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CH2M HILL ENGINEERING CHANGE NOTICE

Page 1 of 3 ☒ DM ☐ FM ☐ TM

1a. **ECN** 722897 R 0

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 03/02/05

5. Originator's Name, Organization, MSIN, & Phone No.
L. J. Kripps, R/C NS&L, S7-90, 376-1061

6. USQ Number No. - - - R - ☒ N/A

7. Related ECNs NA

8. Title Revise document to include hazards related to DBVS design

9. Bldg. / Facility No. NA

10. Equipment / Component ID NA

11. Approval Designator NA

12. Engineering Documents/Drawings to be Changed (Incl. Sheet & Rev. Nos.)
RPP-13510, Rev 3

13. Safety Designation ☐ SC ☐ SS ☐ GS ☒ N/A

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15a. Work Package Number NA

15b. Modification Work Completed NA
Responsible Engineer / Date

15c. Restored to Original Status (TM) NA
Responsible Engineer / Date

16. Fabrication Support ECN? ☐ Yes ☒ No

17. Description of the Change (Use ECN Continuation pages as needed)
RPP-13510, "Flammable Gas Technical Basis Document," has been revised to include evaluation of potential flammable gas hazards associated with the Demonstration Bulk Vitrification System design.

18. Justification of the Change (Use ECN Continuation pages as needed)
RPP-13510 is a technical basis document for the tank farms safety basis and must be maintained as part of the configuration management process.

A USQ evaluation is not needed because the proposed changes to RPP-13510 are in support of a safety basis amendment being submitted to ORP. Implementation will not occur until ORP has issued a SER authorizing the safety basis changes.

19. ECN Category
☒ Direct Revision
☐ Supplemental
☐ Void/Cancel

ECN Type
☐ Supercedure
☒ Revision

20. Distribution

Name	MSIN	Name	MSIN
J. M. Grigsby	S7-90	Central Files (original + 1)	B1-07
E. C. Heubach II	S7-90		
L. J. Kripps	S7-90	DBVS File	T4-67
D. H. Irby	H6-60		
M. Moreno	H6-60		
J. Shuen	H6-60		

Release Stamp

DATE: STA: 4 HANFORD RELEASE ID: 2
MAR 0 3 2005

A-6003-563.1 (09/04)

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1a. ECN 722897 R 0

1b. Proj. ECN - - R

21. Revisions Planned (Include a brief description of the contents of each revision)
NA

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)
NA

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

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	NA		
Operations Procedure	NA		
Maintenance Procedure	NA		

Type of Document	Document Number	Type of Document	Document Number
See page 3 of this ECN			

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	LJ Kripps [signature]	3/3/05	Professional Engineer		
Resp. Manager	JM Grigsby [signature]	3/3/05	Project Engineer		
Quality Assurance			Quality Assurance		
IS&H Engineer			Safety		
NS&L Engineer	LJ Kripps [signature]	3/3/05	Designer		
Environ. Engineer			Environ. Engineer		
Engineering Checker	EC Heubach [signature]	03/03/05	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					

A-6003-563.1 (09/04)

CH2M HILL ENGINEERING CHANGE NOTICE CONTINUATION SHEET	1a. ECN 722897 **R** 0
Page 3 of 3	1b. **Proj. ECN** - - R

Document/Drawing No. N/A   Sheet N/A   Revision N/A

RPP-13510, Rev. 4 supports CH2M submittal and ORP approval of the Preliminary Documented Safety Analysis (PDSA) for Demonstration Bulk Vitrification System (DBVS), and subsequently for DSA amendment submittals and ORP approval for 241-S-109 Partial Retrieval System (PWRS), Phase 1 and DBVS operation. Following ORP approval of these documents, the CH2M Safety Basis Implementation process (TFC-OPS-OPER-C-02) will identify and revise impacted documents as required.

RPP-13510, Rev. 4

Flammable Gas Technical Basis Document

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

EDT/ECN: 722897-R0 UC: N/A
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Key Words: Accident, consequence, frequency, double-shell tank (DST), flammable gas, risk bin, single-shell tank (SST), technical basis document

Abstract: This document describes the qualitative evaluation of frequency and consequences for DST and SST representative flammable gas accidents and associated hazardous conditions without controls. The evaluation indicated that safety-significant SSCs and/ or TSRs were required to prevent or mitigate flammable gas accidents. Discussion on the resulting control decisions is included.

3/3/05
Release Approval Date

DATE: HANFORD
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MAR 03 2005
Release Stamp

Approved For Public Release

A-6002-767 (03/01)

Tank Farm Contractor (TFC) RECORD OF REVISION	(1) Document Number RPP-13510	Page 1

(2) Title
Flammable Gas Technical Basis Document

Change Control Record

(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release	
		(5) Resp. Engr. (print/sign/date)	(6) Resp. Mgr. (print/sign/date)
0	Original Issue per EDT #636625	CA Carro	JM Grigsby 03/21/03
1	Complete revision of document via unnumbered ECN-10 form	CA Carro	RJ Stevens 07/30/03
2	Revision 2 reflects changes to key references that potentially affect calculations.	LJ Kripps	RJ Stevens 10/09/03
3	ECN #722868 R0. Complete revision of document.	LJ Kripps 02/17/05	JM Grigsby 02/17/05
4 RS	ECN #722897 R0. Incorporate changes to analysis for DBVS design.	LJ Kripps 3/3/05	JM Grigsby 3/3/05

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LIST OF TERMS

A	anticipated
AA	analysis assumptions
AC	administrative control
AICC	adiabatic ischoric complete combustion
AMS	articulating mast system
BDGRE	buoyancy displacement gas release event
BEU	beyond extremely unlikely
CAM	continuous air monitor
DBVS	Demonstration Bulk Vitrification System
DCRT	double-contained receiver tank
DDT	deflagration-to-detonation transition
DSA	documented safety analysis (RPP-13033, *Tank Farms Documented Safety Analysis*)
DST	double-shell tank
ERPG	emergency response planning guideline
EU	extremely unlikely
GRE	gas release event
HEPA	high-efficiency particulate air (filter)
IMUST	inactive miscellaneous underground storage tank
ISO	International Organization for Standardization
L	low
LFL	lower flammability limit
LCO	limiting condition for operation
M	moderate
MAR	material at risk
N/A	not applicable
ORP	Office of River Protection
RMCS	rotary mode core sampling
RCSTS	Replacement Cross-Site Transfer System
SACS	Surveillance Analysis Computer System
SMP	safety management program
SOF	sum of fractions
SSC	structures, systems, and components
SST	single-shell tank
TEEL	Temporary Emergency Exposure Limit
TFC	Tank Farm Contractor
TOC	total organic carbon
TSR	technical safety requirement
TWG	Technical Working Group
U	unlikely
ULD	unit-liter dose
USQ	unreviewed safety question

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 for the flammable gas representative accidents 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 condition based on an evaluation of the event 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 SSC 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 Accidents

There are two flammable gas representative accidents: (1) a deflagration in the headspace of a double-shell tank (DST) due to a steady-state accumulation of flammable gas or a spontaneous gas release event (GRE) (Candidate Accident 04), and (2) a deflagration in the headspace of a single-shell tank (SST) due to the steady-state accumulation of flammable gas (Candidate Accident 05). For each accident, is it assumed that the flammable gas concentration exceeds the lower flammability limit (LFL) of approximately 4% hydrogen and that an ignition source is present. The resulting deflagration pressurizes the tank resulting in structural damage and an uncontrolled, airborne release of tank waste.

1.2.2 Bounding Offsite Accident

A limited subset of tank farm accidents were selected for quantitative analysis and comparison to the 25 rem radiological evaluation guideline set forth in DOE-STD-3009-94, Appendix A, "Evaluation Guideline." The accidents were selected as a function of their associated release attributes. Release attributes include the energy of the release, the location of the release, and the physical form of the material being released. Relative to these release attributes, flammable gas accidents are high energy - atmospheric release - vapor/gas/aerosol events. A detonation (versus a deflagration) in an SST has been selected as the bounding event for this release attribute combination. RPP-13470, *Offsite Radiological Consequence Analysis for the Bounding Flammable Gas Accident*, quantifies the consequences of a detonation in an SST. The offsite radiological consequence, calculated using reasonably conservative input parameters, does not challenge the 25 rem Evaluation Guideline. Therefore, safety-class equipment is not required.

DOE-STD-3009-94 does not provide evaluation guidelines for offsite toxicological or onsite radiological and toxicological consequences. These consequences were evaluated for the flammable gas representative accidents and associated hazardous conditions in accordance with the risk binning process described in Section 1.3.

1.2.3 Associated Hazardous Conditions

There are numerous other hazardous conditions associated with the DST flammable gas representative accident. In general, these hazardous conditions address various DST deflagration scenarios (e.g., different flammable gas sources, different ignition sources). Hazardous conditions uniquely different from the representative accident include:

- DST headspace deflagration due to an induced GRE
- DST headspace detonation
- Deflagration in a DST annulus
- DST subsurface deflagration
- Deflagration in DST waste-intruding equipment
- Deflagration in a DST riser
- DST gasoline fuel deflagration
- Deflagration in a flexible receiver bag
- Ignition of a pocket of flammable gas
- Deflagration in a waste transfer line.

There are numerous other hazardous conditions associated with the SST flammable gas representative accident. As was the case with DSTs, these hazardous conditions, in general, address various SST deflagration scenarios. Hazardous conditions uniquely different from the representative accident include:

- SST headspace deflagration due to an induced GRE
- SST headspace detonation due to steady-state accumulation of flammable gas or a GRE
- SST headspace deflagration in one SST that propagates to a second SST
- Deflagration in an SST riser
- Ignition of a pocket of flammable gas
- Deflagration in an SST during rotary mode core sampling (RMCS)
- Deflagration in a double-contained receiver tank (DCRT)
- Deflagration in an active catch tank
- Deflagration in an inactive tank

- Deflagration in a Replacement Cross-Site Transfer System (RCSTS) diversion box or vent station
- SST gasoline fuel deflagration
- SST retrieval/closure aboveground tanks.

1.3 RISK BINNING METHODOLOGY

Direction on risk binning was provided by the U.S. Department of Energy, Office of River Protection (ORP) (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. Initial DSA development was largely completed before Klein and Schepens (2003) was issued and more conservative control selection guidelines were used. During the initial DSA development, safety SSCs or TSRs were required for accidents or hazardous conditions that were assigned to risk bins I or II, and were considered for accidents or hazardous conditions that were assigned to Risk Bin III. For accidents or hazardous conditions assigned to Risk Bin IV, safety SSCs and TSRs were not expected. SMPs were acceptable for addressing the residual risk posed by Risk Bin IV conditions.

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

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

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

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2.0 RISK BINNING RESULTS WITHOUT CONTROLS

During the initial DSA development, risk binning team meetings were conducted on July 8 and 9, 2002, to obtain consensus on the assignment of frequencies, consequences, and risk bins. The attendees represented a wide range of expertise in the areas of engineering, licensing, and operations, and included representatives from the U.S. Department of Energy, Office of River Protection. Appendix A lists the attendees and the organization each attendee represents. After the meetings, the risk binning results were distributed to the Technical Working Group (TWG) for review and concurrence. Subsequent risk binning meetings have been conducted to support amendments to the DSA (see Appendix D). The risk binning results are summarized in Tables 2-1 and 2-2.

Table 2-1. Summary of Double-Shell Tank Flammable Gas Risk Binning Results Without Controls.

Postulated accident	Frequency	Consequences			Risk bin		
		Onsite radiological	Offsite toxicological	Onsite toxicological	Onsite radiological	Offsite toxicological	Onsite toxicological
Representative Accident 04: Headspace deflagration due to steady-state accumulation of flammable gas or a spontaneous GRE	U	L	L	M	III	III	II
Headspace deflagration due to an induced GRE	A	L	L	M	III	III	I
Headspace detonation	EU	L	L	M	IV	IV	III
Annulus deflagration	U	L	L	M	III	III	II
Subsurface deflagration	BEU	L	L	L	IV	IV	IV
Deflagration in waste-intruding equipment	A	L	L	L	III	III	III
Deflagration in a riser	U	L	L	L	III	III	III
Gasoline fuel deflagration	U	L	L	M	III	III	II
Deflagration in flexible receiver bag	EU	L	L	L	IV	IV	IV
Ignition of a pocket of flammable gas	EU	L	L	L	IV	IV	IV
Deflagration in a waste transfer line	U	L	L	L	III	III	III

Notes:

A = anticipated.
BEU = beyond extremely unlikely.
EU = extremely unlikely.
GRE = gas release event.
L = low.
M = moderate.
U = unlikely.

Table 2-2. Summary of Single-Shell Tank Flammable Gas Risk Binning Results Without Controls.

