tank has a cylindrical geometry with outer diameter and height of 76 in. and 103.5 in., respectively. Since the tank is constructed of plastic material, the failure analyzed here is a catastrophic failure of the 241-S-109 Phase I staging tank with rapid drainage of the contents (e.g., the shielding wall falling onto the tank or vehicle impact with the tank). The consequences consist of splash and splatter from the spill and entrainment of aerosol by air movement over the pool of released waste.

D3.0 ASSUMPTIONS

The following conservative assumptions are considered for the catastrophic failure of the 241-S-109 Phase I staging tank:

- The top of the tank is assumed to be 217 cm above the floor, and the bottom of the tank is on grade level (based on drawing H-14-106699, *S-109 PWRS Staging Tank System*).
- Although the nominal working volume of the tank is 1,100 gal, during system operations, it is assumed that the 241-S-109 Phase I staging tank could contain a maximum of 1,200 gal of waste. This assumption is made to be conservative on the material at risk (MAR). (Note this is still far less than the bounding case considered in Appendix C involving the contents of the either one or three large [18,000 gal each] Phase II waste staging tanks, which bounds the other aboveground tanks present in the system). Therefore, the tank is assumed to contain 1,200 gal to maximize the MAR.

- The tank is assumed to drain within 60 seconds due to large breach in the tank.
- For radiological consequence calculations, the tank is assumed to consist of 95% liquid and 5% sludge from single-shell tank (SST) 241-S-109.
- For toxicological consequence calculations, the tank is assumed to contain 95% liquid and 5% solids from SST 241-S-109.
- The specific gravity of the slurry in the tank is assumed to be ~1.2 to maximize the splash and splatter.
- The duration of exposure to entrainment and resuspension is assumed to be 8 hr.

D4.0 INPUT DATA FOR UNIT LITER DOSES AND SUM OF FRACTIONS

The input data used is as follows:

3. Onsite unit liter doses (ULD) for SST 241-S-109 are taken from RPP-5924, *Radiological Source Terms for Tank Farms Safety Analysis*:

Waste Type	ULD (Sv/L)	Basis Tank
SST Liquid	7.8×10^{1}	241-S-109
SST Sludge	3.1×10^{3}	241-S-109

4. Sum of fractions (SOF) multipliers for each Temporary Emergency Exposure Limit (TEEL) for SST 241-S-109 are taken from RPP-8369, *Chemical Source Terms for Tank Farms Safety Analyses*:

Waste Type	TEEL-1	TEEL-2	TEEL-3	Basis Tank
SST Liquid	7.97×10^{8}	1.18×10^{8}	7.03×10^{6}	241-S-109
SST Solids	2.19×10^{9}	3.22×10^{8}	2.30×10^{7}	241-S-109

D5.0 CALCULATION OF MIXTURE UNIT LITER DOSES AND SUM OF FRACTIONS

D5.1 DEMONSTRATION BULK VITRIFICATION SYSTEM UNIT LITER DOSE MULTIPLIERS

Unit liter doses (ULD) and sum of fractions (SOF) multipliers for each TEEL were calculated for consequence calculations.

Since the waste is assumed to be 95% liquid and 5% sludge, the resultant onsite ULD can be found by:

$$[(7.8 \times 10^1 \text{ Sv/L})(0.95) + (3.1 \times 10^3 \text{ Sv/L})(0.05)] = 2.3 \times 10^2 \text{ Sv/L}$$

where:

7.8×10^1 Sv/L = onsite liquid ULD before drying (RPP-5924)
3.1×10^3 Sv/L = onsite sludge ULD before drying (RPP-5924)

D5.2 DEMONSTRATION BULK VITRIFICATION SYSTEM SUMS OF FRACTIONS MULTIPLIERS

As stated above in Section C3.0, the 241-S-109 Phase I staging tank is assumed to contain 95% liquid and 5% solids from SST 241-S-109 for the toxicological consequences. Calculating the SOF multipliers:

TEEL-1 SOF multiplier = $[[(7.97 \times 10^8)(0.95) + (2.19 \times 10^9)(0.05)] = 8.7 \times 10^8$
where:
7.97×10^8 = liquid TEEL-1 SOF multiplier before drying (RPP-8369).
2.19×10^9 = solid TEEL-1 SOF multiplier before drying (RPP-8369).

TEEL-2 SOF multiplier = $[(1.18 \times 10^8)(0.95) + (3.22 \times 10^8)(0.05)] = 1.3 \times 10^8$
where:
1.18×10^8 = liquid TEEL-2 SOF multiplier before drying (RPP-8369).
3.22×10^8 = solid TEEL-2 SOF multiplier before drying (RPP-8369).

TEEL-3 SOF multiplier = $[(7.03 \times 10^6)(0.95) + (2.30 \times 10^7)(0.05)] = 7.8 \times 10^6$
where:
7.03×10^6 = liquid TEEL-3 SOF multiplier before drying (RPP-8369).
2.30×10^7 = solid TEEL-3 SOF multiplier before drying (RPP-8369).

D6.0 ACCIDENT CONSEQUENCE COMPARISON

D6.1 Catastrophic Failure of the 241-S-109 Phase I Staging Tank

The assumed failure is a spill of the entire contents of the 241-S-109 Phase I staging tank within a 60 second period. The consequences consist of two components: (1) splash and splatter from the spill, and (2) entrainment of aerosol by air movement over the pool of released waste.

Splash and Splatter

The airborne release fraction (ARF) for splash/splatter can be calculated with the following equation from DOE-HDBK-3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities,* Section 3.2.3.1:

$$ARF = 8.9 \times 10^{-10} \times Arch^{0.55}$$

$$ARF = 8.9 \times 10^{-10} [(1.2 \times 10^{-3} \text{ g/cm}^3)^2 \times (\text{height})^3 \times (981 \text{ cm/s}^2)/(7.9 \times 10^{-2} \text{ poise})^2]^{0.55}$$

where:

Arch	= Archimedes Number = $(\text{density}_{air})^2$ x $(\text{spill height})^3$ x (g) / $(\text{solution viscosity})^2$
1.2×10^{-3} g/cm^3	= density of air (*CRC Handbook of Chemistry and Physics* [Weast 1981])
height	= spill height in cm.
981 cm/s^2	= g (acceleration due to gravity)
7.9×10^{-2} poise	= solution viscosity (the selected viscosity corresponds to a value from DOE-HDBK-3010-94, Section 3.2.3.3, Table 3-9 to conservatively represent the viscosity of the waste).

As the spill height increases the ARF will increase; however, as the spill height increases the amount of material at risk will decrease. The potential spill heights for the Phase I staging tank could be anywhere across the height (0 to 217 cm) of the tank from an event such as a wall falling onto the tank. In order to conservatively calculate the consequences for the release, the point with the maximum airborne release was found.

An expression for the MAR in gal can be written as:

MAR = 1,200 x (217 – Spill Height) / (217)

A series of spill heights are evaluated for the maximum airborne release using the equations above in Section D6-1.

Table D6-1. Evaluation of Maximum Airborne Release as a Function of Spill Height.

Spill height (cm)	Splash/splatter ARF	Material at risk (MAR) (spill volume in gal)	Airborne release (gal)
5	5.60×10^{-9}	1172	6.56×10^{-6}
25	7.96×10^{-8}	1062	8.46×10^{-5}
50	2.50×10^{-7}	923.5	2.31×10^{-4}
75	4.88×10^{-7}	785.3	3.83×10^{-4}
100	7.85×10^{-7}	647.0	5.07×10^{-4}
125	1.13×10^{-6}	509.0	5.77×10^{-4}
130	2.03×10^{-6}	481.1	5.8179×10^{-4}
134	1.27×10^{-6}	459.0	5.8350×10^{-4}
135	1.29×10^{-6}	453.5	5.8358×10^{-4}
136	1.30×10^{-6}	447.9	5.8353×10^{-4}
140	1.37×10^{-6}	425.8	5.8189×10^{-4}
150	1.53×10^{-6}	370.5	5.67×10^{-4}
175	1.97×10^{-6}	232.3	4.59×10^{-4}
210 (near top of tank)	2.67×10^{-6}	38.7	1.03×10^{-4}

The onsite radiological consequences for the splash/splatter can now be calculated using the ARF found above:

Onsite Radiological Dose$_{splash/splatter}$ =

$$(5.84 \times 10^{-4}\text{ gal})(3.785\text{ L/gal})(0.8)(2.3 \times 10^{2}\text{ Sv/L})(3.28 \times 10^{-2}\text{ s/m}^3)(3.33 \times 10^{-4}\text{ m}^3\text{/s})$$
$$= 4.4 \times 10^{-6}\text{ Sv}$$
$$= 4.4 \times 10^{-4}\text{ rem}$$

where:

5.84×10^{-4} L	= material at risk (see Table D4-1 above)
1.29×10^{-6}	= ARF for splash/splatter
0.8	= respirable fraction for a viscosity of 7.9×10^{-2} poise (DOE-HDBK-3010-94, Section 3.2.3.3, Table 3-9)
2.3×10^{2} Sv/L	= ULD for 95% liquid/5% solids for SST 241-S-109 (calculated above, Section D5.1)
3.28 x 10-2 s/m^3	= onsite 1-hr atmospheric dispersion coefficient (χ/Q) from (RPP-13482, *Atmospheric Dispersion Coefficients and Radiological and Toxicological Exposure Methodology for Use in Tank Farms*)
3.33 x 10-4 m^3/s	= breathing rate (RPP-5924).

The toxicological consequences are based on a release over time. Since the release is assumed to take place within 60 seconds:

$$\text{Release Rate} = [(5.84 \times 10^{-4}\text{ gal})(3.785\text{ L/gal})] / (60\text{ s}) = 3.68 \times 10^{-5}\text{ L/s}$$

The onsite toxicological consequences can now be calculated:

Onsite Moderate Toxicological $SOF_{splash/splatter}$ =
$(3.68 \times 10^{-5}\ L/s)(3.28 \times 10^{-2}\ s/m^3)(1.3 \times 10^8)/(1,000\ L/m^3)$
$= 1.6 \times 10^{-1}$

where:

1.3×10^8	= Temporary Emergency Exposure Limit (TEEL)-2 unitless SOF for 95% liquid/5% solids for SST 241-S-109 (calculated above, Section D5.2)
$1,000\ L/m^3$	= conversion factor.

The offsite toxicological consequences can be calculated similarly:

Offsite Moderate Toxicological $SOF_{splash/splatter}$ =
$(3.68 \times 10^{-5}\ L/s)(2.22 \times 10^{-5}\ s/m^3)(8.7 \times 10^8)/(1,000\ L/m^3)$
$= 7.1 \times 10^{-4}$

where:

$2.22 \times 10^{-5}\ s/m^3$	= offsite 1-hr atmospheric dispersion coefficient (RPP-13482)
8.7×10^8	= TEEL-1 unitless SOF for 95% liquid/5% solids for SST 241-S-109 (calculated above, Section D5.2).

Entrainment of Aerosol

The entrainment of aerosol by air is based on an airborne release rate for a liquid pool exposed to small external wind speeds. An eight hour exposure to entrainment is assumed for radiological consequences.

The onsite radiological consequences for the entrainment can be calculated from:

Onsite Radiological $Dose_{entrainment}$ =
$(1,200\ gal)(3.785\ L/gal)(4 \times 10^{-7}/hr)(8\ hr)(2.3 \times 10^2\ Sv/L)(5.58 \times 10^{-3}\ s/m^3)(3.33 \times 10^{-4}\ m^3/s)$
$= 6.2 \times 10^{-6}\ Sv$
$= 6.2 \times 10^{-4}\ rem$

where:

$4 \times 10^{-7}/hr$	= airborne release rate for entrainment (DOE-HDBK-3010-94, Section 3.2.4.5)
$2.3 \times 10^2\ Sv/L$	= ULD for 95% liquid/5% solids for SST 241-S-109 (calculated above, Section D5.1)
$5.58 \times 10^{-3}\ s/m^3$	= onsite 8-hr atmospheric dispersion coefficient (RPP-13482).

Toxicological consequences can also be calculated as follows:

Onsite Moderate Toxicological $SOF_{entrainment}$ =
$(1,200\ gal)(3.785\ L/gal)(4 \times 10^{-7}/hr)(3.28 \times 10^{-2}\ s/m^3)(1.3 \times 10^8)/(3,600\ s/hr)(1,000\ L/m^3)$
$= 2.1 \times 10^{-3}$

where:

1.3×10^8	= Temporary Emergency Exposure Limit (TEEL)-2 unitless SOF for 95% liquid/5% solids for SST 241-S-109 (calculated above, Section D5.2)
3,600 s/hr	= conversion factor.
1,000 L/m^3	= conversion factor

Offsite Moderate Toxicological $SOF_{entrainment}$ =
(1,200 gal)(3.785 L/gal)(4×10^{-7}/hr)(2.22×10^{-5} s/m^3)(8.7×10^8)/(3,600 s/hr)(1,000 L/m^3)
= 9.8×10^{-6}

where:

2.22×10^{-5} s/m^3	= offsite 1-hr atmospheric dispersion coefficient (RPP-13482)
8.7×10^8	= TEEL-1 unitless SOF for 95% liquid/5% solids for SST 241-S-109 (calculated above, Section D5.2).