Postulated accident	Frequency	Consequences			Risk bin		
		Onsite radiological	Offsite toxicological	Onsite toxicological	Onsite radiological	Offsite toxicological	Onsite toxicological
Representative Accident 05: Headspace deflagration due to steady-state accumulation of flammable gas	U	M	L	M	II	III	II
Headspace deflagration due to an induced GRE	A	M	L	M	I	III	I
Headspace detonation	BEU	M	L	M	IV	IV	IV
Headspace deflagration in one SST that propagates to a second SST	EU	M	L	M	III	IV	III
Deflagration in a riser	BEU	L	L	L	IV	IV	IV
Ignition of a pocket of flammable gas	EU	L	L	L	IV	IV	IV
Deflagration during rotary mode core sampling	U	M	L	M	II	III	II
Deflagration in a double-contained receiver tank	U	M	L	M	II	III	II
Deflagration in an active catch tank	U	M	L	M	II	III	II
Deflagration in an inactive tank	A*	M	L	M	I*	III	I*
Deflagration in a diversion box/vent station	U	M	L	M	II	III	II
Gasoline fuel deflagration	U	M	L	M	II	III	II
Deflagration in SST retrieval/closure aboveground tanks**	A	M	L	M	I	III	I

Notes:

*The frequency and risk bin are dependent on the inactive tank. Anticipated is the highest frequency and the highest risk bin is I without controls.

** The frequency, consequences, and risk bin are dependent on the SST retrieval/closure aboveground tank. The highest risk bin is I for the SST vacuum retrieval system slurry tank and water separator with an anticipated frequency and moderate consequences.

A = anticipated.
BEU = beyond extremely unlikely.
EU = extremely unlikely.
GRE = gas release event.
L = low.
M = moderate.
SST = single-shell tank.
U = unlikely.

2.1 DOUBLE-SHELL TANKS

2.1.1 Representative Accident

The representative accident for DSTs is a headspace deflagration due to a steady-state accumulation of flammable gas or a spontaneous GRE.

2.1.1.1 Scenario

A deflagration in the headspace of a DST can occur if the flammable gas concentration is greater than or equal to the LFL and an ignition source is present. Elevated flammable gas concentrations can result from either the steady-state generation and accumulation of flammable gas or a spontaneous GRE (induced GREs are addressed as a represented hazardous condition in Section 2.1.2.1). RPP-5926, *Steady-State Flammable Gas Release Rate Calculation and Lower Flammability Level Evaluation for Hanford Tank Waste*, calculates the steady-state flammable gas concentration in DSTs. As shown in RPP-5926, under barometric breathing conditions, in which the only movement of air into or out of the tank is due to variations in atmospheric pressure, flammable gas concentrations in excess of the LFL can be reached in some DSTs for existing tank conditions. RPP-5926 also evaluates flammable gas concentrations under a hypothetical zero ventilation condition. Under such a condition, the time to reach the LFL is decreased.

A spontaneous GRE can also result in flammable gas concentrations in excess of the LFL. As documented in RPP-10006, *Methodology and Calculations for the Assignment of Waste Groups for the Large Underground Waste Storage Tanks at the Hanford Site*, there are (for existing tank conditions) DSTs that contain sufficient retained gas that, if all of it were released in a spontaneous GRE, the headspace concentration would exceed 100% of the LFL.

Given a flammable gas concentration in excess of the LFL, a deflagration can occur if an ignition source is present. Studies of the requirements for ignition of hydrogen have defined the minimum ignition energy (i.e., the energy below which the ignition of a combustible mixture cannot occur and above which ignition occurs). As discussed in PNNL-13269, *Overview of the Flammability of Gases Generated in Hanford Waste Tanks*, the minimum ignition energy for hydrogen is on the order of 0.01 mJ. Experiments were conducted at the California Institute of Technology to evaluate the effect of various ignition energies on the LFL of three gas mixtures with compositions relevant to Hanford tank waste gases containing hydrogen, ammonia, nitrous oxide, methane, and nitrogen. The research found that none of the three mixtures showed any pronounced dependence on the LFL for ignition energies between 0.04 and 8 J.

Potential ignition sources for deflagrations in the headspace of DSTs include installed equipment, activities conducted within a DST or its associated process pits, and natural phenomena (i.e., lightning, earthquake). An ignition source is assumed to be present and ignite the flammable gas in the tank headspace resulting in a deflagration.

For a deflagration where the gas concentration in the entire tank headspace is above the LFL, the resultant pressure will be nearly uniform and bounded by the adiabatic isochoric (constant volume) complete combustion (AICC) pressure. Under lean combustion conditions, developed pressures will be less than the AICC pressure because of incomplete combustion. Combustion pressures are well below AICC until fuel concentrations are well above the LFL. AICC pressures are approached when the mixtures are above the limit for downward propagation (i.e., 8% hydrogen). Once concentrations exceed the lower limit for downward propagation, combustion pressures exceed about 59 lb/in^2 gauge.

A panel of experts was convened to evaluate the structural response of DSTs to pressurization loads. As documented in WHC-SD-TWR-RPT-003, *DELPHI Expert Panel Evaluation of Hanford High Level Waste Tank Failure Modes and Release Quantities*, at internal pressures in the range of 55 to 60 lb/in^2 gauge, the steel liner of the primary tank will fail along a transition weld located at a 6-ft radius from the dome center. The energy of the high-pressure air at failure is such that it is postulated that part of the concrete and soil overburden above the center 6-ft radius of the primary tank will blow out. At pressures below 55 to 60 lb/in^2 gauge, the steel liner of the primary tank would not fail, and the pressure would be vented via the primary tank ventilation system and through process pits via connecting risers or drain lines.

2.1.1.2 Frequency Determination

The frequency of a headspace deflagration in a DST due to a steady-state accumulation of flammable gas or a spontaneous GRE was qualitatively determined by the risk binning team to be "unlikely." In making this determination, consideration was given to: (1) the likelihood of reaching the LFL and having an ignition source, (2) the 35-yr operating history of the DST tank farms during which time no deflagrations are known to have occurred, and (3) flammable gas monitoring data.

Calculations in RPP-5926 and RPP-10006 demonstrate that, in the absence of controls, reaching the LFL in the headspace of a DST is a credible event. The risk binning team discussed the bases and assumptions for these calculations and judged them to be conservative. Relative to RPP-5926, the team judged it was conservative to assume barometric breathing. This judgment was based on the fact that it is often difficult to maintain tank vacuum because of the numerous flow paths that exist. Relative to RPP-10006, the team judged it was conservative to assume that 100% of the retained gas would be released in a spontaneous GRE.

In the case of steady-state generation and accumulation, if the flammable gas concentration reaches the LFL, it will remain there indefinitely. In the case of a spontaneous GRE, the flammable gas concentration will remain above the LFL for a period of time dictated by the tank ventilation rate. In both cases, an ignition source is assumed to be present. The risk binning team discussed the validity of this assumption with some stating the opinion that it is overly conservative to assume an ignition source. It was discussed that this was a standard industry assumption supported by the fact that in a relatively large percentage of flammable gas deflagrations that have occurred in industry, no specific ignition source could be identified.

The appropriateness of considering operational history when evaluating the frequency of a scenario "without controls" was discussed. It was recognized by the risk binning team that during the 50-yr history of the tank farms, controls of some type (e.g., active or passive ventilation) were normally in place. Despite this fact, it was the team's judgment that the operational history suggested that a flammable gas deflagration was not an anticipated event.

Monitoring of DST headspaces has shown that flammable gas concentrations due to steady-state generation and accumulation are typically well below 25% of the LFL. As was the case with the operational history, it was recognized by the risk binning team that this data reflects some level of control. Relative to spontaneous GREs, with the exception of DST 241-SY-101 that has since been remediated, spontaneous GREs in DSTs have not resulted in flammable gas concentrations that exceed the LFL. The maximum observed spontaneous GRE occurred in DST 241-AN-105 in 1995 and resulted in a concentration of 47% of the LFL (RPP-7771, *Flammable Gas Safety Issue Resolution*).

2.1.1.3 Consequence Determination

To support the qualitative assessment of consequences, a series of calculations was performed. The calculations, documented in Appendix B, were performed consistent with the methodologies documented in RPP-13482, *Atmospheric Dispersion Coefficients and Radiological and Toxicological Exposure Methodology for Use in Tank Farms.* Table 2-3 identifies the analytical assumptions and input parameters used in the Appendix B calculations, evaluates the sensitivity of the results to the assumption/input parameter, and determines the need to protect the assumption/input parameter.

Table 2-3. Sensitivity of the Representative Double-Shell Tank Accident Analysis to Assumptions and Input Parameters. (4 sheets)

Analysis assumption (AA)/input parameter and basis	***Assumption type***	***Sensitivity***	**Need to protect AA**	**Protection basis**
Deflagration results in dome failure. Based on structural evaluation documented in WHC-SD-TWR-RPT-003.	Reasonably conservative	This is the bounding failure mode defined by the DELPHI panel. A complete dome collapse versus *dome failure could conceivably result in a larger* respirable release. However, complete dome collapse is not expected based on existing stress analyses.	No	N/A
Material released is supernatant.	Best estimate	The type of material released is an important assumption as it defines both the ULD and the SOFs. The waste surface layer in the majority of DSTs is comprised of supernatant. Five DSTs have a floating crust that covers or partially covers the waste surface (DSTs 241-AN-103, -AN-104, -AN-105, 241-AW-101, and 241-SY-103). The sensitivity of the analysis to the supernatant assumption on the ULD and SOF parameters are subsequently addressed in this table.	No	N/A
0.7 L (1 kg) of respirable supernatant is released. Based on expert elicitation documented in HNF-2577. Note that Appendix B calculates consequences for a range of releases from 0.39 L to 4.3 L, all of which were taken into consideration when assigning the consequence level. However, the risk binning team judged that the expert *elicitation process provided a robust* approach to estimating the release.	Best estimate	The consequences are directly proportional to the respirable release. The 0.7 L value represents the aggregate best estimate of a 9-member panel of experts. Holding all other input parameters constant, the release would have to increase from 0.7 L to 195 L (270 kg) in order to challenge the 25 rem "moderate" onsite radiological consequence guideline. In order to challenge the "high" onsite toxicological guideline, the release would have to double from 0.7 L to 1.4 L (2 kg). In order to challenge the "moderate" offsite toxicological guideline (i.e., a TEEL-1 SOF >1), the release would have to increase by a factor of 10 from 0.7 L to 7 L (10 kg).	No	N/A
The release duration is 60 sec. Deflagrations occur very rapidly (i.e., in less than 1 sec). RPP-13482 states that for release durations less than 1 min, the release can be characterized as a continuous release with a rate (mg/s) given by the total release (in mg) divided by 60 sec.	Best estimate	RPP-13482 standard methodology. RPP-13482 states that both the continuous release and puff release models are conservative.	No	N/A

Table 2-3. Sensitivity of the Representative Double-Shell Tank Accident Analysis to Assumptions and Input Parameters. (4 sheets)

Analysis assumption (AA)/input parameter and basis	Assumption type	Sensitivity	Need to protect AA	Protection basis
The density of the supernatant is 1.4 g/ml, based on reported density of the supernatant with the highest applicable ULD (i.e., DST 241-AN-107). Density taken from RPP-5926, Table A-1.	Best estimate	The 0.7 L value is derived by dividing the mass released (i.e., 1 kg) by the density of the supernatant. A density of 1.4 g/ml was selected, as this is the density of the supernatant with the highest ULD. The density of supernatant ranges from 1.1 to 1.5 g/ml. Applying the minimum density of 1.1 g/ml yields a release of 0.9 L versus 0.7 L (see previous table entry for the sensitivity of the respirable release parameter).	No	N/A
The ULD is 1.0 x 10^3Sv/L. This is the highest reported value for DST supernatant (for DST 241-AN-107), as documented in RPP-5924.	Bounding (bounding value reported in RPP-5924)	Based on a 0.7 L release, the onsite radiological consequence is 0.09 rem. The supernatant ULD for DST 241-AN-107 bounds the saltcake solids ULDs for the 5 DSTs with floating crusts with the exception of DST 241-SY-103. Assuming the floating crust is comprised of saltcake solids, the applicable ULD for DST 241-SY-103 would be 1.3 x 10^3 versus the applied supernatant ULD of 1.0 x 10^3. The analysis is not sensitive to this difference as the ULD would need to increase by more than an order of magnitude to challenge the 25 rem "moderate" onsite radiological consequence guideline.	No	N/A
Toxicological consequences are based on application of the following SOF values: TEEL-1, 2.75 E9 TEEL-2, 3.46 E8 TEEL-3, 1.27 E7 These are the highest reported values for DST liquids as documented in RPP-8369.	Bounding (bounding value reported in RPP-8369)	Based on a 0.7 L release, the onsite toxicological consequence is "moderate" (TEEL-2 SOF = 15, TEEL-3 SOF = 0.6) The liquid SOF values bound the solids SOF values for the 5 DSTs with a floating crust with the exception of the TEEL-3 values. Applying the bounding TEEL-3 value (i.e., 2.20 x 10^7) increases the consequence by a factor of approximately 1.7. However, the resultant SOF remains less than 1. The analysis is judged not to be sensitive to assumptions regarding the TEEL as the overall analysis is judged to be conservative. The TEEL values are conservatively derived and are based on a 1 hr exposure period which exceeds the duration of the plume passage for the onsite worker. In addition, the X/Q value is conservative.	Yes	Protected by Administrative Control TSR "Source Term Controls."