Total Consequences

The total consequences for the aboveground tank failure of the 241-S-109 Phase I staging tank during DBVS operations are the sum of the contributions from splash/splatter and entrainment:

Onsite radiological consequences = 4.4×10^{-4} rem + 6.2×10^{-4} rem = 1.1×10^{-3} rem

Onsite moderate toxicological consequences = 1.6×10^{-1} + 2.1×10^{-3} = 1.6×10^{-1}

Offsite moderate toxicological consequences = 7.1×10^{-4} + 9.8×10^{-6} = 7.2×10^{-4}

D7.0 RESULTS

The total consequences are compared to evaluation guidelines in Tables D7-1 and D7-2.

Table D7-1. Summary of Onsite Radiological Consequences Without Controls for the Aboveground Tank Failure of 241-S-109 Phase I Staging Tank During Demonstration Bulk Vitrification System Operations.

Case	Onsite radiological consequences	
	Calculated dose (rem)	Moderate consequence guideline (rem)
Catastrophic failure of 241-S-109 Phase I staging tank with rapid draining of the contents	1.1×10^{-3}	$2.5 \times 10^{+1}$

Table D7-2. Summary of Toxicological Consequences Without Controls for the Aboveground Tank Failure of 241-S-109 Phase I Staging Tank During Demonstration Bulk Vitrification System Operations.

Case	Toxicological consequences					
	Onsite				Offsite	
	Moderate consequence		High Consequence		Moderate consequence	
	SOF	Guideline	SOF	Guideline	SOF	Guideline
Catastrophic failure of 241-S-109 Phase I staging tank with rapid draining of the contents	1.6×10^{-1}	1	--	1	7.2×10^{-4}	1

Note:

SOF = sum of fractions.

The consequence bin associated with the aboveground failure of the 241-S-109 Phase I staging tank with regard to onsite radiological and onsite and offsite toxicological consequences is "low" because the scoping calculations show that all of the consequences are below the moderate consequence evaluation guidelines.

A qualitative evaluation of the sensitivity of the analysis assumptions is documented below in Table D7-3.

Table D7-3. Qualitative Evaluation of Analysis Assumptions for an Aboveground 241-S-109 Phase I Staging Tank Failure During Demonstration Bulk Vitrification System Operations. (4 sheets)

Analysis assumptions (AA) with references/basis	**Assumption type**	**Sensitivity (frequency/consequence)**	**Need to protect AA**	**Protection/evaluation *basis***
Catastrophic failure of the 241-S-109 Phase I staging tank with rapid draining of the contents				
Although the nominal working volume is 1,100 gal, the 241-S-109 Phase I staging tank is assumed to contain a maximum of 1,200 gal (or 4,542 L) of waste.	Bounding value.	No anticipated effect on consequence bin. This is the bounding MAR that could be present. The MAR would have to be increase significantly beyond the physical size of the tank to change a consequence bin.	No	NA
As shown in Table D4-1, an airborne release fraction for splash/splatter was specifically calculated for various spill heights to determine the maximum airborne release using the equation found in DOE-HDBK-3010-94, Section 3.2.3.1. The specific ARF used was 1.29×10^{-6}. Also, from this section of the handbook, a conservative RF of 0.8 was used.	Reasonably conservative.	No anticipated effect on risk bin. The spill height would have to be increased significantly beyond the physical height of the staging tank for the consequence bin to be affected. Also, note that the 241-S-109 Phase I staging tank will not be elevated and the bottom of the tank will be at grade level.	No	NA
For radiological consequence calculations, the staging tank is assumed to contain 95% liquid and 5% sludge. The onsite ULD that was calculated for this mixture is 2.3×10^{2} Sv/L.	Bounding value.	No anticipated effect on consequence bin. The sludge ULD and the liquid ULD bounds the saltcake ULD from SST 241-S-109. Even if 100% sludge were assumed the consequence bin would not change. Onsite ULDs for SST 241-S-109 are taken from RPP-5924, *Radiological Source Terms for Tank Farms Safety Analysis*, and are given as: Waste Type — ULD (Sv/L) SST Liquid — 7.8×10^{1} SST Sludge — 3.1×10^{3}	No	NA

Table D7-3. Qualitative Evaluation of Analysis Assumptions for an Aboveground 241-S-109 Phase I Staging Tank Failure During Demonstration Bulk Vitrification System Operations. (4 sheets)

Analysis assumptions (AA) with references/basis	**Assumption type**	**Sensitivity (frequency/consequence)**	**Need to protect AA**	**Protection/evaluation basis**
For toxicological consequence calculations, the staging tank is assumed to contain 95% liquid and 5% solids. The SOFs that were calculated for this mixture are 8.7×10^8 (TEEL-1), 1.3×10^8 (TEEL-2), and 7.8×10^6 (TEEL-3).	Bounding value.	No anticipated effect on consequence bin. If 100% solids are assumed, the onsite and offsite consequence bin would remain low, even though 100% solids could not physically be transferred into the tanks. SOF multipliers for each TEEL for SST 241-S-109 are taken from RPP-8369and are given as: Waste Type / TEEL-1 / TEEL-2 / TEEL-3 SST Liquid / 7.97×10^8 / 1.18×10^8 / 7.03×10^6 SST Solids / 2.19×10^9 / 3.22×10^8 / 2.30×10^7	No	NA
The specific gravity of the slurry in the tanks is assumed to be ~1.2 to maximize the splash and splatter.	Reasonably conservative.	No anticipated effect on consequence bin. As the specific gravity increases, the viscosity increases thus minimizing the splash/splatter component. The specific gravity is assumed to be 1.2 even though the solution is saturated with salts and some solids are assumed to be present, both of which would tend to increase the specific gravity beyond the value assumed.	No	NA
The duration of exposure to entrainment and resuspension is assumed to be 8 h.	Reasonably conservative.	No anticipated effect on consequence bin. This is a standard assumption for resuspension. Resuspension is a small contributor to the overall dose. The duration of exposure would have to increase by more than three orders of magnitude for the radiological consequence bin to be affected.	No	NA
A breathing rate of 3.33×10^{-4} m^3/s was used to determine the radiological consequences. This is the breathing rate associated with light activity (i.e., it is an 8-hr average which assumes 2.5 hr of sitting and 5.5 hr of light exercise) as derived by the International Commission on Radiological Protection (documented in RPP-5924).	Reasonably conservative.	No anticipated effect on consequence bin. This is a standard analysis assumption.	No	NA

Table D7-3. Qualitative Evaluation of Analysis Assumptions for an Aboveground 241-S-109 Phase I Staging Tank Failure During Demonstration Bulk Vitrification System Operations. (4 sheets)

Analysis assumptions (AA) with references/basis	**Assumption type**	**Sensitivity (frequency/consequence)**	**Need to protect AA**	**Protection/evaluation *basis***
An atmospheric dispersion coefficient of 2.22×10^{-5} s/m^3 was used for offsite consequences and an atmospheric dispersion coefficient of 3.28×10^{-2} s/m^3 was used for onsite consequences.	Reasonably conservative.	No anticipated effect on consequence bin. The atmospheric dispersion coefficients are from RPP-13482 and represent the 95th percent overall value for accidents less than 1 hr with an assumed ground level release point. No credit is taken for plume meander, building wake effects, or deposition.	No	NA
An airborne release rate for entrainment of 4×10^{-7} /hr was used for a liquid pool exposed to small external wind speeds (DOE-HDBK-3010-94, Section 3.2.4.5).	Reasonably conservative.	No anticipated effect on consequence bin. The airborne release rate for entrainment would have to be increased by more than three orders of magnitude for any of the consequence bins to be affected.	No	NA
For toxicological consequence calculations, the 241-S-109 Phase I staging tank is assumed to drain within 60 seconds due to large breach in the tank at the worst possible height.	Reasonably conservative.	No anticipated effect on consequence bin. The entire release is compressed into 60 seconds to maximize the toxicological consequences. Even if the release were assumed to be a puff release, moderate consequence guidelines would not be exceeded. For example, the onsite toxicological consequence is in the low bin, and it would require a decrease (factor of about 6) in duration of the release to change the risk bin from low to moderate. The offsite toxicological consequence is in the low bin, and it would require more than a factor of 1,400 decrease in duration of the release to change the risk bin from low to moderate.	No	NA

Table D7-3. Qualitative Evaluation of Analysis Assumptions for an Aboveground 241-S-109 Phase I Staging Tank Failure During Demonstration Bulk Vitrification System Operations. (4 sheets)

Analysis assumptions (AA) with references/basis	**Assumption type**	**Sensitivity (frequency/consequence)**	**Need to protect AA**	**Protection/evaluation basis**

Notes:

DOE-HDBK-3010-94, 2000, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, Change Notice 1, U.S. Department of Energy, Washington, D.C.

RPP-5924, 2005, *Radiological Source Terms for Tank Farms Safety Analysis*, Rev. 4-A, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-8369, 2003, *Chemical Source Terms for Tank Farms Safety Analyses*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-13482, 2005, *Atmospheric Dispersion Coefficients and Radiological and Toxicological Exposure Methodology for Use in Tank Farms*, Rev. 5, CH2M HILL Hanford Group, Inc., Richland, Washington.

AA = analysis assumption.
ARF = aerosol release fraction.
MAR = material at risk.
NA = not applicable.
RF = respirable fraction.
SOF = sum of fractions.
TEEL = Temporary Emergency Exposure Limit.
ULD = unit-liter dose.

D8.0 REFERENCES

DOE-HDBK-3010-94, 2000, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, Change Notice 1, U.S. Department of Energy, Washington, D.C.

H-14-106699, 2005, *S-109 PWRS Staging Tank System*, U.S. Department of Energy, Richland, Washington.

RPP-5924, 2005, *Radiological Source Terms for Tank Farm Safety Analysis*, Rev. 4-A, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-8369, 2003, *Chemical Source Terms for Tank Farm Safety Analyses*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-13482, 2005, *Atmospheric Dispersion Coefficients and Radiological and Toxicological Exposure Methodology for Use in Tank Farms*, Rev. 5, CH2M HILL Hanford Group, Inc., Richland, Washington.

Weast, R. C., 1981, *CRC Handbook of Chemistry and Physics*, 61st Ed., CRC Press, Inc., Boca Raton, Florida.

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APPENDIX E

BULK VITRIFICATION STAGING TANK NOZZLE AND S-109 PWRS STAGING TANK SYSTEM DRAWINGS

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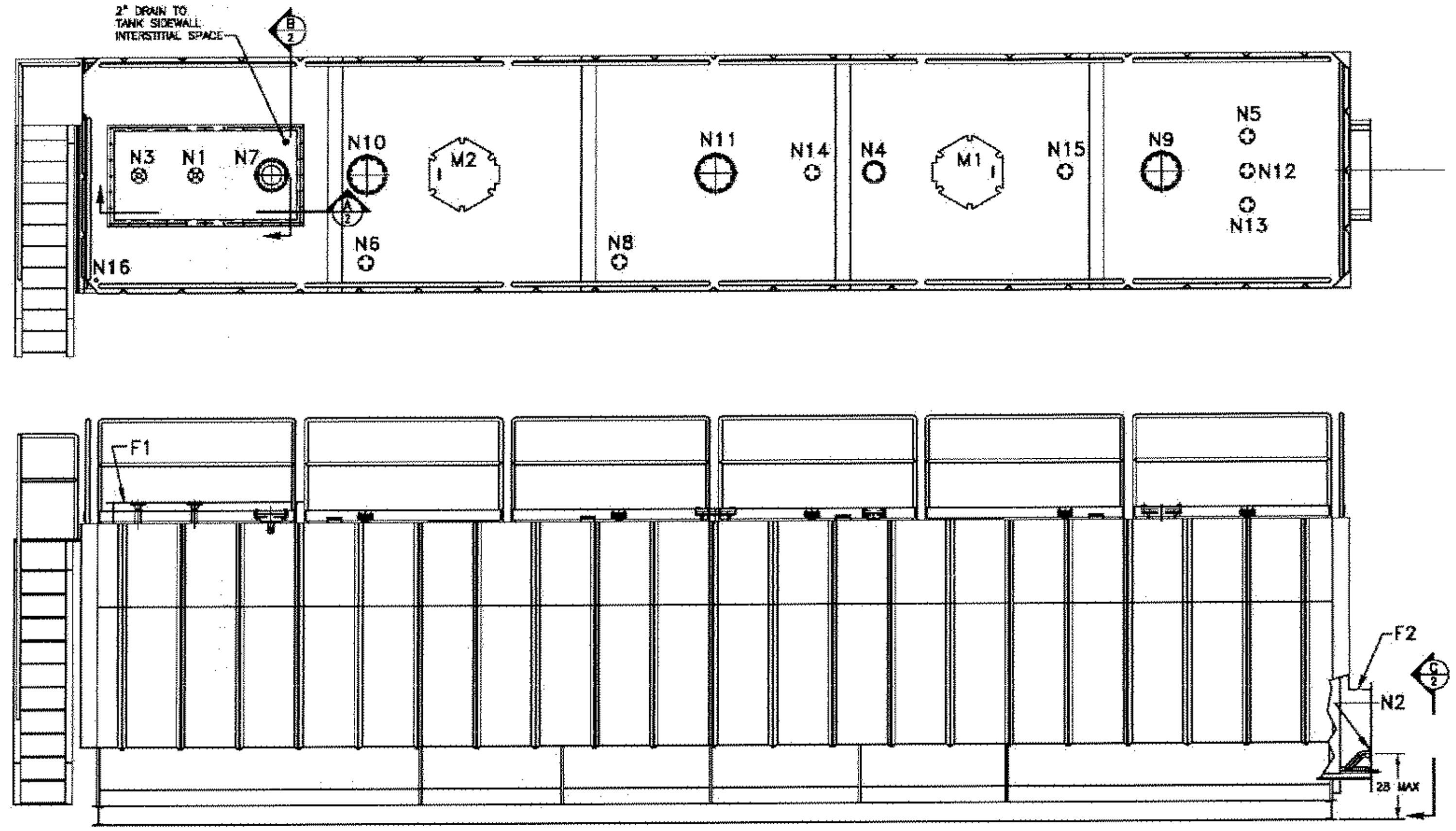


STAGING TANK NOZZLE ARRANGEMENT

SCALE: 1/2" = 12"

LIQUID EFFLUENT TANK NOZZLES

NOZZLE	NOZZLE FUNCTION	NOZZLE TYPE/SIZE	LOCATION
N1	WASTE RECEIPT	2" 150 CLASS RF FLANGE ASTM A105/ A105M OR ASTM A106	LOCATED ON TOP OF TANK INSIDE VALVE SECONDARY CONTAINMENT HOUSING FLANGE NEAR BACK OF TANK
N2	WASTE OUTLET	2" 150 CLASS RF FLANGE ASTM A105/ A105M OR ASTM A106	LOCATED ON FRONT OF TANK, CONFIGURATION TBD BY SELLER
N3	WASTE RETURN	2" 150 CLASS RF FLANGE ASTM A105/ A105M OR ASTM A106	LOCATED ON TOP OF TANK INSIDE VALVE SECONDARY CONTAINMENT HOUSING FLANGE NEAR BACK OF TANK
N4	SPARE EQUIPMENT	4" 150 CLASS RF FLANGEASTM A105/ A105M OR ASTM A106	LOCATED ON TOP OF TANK
N5	PRIMARY CONTAINMENT VENTILATION OUTLET	2" 150 CLASS RF FLANGE ASTM A105/ A105M OR ASTM A106	LOCATED ON TOP OF TANK
N6	PRIMARY CONTAINMENT VENTILATION INLET	2" 150 CLASS RF FLANGE ASTM A105/ A105M OR ASTM A106	LOCATED ON TOP OF TANK
N7	VACUUM/PRESSURE RELIEF	TBD (NOZZLE NOT TO BE LESS THAN 2"ø	LOCATED ON TOP OF TANK INSIDE VALVE SECONDARY CONTAINMENT HOUSING FLANGE NEAR BACK OF TANK. DEVICE TO VENT INTO VALVE SECONDARY CONTAINMENT HOUSING
N8	SECONDARY CONTAINMENT ATMOSPHERIC VENTILATION	2" 150 CLASS RF FLANGE ASTM A105/ A105M OR ASTM A106	LOCATED ON TOP OF TANK
N9	HEATER	10" 150 CLASS RF FLANGE ASTM A105/ A105M OR ASTM A106	LOCATED ON TOP OF TANK W/IN 10' OF FRONT END
N10	HEATER	10" 150 CLASS RF FLANGE ASTM A105/ A105M OR ASTM A106	LOCATED ON TOP OF TANK W/IN 10' OF BACK END
N11	HEATER (SPARE)	10" 150LB RF FLANGE ASTM A105/A105M OR ASTM A106	LOCATED ON TOP OF TANK W/IN 5' OF CENTER
N12	TANK LEVEL DETECTION	2" 150 CLASS RF FLANGE ASTM A105/ A105M OR ASTM A106	LOCATED ON TOP OF TANK
N13	TANK HIGH LEVEL SWITCH	2" 150 CLASS RF FLANGE ASTM A105/ A105M OR ASTM A106	LOCATED ON TOP OF TANK
N14	TEMPERATURE INSTRUMENT	2" 150 CLASS RF FLANGE ASTM A105/ A105M OR ASTM A106	LOCATED ON TOP OF TANK
N15	PRIMARY TANK FLUSH	TBD	TOP OF TANK – QTY & LOCATIONS TBD
N16	ANNULUS FLUSH	TBD	TOP OF TANK – QTY & LOCATIONS TBD
F1	SECONDARY CONTAINMENT BODY FLANGE	AS CONFIGURED	LOCATED ON TOP OF TANK AT THE REAR
F2	SECONDARY CONTAINMENT BODY FLANGE	AS CONFIGURED	LOCATED ON FRONT FACE OF TANK
M1	MANWAY	30"	TOP OF TANK
M2	MANWAY	30"	TOP OF TANK

NOTE:
1. SEE PROCUREMENT SPECIFICATION: 145579-D-SP-028, WASTE RECEIPT SYSTEM LIQUID WASTE STAGING TANKS

PRELIMINARY

NOT APPROVED FOR CONSTRUCTION

DMJM Technology

amec

145579-FINAL DBVS DESIGN

U.S. DEPARTMENT OF ENERGY

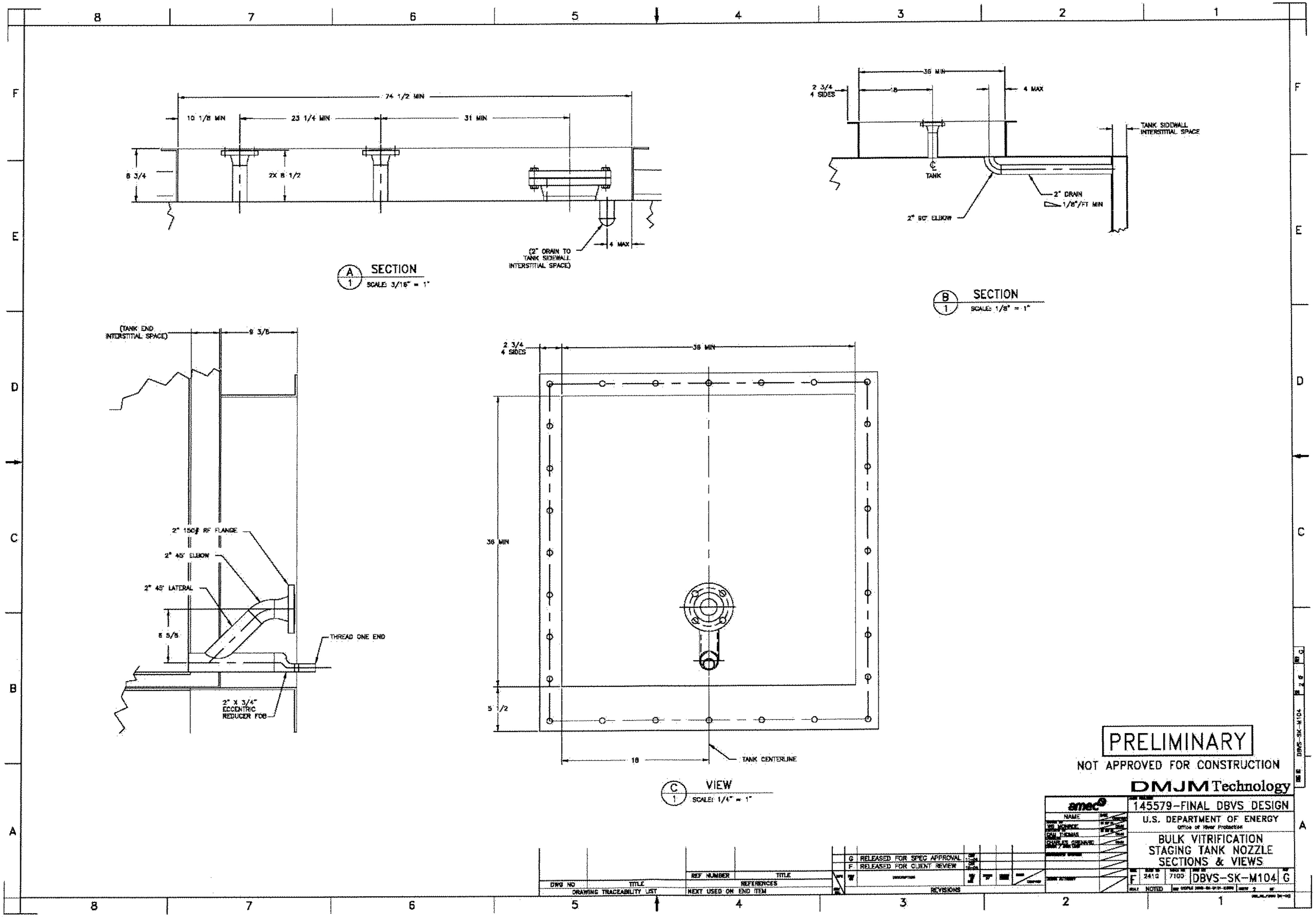
Office of River Protection

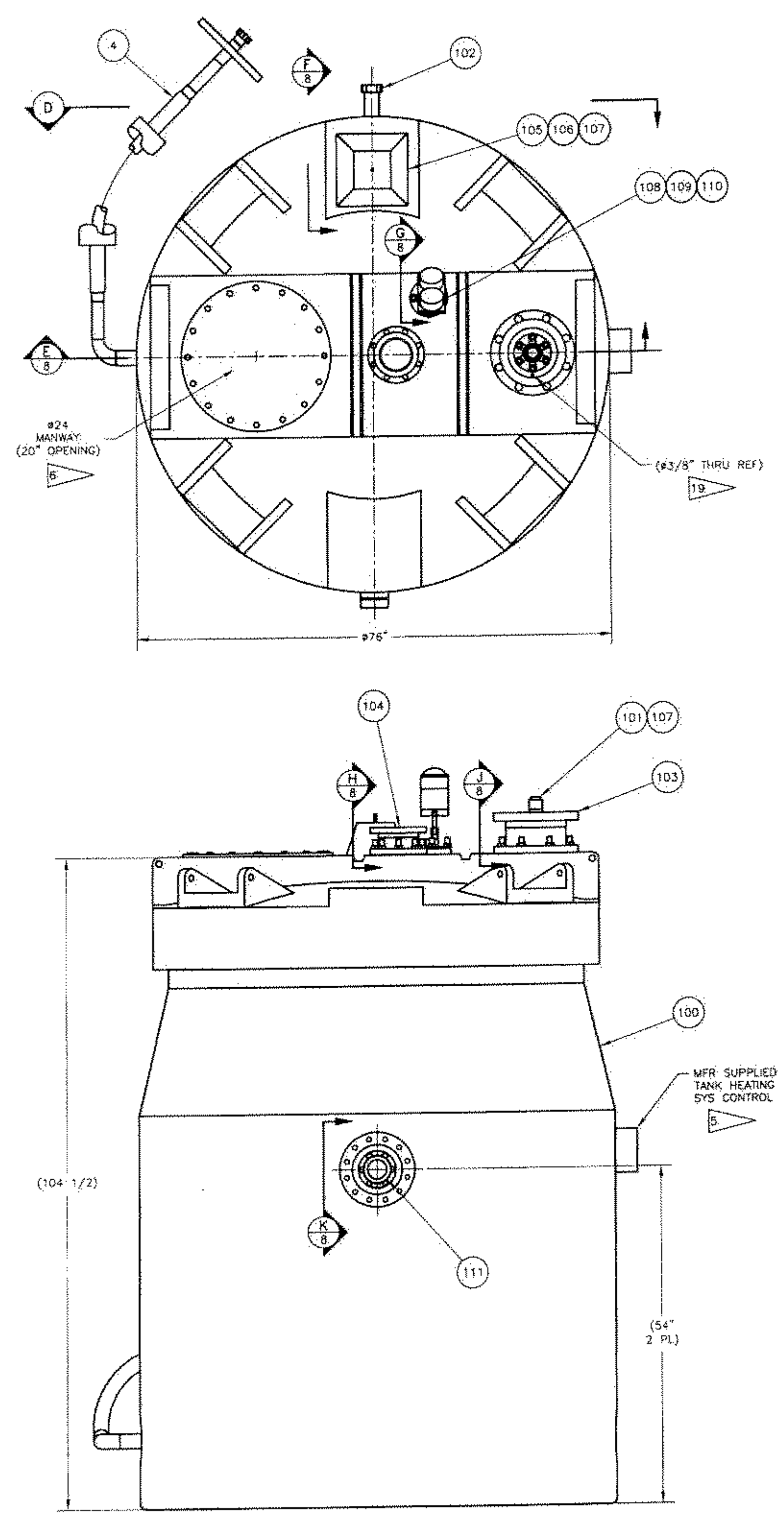
BULK VITRIFICATION STAGING TANK NOZZLE ARRANGEMENT

F 241G 7100 DBVS-SK-M104 G

G	RELEASED FOR SPEC APPROVAL	
F	RELEASED FOR CLIENT REVIEW	
		REVISIONS

DWG NO	TITLE	REF NUMBER	TITLE
DRAWING TRACEABILITY LIST		REFERENCES	
		NEXT USED ON END ITEM	


74 1/2 MIN
10 1/8 MIN
23 1/4 MIN
31 MIN
8 3/4
2X 8 1/2
(2" DRAIN TO TANK SIDEWALL INTERSTITIAL SPACE)
4 MAX
A 1 SECTION
SCALE: 3/16" = 1"
36 MIN
2 3/4 4 SIDES
18
4 MAX
TANK SIDEWALL INTERSTITIAL SPACE
TANK
2" DRAIN
1/8"/FT MIN
2" 90° ELBOW
B 1 SECTION
SCALE: 1/8" = 1"
(TANK END INTERSTITIAL SPACE)
9 3/8
2" 150# RF FLANGE
2" 45° ELBOW
2" 45° LATERAL
8 5/8
THREAD ONE END
2" X 3/4" ECCENTRIC REDUCER FOB
2 3/4 4 SIDES
36 MIN
36 MIN
5 1/2
18
TANK CENTERLINE
C 1 VIEW
SCALE: 1/4" = 1"
PRELIMINARY
NOT APPROVED FOR CONSTRUCTION
DMJM Technology
amec
145579-FINAL DBVS DESIGN
U.S. DEPARTMENT OF ENERGY
BULK VITRIFICATION
STAGING TANK NOZZLE
SECTIONS & VIEWS
F 2413 7100 DBVS-SK-M104 G
NOTED
G RELEASED FOR SPEC APPROVAL
F RELEASED FOR CLIENT REVIEW
REVISIONS
DWG NO
TITLE
DRAWING TRACEABILITY LIST
REF NUMBER
TITLE
REFERENCES
NEXT USED ON END ITEM



② STAGING TANK ASSEMBLY
SCALE: 1/10"

1. SEE CONTROLLED VENDOR INFORMATION FILE VI-50355 FOR MFR'S DESIGN, OPERATION, AND INSTALLATION INFORMATION RELATED TO PURCHASED COMPONENTS.