Table 2-3. Sensitivity of the Representative Double-Shell Tank Accident Analysis to Assumptions and Input Parameters. (4 sheets)

Analysis assumption (AA)/input parameter and basis	Assumption type	Sensitivity	Need to protect AA	Protection basis
For onsite consequence analyses, the integrated atmospheric dispersion coefficient used for the 0.7 L release dome failure scenario is 3.73 10^{-3} s/m^3, as documented in RPP-13482. This value was derived to account for a pressurized release.	Reasonably conservative	This atmospheric dispersion coefficient is based on 95% meteorology, which is recommended for conservative analysis.	No	N/A
For the offsite toxicological consequence analysis, the integrated atmospheric dispersion coefficient is 5.06×10^{-8} 1/m^3 as documented in RPP-13482. This value represents the 95% χ/Q for a ground-level, point source, puff release.	Reasonably conservative	This atmospheric dispersion coefficient is based on 95% meteorology, which is recommended for conservative analysis. (Note: The smaller χ/Q values for a volume release were not used because they are essentially the same as the ground-level point source puff release.)	No	N/A
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 (documented in RPP-5924).	Reasonably conservative	This is a standard analysis assumption.	No	N/A

Table 2-3. Sensitivity of the Representative Double-Shell Tank Accident Analysis to Assumptions and Input Parameters. (4 sheets)

Analysis assumption (AA)/input parameter and basis	Assumption type	Sensitivity	Need to protect AA	Protection basis

Notes:

HNF-2577, 1998, *Flammable Gas Project Expert Elicitation Results for Hanford Site Double-Shell Tanks*, Duke Engineering and Services Hanford, Inc., Richland, Washington.

RPP-5924, 2003, *Radiological Source Terms for Tank Farms Safety Analysis*, Rev. 4, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-5926, 2005, *Steady-State Flammable Gas Release Rate Calculation and Lower Flammability Level Evaluation for Hanford Tank Waste*, 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. 4, CH2M HILL Hanford Group, Inc., Richland, Washington.

WHC-SD-TWR-RPT-003, 1996, *DELPHI Expert Panel Evaluation of Hanford High Level Waste Tank Failure Modes and Release Quantities*, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

AA = analysis assumption.
DST = double-shell tank.
N/A = not applicable.
SOF = sum of fractions.
TEEL = Temporary Emergency Exposure Limit.
TSR = technical safety requirement.
ULD = unit-liter dose.

The radiological and toxicological consequences are a function of the quantity of tank waste suspended by a deflagration, which in turn is a function of the tank failure mode. Table 2-4 summarizes the estimated quantities of respirable material released assuming no tank damage, dome failure, and dome collapse. The bases for the values shown in Table 2-4 are provided in Appendix B.

Table 2-4. Respirable Releases as Function of Double-Shell Tank Failure Scenario.

DST failure scenario	Respirable release (L) DST supernatant
No tank damage-1	0.39
No tank damage-2	0.3
Dome failure – 1	0.7
Dome failure – 2	0.7
Dome collapse	4.3

Notes:
DST = double-shell tank.

Table 2-5 presents the onsite radiological consequences calculated in Appendix B for the respirable releases shown in Table 2-4. Two calculations were performed applying two different modeling approaches. In the first calculation, the respirable release from the tank is modeled as a ground level, point source release. This is analogous to assuming the release occurs from a single riser, at ground level, at ambient temperature, and with no momentum. The resultant onsite atmospheric dispersion coefficient is 3.28×10^{-2} s/m^3 (RPP-13482). Given a deflagration, however, the tank will pressurize and the respirable material will be ejected as the tank depressurizes. If the pressure is sufficiently low that the tank does not fail, the release will occur via multiple pathways (i.e., from numerous risers and drains into associated process pits and via ventilation system inlets and outlets). If the pressure is high enough to fail the tank, the release will occur primarily at the point of failure. In either case, the result is a pressurized release. To account for a pressurized release, it is assumed that the respirable material is dispersed into a cloud above the tank. The cloud is assumed to be a right cylinder with a diameter equal to the diameter of the tank (i.e., 75 ft). The height of the cloud is varied as a function of the tank pressure (i.e., the volume of the cylinder is equal to the volume of gas that must be released from the tank for the post-combustion headspace pressure to fall back to the original level). This volume source term is then dispersed downwind. The resultant onsite atmospheric dispersion coefficients range from 7.35×10^{-3} s/m^3 at a tank pressure of 15 lb/in^2 gauge to 2.97×10^{-3} s/m^3 at a tank pressure of 60 lb/in^2 gauge (RPP-13482). The calculations in Appendix B assume that the material released is DST supernatant. Supernatant unit-liter doses (ULD) range in value from 20 Sv/L to 1.0×10^3 Sv/L (RPP-5924, *Radiological Source Terms for Tank Farms Safety Analysis*). The radiological consequences were calculated based on the bounding supernatant ULD of 1.0×10^3 Sv/L.

Table 2-5. Onsite Radiological Consequences of a Double-Shell Tank Headspace Deflagration.

DST failure scenario	**Dose (rem)**	
	Ground level/point source	**Volume release**
No tank damage-1	0.4	0.1[a]
No tank damage-2	0.3	0.07[a]
Dome failure-1	0.8	0.09[b]
Dome failure-2	0.8	0.09[b]
Dome collapse	4.7	0.5[b]

Notes:

[a]Assumes 15 lb/in^2 gauge tank pressure.
[b]Assumes 45 lb/in^2 gauge tank pressure.

DST = double-shell tank.

Table 2-6 presents the onsite toxicological consequences calculated in Appendix B for the respirable releases shown in Table 2-4. Identical to the onsite radiological calculations, two calculations were performed; one assuming a ground level, point source release; and one assuming a volume release. The calculations in Appendix B assume the material released is DST supernatant. Liquids sum of fractions (SOF) Temporary Emergency Exposure Limit (TEEL) values typically range by a factor of 10 from the tank with the lowest value to the tank with the highest value, e.g., the lowest TEEL-2 is 2.84×10^7 and the highest TEEL-2 is 3.46×10^8 (RPP-8369, *Chemical Source Terms for Tank Farm Safety Analyses*). The onsite and offsite toxicological consequences were calculated using the bounding DST liquids TEEL-1, TEEL-2, and TEEL-3 SOF values.

Table 2-6. Onsite Toxicological Consequences of a Double-Shell Tank Headspace Deflagration.

DST failure scenario	Sum of fractions	
	Ground level/ Point source	Volume release
No tank damage-1	74 (TEEL-2)	17 (TEEL-2)
	2.7 (TEEL-3)	0.6 (TEEL-3)
No tank damage-2	57 (TEEL-2)	13 (TEEL-2)
	2.1 (TEEL-3)	0.5 (TEEL-3)
Dome failure-1	130 (TEEL-2)	15 (TEEL-2)
	4.9 (TEEL-3)	0.6 (TEEL-3)
Dome failure-2	130 (TEEL-2)	15 (TEEL-2)
	4.9 (TEEL-3)	0.6 (TEEL-3)
Dome collapse	810 (TEEL-2)	92 (TEEL-2)
	30 (TEEL-3)	3.4 (TEEL-3)

Notes:
DST = double-shell tank.
TEEL = Temporary Emergency Exposure Limit.

Table 2-7 presents the offsite toxicological consequences calculated in Appendix B for the respirable releases shown in Table 2-4. The consequences were calculated assuming a puff release at ground level from a point source. Calculations were not performed for a volume release, as the associated atmospheric dispersion coefficients are essentially the same as the ground level, point source, puff release (e.g., 4.9×10^{-8} 1/m^3 versus 5.06×10^{-8} 1/m^3).

Table 2-7. Offsite Toxicological Consequences of a Double-Shell Tank Headspace Deflagration.

DST failure scenario	Sum of fractions
No tank damage-1	0.05 (TEEL-1)
No tank damage-2	0.04 (TEEL-1)
Dome failure-1	0.1 (TEEL-1)
Dome failure-2	0.1 (TEEL-1)
Dome collapse	0.6 (TEEL-1)

Notes:
DST = double-shell tank.
TEEL = Temporary Emergency Exposure Limit.

2.1.1.3.1 Assignment of Consequence Levels for the Onsite and Offsite Receptors

The risk binning team discussed the two modeling approaches (i.e., volume release versus ground-level, point source release) and reached consensus that the qualitative determination of onsite consequences should consider the volume release values. The ground-level, point source approach was judged to be overly conservative in that it does not account for the pressures associated with a deflagration.

The onsite radiological consequence of a headspace deflagration in a DST was qualitatively determined by the risk binning team to be "low." A "low" consequence was assigned because the doses shown in Table 2-5 for a volume release are less than 25 rem.

The onsite toxicological consequence of a headspace deflagration in a DST was qualitatively determined by the risk binning team to be "moderate." A "moderate" consequence was assigned because: (1) the volume release TEEL-2 values are greater than 1, and (2) the volume release TEEL-3 values are less than 1, with the exception of the dome collapse scenario. The risk binning team discussed if a "high" consequence should be assigned, since a TEEL-3 SOF of 3.4 was calculated for the dome collapse. The team concluded that it should not. It was the team's opinion that the expert elicitation process used for the dome failure-2 scenario provided a more robust approach to estimating the release, as the 0.7 L value represented the aggregate best estimate of nine subject matter experts. In addition, the team discussed that some agglomeration and deposition would occur during the downwind transport of the plume, which would reduce consequences to below the calculated values. Further, although the volumetric χ/Q accounts for a pressurized release, it does not address temperature or momentum effects associated with a deflagration. These would increase dispersion, thereby further reducing consequences to below the calculated values. In addition, as discussed in Appendix B, the dome collapse scenario assumes complete collapse of the dome which, based on the structural evaluations in WHC-SD-TWR-RPT-003, is not the expected tank failure mode. Lastly, the TEEL SOF values reported in RPP-8369 were conservatively derived and are based on a 1-hr exposure duration. For a hypothetical onsite worker at a distance of 100 m, plume passage will be less than 1 hr.

The offsite toxicological consequence of a headspace deflagration in a DST was qualitatively determined by the risk binning team to be "low." A "low" consequence was assigned because the TEEL-1 SOF values are less than 1 for all DST failure scenarios.

2.1.1.3.2 Assignment of Environmental Consequences

The risk binning team qualitatively assigned an environmental consequence of "E2," meaning there is the potential for a significant discharge of tank waste onsite. This consequence was assigned due to the potential release and subsequent dispersion of approximately 0.7 L of tank waste (associated with the partial dome failure-2 scenario).

2.1.1.3.3 Assignment of Risk Bins

Table 2-8 presents the risk bins for the DST representative accident. The risk bins are based on the methodology presented in Section 1.3 and the risk binning team's qualitative determination of frequency and consequence.

Table 2-8. Risk Bins for a Double-Shell Tank Headspace Deflagration Due to a Steady-State Accumulation of Flammable Gas or a Spontaneous Gas Release Event.

Receptor	Frequency	Consequence	Risk bin
Onsite radiological	Unlikely	Low	III
Onsite toxicological		Moderate	II
Offsite toxicological		Low	III

2.1.2 Associated Hazardous Conditions

As stated in Section 1.2.3, there are numerous other hazardous conditions associated with the DST flammable gas representative accident. In general, these hazardous conditions address various DST deflagration scenarios (e.g., different flammable gas sources, different ignition sources). Ten hazardous conditions were identified as being sufficiently different from the representative accident to warrant further review.

2.1.2.1 Double-Shell Tank Headspace Deflagration Due to an Induced Gas Release Event

Operations and activities that disturb tank waste can induce the release of retained gas. Examples include mixer pump operation, air-lift circulator operation, and decanting activities. The risk binning team discussed the impact of such operations and activities on the frequency of a deflagration without controls. The team qualitatively concluded that the frequency of a headspace deflagration in a DST due to an induced GRE was "anticipated."

The manner in which the headspace reaches the LFL (i.e., steady-state, spontaneous or induced GRE) does not impact the consequences. Therefore, the consequence levels assigned in Sections 2.1.1.3.1 and 2.1.1.3.2 are applicable. Table 2-9 presents the resultant risk bins.

Table 2-9. Risk Bins for a Double-Shell Tank Headspace Deflagration Due to an Induced Gas Release Event.

Receptor	Frequency	Consequence	Risk bin
Onsite radiological	Anticipated	Low	III
Onsite toxicological		Moderate	I
Offsite toxicological		Low	III

2.1.2.2 Double-Shell Tank Headspace Detonation Due to a Steady-State Accumulation of Flammable Gas or a Gas Release Event

Under special conditions, a detonation versus a deflagration can occur. The difference between a detonation and deflagration is the speed of the flame front. For detonations, the flame front moves at supersonic speeds. These higher flame speeds can result in a greater suspension of tank waste. If a detonation occurs, it is estimated that 5 L of respirable material would be released.

The 5 L value approximates the aggregate best-estimate value of nine subject matter experts (HNF-2577, *Flammable Gas Project Expert Elicitation Results for Hanford Site Double-Shell Tanks*).

A direct detonation requires a higher flammable gas concentration than a deflagration (i.e., a hydrogen concentration from 8% to 11% [or higher] versus 4%). A deflagration-to-detonation transition (DDT) requires even higher flammable gas concentrations as well as special geometry, confinement, or configuration conditions that serve to accelerate the deflagration to a detonation. The headspace of a DST is not conducive to DDTs, as it represents an unconfined geometry. However, the primary tank ventilation system piping represents a confined geometry where flame acceleration could occur.

Detonable and DDT limits can conceivably be reached in some DSTs due to either steady-state accumulation or a spontaneous or induced GRE. For example, calculations in RPP-5926 show that some DSTs can reach a steady-state hydrogen concentration of > 8% of the LFL under barometric breathing conditions. If the detonable or DDT limits are reached, an ignition source must be present. The direct ignition of a detonation requires an ignition source of high energy, high power, or large size (i.e., 4.6 kJ, roughly equivalent to 1 g of high explosive [PNNL-13269]).

The frequency of a headspace detonation in a DST that results in a 5 L respirable release was qualitatively determined by the risk binning team to be "extremely unlikely." In making this determination, consideration was given to: (1) the likelihood of reaching detonable limits and not having an ignition source prior to reaching detonable limits that initiates a deflagration, (2) the strong ignition source requirement for the direct initiation of a detonation, and (3) the special geometry conditions required for a DDT.

Table 2-10 presents the onsite radiological consequences calculated in Appendix B for a 5 L respirable release. Two calculations were performed: one assuming a ground level, point source release; and one assuming a volume release, as described in Section 2.1.1.3.

Table 2-10. Onsite Radiological Consequences of a Double-Shell Tank Headspace Detonation.

Respirable release	Dose (rem)	
	Ground level/point source	Volume release[a]
5 L	5.5	0.6

Note:
[a]Assumes 45 lb/in^2 gauge tank pressure.

Table 2-11 presents the onsite toxicological consequences calculated in Attachment B for a 5 L respirable release. Identical to the onsite radiological calculations, two calculations were performed; one assuming a ground level, point source release; and one assuming a volume release.

Table 2-11. Onsite Toxicological Consequences of a Double-Shell Tank Headspace Detonation.

Respirable release	Sum of fractions	
	Ground level/point source	Volume release[a]
5 L	950 (TEEL-2)	110 (TEEL-2)
	35 (TEEL-3)	3.9 (TEEL-3)

Notes:
[a]Assumes 45 lb/in^2 tank pressure.

TEEL = Temporary Emergency Exposure Limit.

Table 2-12 presents the offsite toxicological consequences calculated in Appendix B for a 5 L respirable release. The consequences were calculated assuming a puff release at ground level from a point source release.

Table 2-12. Offsite Toxicological Consequences of a Double-Shell Tank Headspace Detonation.

Respirable release	Sum of fractions
5 L	0.7 (TEEL-1)

Note:
TEEL = Temporary Emergency Exposure Limit.

Consistent with Section 2.1.1.3.1, the risk binning team reached consensus that the qualitative determination of onsite consequences should consider the volume release values. The onsite radiological consequence of a headspace detonation in a DST was qualitatively determined by the risk binning team to be "low." A "low" consequence was assigned because the dose shown in Table 2-10 for a volume release is less than 25 rem.

The onsite toxicological consequence of a headspace detonation in a DST was qualitatively determined by the risk binning team to be "moderate." The risk binning team discussed if a "high" consequence should be assigned, since a TEEL-3 SOF of 3.9 was calculated. The team concluded that it should not. In making this determination, the team considered that the TEEL-3 value was calculated using the bounding SOF value for DST supernatant and did not consider agglomeration and deposition during the downwind transport plume. Further, although the volumetric χ/Q accounts for a pressurized release, it does not address temperature or momentum effects associated with a deflagration. These effects would increase dispersion thereby further reducing consequences to below the calculated values.

The offsite toxicological consequence of a headspace detonation in a DST was qualitatively determined by the risk binning team to be "low" based on a calculated TEEL-1 SOF value of 0.7.

Table 2-13 presents the risk bins for a headspace detonation in a DST. The risk bins are based on the methodology presented in Section 1.3 and risk binning team's qualitative determination of frequency and consequence.

Table 2-13. Risk Bins for a Double-Shell Tank Headspace Detonation.

Respirable release	Receptor	Frequency	Consequence	Risk bin
5 L	Onsite radiological	Extremely unlikely	Low	IV
	Onsite toxicological		Moderate	III
	Offsite toxicological		Low	IV

2.1.2.3 Deflagration in a Double-Shell Tank Annulus

Double-shell tanks are constructed with a primary and secondary tank. The secondary tank is approximately 5 ft larger in diameter than the primary tank, which forms a 2.5-ft annular space between the two tanks. Under normal operating conditions, the annular space contains no waste. Conceivably, waste could enter a DST annulus in two ways: (1) a leak from the primary tank, or (2) a mistransfer into the annulus.

RPP-8050, *Lower Flammability Limit Calculation for Catch Tanks, IMUST, DST Annuli, Pit Structures and Double-Contained Receiver Tanks in Tank Farms at the Hanford Site*, estimates the steady-state flammability level in the annular space of DSTs under barometric breathing conditions for varying waste types and quantities. The waste quantity was varied in 10% increments of the annulus volume up to 86% (i.e., the value at which the liquid level in the primary tank and annulus would equilibrate if a primary tank leaked and that tank was initially full). Two waste types were analyzed. In the first case, the waste characteristics are taken to be identical to the liquid fraction of the waste present in the DST (raw liquid waste). In the second case, it is assumed that liquid and solid wastes are present in the same ratios and with the same characteristics as the DST (raw waste). The waste with the highest hydrogen generation rate is DST 241-AY-102 raw waste and, to reach 100% of the LFL under barometric breathing conditions, the annular space must be > 20% full. This equates to a waste volume of > 30,000 gal. For the raw liquid waste with the highest hydrogen generation rate (DST 241-AZ-102), the annular space must be > 50% full (> 80,000 gal) to reach 100% of the LFL.

RPP-8050 also calculates the times to LFL under zero ventilation conditions for small waste leaks. These calculations demonstrate that the times to LFL for small leaks (i.e., 8,000 gal) are very long (i.e., > 4 yr for DST 241-AY-102 raw waste). Leaks on the order of 8,000 gal are detectable by monitoring the tank waste level. Theoretically, a very small leak that could not be detected by waste level monitoring, would, under zero ventilation conditions, eventually reach 100% of the LFL. The risk of such an event is judged to be acceptable given the long time duration to the LFL and given redundant leak detection capabilities (e.g., leak detectors located in the annulus, annulus continuous air monitors) provided for compliance with environmental requirements. Normal operation of the annulus ventilation system also prevents a flammable gas accident from a small, undetected leak into the annulus.

The frequency of a primary tank failure due to corrosion resulting in a leak of 80,000 gal to the annulus has been evaluated (Shuford, 2002, "Hydrogen Deflagration Double-Shell Tank/Aging Waste Facility PISA USQD"). Based on the estimated rate of through-wall pit corrosion and the likelihood that through-wall pits would self-plug prior to leaking 80,000 gal, the evaluation concluded the frequency to be "unlikely" for the population of 28 DSTs, in the next 3 to 5 yr. The "unlikely" frequency is judged to be applicable beyond the 3 to 5 yr specified in Shuford (2002) based on the ongoing tank integrity program which monitors the structural integrity.

The frequency of a mistransfer resulting in the presence of waste in a DST annulus is also "unlikely." Mistransfers, in general, are "anticipated" events. However, for waste to reach the annulus a specific mistransfer must occur, i.e., the transfer route must pass through the central pump pit of a DST and a piping configuration error within the pit must occur such that the transfer is routed to the annulus pump-out pit. This specific mistransfer is judged to be "unlikely."

Given the presence of a large quantity of waste in the annulus, a deflagration will occur if an ignition source is present. Assuming that an ignition source would be present, the risk binning team concluded that "unlikely" was a conservative yet appropriate frequency to assign to a deflagration in a DST annulus.

It is assumed that a deflagration in the annulus of a DST would result in a respirable release similar to that for a primary tank headspace deflagration. The probable failure mode is between the annulus and the primary tank, such that the primary tank becomes pressurized. The rapid blowdown of the annulus into the primary tank would entrain waste material. The venting of the headspace through tank openings and cracks in the dome would release the entrained waste to the atmosphere. The consequence levels are, therefore, the same as presented in Sections 2.1.1.3.1 and 2.1.1.3.2. The resultant risk bins are presented in Table 2-14.

Table 2-14. Risk Bins for a Deflagration in a Double-Shell Tank Annulus.

Receptor	Frequency	Consequence	Risk bin
Onsite radiological	Unlikely	Low	III
Onsite toxicological		Moderate	II
Offsite toxicological		Low	III

2.1.2.4 Double-Shell Tank Subsurface Deflagration

Retained gas is present in Hanford Site waste in several different forms:

- Small bubbles of bubble/solid aggregates in the liquid in convective layers
- Particle-displacing bubbles that may be isolated or connected in networks of limited extent

- Pore-filling bubbles in networks of limited extent
- Pores at the top of dry waste that are primarily air-filled but that diffuse gas generated in the lower, wetter waste.

PNNL-13269 evaluates the flammability of these retained gases. It concludes that deflagrations are unlikely to propagate within Hanford Site wastes because retained gas does not appear to take the form of millimeter-diameter pores interconnected in a large network. Creating an ignition source is also problematic. However, small-scale deflagrations involving fracture bubbles of several centimeters or bubble networks up to 1 m extent cannot be ruled out.

Based on PNNL-13269, the risk binning team concluded that a subsurface deflagration that presented a potential hazard to facility workers, onsite workers, or the offsite receptor was a "beyond extremely unlikely" event. Further, the risk binning team concluded that, even if a deflagration propagated in a bubble network greater than 1 m extent, the consequences would be low as there would not be structural damage to the tank and the quantity of waste disturbed would be small. The resultant risk bins are presented in Table 2-15.

Table 2-15. Risk Bins for a Double-Shell Tank Subsurface Deflagration.

Receptor	Frequency	Consequence	Risk bin
Onsite radiological	Beyond extremely unlikely	Low	IV
Onsite toxicological		Low	IV
Offsite toxicological		Low	IV

2.1.2.5 Deflagration in Double-Shell Tank Waste-Intruding Equipment

In September 1995, an Occurrence Report (as summarized in RPP-13121, *Historical Summary of Occurrences for the Tank Farms Final Safety Analysis Report*) was issued because the flammable gas concentration inside a push-mode core sampling drill string was in excess of the LFL. Another incident occurred one month later. In both incidents, the cause was attributed to encountering gas pockets in the waste, which in turn caused flammable gases to enter and accumulate in the drill string in concentrations that were in excess of the LFL. Flammable gas is known to have accumulated in drill strings in several other tanks. Flammable gas has also accumulated inside waste-intruding equipment due to steady-state generation (HNF-5985, *Tank 241-ER-311 Flammable Gas Response and Findings*). Given this operational history, the risk binning team concluded that the frequency of a deflagration in waste-intruding equipment is "anticipated" in the absence of controls.

The consequence of a deflagration in waste-intruding equipment was qualitatively evaluated by the risk binning team. The team concluded that there would be no damage to the DST. In addition, the amount of waste available for dispersion would be small. Based on these considerations, the risk bin team concluded that the onsite radiological and onsite and offsite toxicological consequences would be "low." The resultant risk bins are shown in Table 2-16.

Table 2-16. Risk Bins for a Deflagration in Double-Shell Tank Waste-Intruding Equipment.

Receptor	Frequency	Consequence	Risk bin
Onsite radiological	Anticipated	Low	III
Onsite toxicological		Low	III
Offsite toxicological		Low	III

2.1.2.6 Deflagration in a Double-Shell Tank Riser

Risers extend from the headspace of DSTs into process pits. Therefore, the concentration of flammable gas in a riser approximates the concentration in the headspace under steady-state conditions. In the event of a large GRE, it is conceivable that momentum effects could result in a flammable gas concentration in a riser in excess of the LFL, while the headspace was less than the LFL. The frequency of deflagration in a riser was therefore assigned the frequency of a deflagration due to a spontaneous GRE. The risk binning team concluded this was a conservative assumption.