2. TANK IS PER SNYDER INDUSTRIES SPECIFICATION 199901, REV B AND ASTM D1998-97, MAT'L TYPE 1 (MAX 140 DEG F OPERATING TEMP). TESTS REQ'D INCLUDE UT WALL THICKNESS, HYDROSTATIC, AND HEATING SYSTEM FUNCTION. FITTINGS, ATTACHMENTS, AND ACCESSORIES ARE AS DEPICTED ON THIS DWG.

3. TANK LIFTING AND HANDLING SHALL BE BY FORKLIFT. CARE SHOULD BE TAKEN TO PREVENT DAMAGE TO INSULATION. PRIMARY AND CONTAINMENT TANK ARE HELD TOGETHER WITH A SHIPPING CABLE UPON DELIVERY FROM THE MFR. DO NOT REMOVE CABLE UNTIL FINAL PLACEMENT OF TANK IN FARM.

4. TANK GROSS STORAGE CAPACITY IS 1100 GALLONS. STAND-PIPE SHOWN IN SECTION VIEW LIMITS TANK'S OPERATIONAL STORAGE VOLUME TO 850 GALLONS OR LESS.

5. TANK TO BE FITTED WITH HEATING SYSTEM AND INSULATION. STORAGE TEMPERATURE SETPOINT IS 80 DEG F, HEATING SYSTEM OVERLIMIT TEMP SETPOINT IS 90 DEG F. HEATING SYSTEM AND INSULATION IS SIZED TO PROVIDE A MAXIMUM DIFFERENTIAL TEMP OF 80 DEG F. HEATING SYSTEM IS 220 VAC. MAXIMUM CURRENT DRAW IS APPROXIMATELY 5 A.

6. TIGHTEN MFR-SUPPLIED THREADED AND FLANGED FITTINGS AND MANWAY AS SPECIFIED IN SNYDER INDUSTRIES PUBLICATION "GUIDELINES FOR USE AND INSTALLATION", SECTION 3, PRIOR TO INSTALLATION OF TANK. VERIFY GASKET COMPRESSION IS 25% TO 50% OF FREE HEIGHT.

7. FABRICATION AND EXAMINATION OF WELDED SUBASSEMBLIES SHALL COMPLY WITH ASME B31.3 REQUIREMENTS FOR NORMAL FLUID SERVICE. WELDER AND WELD PROCEDURE QUALIFICATION SHALL BE AS SPECIFIED IN ASME BOILER AND PRESSURE VESSEL CODE, SECTION IX.

8. ITEM 4, TANK SUCTION PIPING SUBASSEMBLY, SHALL BE HYDROSTATICALLY TESTED AFTER FABRICATION AND BEFORE INSTALLATION ON TANK. TEST FLUID SHALL BE WATER AT AMBIENT TEMPERATURE. TEST PRESSURE SHALL BE 450 PSIG (+0/-25 PSIG). ACCEPTANCE CRITERIA SHALL BE NO VISIBLE EXTERNAL LEAKAGE OVER 10 MINUTE DURATION.

9. ALL PIPE THREADS SHALL BE ASSEMBLED USING SEALANT AS SPECIFIED IN APPROVED WORK INSTRUCTIONS.

10. ALL SOLVENT WELD JOINTS FOR PVC FITTINGS SHALL BE ASSEMBLED AS SPECIFIED IN ASME B31.3, CHAPTER 7, SECTION A328, USING QUALIFIED BONDERS AND BONDING PROCEDURES.

11. REMOVE TANK FILL PIPE AFTER RECEIPT FROM MFR AND MODIFY PER INSTRUCTIONS SHOWN IN DETAIL 1. UPON RE-INSTALLATION, TANK FILL PIPE DISCHARGE HOLES SHALL BE ORIENTED TO DISCHARGE PARALLEL TO TANK WALL, AS SHOWN IN SECTION E.

12. ORIENT MFR-SUPPLIED SIPHON TUBE AND OVERFLOW PIPE AS SHOWN IN VIEWS M AND SECTION N, RESPECTIVELY, PRIOR TO TIGHTENING MFR'S FITTING.

13. ITEM 109, LEVEL PROBE, SHALL BE SHORTENED AS REQUIRED TO PROVIDE THE INSERTION LENGTH SHOWN USING ITEM 110, LEVEL PROBE KIT, AS SPECIFIED IN MFR INSTRUCTIONS.

14. ASSEMBLE ITEMS 114 AND 113 AS SPECIFIED IN MFR INSTRUCTIONS AND INSTALL IN TANK ANNULUS AS SHOWN. ITEM 113, LEAK DETECTOR SENSING CABLE SHALL BE POSITIONED TO DETECT FLUID AT A DEPTH IN TANK ANNULUS OF ½ INCH.

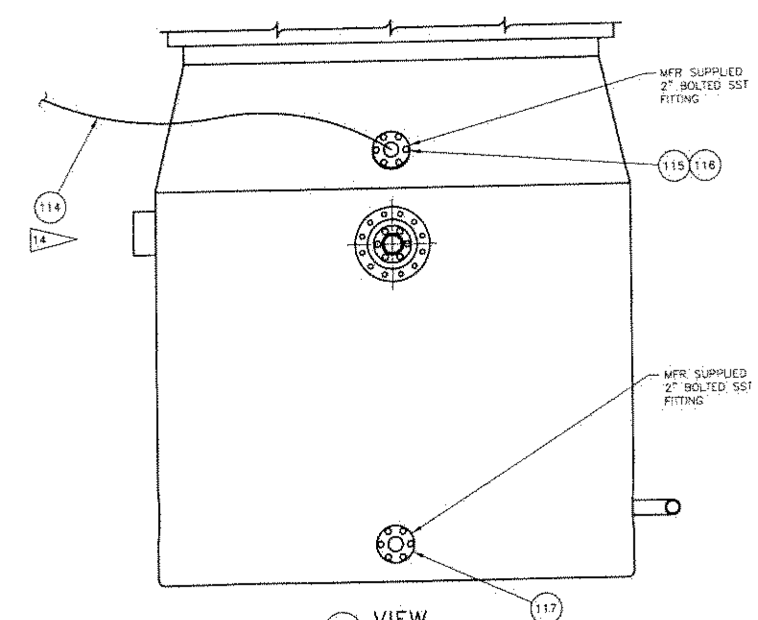
15. ITEM 112, TEMPERATURE SENSOR, AND ITEM 111, TANK LEVEL SWITCH, ARE TO BE INSTALLED AS SPECIFIED IN MFR INSTRUCTIONS.

16. AFTER ASSEMBLY OF ALL FLUID-RETAINING JOINTS, TANK SYSTEM SHALL BE SUBJECTED TO A LEAK TEST BY FILLING THE TANK TO ITS OPERATING CAPACITY WITH WATER AT AMBIENT TEMPERATURE AND HOLDING FOR A CONTINUOUS PERIOD OF AT LEAST 5 HOURS. ACCEPTANCE CRITERIA SHALL BE NO VISABLE LEAKAGE DETECTED. A COPY OF TESTS RESULTS SHOULD BE SUBMITTED TO THE TANK MFR FOR RECORD, AS SPECIFIED IN SNYDER INDUSTRIES PUBLICATION "GUIDELINES FOR USE AND INSTALLATION".

17. SEE SHEET 11 FOR CONDUIT AND WIRING DETAILS ASSOCIATED WITH TANK ELECTRICAL EQUIPMENT.

18. DIMENSIONS SHOWN WITHOUT INSULATION. INSULATION THICKNESS IS APPROXIMATLY 2".

19. ENSURE 3/8" DIA HOLE IN ANNULUS SPACE IS CLEAR BEFORE CLOSING ENCASEMENT JOINT.



Ⓓ VIEW
SCALE: 1/10"

PARTS LIST/MATERIAL LIST

QTY REQD -040	QTY REQD -020	PARTS / DASH NUMBER	NOMENCLATURE/DESCRIPTION	MATERIAL/REFERENCE	SHEET	ITEM NO
	X	-020	STAGING TANK ASSEMBLY		3,7	2
X	1	-040	TANK SUCTION PIPING ASSEMBLY		7,8	4
	1	"CAPTOR" MODEL 5470	TANK, DOUBLE WALL, 1100 GALLON	SNYDER INDUSTRIES	7	100
	1	H-14-106696-110	TANK FILL PIPE CONNECTOR ASSEMBLY		7	101
	1	H-14-106696-120	TANK OVERFLOW PIPE CONNECTOR ASSEMBLY		7	102
	1		SPIGOT FLANGE, 8" CLASS 150 PER ASME B16.5	PVC PER ASTM D1784 AND F1970	7	103
	1		SPIGOT FLANGE, 4" CLASS 150 PER ASME B16.5	PVC PER ASTM D1784 AND F1970	7	104
	1	D-007-1-12-RF-NU-00-E3-Z04059A	FILTER, HEPA, 40 CFM	FLANDERS	7	105
	1	F0622997	WEATHER CAP, FOR FLANDERS FILTER Z04059A	FLANDERS	7	106
	2		REDUCING BUSHING, THREADED, 2 X 1 1/2, PER ASME B16.11	ASTM A182 304/316 SS	7	107
	1	705-501A-110	TRANSMITTER, TANK LEVEL	MAGNETROL	7	108
	1	7EB-A410-103	PROBE, TANK LEVEL	MAGNETROL	7	109
	AR	089-9112-001	TANK PROBE KIT	MAGNETROL	7	110
	1	T35-002N-B1B	SWITCH, TANK LEVEL	MAGNETROL	7	111
	1	R5T185L3-S4C0408-8HN31-SL-T440-385U-S(-20-120)F	TEMPERATURE TRANSMITTER, SERIES 440 -20 TO -120 DEG F	PYROMATION	8	112
	1	TT3000-1.5M/5FT-HSE-MC	SENSING CABLE, TRACE-TEK LEAK DETECTION SYSTEM, 5 FT LG.	RAYCHEM	8	113
	1	TT-MJC-15M/50FT-MC	JUMPER CABLE, TRACE-TEK LEAK DETECTION SYS, WITH METAL CONNECTORS, 50 FT G.	RAYCHEM	7	114
	1	TT-PFT-3/4-SS/MC	PRESSURE FEED-THROUGH, TRACE-TEK LEAK DETECTION SYS, 3/4" NPT, SST	RAYCHEM	7	115
	1		REDUCING BUSHING, THREADED, 2 X 3/4, PER ASME B16.11	ASTM A182 304/316 SS	7	116
	1		PLUG, THREADED, 2" NPT PER ASME B16.11	ASTM A182 304/316 SS	7	117
1		H-14-106696-100	TANK SUCTION PIPE CONNECTOR ASSEMBLY		8	118
1		H-14-106697-070	TANK SUCTION JUMPER ASSEMBLY		8	119
1		H-14-106696-090	PIT SUCTION PIPING CONNECTOR ASSEMBLY		8	120
	1		REDUCING BUSHING, THREADED, 2 X 1/2, PER ASME B16.11	ASTM A182 304/304L SS	8	121

SEE SHEET 1 FOR GENERAL NOTES

REF NUMBER	TITLE
H-14-106697	STS JUMPER ASSEMBLIES
H-14-106696	STS MANIFOLD
RPP-22420	S-109 PWRS PROJECT CALCS

REFERENCES
NEXT USED ON H-14-106899-010

DWG NO | TITLE
DRAWING TRACEABILITY LIST

REVISIONS

DRAWN BY: DC SHELDON
DESIGN AUTHORITY: GP JANICEK

U.S. DEPARTMENT OF ENERGY
Office of River Protection

S-109 PWRS
STAGING TANK SYSTEM
TANK ASSEMBLY

SIZE F | BLDG NO 241S | INDEX NO 8409 | DWG NO H-14-106699 | REV 0
SCALE SHOWN | 821297 | SHEET 7 OF
21486

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APPENDIX F

HUMAN FACTORS EVALUATION AND PEER REVIEW CHECKLIST FOR DEMONSTRATION BULK VITRIFICATION SYSTEM

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APPENDIX F

HUMAN FACTORS EVALUATION AND PEER REVIEW CHECKLIST FOR DEMONSTRATION BULK VITRIFICATION SYSTEM

Human Factors Evaluation Checklist.

Hazard Analysis Title: Demonstration Bulk Vitrification System Accidents

Documented Safety Analysis Section Number: RPP-23429, *Preliminary Documented Safety Analysis for the Demonstration Bulk Vitrification System*, Section 3.3.2.4.9, "Release from Aboveground Tank Failure"

Item No.	Issue	Yes, No, Unknown
1	Does the activity/event being planned/analyzed require human interaction to successfully complete the activity or mitigate consequences of the event? If the answer is No, go to Item No. 23. Otherwise continue with Item No. 2.	Yes
2	Are procedures/instructions available to the individuals responsible for the action?	*
3	Are procedures/instructions complete, accurate, and validated?	*
4	Are the individuals responsible for the action also responsible for collateral duties?	*
5	Are staffing levels adequate to perform the activity?	*
6	Are the individuals responsible for the action adequately trained, qualified, and experienced to perform the actions?	*
7	Have the required actions been walked down in the field to verify execution within the time constraints identified in the hazard analysis?	*
8	Have physical obstacles that could prevent successful completion of the activity been removed or accounted for?	*
9	Have work area environmental concerns been identified and accounted for?	*
10	Has PPE been dedicated and is available, if required?	*
11	Have the appropriate tools been dedicated and are available, if required?	*
12	Does workstation configuration facilitate completion of the actions?	*
13	Are instruments, valves, switches, or other devices accessible?	*
14	Are instruments, valves, switches, or other devices properly tagged or labeled?	*
15	Is communication equipment operable, dedicated, and available, if necessary?	*
16	Is adequate fixed lighting in place?	*
17	Is portable lighting dedicated, functional, and available, if necessary?	*
18	Are confined space restrictions adequately addressed?	*
19	Is temperature, humidity, radiological, and toxicological conditions acceptable for human occupancy?	*
20	Is hazard material or radiological monitoring equipment dedicated, functional, and available, if needed?	*
21	Are access controls identified and keys available?	*
22	Can activities be completed within the time prescribed in the hazard analysis?	*
	If any answer for Items 2 through 22 is No or Unknown, corrective actions may be required to ensure successful completion of the activity as described in the hazard analysis. Complete and document corrective actions on Documented Safety Analysis Implementation Checklist and go to Item No. 23.	
23	Evaluator: Andrew R. Marchese (Print) — [signature] (Signature) — 1-6-05 (Date) Peer Reviewer: Kevin R. Sandgren (Print) — [signature] (Signature) — 1/7/05 (Date)	

*No or Unknown. As of this date, the design and/or construction of the facility is not complete, procedures have not been written, and staffing has not been established. The questions presented in the checklist will be addressed as part of the DSA implementation process.

Effective Date: 2/12/2004

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: RPP-13175, *Technical Basis Document for the Aboveground Tank Failure Representative Accident and Associated Represented Hazardous Conditions*, Rev. 1

Scope of Review (e.g., document section or portion of calculation): Changes made for revision 1 of this document.

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

XRL

Effective Date: 2/12/2004

[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] [ ] [ ] 40. Impacted documents are appropriately identified in Blocks 7 and 25 of the Engineering Change Notice (form A-6003-563.1).
[X] [ ] [ ] 41. If more than one Technical Peer Reviewer was designated for this document, an overall review of the entire document was performed after resolution of all Technical Peer Review comments and confirmed that the document is self-consistent and complete.
[X] [ ] [ ] Concurrence

Kevin Sandgren [signature] 1/7/05
Reviewer (Printed Name and Signature) Date

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

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: RPP-13175 Rev 1

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

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.

CHECKLIST FOR TECHNICAL PEER REVIEW

[ ] [ ] [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)*
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[ ] [ ] [x] 41. If more than one Technical Peer Reviewer was designated for this document, an overall review of the entire document was performed after resolution of all Technical Peer Review comments and confirmed that the document is self-consistent and complete.
[x] [ ] [ ] Concurrence

Leona Aamot [signature] 3/2/05
Reviewer (Printed Name and Signature) Date

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APPENDIX G

CALCULATIONS FOR ABOVEGROUND TANK FAILURE DURING CONTACT-HANDLED TRANSURANIC MIXED WASTE FACILITY OPERATIONS

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APPENDIX G

CALCULATIONS FOR ABOVEGROUND TANK FAILURE DURING CONTACT-HANDLED TRANSURANIC MIXED WASTE FACILITY OPERATIONS

G1.0 INTRODUCTION

The purpose of this appendix is to provide a basis for the qualitative assessment of consequences to be used for risk binning. Consequences are calculated for the radiological and toxicological exposures resulting from a release of radioactive or hazardous waste materials from the above ground tanks associated with the Contact-Handled Transuranic Mixed (CH-TRUM) Waste Facility operations.

G2.0 WASTE RETRIEVAL SYSTEM OPERATIONS HAZARDOUS CONDITIONS

The aboveground tanks associated with the CH-TRUM are subject to failure from one of several possible causes (e.g., seismic event, high winds, manufacturing defects, structural degradation, vehicle impacts). The primary structures of concern are the five large Feed Receipt Processing System (FRPS) receipt tanks and the two waste dryers. During system operations each FRPS receipt tank and each dryer could contain a maximum of 30,280 L and 10,200 L, respectively, of waste and dilution water which bounds the other aboveground tanks and vessels present in the CH-TRUM Facility and exceeds the volume of material at risk in the aboveground tank failure representative accident. Four failures are analyzed here: (1) catastrophic failure of all FRPS receipt tanks (five for CH-TRUM) with rapid drainage of the contents (e.g., seismic event), (2) catastrophic failure of a single FRPS receipt tank with rapid drainage of the contents, (3) catastrophic failure of a dryer with rapid drainage of the contents, and (4) single tank failure with drainage through a broken overflow line penetration. The consequences consist of splash and splatter from the spill and entrainment of aerosol by air movement over the pool of released waste.

G3.0 ASSUMPTIONS

The following enabling assumptions are considered for the catastrophic failure of three tanks:

- The FRPS receipt tank height is 501 cm. The tank is assumed to be 68 cm above the floor of the International Organization for Standardization (ISO) container (estimated from Drawing 20843.M002, *FRPS Waste Receipt Tank Details and Interface*). Therefore, the height of the top of the tank is assumed to be 569 cm above the floor of the ISO container. The top and bottom of the dryer are assumed to be at 710 cm and 550 cm, respectively, above grade (estimated from Drawing 056-001-2-007, *RNC CD-10,000 General Arrangement & Details Dryer B*).

- The FRPS receipt tanks and waste dryers are assumed to be full to maximize the material at risk (30,280 L per tank and 10,200 L per dryer).

- Each tank and each dryer are assumed to drain within 60 sec due to large breach at the worst possible height.

- The assumed failure is a spill of the contents of each FRPS receipt tank or dryer. The consequences consist of two components: (1) splash and splatter from the spill, and (2) entrainment of aerosol by air movement over the pool of released waste.

- The waste in each FRPS receipt tank and dryer is conservatively assumed to be the bounding CH-TRUM waste. CH-TRUM waste consists of waste from single-shell tanks (SST) 241-B-201, 241-B-202, 241-B-203, 241-B-204, 241-T-110, 241-T-111, 241-T-201, 241-T-202, 241-T-203, 241-T-204, and 241-T-104.

- The bounding unit-liter doses (ULDs) and sum of fraction (SOF) multipliers documented in RPP-5924, *Radiological Source Terms for Tank Farms Safety Analysis*, and RPP-8369, *Chemical Source Terms for Tank Farm Safety Analysis,* respectively, for the CH-TRUM tanks are considered for estimating consequences. See Tables G4-1 and G4-2.

- For the radiological and toxicological consequence calculations, each FRPS receipt tank and each dryer are assumed to contain slurry consisting of 50% water mixed with the bounding solid CH-TRUM waste as shown in Section G4.0.

- The specific gravity of the slurry in the tanks is assumed to be ~1.2 to maximize the splash and splatter.

- For the splash/splatter component, the waste solution viscosity is assumed to be 7.9×10^{-2} poise (the selected viscosity corresponds to a value from DOE-HDBK-3010-94, Table 3-9, for the above specific gravity to conservatively represent the viscosity of the waste).

- For the FRPS receipt tank, spill heights between 68 cm to 569 cm are examined to determine the point with the maximum airborne release. The tank will leak about 60 L for every centimeter above the leak point (30,280 L/501 cm). For the dryer, spill heights between 550 cm and 710 cm are examined to determine the point with the maximum airborne release. Since the dryer is a horizontal cylindrical vessel, spill volumes as a function of height (between 550 cm to 710 cm) are calculated as described below.

- For the single tank failure case, the tank is assumed to drain through one broken penetration. The only tank penetration that is not on the top of the tank is assumed to be the overflow penetration which is assumed to be 493 cm above grade level (based on Drawing 20843.M002). The tank penetration is assumed to be 2 in. in diameter and is assumed to have a sharp edged entrance and exit.

- To maximize the airborne release rate for the single tank failure draining through one broken penetration, the tank is assumed to be full of waste to maximize the head and material at risk (30,280 L of CH-TRUM slurry). The tank is assumed to have a maximum head of 76 cm (tank height of 569 cm – spill height of 493 cm).

- The entrainment of aerosol by air will be based on an airborne release rate of 4 x 10^{-7}/hr from DOE-HDBK-3010-94 for a liquid pool exposed to small external wind speeds.
- The duration of exposure to entrainment and resuspension is assumed to be 8 hr.
- The onsite and offsite 1-hr atmospheric dispersion coefficients for a ground level release with no credit taken for plume meander, building wake effects, or deposition are 3.28 x 10^{-2} sec/m^3 and 2.22 x 10^{-5} sec/m^3, respectively, from RPP-13482, *Atmospheric Dispersion Coefficients and Radiological and Toxicological Exposure Methodology for Use in Tank Farms*. For the onsite radiological dose due to entrainment over an 8-hr period, the onsite 8-hr atmospheric dispersion coefficient of 5.58 x 10^{-3} sec/m^3 from RPP-13482 are used.
- The breathing rate for light activity is used and is 3.33 x 10^{-4} m^3/sec.

G4.0 INPUT DATA FOR UNIT LITER DOSES AND SUM OF FRACTIONS

The input data used is as follows:

Onsite ULD for CH-TRUM tanks are taken from RPP-5924 and are shown in Table G4-1.

Table G4-1. Unit-Liter Doses for Contact-Handled Transuranic Mixed Waste from RPP-5924, Rev. 4-A.

Waste tank	Unit liter dose (Sv/L)(onsite)
241-B-201	**1.2 E+03**
241-B-202	3.1 E+02
241-B-203	3.1 E+02
241-B-204	3.8 E+02
241-T-201	1.2 E+03
241-T-202	3.1 E+02
241-T-203	2.8 E+02
241-T-204	2.0 E+02
241-T-110	1.1 E+02
241-T-111	2.7 E+02
241-T-104	2.5E+02

Notes:

RPP-5924, 2005, *Radiological Source Terms for Tank Farm Safety Analysis*, Rev. 4-A, CH2M HILL Hanford Group, Inc., Richland, Washington.

Sum of fractions (SOF) multipliers for each Temporary Emergency Exposure Limit (TEEL) for CH-TRUM tanks are taken from RPP-8369 are shown in Table G4-2.

Table G4-2. Sum of Fractions Multipliers from RPP-8369, Rev. 2.

Basis Tank	TEEL-1	Basis Tank	TEEL-2	Basis Tank	TEEL-3
241-B-203	**1.71 E+09**	241-B-203	**5.60 E+08**	241-T-202	**3.39 E+08**
241-B-204	1.62 E+09	241-T-201	5.37 E+08	241-T-203	3.27 E+08
241-T-204	1.62 E+09	241-T-204	5.33 E+08	241-T-204	3.17 E+08
241-T-202	1.60 E+09	241-B-204	5.28 E+08	241-T-201	2.98 E+08
241-T-201	1.57 E+09	241-T-202	5.22 E+08	241-B-203	2.98 E+08
241-T-203	1.54 E+09	241-T-203	4.78 E+08	241-B-204	2.77 E+08
241-B-202	1.40 E+09	241-B-202	4.70 E+08	241-B-202	2.49 E+08
241-B-201	1.13 E+09	241-B-201	3.85 E+08	241-B-201	1.90 E+08
241-T-110	7.37 E+08	241-T-110	3.23 E+08	241-T-111	8.20 E+07
241-T-111	7.23 E+08	241-T-111	2.74 E+08	241-T-110	4.81 E+07
241-T-104	2.03E+08	241-T-104	9.02E+07	241-T-104	6.74E+06

Notes:

RPP-8369, 2003, *Chemical Source Terms for Tank Farm Safety Analyses*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

TEEL = Temporary Emergency Exposure Limit.