The consequences of a deflagration in a riser were qualitatively judged by the risk binning team to be the same as a deflagration in waste-intruding equipment, i.e., the onsite radiological and onsite and offsite toxicological consequences would be "low." The resultant risk bins are shown in Table 2-17.

Table 2-17. Risk Bins for a Deflagration in a Double-Shell Tank Riser.

Receptor	Frequency	Consequence	Risk bin
Onsite radiological	Unlikely	Low	III
Onsite toxicological		Low	III
Offsite toxicological		Low	III

2.1.2.7 Double-Shell Tank Gasoline Fuel Deflagration

Vehicles are routinely used in the tank farms to support surveillance, sampling, maintenance, and construction activities. A vehicle accident in a tank farm could result in fuel from a ruptured fuel tank spilling into a waste storage tank. Fuel could also leak or spill into a waste storage tank during tank farm fueling activities. A deflagration could occur if the fuel was to subsequently volatilize and ignite. Based on the volatility of gasoline, it is postulated that gasoline vapors could reach the LFL within the headspace of waste tanks. Because of the low vapor pressure of diesel fuel, diesel fuel vapors are not expected to reach the LFL.

RPP-13261, *Analysis of Vehicle Fuel Release Resulting in Waste Tank Fire*, analyzes several scenarios in which gasoline enters a waste storage facility. The estimated frequency of: (1) a vehicle striking a riser such that the fuel tank is ruptured, (2) the fuel draining into a waste tank, (3) the fuel-air concentration reaching the LFL, and (4) the presence of an ignition source, is approximately 6 x 10^{-4}/yr. Based on this evaluation, the frequency of a headspace gasoline/diesel fuel deflagration in a DST was qualitatively determined by the risk binning team to be "unlikely." A deflagration resulting from tank farm fueling activities is also qualitatively determined to be "unlikely" based on the accident scenario requiring a fuel leak or spill and that the fuel enters a waste storage tank.

As was the case with hydrogen, a deflagration caused by gasoline would result in a peak pressure sufficient to damage the tank structure (i.e., greater than 55 to 60 lb/in^2 gauge). Therefore, the risk binning team concluded that the consequences of a gasoline deflagration would either be bounded by, or be approximately the same as, a hydrogen deflagration. The resultant risk bins are shown in Table 2-18.

Table 2-18. Risk Bins for a Double-Shell Tank Gasoline/Diesel Fuel Deflagration.

Receptor	Frequency	Consequence	Risk bin
Onsite radiological	Unlikely	Low	III
Onsite toxicological		Moderate	II
Offsite toxicological		Low	III

2.1.2.8 Deflagration in a Flexible Receiver Bag

Flexible receiver bags are used to encase long-length, contaminated equipment removed from waste tanks. If the headspace of a tank was above the LFL or a GRE occurred, and a flexible receiver bag was attached to a riser, it is conceivable that a deflagration in the flexible receiver bag could occur.

The frequency of a deflagration in a flexible receiver bag was qualitatively determined by the risk binning team to be "extremely unlikely." In making this determination, consideration was given to: (1) the "unlikely" frequency assigned to a deflagration due to a steady-state accumulation of flammable gas or a spontaneous GRE, (2) the probability of concurrent flexible receiver bag operations, and (3) the presence of an ignition source such that the deflagration occurs in the flexible receiver bag but not the tank headspace.

Given a deflagration in a flexible receiver bag, the amount of waste available for dispersion would be limited to that present as equipment contamination. Accordingly, the risk bin team concluded that the onsite radiological and onsite and offsite toxicological consequences would be "low." The resultant risk bins are shown in Table 2-19.

Table 2-19. Risk Bins for a Deflagration in a Flexible Receiver Bag.

Receptor	Frequency	Consequence	Risk bin
Onsite radiological	Extremely unlikely	Low	IV
Onsite toxicological		Low	IV
Offsite toxicological		Low	IV

2.1.2.9 Ignition of a Pocket of Flammable Gas

As discussed in Section 2.1.2.5, it is believed that pockets of flammable gas have been encountered during push-mode core sampling. Conceivably, a gas pocket could ignite under the waste as a result of the core sampling activity.

Section 2.1.2.4 addressed subsurface deflagrations. The risk binning team concluded that a subsurface deflagration that presented a potential hazard to facility workers, onsite workers, and the offsite receptor was a "beyond extremely unlikely" event. For the specific case of push-mode core sampling, the risk binning team qualitatively increased the frequency to "extremely unlikely" based on the assumption that the sampling activity provided the ignition source. Consistent with Section 2.1.2.4, the risk binning team concluded the consequences would be "low." The resultant risk bins are presented in Table 2-20.

Table 2-20. Risk Bins for the Ignition of a Pocket of Flammable Gas in a Double-Shell Tank.

Receptor	Frequency	Consequence	Risk bin
Onsite radiological	Extremely unlikely	Low	IV
Onsite toxicological		Low	IV
Offsite toxicological		Low	IV

2.1.2.10 Deflagration in a Waste Transfer Line

There is limited potential for flammable gas accumulation in either the primary or encasement piping of a waste transfer line. Transfer lines are full during waste transfers, with the exception of saltwell pumping transfers that have low flow rates that allow the pipe to remain partially empty. When the transfer pipe is full, there is no space for flammable gas accumulation and thus no hazard. After the waste transfer is stopped, there is some potential for flammable gas accumulation, particularly if the line is not flushed. There is also some potential for flammable gas accumulation in the encasement of encased lines if there is a leak in the primary pipe. However, most of the waste is expected to drain from the line after the transfer is terminated, a factor that limits flammable gas generation and increases the time needed to reach the LFL. In addition, there are few ignition sources available to initiate a deflagration in a waste transfer line.

Consequences from a deflagration within a pipe would be limited by the diameter of the pipe and the inverse proportionality between the volume of flammable gas present and the volume of waste available for release. Thus, pipes with the largest volume of headspace available for flammable gas accumulation will have the highest potential deflagration energy, but will also have the least amount of waste available for: (1) flammable gas generation, and (2) release given a deflagration occurs. Conversely, pipes largely filled with waste will generate the most gas and, because of the small amount of available headspace, will reach the LFL most rapidly. However, the energy produced by a deflagation in such a line would be limited by the small volume of gas present.

The ability of various piping (both primary and encasements) to withstand flammable gas deflagrations has been evaluated (HNF-2251, *Calculation Note on Flammable Gas in Waste Transfer Lines*). It was determined that most primary piping and encasements would withstand an assumed pressure of 2,832 kPa (411 lb/in^2) absolute. The ability of older underground encased or directed buried piping to withstand such pressures was considered to be uncertain because the precise loss of wall thickness due to corrosion was not available as an input to the calculations. However, this buried piping is typically covered by several feet of dirt, which would mitigate the effects of the accident.

Based on the above considerations, the risk binning team concluded that the frequency of a deflagration in a waste transfer line was "unlikely," and that the consequences to onsite and offsite receptors would be "low." The resultant risk bins are shown in Table 2-21. It was noted that a deflagration in a waste transfer line has the potential for significant facility worker consequences.

Table 2-21. Risk Bins for a Deflagration in Waste Transfer Line.

Receptor	Frequency	Consequence	Risk bin
Onsite radiological	Unlikely	Low	III
Onsite toxicological		Low	III
Offsite toxicological		Low	III

2.2 SINGLE-SHELL TANKS

2.2.1 Representative Accident

The representative accident for SSTs is a headspace deflagration due to a steady-state accumulation of flammable gas. Spontaneous GREs in SSTs resulting in a deflagration are considered "beyond extremely unlikely." Although spontaneous GREs in SSTs have occurred, they are uniformly small and slow, and the resultant flammable gas concentrations have been well below 25% of the LFL (RPP-7771).

2.2.1.1 Scenario

A deflagration in the headspace of an SST can occur if the flammable gas concentration is greater than or equal to the LFL and an ignition source is present. RPP-5926 calculates the steady-state flammable gas concentration in SSTs. Under barometric breathing conditions, in which the only movement of air into or out of the tank is due to variations in atmospheric pressure, flammable gas concentrations in excess of the LFL can be reached in some SSTs. Under zero ventilation conditions, in which the SSTs are essentially modeled as sealed pressure vessels, concentrations in excess of the LFL will eventually be reached in all SSTs. For the majority of the tanks, however, this requires years of flammable gas generation and accumulation. A zero ventilation condition is considered for SSTs because isolation activities (e.g., cutting and capping transfer lines, foaming-over pits) have been undertaken to prevent inadvertent waste transfers and water intrusion.

Similar to the DST scenario described in Section 2.1.1.1, an ignition source is assumed to be present and ignites the flammable gas in the SST headspace resulting in a deflagration.

As documented in WHC-SD-TWR-RPT-003, at internal pressures in the range of 11 to 15 lb/in^2 gauge, some cracking of the SST concrete tank dome with distributed pressure venting and overstressing of rebar is predicted. This failure would lead to self-venting through the soil overburden. Given a very rapid, high pressure (e.g., up to 44 lb/in^2 gauge) transient, the pressure may not have time to vent. At pressures significantly greater than 11 to 15 lb/in^2 gauge, the center portion of the dome to a radial distance of 2 to 20 ft, along with the soil overburden, would likely be blown out. Based on existing stress analyses, the DELPHI panel concluded there is no reason to expect complete dome collapse (WHC-SD-TWR-RPT-003).

2.2.1.2 Frequency Determination

The frequency of a headspace deflagration in an SST due to a steady-state accumulation of flammable gas was qualitatively determined by the risk binning team to be "unlikely." In making this determination, consideration was given to: (1) the likelihood of reaching the LFL and having an ignition source, (2) the 50-yr operating history of the tank farms during which time no deflagrations are known to have occurred, and (3) flammable gas monitoring data.

Calculations in RPP-5926 demonstrate that in the absence of controls, reaching the LFL in the headspace of an SST is a credible event. The risk binning team discussed the bases and assumptions for these calculations and judged them to be conservative.

For steady-state generation and accumulation, if the steady-state equilibrium concentration reaches or exceeds the LFL it will remain there indefinitely. Therefore, an ignition source is assumed to be present. The risk binning team discussed the validity of this assumption with some stating the opinion that it is overly conservative to assume an ignition source. It was discussed that this was a standard industry assumption, supported by the fact that, in a relatively large percentage of flammable gas deflagrations that have occurred in industry, no specific ignition source could be identified.

The appropriateness of considering operational history when evaluating the frequency of a scenario "without controls" was discussed. The risk binning team recognized that during the 50-yr history of the tank farms, controls of some type (e.g., active or passive ventilation) were normally in place. Despite this fact, it was the team's judgment that the operational history suggested that a flammable gas deflagration was not an anticipated event.

Monitoring of SST headspaces has shown that flammable gas concentrations due to steady-state generation and accumulation are typically well below 25% of the LFL. As in the case with operational history, the risk binning team recognized that this data reflects some level of control.

2.2.1.3 Consequence Determination

To support the qualitative assessment of consequences, a series of calculations was performed. The calculations, documented in Appendix B, were performed consistent with the methodologies documented in RPP-13482. Table 2-22 identifies the analytical assumptions and input parameters used in the Appendix B calculations, evaluates the sensitivity of the results to the assumption/input parameter, and determines the need to protect the assumption/input parameter.