G5.0 CALCULATION OF MIXTURE UNIT LITER DOSES AND SUM OF FRACTIONS

ULDs and SOF multipliers for each TEEL were calculated for consequence calculations.

G5.1 CONTACT-HANDLED TRANSURANIC MIXED WASTE UNIT LITER DOSE MULTIPLIERS

From consideration of the above tanks, the bounding onsite CH-TRUM sludge ULD for SST 241-B-201 are used and is $1.2 \times 10^{+3}$ Sv/L. However, since the FRPS receipt tank is diluted with 50% water the following expression is used to calculate the diluted tank and dryer waste ULD for the slurry:

$$[(0.5)(1.2 \times 10^{+3}) + (0.5)(0.0)] = 6.0 \times 10^{+2} \text{ Sv/L}.$$

where:

1.2×10^{3} Sv/L = onsite sludge ULD for SST 241-B-201 before drying (RPP-5924)

0.0×10^{0} Sv/L = water ULD

G5.2 DEMONSTRATION BULK VITRIFICATION SYSTEM SUMS OF FRACTIONS MULTIPLIERS

From consideration of the above tanks, the bounding SOFs for solids are: TEEL-1 = $1.71 \times 10^{+9}$, TEEL-2 = $5.60 \times 10^{+8}$ and TEEL-3 = $3.39 \times 10^{+8}$. However, since the FRPS receipt tank is diluted with 50% water the following expressions is used to calculate the diluted tank and dryer waste SOF multipliers for the slurry:

TEEL-1 SOF multiplier = $[(1.71 \times 10^{9})(0.5) + (0.00 \times 10^{0})(0.5)] = 8.55 \times 10^{8}$

where:

1.71×10^{9}	= solid TEEL-1 SOF multiplier for SST 241-B-203 (RPP-8369).
0.00×10^{0}	= water TEEL SOF multiplier.

TEEL-2 SOF multiplier = $[(5.60 \times 10^{8})(0.5) + (0.00 \times 10^{0})(0.5)] = 2.80 \times 10^{8}$

where:

5.60×10^{8}	= solid TEEL-2 SOF multiplier for SST 241-B-203 (RPP-8369).

TEEL-3 SOF multiplier = $[(3.39 \times 10^{8})(0.5) + (0.00 \times 10^{0})(0.5)] = 1.70 \times 10^{8}$

where:

3.39×10^{8}	= solid TEEL-3 SOF multiplier for SST 241-T-202 (RPP-8369).

C6.0 ACCIDENT CONSEQUENCE COMPARISON

G6.1 Catastrophic Failure of Five Feed Receipt Processing System Receipt Tanks

This scenario assumes that a simultaneous failure of all five FRPS receipt tanks occurs resulting in rapid draining of the entire contents of all five FRPS receipt tanks within a 60 sec period. The consequences consist of two components: (1) splash and splatter from the spill and (2) entrainment of aerosol by air movement over the pool of released waste.

Splash and Splatter

The airborne release fraction (ARF) for splash/splatter can be calculated with the following equation from DOE-HDBK-3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, Section 3.2.3.1:

$$ARF = 8.9 \times 10^{-10} \times Arch^{0.55}$$

$$ARF = 8.9 \times 10^{-10} [(1.2 \times 10^{-3}\ g/cm^3)^2 \times (height)^3 \times (981\ cm/s^2)/(7.9 \times 10^{-2}\ poise)^2]^{0.55}$$

where:

Arch	= Archimedes Number
	= $(\text{density}_{air})^2$ x $(\text{spill height})^3$ x (g) / $(\text{solution viscosity})^2$
1.2×10^{-3} g/cm^3	= density of air (*CRC Handbook of Chemistry and Physics* [Weast 1981])
height	= spill height in cm.
981 cm/s^2	= g (acceleration due to gravity)
7.9×10^{-2} poise	= solution viscosity (the selected viscosity corresponds to a value from DOE-HDBK-3010-94, Table 3-9, to conservatively represent the viscosity of the waste).

As the spill height increases the ARF will increase; however, as the spill height increases the amount of material at risk will decrease. The potential spill heights for the tank could be anywhere across the height of the tank from an event such as an earthquake. In order to conservatively calculate the consequences for the release, the point with the maximum airborne release was found. Since the FRPS receipt tank is 501 cm high, each tank will leak about 60 L (30,280 L/501 cm) for every cm above the leak point. A series of spill heights between 68 cm to 569 cm were evaluated to determine the maximum airborne release using the equation above.

Table G6-1. Evaluation of Maximum Airborne Release as a Function of Spill Height for a Feed Receipt Processing System Receipt Tank.

Spill height (cm)	**Splash/splatter airborne release fraction**	**Material at risk per tank (spill volume in L)**	**Airborne release (L)**
569 (top of receipt tank)	1.3818 E-05	0	0.0000 E+00
520	1.1910 E-05	2962	3.5273 E-02
493 (overflow penetration height)	1.0907 E-05	4593	5.0102 E-02
400	7.7253 E-06	10214	7.8909 E-02
360	6.4926 E-06	12632	8.2014 E-02
358	6.4332 E-06	12753	8.2041 E-02
355	6.3445 E-06	12934	8.2060 E-02
353	6.2856 E-06	13055	8.2059 E-02
350	6.1977 E-06	13236	8.2035 E-02
340	5.9082 E-06	13841	8.1774 E-02
300	4.8058 E-06	16258	7.8135 E-02
250	3.5573 E-06	19280	6.8586 E-02
200	2.4616 E-06	22302	5.4899 E-02
147	1.4811 E-06	25506	3.7777 E-02
68 (bottom of the tank)	4.1510 E-07	30280	1.2570 E-02

The onsite radiological consequences for the splash/splatter can now be calculated using the maximum airborne release found above:

Onsite Radiological $Dose_{splash/splatter}$ =

$$(8.21 \times 10^{-2}\ L/tank)(5\ tanks)(0.8)(6.0 \times 10^{2}\ Sv/L)(3.28 \times 10^{-2}\ s/m^3)(3.33 \times 10^{-4}\ m^3/s)$$
$$= 2.2 \times 10^{-3}\ Sv$$
$$= 2.2 \times 10^{-1}\ rem$$

where:

8.21×10^{-2} L/tank	= maximum airborne splash/splatter release found above in Table G6-1
0.8	= respirable fraction for a viscosity of 7.9×10^{-2} poise (DOE-HDBK-3010-94)
6.0×10^{2} Sv/L	= ULD for the diluted receipt tank waste (calculated above, Section G5.1)
3.28×10^{-2} s/m^3	= onsite 1-hr atmospheric dispersion coefficient (χ/Q) from (RPP-13482, *Atmospheric Dispersion Coefficients and Radiological and Toxicological Exposure Methodology for Use in Tank Farms*)
3.33×10^{-4} m^3/s	= breathing rate for light activity (RPP-5924).

The toxicological consequences are based on a release over time. Since the release is assumed to take place within 60 sec:

$$\text{Release Rate} = (12{,}934\ L/tank)\ (5\ tanks) / (60\ s) = 1.08 \times 10^{3}\ L/s$$

The onsite toxicological consequences can now be calculated:

Onsite Moderate Toxicological $SOF_{splash/splatter}$ =

$$(1.08 \times 10^{3}\ L/s)(6.34 \times 10^{-6})(3.28 \times 10^{-2}\ s/m^3)(2.8 \times 10^{8})/(1{,}000\ L/m^3) = 6.3 \times 10^{+1}$$

where:

6.34×10^{-6}	= ARF for splash/splatter found above in Table G6-1
2.8×10^{8}	= Temporary Emergency Exposure Limit (TEEL)-2 unitless SOF for the diluted receipt tank waste (calculated above, Section G5.2)
1,000 L/m^3	= conversion factor.

Onsite High Toxicological $SOF_{splash/splatter}$ =

$$(1.08 \times 10^{3}\ L/s)(6.34 \times 10^{-6})(3.28 \times 10^{-2}\ s/m^3)(1.7 \times 10^{8})/(1{,}000\ L/m^3) = 3.8 \times 10^{+1}$$

where:

1.7×10^{8} = TEEL-3 unitless SOF for the diluted receipt tank waste (calculated above, Section G5.2).

The offsite toxicological consequences can be calculated similarly:

Offsite Moderate Toxicological $SOF_{splash/splatter}$ =

$$(1.08 \times 10^{3}\ L/s)(6.34 \times 10^{-6})(2.22 \times 10^{-5}\ s/m^{3})(8.55 \times 10^{8})/(1{,}000\ L/m^{3}) = 1.3 \times 10^{-1}$$

where:

2.22×10^{-5} s/m^3	= offsite 1-hr atmospheric dispersion coefficient (RPP-13482)
8.55×10^{8}	= TEEL-1 unitless SOF for the diluted receipt tank waste (calculated above, Section G5.2).

Entrainment of Aerosol

The entrainment of aerosol by air is based on an airborne release rate for a liquid pool exposed to small external wind speeds. An 8-hr exposure to entrainment and an 8-hr atmospheric dispersion coefficient are assumed for radiological consequences.

The onsite radiological consequences for the entrainment can be calculated from:

Onsite Radiological $Dose_{entrainment}$ =

$$(12{,}934\ L/tank)(5\ tanks)(4 \times 10^{-7}/hr)(8\ hr)(6.0 \times 10^{2}\ Sv/L)(5.58 \times 10^{-3}\ s/m^{3})(3.33 \times 10^{-4}\ m^{3}/s)$$
$$= 2.3 \times 10^{-4}\ Sv$$
$$= 2.3 \times 10^{-2}\ rem$$

where:

12,934 L	= spill volume found above in Table G6-1
4×10^{-7}/hr	= airborne release rate for entrainment (DOE-HDBK-3010-94, Section 3.2.4.5)
6.0×10^{2} Sv/L	= ULD for diluted receipt tank waste (calculated above, Section G5.1)
5.58×10^{-3} s/m^3	= onsite 8-hr atmospheric dispersion coefficient (RPP-13482).

Toxicological consequences can also be calculated:

Onsite Moderate Toxicological $SOF_{entrainment}$ =

$$(12{,}934\ L/tank)(5\ tanks)(4 \times 10^{-7}/hr)(3.28 \times 10^{-2}\ s/m^{3})(2.8 \times 10^{8})/(3{,}600\ s/hr)(1{,}000\ L/m^{3})$$
$$= 6.6 \times 10^{-2}$$

where:

2.8×10^{8}	= TEEL-2 unitless SOF for the diluted receipt tank waste (calculated above, Section G5.2)
3,600 s/hr	= conversion factor.

Onsite High Toxicological $SOF_{entrainment}$ =

$$(12{,}934\ L/tank)(5\ tanks)(4 \times 10^{-7}/hr)(3.28 \times 10^{-2}\ s/m^3)(1.7 \times 10^{8})/(3{,}600\ s/hr)(1{,}000\ L/m^3) = 4.0 \times 10^{-2}$$

where:

1.7×10^{8} = TEEL-3 unitless SOF for the diluted receipt tank waste (calculated above, Section G5.2).

Offsite Moderate Toxicological $SOF_{entrainment}$ =

$$(12{,}934\ L/tank)(5\ tanks)(4 \times 10^{-7}/hr)(2.22 \times 10^{-5}\ s/m^3)(8.55 \times 10^{8})/(3{,}600\ s/hr)(1{,}000\ L/m^3) = 1.4 \times 10^{-4}$$

where:

8.55×10^{8} = TEEL-1 unitless SOF for the diluted receipt tank waste (calculated above, Section G5.2).

Total Consequences

The total consequences for the simultaneous failure of 5 FRPS receipt tanks at the worst possible location during CH-TRUM operations are the sum of the contributions from splash/splatter and entrainment:

Onsite radiological consequences	$= 2.2 \times 10^{-1}$ rem + 2.3×10^{-2} rem	$= 2.4 \times 10^{-1}$ rem
Onsite moderate toxicological consequences	$= 6.3 \times 10^{+1} + 6.6 \times 10^{-2}$	$= 6.3 \times 10^{+1}$
Onsite high toxicological consequences	$= 3.8 \times 10^{+1} + 4.0 \times 10^{-2}$	$= 3.8 \times 10^{+1}$
Offsite moderate toxicological consequences	$= 1.3 \times 10^{-1} + 1.4 \times 10^{-4}$	$= 1.3 \times 10^{-1}$

As is evident from the above results, the toxicological consequences from splash/splatter are about three orders of magnitude greater than those from entrainment.

G6.2 Catastrophic Failure of One FRPS Receipt Tank

This scenario assumes that a failure of single FRPS receipt tank occurs resulting in rapid draining of the contents of the tank. This scenario is identical to the multiple tank scenario, except the radiological and toxicological consequences are a factor of five lower since a single tank is involved. Therefore, if only one FRPS receipt tank fails in a catastrophic manner in the worst possible location with rapid draining of the contents, the radiological and toxicological consequences can be determined from the above results by dividing by five.

Accordingly, the total consequences from the contributions from splash/splatter and entrainment are:

Onsite radiological consequences	$= 2.2 \times 10^{-1}$ rem / 5	$= 4.8 \times 10^{-2}$ rem

Onsite moderate toxicological consequences	$= 6.3 \times 10^{+1} / 5$	$= 1.3 \times 10^{+1}$
Onsite high toxicological consequences	$= 3.8 \times 10^{+1} / 5$	$= 7.6 \times 10^{+0}$
Offsite moderate toxicological consequences	$= 1.3 \times 10^{-1} / 5$	$= 2.6 \times 10^{-2}$

G6.3 Catastrophic Failure of One Waste Dryer

This scenario assumes that a failure of single dryer occurs resulting in rapid draining of the contents of the dryer vessel. This scenario is similar to the single FRPS receipt tank failure scenario. Each dryer is mounted on a superstructure directly over its dedicated waste packaging unit. The bottom of the dryer is at approximately 550 cm above grade level, and the top of the dryer is at approximately 710 cm above grade level.

The dryer vessel was assumed to be filled to capacity (10,200 L). The consequences were determined based on the worst case spill height with respect to ARF and volume of material released for the dryer. The assumed failure is a spill of the entire contents of one dryer vessel within a 60 sec period. The consequences consist of two components: (1) splash and splatter from the spill and (2) entrainment of aerosol by air movement over the pool of released waste.

Splash and Splatter

The ARF for splash/splatter can be calculated with the following equation from DOE-HDBK-3010-94, Section 3.2.3.1:

$$ARF = 8.9 \times 10^{-10} \times Arch^{0.55}$$

$$ARF = 8.9 \times 10^{-10} [(1.2 \times 10^{-3} \text{ g/cm}^3)^2 \times (\text{height})^3 \times (981 \text{ cm/s}^2)/(7.9 \times 10^{-2} \text{ poise})^2]^{0.55}$$

where:

Arch	= Archimedes Number $= (\text{density}_{air})^2 \times (\text{spill height})^3 \times (g) / (\text{solution viscosity})^2$
1.2×10^{-3} g/cm^3	= density of air (*CRC Handbook of Chemistry and Physics* [Weast 1981])
height	= spill height in cm.
981 cm/s^2	= g (acceleration due to gravity)
7.9×10^{-2} poise	= solution viscosity (the selected viscosity corresponds to a value from DOE-HDBK-3010-94, Table 3-9, to conservatively represent the viscosity of the waste).

As the spill height increases the ARF will increase; however, as the spill height increases the amount of material at risk will decrease. The potential spill heights for the tank could be anywhere across the height of the dryer from an event such as an earthquake. In order to conservatively calculate the consequences for the release, the point with the maximum airborne release was found. A series of spill heights between 550 cm (bottom of dryer) to 710 cm (top of dryer) were evaluated to determine the maximum airborne release using the equation above.

The waste dryer is a horizontal cylinder lying on its side. The volume above a breach is determined as a function of the height of the breach above the dryer bottom; that is, the cross-sectional area of the waste dryer that is above the breach is multiplied by the length, 5.1 m, of the waste dryer.

When the breach is above the middle of the tank, the formula for the cross-sectional area above it is the formula for a circular segment:

$$A = r^2 \cos^{-1}\left(\frac{r-x}{r}\right) - (r-x)\sqrt{2rx - x^2}$$

For: $x \leq r$

When the breach is below the midpoint of the tank, the formula for the waste above the breach is:

$$A = \pi r^2 - \left[r^2 \cos^{-1}\left(\frac{r-x'}{r}\right) - (r-x')\sqrt{2rx' - x'^2}\right]$$

And

$$x' = 2r - x$$

For: $x > r$

where:

r = the radius of the dryer cross section, 0.8 m

x = the vertical distance from the dryer top to the plane of the breach, m

x' = the vertical distance from the dryer bottom to the plane of the breach, m

Table G6-2 shows the results of calculating the ARF, spill volume, and airborne release for a series of assumed breach heights.

Table G6-2. Evaluation of Maximum Airborne Release as a Function of Spill Height for the Waste Dryer.

Spill height (cm)	Splash/splatter airborne release fraction	Material at risk per dryer (spill volume in L)	Airborne release (L)
710 (top of the dryer)	1.991 E-05	0	0.000E+00
700	1.945 E-05	265	5.163 E-03
690	1.899 E-05	736	1.398 E-02
680	1.854 E-05	1324	2.455 E-02
670	1.809 E-05	1994	3.608 E-02
660	1.765 E-05	2723	4.807 E-02
650	1.721 E-05	3494	6.013 E-02
640	1.678 E-05	4290	7.198 E-02
630	1.635 E-05	5100	8.337 E-02
620	1.592 E-05	5910	9.409 E-02
610	1.550 E-05	6706	1.039 E-01
600	1.508 E-05	7477	1.128 E-01
590	1.467 E-05	8206	1.204 E-01
580	1.426 E-05	8876	1.266 E-01
570	1.386 E-05	9464	1.312 E-01
560	1.346 E-05	9935	1.337 E-01
550 (bottom of the dryer)	1.307 E-05	10200	1.333 E-01

The onsite radiological consequences for the splash/splatter can now be calculated using the maximum airborne release found above:

Onsite Radiological Dose$_{splash/splatter}$ =

$$(1.34 \times 10^{-1}\ L)(0.8)(6.0 \times 10^{2}\ Sv/L)(3.28 \times 10^{-2}\ s/m^3)(3.33 \times 10^{-4}\ m^3/s)$$
$$= 7.0 \times 10^{-4}\ Sv$$
$$= 7.0 \times 10^{-2}\ rem$$

where:

1.34×10^{-1} L	= maximum airborne splash/splatter release found above in Table G6-2
0.8	= respirable fraction for a viscosity of 7.9×10^{-2} poise (DOE-HDBK-3010-94)
6.0×10^{2} Sv/L	= ULD for the diluted dryer waste (calculated above, Section G5.1)

3.28×10^{-2} s/m^3	= onsite 1-hr atmospheric dispersion coefficient (χ/Q) from (RPP-13482, *Atmospheric Dispersion Coefficients and Radiological/Toxicological Exposure Methodology for Use in Tank Farms*)
3.33×10^{-4} m^3/s	= breathing rate for light activity (RPP-5924).

The toxicological consequences are based on a release over time. Since the release is assumed to take place within 60 sec:

Release Rate = (9,935 L) / (60 s) = 1.66×10^2 L/s

The onsite toxicological consequences can now be calculated:

Onsite Moderate Toxicological $SOF_{splash/splatter}$ =

$$(1.66 \times 10^2 \text{ L/s})(1.35 \times 10^{-5})(3.28 \times 10^{-2} \text{ s/m}^3)(2.8 \times 10^8)/(1{,}000 \text{ L/m}^3) = 2.1 \times 10^{+1}$$

where:

1.35×10^{-5}	= ARF for splash/splatter found above in Table G6-2
2.8×10^8	= Temporary Emergency Exposure Limit (TEEL)-2 unitless SOF for the diluted dryer waste (calculated above, Section G5.2)
1,000 L/m^3	= conversion factor.

Onsite High Toxicological $SOF_{splash/splatter}$ =

$$(1.66 \times 10^2 \text{ L/s})(1.35 \times 10^{-5})(3.28 \times 10^{-2} \text{ s/m}^3)(1.7 \times 10^8)/(1{,}000 \text{ L/m}^3) = 1.3 \times 10^{+1}$$

where:

1.7×10^8 = TEEL-3 unitless SOF for the diluted dryer waste (calculated above, Section G5.2).

The offsite toxicological consequences can be calculated similarly:

Offsite Moderate Toxicological $SOF_{splash/splatter}$ =

$$(1.66 \times 10^2 \text{ L/s})(1.35 \times 10^{-5})(2.22 \times 10^{-5} \text{ s/m}^3)(8.55 \times 10^8)/(1{,}000 \text{ L/m}^3) = 4.3 \times 10^{-2}$$

where:

2.22×10^{-5} s/m^3	= offsite 1-hr atmospheric dispersion coefficient (RPP-13482)
8.55×10^8	= TEEL-1 unitless SOF for the diluted dryer waste (calculated above, Section G5.2).

Entrainment of Aerosol

The entrainment of aerosol by air is based on an airborne release rate for a liquid pool exposed to small external wind speeds. An eight hour exposure to entrainment and an 8-hr atmospheric dispersion coefficient are assumed for radiological consequences.

The onsite radiological consequences for the entrainment can be calculated from:

Onsite Radiological Dose$_{entrainment}$ =

$$(9{,}935\ L)(4 \times 10^{-7}/hr)(8\ hr)(6.0 \times 10^{2}\ Sv/L)(5.58 \times 10^{-3}\ s/m^{3})(3.33 \times 10^{-4}\ m^{3}/s)$$
$$= 3.5 \times 10^{-5}\ Sv$$
$$= 3.5 \times 10^{-3}\ rem$$

where:

9,935 L	= spill volume found above in Table G6-2
4×10^{-7}/hr	= airborne release rate for entrainment (DOE-HDBK-3010-94, Section 3.2.4.5)
6.0×10^{2} Sv/L	= ULD for diluted dryer waste (calculated above, Section G5.1)
5.58×10^{-3} s/m^3	= onsite 8-hr atmospheric dispersion coefficient (RPP-13482).

Toxicological consequences can also be calculated:

Onsite Moderate Toxicological SOF$_{entrainment}$ =

$$(9{,}935\ L)(4 \times 10^{-7}/hr)(3.28 \times 10^{-2}\ s/m^{3})(2.8 \times 10^{8})/(3{,}600\ s/hr)(1{,}000\ L/m^{3})$$
$$= 1.0 \times 10^{-2}$$

where:

2.8×10^{8}	= TEEL-2 unitless SOF for the diluted dryer waste (calculated above, Section G5.2)
3,600 s/hr	= conversion factor.

Onsite High Toxicological SOF$_{entrainment}$ =

$$(9{,}935\ L)(4 \times 10^{-7}/hr)(3.28 \times 10^{-2}\ s/m^{3})(1.7 \times 10^{8})/(3{,}600\ s/hr)(1{,}000\ L/m^{3})$$
$$= 6.2 \times 10^{-3}$$

where:

1.7×10^{8}	= TEEL-3 unitless SOF for the diluted dryer waste (calculated above, Section G5.2).

Offsite Moderate Toxicological SOF$_{entrainment}$ =

$$(9{,}935\ L)(4 \times 10^{-7}/hr)(2.22 \times 10^{-5}\ s/m^{3})(8.55 \times 10^{8})/(3{,}600\ s/hr)(1{,}000\ L/m^{3})$$
$$= 2.1 \times 10^{-5}$$

where:

8.55×10^8 = TEEL-1 unitless SOF for the diluted dryer waste (calculated above, Section G5.2).

Total Consequences

The total consequences for the catastrophic failure of one waste dryer at the worst possible location during CH-TRUM operations are the sum of the contributions from splash/splatter and entrainment:

Onsite radiological consequences	$= 7.0 \times 10^{-2}$ rem + 3.5×10^{-3} rem	$= 7.4 \times 10^{-2}$ rem
Onsite moderate toxicological consequences	$= 2.1 \times 10^{+1} + 1.0 \times 10^{-2}$	$= 2.1 \times 10^{+1}$
Onsite high toxicological consequences	$= 1.3 \times 10^{+1} + 6.2 \times 10^{-3}$	$= 1.3 \times 10^{+1}$
Offsite moderate toxicological consequences	$= 4.3 \times 10^{-2} + 2.1 \times 10^{-5}$	$= 4.3 \times 10^{-2}$

As is evident from the above results, the toxicological consequences from splash/splatter are about three orders of magnitude greater than those from entrainment. In addition, although the FRPS receipt tank contains more MAR than the dryer (30,280 L versus 10,200 L), the splash/splatter ARF and the quantity of airborne release are greater than the corresponding values for the FRPS tank because of the higher elevation of the dryer. Therefore, the consequences for the single dryer scenario are greater than those obtained for the single FRPS receipt tank scenario.

G6.4 Single Tank Failure through a Broken Overflow Penetration

The assumed failure is a spill of the entire contents of a single large FRPS receipt tank through a broken 2-in. overflow penetration, which is assumed to be at a height of 493 cm above grade level (based on Drawing 20843.M002). The consequences consist of two components: (1) splash and splatter from the spill and (2) entrainment of aerosol by air movement over the pool of released waste. The overflow line was selected to maximize the splash/splatter component.

Splash and Splatter

The ARF for splash/splatter can be calculated with the following equation from DOE-HDBK-3010-94:

$$ARF = 8.9 \times 10^{-10} \times Arch^{0.55}$$
$$ARF = 8.9 \times 10^{-10} [(1.2 \times 10^{-3} \text{ g/cm}^3)^2 \times (493 \text{ cm})^3 \times (981 \text{ cm/s}^2)/(7.9 \times 10^{-2} \text{ poise})^2]^{0.55}$$
$$ARF = 1.09 \times 10^{-5}$$

where:

Arch = Archimedes Number
= $(\text{density}_{air})^2 \times (\text{spill height})^3 \times (g) / (\text{solution viscosity})^2$

1.2×10^{-3} g/cm^3 = density of air (Weast 1981)

493 cm	= spill height.
981 cm/s^2	= g (acceleration due to gravity)
7.9×10^{-2} poise	= solution viscosity (the selected viscosity corresponds to a value from DOE-HDBK-3010-94, Table 3-9, to conservatively represent the viscosity of the waste).