Table 2-22. Sensitivity of the Representative Single-Shell Tank Accident Analysis to Assumptions and Input Parameters. (3 sheets)

Analysis assumption (AA)/input parameter and basis	Assumption type	Sensitivity	Need to protect AA	Protection basis
Deflagration results in partial dome collapse. Based on structural evaluation documented in WHC-SD-TWR-RPT-003.	Reasonably conservative	This is the bounding failure mode defined by the DELPHI panel. This failure mode results in a larger suspension of respirable material than dome cracking and self-venting through the soil overburden. A complete versus partial dome collapse could conceivably result in a larger respirable release. However, complete dome collapse is not expected based on existing stress analyses.	No	N/A
Material released is saltcake solids.	Reasonably conservative	The type of material released is an important assumption as it defines both the ULD and the SOFs. The waste surface layer in the majority of SSTs is comprised of saltcake. The sensitivity of the analysis to the saltcake assumption on the ULD and SOF parameters are subsequently addressed in this table.	No	N/A
3.3 L (6 kg) of respirable saltcake is released. Based on expert elicitation documented in HNF-SD-WM-ES-412. Note that Appendix B calculates consequences for a range of releases from 0.011 L to 4 L, all of which were taken into consideration when assigning the consequence level. However, the risk binning team judged that the expert *elicitation process provided a robust* approach to estimating the release.	Reasonably conservative	The consequences are directly proportional to the respirable release. The 3.3 L value represents the aggregate best estimate of a seven-member panel of experts. Holding all other input parameters constant, *the release would have to increase from* 3.3 L *to* 14 L (26 kg) in order to challenge the 100 rem high onsite radiological consequence guideline. In order to challenge the moderate offsite toxicological guideline (i.e., a TEEL-1 SOF>1), the release would have to increase from 3.3 L to 8.3 L (15 kg).Relative to onsite toxicological consequences, the TEEL-3 SOF value for the 3.3 L release is greater than 1.	No	N/A
The release duration is 60 sec. Deflagrations occur very rapidly (i.e., in less than 1 sec). RPP-13482 states that for release durations less than 1 min, the release can be characterized as a continuous release with a rate (mg/s) given by the total release (in mg) divided by 60 sec.	Best estimate	RPP-13482 standard methodology. RPP-13482 states that both the continuous release and puff release models are conservative.	No	N/A

Table 2-22. Sensitivity of the Representative Single-Shell Tank Accident Analysis to Assumptions and Input Parameters. (3 sheets)

Analysis assumption (AA)/input parameter and basis	Assumption type	Sensitivity	Need to protect AA	Protection basis
The density of the saltcake is 1.8 g/ml, based on reported density of the saltcake with the highest applicable ULD (i.e., SST 241-TX-118). Density taken from RPP-5926, Table A-1.	Best estimate	The 3.3 L value is derived by dividing the mass released (i.e., 6 kg) by the density of the saltcake. A density of 1.8 g/ml was selected, as this is the density *of the surface layer saltcake with the highest ULD*. The density of saltcake ranges from 1.4 to 1.9 g/ml. Applying the minimum density of 1.4 g/ml yields a release of 4.3 L versus 3.3 L (see previous table entry for the sensitivity of the respirable release parameter).	No	N/A
The ULD is 1.0 x 10^5 Sv/L. This is the second highest reported value for SST solids (for SST 241-TX-118 saltcake) as documented in RPP-5924. SST 241-AX-104 sludge has the highest SST solids ULD, but even under zero ventilation conditions SST 241-AX-104 cannot reach the LFL because of diffusion through the SST concrete dome.	Bounding	Based on a 3.3 L release, the onsite radiological consequence is 23 rem. The ULD would have to increase by a factor of 4 to challenge the 100 rem "high" onsite radiological consequence guideline.	Yes	Protected by Administrative Control TSR "Source Term Controls"
Toxicological consequences are based on application of the following SOF values: TEEL-1, 3.71 x 10^9 TEEL-2, 6.28 x 10^8 TEEL-3, 9.80 x 10^7 These are the highest reported values for 100-series SST liquids or solids, as documented in RPP-8369.	Bounding (bounding value reported in RPP-8369) for 100-series SST liquids or solids	Based on a 3.3 L release, the onsite toxicological consequence was judged to be "moderate" although the TEEL-3 SOF was greater than 1 (i.e., 11). If the TEEL-3 SOF was increased significantly, the onsite consequence could be judged to be "high."	Yes	Protected by Administrative Control TSR "Source Term Controls."
For onsite consequence analyses, the integrated atmospheric dispersion coefficient used for the 3.3 L release dome collapse scenario is 2.06 10^{-3} s/m^3, as documented in RPP-13482. This value was derived to account for a pressurized release.	Reasonably conservative	This atmospheric dispersion coefficient is based on 95% meteorology, which is recommended for conservative analysis.	No	N/A

Table 2-22. Sensitivity of the Representative Single-Shell Tank Accident Analysis to Assumptions and Input Parameters. (3 sheets)

Analysis assumption (AA)/input parameter and basis	Assumption type	Sensitivity	Need to protect AA	Protection basis
For the offsite toxicological consequence analysis, the integrated atmospheric dispersion coefficient is 5.06×10^{-8} 1/m^3, as documented in RPP-13482. This value represents the 95% χ/Q for a ground-level, point source, puff release.	Reasonably conservative	This atmospheric dispersion coefficient is based on 95% meteorology, which is recommended for conservative analysis.	No	N/A
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 (documented in RPP-5924).	Reasonably conservative	This is a standard analysis assumption.	No	N/A

Notes:

HNF-SD-WM-ES-412, 1997, *Safety Controls Optimization by Performance Evaluation (SCOPE) Expert Elicitation Results for Hanford Site Single-Shell Tanks*, Rev. 0, Duke Engineering and Services Hanford, Inc., Richland, Washington.

RPP-5924, 2003, *Radiological Source Terms for Tank Farms Safety Analysis*, Rev. 4, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-5926, 2005, *Steady-State Flammable Gas Release Rate Calculation and Lower Flammability Level Evaluation for Hanford Tank Waste*, 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. 4, CH2M HILL Hanford Group, Inc., Richland, Washington.

WHC-SD-TWR-RPT-003, 1996, *DELPHI Expert Panel Evaluation of Hanford High Level Waste Tank Failure Modes and Release Quantities*, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

AA = analysis assumption.
N/A = not applicable.
SOF = sum of fractions.
SST = single-shell tank.
TEEL = Temporary Emergency Exposure Limit.
TSR = technical safety requirement.
ULD = unit-liter dose.
USQ = unreviewed safety question.

The radiological and toxicological consequences are a function of the quantity of tank waste suspended by a deflagration, which in turn is a function of the tank failure mode. Table 2-23 summarizes the estimated quantities of respirable material released assuming dome cracking, no tank damage, and partial dome collapse. The bases for the values shown in Table 2-23 are provided in Appendix B.

Table 2-23. Respirable Releases as a Function of the Single-Shell Tank Failure Scenario.

SST failure scenario	Respirable release (L) SST solids
Cracked dome-1	0.011
Cracked dome-2	0.6
No tank damage	0.12
Partial dome collapse-1	4
Partial dome collapse-2	3.3

Notes:
SST = single-shell tank.

Table 2-24 presents the onsite radiological consequences calculated in Appendix B for the respirable releases shown in Table 2-23. As was the case with the DST consequences, two calculations were performed applying two different modeling approaches: one assuming a ground level, point source release; and one assuming a volume release. The ULDs are derived in RPP-5924 for each waste phase in each tank. For the 149 SSTs, ULDs ranged in value from 1.9×10^{-1} Sv/L (associated with 8 kL of liquids in SST 241-T-201) to 1.4×10^{5} Sv/L (associated with 28 kL of sludge in SST 241-AX-104). SST 241-AX-104 sludge, which has the highest SST waste ULD, was not selected because even under zero ventilation conditions the headspace in this SST cannot reach the LFL due to diffusion through the concrete dome (RPP-5926, Table 4-5). Therefore, SST 241-TX-118 saltcake was selected because it has the second highest SST waste ULD of 1.0×10^{5} Sv/L and SST 241-TX-118 can reach the LFL and detonable limits assuming zero ventilation conditions.

Table 2-24. Onsite Radiological Consequences of a Single-Shell Tank Headspace Deflagration.

SST failure scenario	Dose (rem)	
	Ground level/point source	Volume release
Cracked dome-1	1.2	0.2[a]
Cracked dome-2	66	9.8[a]
No tank damage	13	2.0[a]
Dome collapse-1	440	27[b]
Dome collapse-2	360	23[b]

Notes:
[a]Assumes 15 lb/in^2 gauge tank pressure
[b]Assumes 44 lb/in^2 gauge tank pressure.

SST = single-shell tank.

Table 2-25 presents the onsite toxicological consequences calculated in Appendix B for the respirable releases shown in Table 2-23. Identical to the onsite radiological calculations, two calculations were performed; one assuming a ground-level, point source release; and one assuming a volume release. The calculations in Appendix B assume the material released is 100-series SST solids. The SOF TEEL-2 and TEEL-3 values selected for use in calculating the onsite toxicological consequences are 6.28×10^8 and 9.80×10^7, respectively. These are the highest reported 100-series SST liquids or solids TEEL-2 and TEEL-3 SOF values reported in RPP-8369. The highest reported 100-series SST solids TEEL-2 value also bounds the 200-series SST solids TEEL-2 values with the exception of the 241-C Tank Farm 200-series tanks. These relatively small (i.e., 50,000 gal) tanks only contain from 800 to 2,600 gal of waste and are judged not to present a significant flammable gas hazard. Excluding 241-C Tank Farm 200-series tanks, the highest reported 200-series SST solids TEEL-3 value is 3.39×10^8 for SST 241-T-202.

Table 2-25. Onsite Toxicological Consequences of a Single-Shell Tank Headspace Deflagration.

SST failure scenario	Sum of fractions*	
	Ground level/point source	Volume release
Cracked dome-1	3.8 (TEEL-2)	0.6 (TEEL-2)
	0.6 (TEEL-3)	0.1 (TEEL-3)
Cracked dome-2	210 (TEEL-2)	31 (TEEL-2)
	32 (TEEL-3)	4.8 (TEEL-3)
No tank damage	41 (TEEL-2)	6.1 (TEEL-2)
	6.4 (TEEL-3)	1.0 (TEEL-3)
Dome collapse-1	1,400 (TEEL-2)	86 (TEEL-2)
	210 (TEEL-3)	13 (TEEL-3)
Dome collapse-2	1,100 (TEEL-2)	71 (TEEL-2)
	180 (TEEL-3)	11 (TEEL-3)

Notes:
*TEEL-3 values are for 100-series SSTs.
SST = single-shell tank.
TEEL = Temporary Emergency Exposure Limit.

Table 2-26 presents the offsite toxicological consequences calculated in Appendix B for the respirable releases shown in Table 2-23. The consequences were calculated assuming a puff release at ground level from a point source release. Calculations were not performed for a volume release, as the associated atmospheric dispersion coefficients are essentially the same as the ground level, point source puff release (e.g., 4.9×10^{-8} 1/m^3 versus 5.06×10^{-8} 1/m^3).

The TEEL-1 value selected for use is 3.71×10^9. This is the highest reported SST liquids or solids TEEL-1 SOF value reported in RPP-8369 with the exception of the 241-C Tank Farm 200-series tanks. These relatively small (i.e., 50,000 gal) tanks only contain from 800 to 2,600 gal of waste and are judged not to present a significant flammable gas hazard.

Table 2-26. Offsite Toxicological Consequences of a Single-Shell Tank Headspace Deflagration.

SST failure scenario	Sum of fractions
Cracked dome-1	0.002 (TEEL-1)
Cracked dome-2	0.1 (TEEL-1)
No tank damage	0.02 (TEEL-1)
Dome collapse-1	0.8 (TEEL-1)
Dome collapse-2	0.6 (TEEL-1)

Notes:
SST = single-shell tank.
TEEL = Temporary Emergency Exposure Limit.

2.2.1.3.1 Assignment of Consequence Levels for the Onsite and Offsite Receptors

Consistent with the assignment of DST consequence levels, the risk binning team discussed the two modeling approaches (i.e., volume release versus ground level, point source release) and reached consensus that the qualitative determination of onsite consequences should consider the volume release values.

The onsite radiological consequence of a headspace deflagration in an SST was qualitatively determined by the risk binning team to be "moderate." A "moderate" consequence was assigned because the dome collapse scenario doses shown in Table 2-24 for a volume release are approximately 25 rem.

The onsite toxicological consequence of a headspace deflagration in an SST was qualitatively determined by the risk binning team to be "moderate." A "moderate" consequence was assigned because: (1) the volume release TEEL-2 values are greater than 1, and (2) the volume release TEEL-3 (100-series) values range from 0.1 to 13. Although the TEEL-3 (200-series) consequences are higher, it was determined that the TEEL-3 (100-series) toxicological consequences best represent the toxicological hazard associated with a flammable gas deflagration in an SST. This determination was based on the relative number of 100-series to 200-series tanks, the fact that the 100-series tanks are significantly larger in storage volume (i.e., from 0.5 Mgal to 1.0 Mgal) than are the 200-series tanks (i.e., 0.05 Mgal), and the fact that the 100-series tanks contain significantly larger waste volumes. The risk binning team discussed if a "high" consequence should be assigned, since TEEL-3 (100-series) SOF values greater than 1 were calculated. The team concluded that it should not. In reaching this conclusion, the team discussed that some agglomeration and deposition would occur during the downwind transport of the plume, which would serve to reduce consequences to below the calculated values. Further, although the volumetric χ/Q accounts for a pressurized release, it does not address temperature or momentum effects associated with a deflagration. These would increase dispersion thereby further reducing consequences to below the calculated values. In addition, the TEEL SOF values reported in RPP-8369 were conservatively derived and are based on a 1-hr exposure duration. For a hypothetical onsite worker at a distance of 100 m, plume passage will be less than 1 hr.

The offsite toxicological consequence of a headspace deflagration in an SST was qualitatively determined by the risk binning team to be "low." A "low" consequence was assigned because the TEEL-1 SOF values are less than 1 for all SST failure scenarios.

2.2.1.3.2 Assignment of Environmental Consequences

The risk binning team qualitatively assigned an environmental consequence of "E2," meaning that there is the potential for a significant discharge of tank waste onsite. This consequence was assigned due to the potential release and subsequent dispersion of approximately 3.3 L of tank waste (associated with the dome collapse-2 scenario).

2.2.1.3.3 Assignment of Risk Bins

Table 2-27 presents the risk bins for the SST representative accident. The risk bins are based on the methodology presented in Section 1.3 and the risk binning team's qualitative determination of frequency and consequence.

Table 2-27. Risk Bins for a Single-Shell Tank Headspace Deflagration Due to a Steady-State Accumulation of Flammable Gas.

Receptor	Frequency	Consequence	Risk bin
Onsite radiological	Unlikely	Moderate	II
Onsite toxicological		Moderate	II
Offsite toxicological		Low	III

2.2.2 Associated Hazardous Conditions

As stated in Section 1.2.3, there are numerous other hazardous conditions associated with the SST flammable gas representative accident. In general, these hazardous conditions address various SST deflagration scenarios (e.g., different flammable gas sources, different ignition sources). Twelve hazardous conditions were identified as being sufficiently different from the representative accident to warrant further review.

2.2.2.1 Single-Shell Tank Headspace Deflagration Due to an Induced Gas Release Event

Operations and activities that disturb tank waste can induce the release of retained gas. For SSTs, saltwell pumping is known to result in a release of retained gas. Historically, flammable gas monitoring has been conducted during saltwell pumping, and pumping operations have been halted if the concentration approached 25% of the LFL. The risk binning team discussed past saltwell pumping operations and flammable gas monitoring results and qualitatively concluded that the frequency without controls of a headspace deflagration in an SST due to an induced GRE was "anticipated."

The manner in which the headspace reaches the LFL (i.e., steady-state, spontaneous, or induced GRE) does not impact the consequences. Therefore, the consequence levels assigned in Sections 2.2.1.3.1 and 2.2.1.3.2 are applicable. Table 2-28 presents the resultant risk bins.

Table 2-28. Risk Bins for a Single-Shell Tank Headspace Deflagration Due to an Induced Gas Release Event.

Receptor	Frequency	Consequence	Risk Bin
Onsite radiological	Anticipated	Moderate	I
Onsite toxicological		Moderate	I
Offsite toxicological		Low	III

2.2.2.2 Single-Shell Tank Headspace Detonation Due to a Steady-State Accumulation of Flammable Gas or a Gas Release Event

As previously stated, a direct detonation requires a higher flammable gas concentration than a deflagration (i.e., a hydrogen concentration from 8% to 11% [or higher] versus 4%). A DDT requires even higher flammable gas concentrations as well as special geometry, confinement, or configuration conditions that serve to accelerate the deflagration to a detonation. The headspace of an SST is not conducive to DDTs, as it represents an unconfined geometry.

Detonable and DDT limits can conceivably be reached in some SSTs due to steady-state generation and accumulation. As documented in RPP-5926, under barometric breathing conditions, the maximum calculated steady-state hydrogen concentration in an SST does not reach the limiting detonable limit of 8%. Under zero ventilation conditions, concentrations in excess of the detonable and DDT limits will eventually be reached. For the majority of SSTs, this requires years of flammable gas generation and accumulation. The risk binning team discussed the bases and assumptions for these calculations and judged them to be conservative.

GREs in SSTs that could cause flammable gas concentrations in the tank headspace to exceed the lower detonable limit are not expected based on operating experience and evaluations of GRE flammable gas hazards in SSTs. First, there are only a limited number of SSTs estimated to contain sufficient retained gas to achieve a hydrogen concentration of 8%, even if 100% of the retained gas was released into the tank headspace. Second, retained gas release in SSTs is a slow process thus limiting the maximum flammable gas concentrations (RPP-7771).

Given the detonable or DDT limits are reached, an ignition source must be present. As previously stated, the direct ignition of a detonation requires an ignition source of high energy, high power, or large size. Lightning has been identified as the only ignition source of sufficient strength to ignite a direct detonation. In the case of the zero airflow condition, a tank would reside above the LFL for a considerable time period before reaching detonable or DDT limits. Given that deflagrations can be ignited by relatively small ignition sources, the risk binning team factored the likelihood of a deflagration occurring before a detonation or DDT into their frequency estimate.

Based on the above considerations, the risk binning team qualitatively determined the frequency of a headspace detonation in an SST to be "beyond extremely unlikely."

No scoping calculations for a detonation in an SST have been performed in support of risk binning. Based on a review of the consequence level assignments for both a deflagration and a detonation in a DST, the risk binning team concluded that the consequences of a detonation in an SST would be approximately equal to those of a deflagration. The resultant risk bins are presented in Table 2-29.

Table 2-29. Risk Bins for a Single-Shell Tank Headspace Detonation.

Receptor	Frequency	Consequence	Risk Bin
Onsite radiological	Beyond extremely unlikely	Moderate	IV
Onsite toxicological		Moderate	IV
Offsite toxicological		Low	IV

2.2.2.3 Headspace Deflagration in One Single-Shell Tank that Propagates to a Second Single-Shell Tank

This scenario requires the flammable gas concentration in the headspaces of two tanks connected by process overflow lines to be at the LFL. Under barometric breathing conditions, two such tanks do not exist. (Note: Referring to RPP-5926, SSTs 241-B-203 and 241-B-204 are in different overflow cascades and are not interconnected.) Under zero airflow conditions, the flammable gas concentration in two SSTs connected by process overflow lines could eventually both reach the LFL. Given an ignition source, a deflagration in one tank could then propagate to the second. The risk binning team qualitatively judged the frequency of this scenario to be "extremely unlikely." In making this determination, the risk binning team considered: (1) the "unlikely" frequency for a deflagration in a single SST, (2) that the scenario requires a zero airflow condition, and (3) that both tanks must reach the LFL at approximately the same time (otherwise a deflagration in one tank could occur prior to the second tank reaching the LFL).

The risk binning team discussed the extent to which consequences would be increased if simultaneous deflagrations occurred in adjacent tanks. Given the distance to the offsite receptor, the event would appear to be a single release. Doubling the offsite toxicological consequences shown in Table 2-26 still results in a "low" consequence. For the onsite receptor located at 100 m, the consequences would be increased but not doubled as the receptor cannot simultaneously be at the centerline of each plume. Based on a review of the onsite consequences shown in Tables 2-24 and 2-25, the risk binning team qualitatively determined the onsite radiological and toxicological consequences to be "low" and "moderate," respectively. The resultant risk bins are presented in Table 2-30.

Table 2-30. Risk Bins for a Headspace Deflagration in One Single-Shell Tank That Propagates to a Second Single-Shell Tank.

Receptor	Frequency	Consequence	Risk bin
Onsite radiological	Extremely unlikely	Moderate	III
Onsite toxicological		Moderate	III
Offsite toxicological		Low	IV

2.2.2.4 Deflagration in a Single-Shell Tank Riser

Risers extend from the headspace of SSTs into process pits. Therefore, the concentration of flammable gas in a riser approximates the concentration in the headspace under steady-state conditions. In the event of a large GRE, it is conceivable that momentum effects could result in a flammable gas concentration in a riser in excess of the LFL while the headspace is less than the LFL. However, as was previously stated, GREs in SSTs that could cause flammable gas concentrations in the tank headspace to exceed the LFL are not expected based on operating experience and evaluations of GRE flammable gas hazards in SSTs. Specifically, retained gas release in SSTs is a slow process thus limiting the maximum flammable gas concentrations (RPP-7771). Based on this consideration, the risk binning qualitatively determined the frequency of a deflagration in an SST riser to be "beyond extremely unlikely."

The consequence of a deflagration in a riser was qualitatively evaluated by the risk binning team. The team concluded that there would be no damage to the SST. In addition, the amount of waste available for dispersion would be small. Based on these considerations, the risk binning team concluded that the onsite radiological and onsite and offsite toxicological consequences would be "low." The resultant risk bins are shown in Table 2-31.

Table 2-31. Risk Bins for a Deflagration in a Single-Shell Tank Riser.

Receptor	Frequency	Consequence	Risk bin
Onsite radiological	Beyond Extremely Unlikely	Low	IV
Onsite toxicological		Low	IV
Offsite toxicological		Low	IV

2.2.2.5 Ignition of a Pocket of Flammable Gas

As discussed in Section 2.1.2.5, it is believed that pockets of flammable gas have been encountered during push-mode core sampling. Logically, a pocket of flammable gas could also be encountered during RMCS in an SST. Conceivably, such a gas pocket could ignite under the waste as a result of the core sampling activity.

In Section 2.1.2.9, the risk binning team assigned a frequency of "extremely unlikely" to the ignition of a pocket of flammable gas in a DST. Consistent with that section, the risk binning team assigned a frequency of "extremely unlikely" for a similar scenario in an SST. In addition, the risk binning team concluded that the consequences would be "low," as there would be no structural damage to the tank and the quantity of disturbed waste would be small. The resultant risk bins are shown in Table 2-32.

Table 2-32. Risk Bins for the Ignition of a Pocket of Gas in a Single-Shell Tank.

Receptor	Frequency	Consequence	Risk bin
Onsite radiological	Extremely unlikely	Low	IV
Onsite toxicological		Low	IV
Offsite toxicological		Low	IV

2.2.2.6 Deflagration in a Single-Shell Tank During Rotary Mode Core Sampling

RMCS operations generate airborne material within the headspace of a tank and thus have the potential to increase the consequences if a deflagration simultaneously occurs. RPP-13437, *Technical Basis Document for Ventilation System Filtration Failures Leading to Unfiltered Release*, Appendix D, "RMCS System Parameters," evaluates the mass loading in a tank headspace due to RMCS operations. Based on this analysis, the risk binning team concluded that RMCS operations do not significantly increase the consequences of a flammable gas deflagration in an SST. The team also concluded that RMCS operations do not significantly impact the frequency of a deflagration. The frequency, consequences, and risk bins are, therefore, those of the representative accident.

2.2.2.7 Deflagration in a Double-Contained Receiver Tank

DCRTs are typically used for the interim storage of waste transferred from other facilities. There are three DCRTs: 244-BX, 244-S, and 244-TX. Flammable gases are released into the headspace of DCRT by several processes: (1) transferred in with the waste (e.g., soluble gases, gas bubbles); (2) produced in the tank during waste storage by radiolysis of water and organics, chemical reactions (or thermolysis), and corrosion; and (3) produced by chemical adjustments of the waste before transfer to a DST (e.g., ammonia release). RPP-8050 analyzes the concentration of flammable gas in a DCRT headspace subsequent to expected waste transfers. The results show that the maximum concentration can, without controls (i.e., under zero ventilation conditions), exceed the LFL. The potential for GRE flammable gas hazards in DCRTs is evaluated in RPP-10007, *Flammable Gas Release Calculational Methodology and Results for Active Catch Tanks and DCRTs*. RPP-10007 concluded that there is no spontaneous or induced GRE hazard in DCRTs.

The risk binning team concluded that the frequency, consequences, and risk bins of the representative SST accident conservatively bound a deflagration in a DCRT. The resultant risk bins are shown in Table 2-33.

Table 2-33. Risk Bins for a Double-Contained Receiver Tank Flammable Gas Deflagration.

Receptor	Frequency	Consequence	Risk bin
Onsite radiological	Unlikely	Moderate	II
Onsite toxicological		Moderate	II
Offsite toxicological		Low	III

2.2.2.8 Deflagration in an Active Catch Tank

Active catch tanks are underground storage tanks used to collect waste drained from waste transfer systems and DST equipment. Typically, the waste present in active catch tanks is condensate from equipment versus tank waste. RPP-8050 estimates the steady-state flammability level in active catch tanks under barometric breathing conditions for varying waste types and volumes, including existing waste characteristics and conditions. The tank-specific geometry of each active catch tank was modeled, and the waste type analyzed was based on the tank operating history and mission, sample data, and best-basis inventory data. The waste volume was analyzed in 10% increments up to 90% full. As reported in RPP-8050, active catch tanks can reach the LFL depending on the assumed waste characteristics and volume. The potential for GRE flammable gas hazards in active catch tanks is evaluated in RPP-10007. RPP-10007 concluded that there is no spontaneous or induced GRE hazard in active catch tanks.

The risk binning team concluded that the frequency, consequences, and risk bins of the representative SST accident conservatively bound a deflagration in an active catch tank. The resultant risk bins are shown in Table 2-34.

Table 2-34. Risk Bins for an Active Catch Tank Flammable Gas Deflagration.