The onsite radiological consequences for the splash/splatter can now be calculated using the ARF found above:

Onsite Radiological $Dose_{splash/splatter}$ =

$$(4{,}593\ L)(1.09 \times 10^{-5})(0.8)(6.0 \times 10^{2}\ Sv/L)(3.28 \times 10^{-2}\ s/m^{3})(3.33 \times 10^{-4}\ m^{3}/s)$$
$$= 2.6 \times 10^{-4}\ Sv$$
$$= 2.6 \times 10^{-2}\ rem$$

where:

4,593 L	= spill volume at a spill height of 493 cm found above in Table G6-2
1.09×10^{-5}	= ARF for splash/splatter at a spill height of 493 cm found above in Table G6-2
0.8	= respirable fraction for a viscosity of 7.9×10^{-2} poise (DOE-HDBK-3010-94)
6.0×10^{2} Sv/L	= ULD for diluted receipt tank waste (calculated above, Section G5.1)
$3.28 \times 10^{-2}\ s/m^3$	= onsite 1-hr atmospheric dispersion coefficient (χ/Q) from (RPP-13482)
$3.33 \times 10^{-4}\ m^3/s$	= breathing rate (RPP-5924).

The toxicological consequences are based on a release over time. The flow rate out of the penetration is a function of head which decreases as the spill height increases. The flow rate can be found using $h_L = K (v^2/2g)$ (Crane 1988, *Flow of Fluids Through Valves, Fittings, and Pipe*). The estimated flow rate is based on a sharp edged 2-in. pipe entrance and exit and conservatively assumes the fluid being released has the viscosity of pure water instead of the viscosity of SST waste solids.

A head of 76 cm (tank height of 569 cm – spill height of 493 cm) is used:

$$76\ cm = 1.5\ (v^2/[(2)(981\ cm/s^2)])$$
$$V = 315\ cm/s$$

where:

76 cm	= head
1.5	= a constant (K) for a sharp edged pipe entrance and exit (Crane 1988)
981 cm/s^2	= g (the acceleration due to gravity).

The velocity can be converted into a flow rate:

Velocity x cross-sectional area $= (315\ cm/s)[(\pi)(2.54\ cm)^2] = 6.38 \times 10^3\ cm^3/s$
$= 6.38\ L/s.$

where:

2.54 cm = radius of the 2-in. penetration.

The onsite toxicological consequences can now be calculated:

Onsite Moderate Toxicological $SOF_{splash/splatter} =$
$(6.38\ L/s)(1.09 \times 10^{-5})(3.28 \times 10^{-2}\ s/m^3)(2.8 \times 10^8)/(1{,}000\ L/m^3) = 6.4 \times 10^{-1}$

where:

2.8×10^8 = TEEL-2 unitless SOF for the diluted receipt tank waste (calculated above, Section G5.2)
$1{,}000\ L/m^3$ = conversion factor.

The offsite toxicological consequences can be calculated similarly:

Offsite Moderate Toxicological $SOF_{splash/splatter} =$
$(6.38\ L/s)(1.09 \times 10^{-5})(2.22 \times 10^{-5}\ s/m^3)(8.55 \times 10^8)/(1{,}000\ L/m^3) = 1.3 \times 10^{-3}$

where:

$2.22 \times 10^{-5}\ s/m^3$ = offsite 1-hr atmospheric dispersion coefficient (RPP-13482)
8.55×10^8 = TEEL-1 unitless SOF for the diluted receipt tank waste (calculated above, Section G5.2)

Entrainment of Aerosol

The entrainment of aerosol by air is based on an airborne release rate for a liquid pool exposed to small external wind speeds. An 8-hr exposure to entrainment and an 8-hr atmospheric dispersion coefficient are assumed for radiological consequences.

The onsite radiological consequences for the entrainment can be calculated from:

Onsite Radiological $Dose_{entrainment} =$
$(4{,}593\ L)(4 \times 10^{-7}/hr)(8\ hr)(6.0 \times 10^2\ Sv/L)(5.58 \times 10^{-3}\ s/m^3)(3.33 \times 10^{-4}\ m^3/s)$
$= 1.6 \times 10^{-5}\ Sv$
$= 1.6 \times 10^{-3}\ rem$

where:

4,593 L = spill volume at a spill height of 493 cm found above in Table G6-2
$4 \times 10^{-7}/hr$ = airborne release rate for entrainment (DOE-HDBK-3010-94, Section 3.2.4.5)

6.0×10^2 Sv/L = ULD for diluted receipt tank waste (calculated above, Section G5.1)
5.58×10^{-3} s/m^3 = onsite 8-hr atmospheric dispersion coefficient (RPP-13482).

Toxicological consequences can also be calculated:

Onsite Moderate Toxicological $SOF_{entrainment}$ =

$$(4{,}593 \text{ L})(4 \times 10^{-7}/\text{hr})(3.28 \times 10^{-2} \text{ s/m}^3)(2.8 \times 10^8)/(3{,}600 \text{ s/hr})(1{,}000 \text{ L/m}^3)$$

$$= 4.7 \times 10^{-3}$$

where:

2.8×10^8 = TEEL-2 unitless SOF for the diluted receipt tank waste (calculated above, Section G5.2)
3,600 s/hr = conversion factor.

Offsite Moderate Toxicological $SOF_{entrainment}$ =

$$(4{,}593 \text{ L})(4 \times 10^{-7}/\text{hr})(2.22 \times 10^{-5} \text{ s/m}^3)(8.55 \times 10^8)/(3{,}600 \text{ s/hr})(1{,}000 \text{ L/m}^3)$$

$$= 9.7 \times 10^{-6}$$

where:

8.55×10^8 = TEEL-1 unitless SOF for the diluted receipt tank waste (calculated above, Section G5.2)

Total Consequences

The total consequences for failure of a single FRPS receipt tank through a broken overflow line penetration during CH-TRUM operations are the sum of the contributions from splash/splatter and entrainment:

Onsite radiological consequences	$= 2.6 \times 10^{-2}$ rem + 1.6×10^{-3} rem	$= 2.8 \times 10^{-2}$ rem
Onsite moderate toxicological consequences	$= 6.4 \times 10^{-1} + 4.7 \times 10^{-3}$	$= 6.4 \times 10^{-1}$
Offsite moderate toxicological consequences	$= 1.3 \times 10^{-3} + 9.7 \times 10^{-6}$	$= 1.3 \times 10^{-3}$

G7.0 RESULTS

The radiological and toxicological consequence results for each of the aboveground tank failure scenarios described above are summarized in Tables G7-1 and G7-2 below. Additionally, the total consequences are compared to evaluation guidelines.

Table G7-1. Summary of Onsite Radiological Consequences Without Controls for the Aboveground Tank Failures During Contact-Handled Transuranic Mixed Waste Facility Operations.

Case	Onsite radiological consequences	
	Calculated dose (rem)	Moderate consequence guideline (rem)
Catastrophic failure of five FRPS receipt tanks due to seismic event with rapid draining of the contents	2.4×10^{-1}	$2.5 \times 10^{+1}$
Catastrophic failure of one FRPS receipt tank due to seismic event with rapid draining of the contents	4.8×10^{-2}	$2.5 \times 10^{+1}$
Catastrophic failure of one dryer due to seismic event with rapid draining of the contents	7.4×10^{-2}	$2.5 \times 10^{+1}$
Failure of a single FRPS receipt tank with drainage through a broken overflow penetration	2.8×10^{-2}	$2.5 \times 10^{+1}$

Notes:
FRPS = Feed Receipt Processing System.

Table G7-2. Summary of Toxicological Consequences Without Controls for the Aboveground Tank Failures During CH-TRUM Operations.

Case	Toxicological consequences					
	Onsite				Offsite	
	Moderate consequence		High Consequence		Moderate consequence	
	SOF	Guideline	SOF	Guideline	SOF	Guideline
Catastrophic failure of five FRPS receipt tanks due to seismic event with rapid draining of the contents	$6.3 \times 10^{+1}$	1	$3.8 \times 10^{+1}$	1	1.3×10^{-1}	1
Catastrophic failure of one FRPS receipt tank due to seismic event with rapid draining of the contents	$1.3 \times 10^{+1}$	1	7.6×10^{0}	1	2.6×10^{-2}	1
Catastrophic failure of one dryer due to seismic event with rapid draining of the contents	$2.1 \times 10^{+1}$	1	$1.3 \times 10^{+1}$	1	4.3×10^{-2}	1
Failure of a single FRPS receipt tank with drainage through a broken overflow penetration	6.4×10^{-1}	1	---	1	1.3×10^{-3}	1

Notes:

FRPS = Feed Receipt Processing System.

SOF = sum of fractions.

The results show that the radiological consequences to the onsite worker and toxicological consequences to the offsite public are "low" (< 25 rem and < TEEL-1, respectively) for either the single or multiple tank failure cases, and for the failure of one dryer. For the failure of a single FRPS receipt tank through a broken overflow penetration, the offsite toxicological and onsite radiological and toxicological consequences are low. The toxicological consequences to the onsite worker are "high" (≥ TEEL-3) for the aboveground tank failure accident involving simultaneous failure of all five FRPS receipt tanks, failure of one FRPS receipt tank, or failure of one dryer.

G8.0 REFERENCES

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APPENDIX H

HUMAN FACTORS EVALUATION AND PEER REVIEW CHECKLIST FOR THE CONTACT-HANDLED TRANSURANIC MIXED WASTE FACILITY

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APPENDIX H

HUMAN FACTORS EVALUATION AND PEER REVIEW CHECKLIST FOR THE CONTACT-HANDLED TRANSURANIC MIXED WASTE FACILITY

Human Factors Evaluation Checklist.

Hazard Analysis Title:	Contact-Handled Transuranic/Mixed Waste Facility Accidents
Documented Safety Analysis Section Number:	RPP-23479, *Preliminary Documented Safety Analysis for the Contact-Handled Transuranic Mixed (CH-TRUM) Waste Facility*, Section 3.3.2.4.8, "Aboveground Tank Failure"

Item No.	Issue	Yes, No, Unknown
1	Does the activity/event being planned/analyzed require human interaction to successfully complete the activity or mitigate consequences of the event? If the answer is No, go to Item No. 23. Otherwise continue with Item No. 2.	Yes
2	Are procedures/instructions available to the individuals responsible for the action?	*
3	Are procedures/instructions complete, accurate, and validated?	*
4	Are the individuals responsible for the action also responsible for collateral duties?	*
5	Are staffing levels adequate to perform the activity?	*
6	Are the individuals responsible for the action adequately trained, qualified, and experienced to perform the actions?	*
7	Have the required actions been walked down in the field to verify execution within the time constraints identified in the hazard analysis?	*
8	Have physical obstacles that could prevent successful completion of the activity been removed or accounted for?	*
9	Have work area environmental concerns been identified and accounted for?	*
10	Has PPE been dedicated and is available, if required?	*
11	Have the appropriate tools been dedicated and are available, if required?	*
12	Does workstation configuration facilitate completion of the actions?	*
13	Are instruments, valves, switches, or other devices accessible?	*
14	Are instruments, valves, switches, or other devices properly tagged or labeled?	*
15	Is communication equipment operable, dedicated, and available, if necessary?	*
16	Is adequate fixed lighting in place?	*
17	Is portable lighting dedicated, functional, and available, if necessary?	*
18	Are confined space restrictions adequately addressed?	*
19	Is temperature, humidity, radiological, and toxicological conditions acceptable for human occupancy?	*
20	Is hazard material or radiological monitoring equipment dedicated, functional, and available, if needed?	*
21	Are access controls identified and keys available?	*
22	Can activities be completed within the time prescribed in the hazard analysis?	*
	If any answer for Items 2 through 22 is No or Unknown, corrective actions may be required to ensure successful completion of the activity as described in the hazard analysis. Complete and document corrective actions on Documented Safety Analysis Implementation Checklist and go to Item No. 23.	
23	Evaluator: Andrew R. Marchese (Print) — [signature] (Signature) — 2-22-05 (Date) Peer Reviewer: Kevin R. Sandgren (Print) — [signature] (Signature) — 2/22/05 (Date)	

*No or Unknown. As of this date, the design and/or construction of the facility is not complete, procedures have not been written, and staffing has not been established. The questions presented in the checklist will be addressed as part of the DSA implementation process.

Effective Date: 2/12/2004

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: RPP-13175, *Technical Basis Document for the Aboveground Tank Failure Representative Accident and Associated Represented Hazardous Conditions*, Rev. 2

Scope of Review (e.g., document section or portion of calculation): Changes made for revision 2 of this document.

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

KRL

Effective Date: 2/12/2004

[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] [ ] [ ] 40. Impacted documents are appropriately identified in Blocks 7 and 25 of the Engineering Change Notice (form A-6003-563.1).

[X] [ ] [ ] 41. If more than one Technical Peer Reviewer was designated for this document, an overall review of the entire document was performed after resolution of all Technical Peer Review comments and confirmed that the document is self-consistent and complete.

[X] [ ] [ ] Concurrence

K. R. Sandgren K R Sandgren 3/7/05

Reviewer (Printed Name and Signature) Date

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

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