Receptor	Frequency	Consequence	Risk bin
Onsite radiological	Unlikely	Moderate	II
Onsite toxicological		Moderate	II
Offsite toxicological		Low	III

2.2.2.9 Inactive Tanks

Inactive tanks include inactive miscellaneous underground storage tanks (IMUST), 244-AR Vault tanks 244-AR TK-001, -002, -003, and -004; 244-CR Vault tanks 244-TK-CR-001, -002, -003, and -011; 242-T Evaporator vessels 242-T-101 through -107 and -110; and inactive catch tanks 241-A-302A, A-417, AX-152, and AZ-154. The residual waste in these facilities potentially represent a flammable gas hazard.

Most of the IMUSTs have been interim stabilized, meaning that pumpable liquids have been removed and the tanks isolated. In many cases, it is not practical to verify the existence of a flow path for barometric breathing (i.e., it is conceivable that isolation activities have created a zero airflow condition for some IMUSTs). RPP-8050 evaluates the steady-state flammable gas hazard in 32 IMUSTs. Evaluation of 32 tanks was possible as the waste volume and characteristics could be estimated from historical documentation. Each of the 32 tanks was analyzed under barometric breathing and zero airflow conditions. Under barometric breathing conditions, one of the IMUSTs will reach 100% of the LFL. Under zero ventilation conditions, all 32 tanks analyzed could eventually reach the LFL.

The 244-AR Vault is evaluated in RPP-8720, *Steady State Flammable Gas Calculations for 244-AR Vault Tanks*. For the 244-CR Vault and the 242-T Evaporator, the potential flammable gas hazard is based on process history.

The risk binning team initially concluded that the frequency, consequences, and risk bins of the representative SST accident conservatively bounded deflagrations in inactive tanks. While the consequences are judged to be bounding, it was subsequently determined that the representative SST accident frequency of "unlikely" for steady-state flammable gas hazards was not bounding for all inactive tanks. Table 2-35 presents the estimated deflagration frequency based on an evaluation of the ventilation potentially available without controls. In the absence of any evaluation, the frequency of a spontaneous or induced GRE flammable gas hazard in inactive tanks is conservatively assumed to be "unlikely." Table 2-36 presents the resultant risk bins.

Table 2-35. Inactive Tank Deflagration Frequency Without Controls.

Tank	Frequency w/o controls	Basis
Sealed, steel IMUSTs	Anticipated	Zero ventilation is assumed for IMUSTs that have been sealed. In addition, because the tanks are constructed of steel versus concrete, diffusion will be relatively ineffective in reducing the hydrogen concentration in the tanks.
Potentially vented IMUSTs	Anticipated*	Barometric breathing can be reasonably assumed for IMUSTs that have not been sealed. Given barometric breathing, an "unlikely" frequency would be applied. However, in the absence of a known barometric breathing path, an "anticipated" frequency is conservatively applied.
Known vented IMUSTs	Unlikely	Barometric breathing is assumed for IMUSTs that are known to have an opening that provides communication with the atmosphere.
244-CR Vault, tank 244-CR TK-003	Anticipated*	This tank is known to be vented such that an "unlikely" frequency could be applied. However, it has not been physically isolated such that waste could be added. An "anticipated" frequency is therefore conservatively applied.
244-CR Vault, tanks 244-CR TK-001, -002, -011	Anticipated*	Barometric breathing can be reasonably assumed for these tanks because they have not been sealed. Given barometric breathing, an "unlikely" frequency would be applied. However, in the absence of a known barometric breathing path, an "anticipated" frequency is conservatively applied.
244-AR Vault	Unlikely	Barometric breathing is assumed for the tanks in 244-AR, as they known to have openings that provide communication with the atmosphere.
242-T Evaporator	Anticipated*	Barometric breathing can be reasonably assumed for 242-T inactive tanks because they have not been sealed. Given barometric breathing, an "unlikely" frequency would be applied. However, in the absence of a known barometric breathing path, an "anticipated" frequency is conservatively applied.
4 Inactive Catch Tanks	Unlikely	Barometric breathing is assumed for these tanks that are known to have an opening that provides communication with the atmosphere.

Notes:

Anticipated* - conservatively assigned an "anticipated" frequency but judged to be approaching "unlikely."

IMUST = inactive miscellaneous underground storage tank.
LFL = lower flammability limit.

Table 2-36. Risk Bins for an Inactive Tank Flammable Gas Deflagration.

Receptor	Frequency	Consequence	Risk bin
Onsite radiological	Anticipated	Moderate	I
Onsite toxicological		Moderate	I
Offsite toxicological		Low	III
Onsite radiological	Unlikely	Moderate	II
Onsite toxicological		Moderate	II
Offsite toxicological		Low	III

2.2.2.10 Deflagration in Replacement Cross-Site Transfer System Diversion Box 6241-A or Vent Station 6241-V

There are two means by which flammable gas can be present in a waste transfer-associated structure. First, flammable gases can enter a structure if it is connected via open piping, drain lines, or risers to an SST, DST, or other waste storage facility. Second, flammable gases would be produced if waste was present in a structure due to a waste transfer misroute or transfer line failure. In the absence of controls, the flammable gas concentration could exceed the LFL via either means.

Risk binning for flammable gas deflagrations in typical waste transfer-associated structures (e.g., pump pits, valve pits) are addressed in RPP-13354, *Technical Basis Document for the Release from Contaminated Facility Representative Accident and Associated Represented Hazardous Conditions*. However, because of their very large size (and thus their ability to hold more waste), two RCSTS waste transfer-associated structures (i.e., Diversion Box 6241-A and Vent Station 6241-V), are more appropriately addressed under the SST flammable gas representative accident. Diversion Box 6241-A and Vent Station 6241-V are not connected to waste storage facilities. Therefore, a flammable gas hazard potentially exists only in the case of a transfer line failure that results in the accumulation of a large volume of waste within one of the structures.

The risk binning team concluded that the frequency, consequences, and risk bins of the representative SST accident conservatively bound a deflagration in the subject diversion box or vent station. The resultant risk bins are shown in Table 2-37.

Table 2-37. Risk Bins for a Flammable Gas Deflagration in Diversion Box 6241-A or Vent Station 6241-V.

Receptor	Frequency	Consequence	Risk bin
Onsite radiological	Unlikely	Moderate	II
Onsite toxicological		Moderate	II
Offsite toxicological		Low	III

2.2.2.11 Single-Shell Tank Gasoline Fuel Deflagration

Section 2.1.2.7 discusses a gasoline fuel deflagration in a DST. The same event can potentially occur in an SST. Based on the evaluations included in RPP-13261 and the evaluations of fueling accidents in the tank farms, the frequency of a headspace gasoline fuel deflagration in an SST was qualitatively determined by the risk binning team to be "unlikely," and the consequences were conservatively judged to be the same as a deflagration due to waste-generated flammable gas. The resultant risk bins are shown in Table 2-38.

Table 2-38. Risk Bins for a Single-Shell Tank Gasoline Fuel Deflagration.

Receptor	Frequency	Consequence	Risk bin
Onsite radiological	Unlikely	Moderate	II
Onsite toxicological		Moderate	II
Offsite toxicological		Low	III

2.2.2.12 Deflagration in Single-Shell Tank Retrieval/Closure Aboveground Tanks

The following SST retrieval/closure systems include aboveground tanks that contain waste.

- SST vacuum retrieval system slurry tank and water separator.
- SST 241-S-109 waste staging tank for Phase 1 of the Demonstration Bulk Vitrification System (DBVS) Project
- DBVS waste staging tanks, waste dryer, and condensate recovery system, off-gas treatment system, and secondary waste storage system tanks (i.e., the condensate receiver tank, condensate holding tanks, scrubber tanks, scrubber bleed tanks, and Tri-Mer[1] effluent tanks).

The frequency, consequences, and resulting risk bin for potential steady-state and GRE flammable gas hazardous conditions in the aboveground tanks for these SST retrieval/closure systems are presented in the following sections.

2.2.2.12.1 Single-Shell Tank Vacuum Retrieval System

The SST vacuum retrieval system relies on a pneumatically assisted vacuum system to retrieve waste from an SST. The system uses an articulating mast system (AMS) and a slurry tank to retrieve the waste from the SST. The slurry tank is located aboveground in an ISO freight container. The airflow necessary to retrieve the waste from the SST and draw it into the slurry tank is drawn through the AMS and the slurry tank by one or two liquid-ring vacuum pumps. The airflow is exhausted from the vacuum pumps into a water separator where the entrained liquid is removed from the exhaust stream prior to its return to the SST being retrieved. The water separator is also located in an ISO freight container aboveground.

[1] Tri-Mer is a registered trademark of Tri-Mer Corporation, Owosso, Michigan.

Because waste is present in the slurry tank and the water separator during vacuum retrieval operations, flammable gas buildup within these tanks could occur under steady-state conditions if waste remained in the tanks for extended durations. Calculations of flammable gas generation and accumulation in the vacuum retrieval system slurry tank show that the flammable gas concentration in the tank headspace could reach the 100% of the LFL within approximately 11 days if the tank were filled with the highest SST 200-series hydrogen generating waste with no ventilation (RPP-17512, *Flammable Gas Generation and Release Rate of the Pump Skid Tank for the Sludge Retrieval of the C-200 Tanks*). The frequency without controls of a steady-state flammable gas deflagration in the slurry tank or water separator are qualitatively determined to be "anticipated."

Induced and spontaneous GRE flammable gas hazards are also postulated in the vacuum system slurry tank and water separator. In one postulated scenario, flammable gases retained in the SST waste are vacuumed into the slurry tank or water separator. However, considering the retained gas characteristics in the SST waste and the inherent dilution that occurs during the vacuum retrieval process, the frequency of this accident scenario was qualitatively estimated as "extremely unlikely." Induced and spontaneous GREs from waste present in the slurry tank and water separator were also postulated. Because any retained gas originally present in the SST waste is released as it is vacuumed into the vacuum retrieval system, it was qualitatively determined to be "extremely unlikely" that waste present in the slurry tank or water separator could build up sufficient retained gas that if suddenly released could cause a flammable gas hazard (i.e., a flammable gas concentration in the slurry tank or water separator exceeding 100% of the LFL).

The consequences of a flammable deflagration in the aboveground vacuum retrieval system slurry tank or water separator are qualitatively determined to be bounded by the representative SST flammable gas deflagration accident. In making this determination, the following factors were considered.

- The quantity of respirable tank waste released by an SST flammable gas deflagration bounds that from a flammable gas deflagration in an aboveground tank because:

  - The estimated releases for the representative SST flammable gas deflagration accident are assumed to be directly to the environment (i.e., there is no reduction in the release assumed because the SSTs are located underground)

  - For the SST dome collapse scenarios, the estimated SST releases are dominated by releases from debris, included soil, falling back on the waste in the tank. This release mechanism is not applicable for aboveground tanks

  - The material at risk (MAR) is smaller for an aboveground tank, and the aboveground flammable gas deflagration involves less energy than an SST deflagration because the tank headspace (i.e., volume of hydrogen) is smaller.

- The waste in aboveground tanks is generally diluted with water, therefore, reducing the ULD and SOF values. The waste surface in an aboveground tank is also generally a liquid versus a solid and, therefore, the applicable ULD for a flammable gas deflagration is a liquid which is significantly lower than the saltcake or sludge ULD.

- The lower atmospheric dispersion coefficients developed to account for the rapid venting of SST releases are not applicable for the aboveground tanks. However, the largest difference in the ground level, point source versus rapid venting (i.e., volume release) atmospheric dispersion coefficients used in the SST flammable gas deflagration consequence calculations is less than a factor of 10.

Based on the above estimated frequency and consequences, the resultant risk bins for steady-state and GRE (induced and spontaneous) flammable gas deflagrations in the vacuum retrieval system slurry tank and water separator are presented in Tables 2-39 and 2-40, respectively.

Table 2-39. Risk Bins for a Steady-State Flammable Gas Deflagration in the Vacuum Retrieval System Slurry Tank or Water Separator.

Receptor	Frequency	Consequence	Risk bin
Onsite radiological	Anticipated	Moderate	I
Onsite toxicological		Moderate	I
Offsite toxicological		Low	III

Table 2-40. Risk Bins for a Gas Release Event Flammable Gas Deflagration in the Vacuum Retrieval System Slurry Tank or Water Separator.

Receptor	Frequency	Consequence	Risk bin
Onsite radiological	Extremely Unlikely	Moderate	III
Onsite toxicological		Moderate	III
Offsite toxicological		Low	IV

2.2.2.12.2 Demonstration Bulk Vitrification System Phase 1 Staging Tank

For Phase 1 of the Demonstration Bulk Vitrification System (DBVS) Project (see Section 2.2.2.12.3), waste retrieved from SST 241-S-109 is transferred to a 1,100 gal nominal capacity staging tank for sampling prior to transfer to the DBVS. Sampling is performed to limit the radionuclide inventory transferred to DBVS below the Hazard Category 3 threshold in DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*, for Phase 1 operations of the DBVS Project.

The potential for a steady-state flammable gas hazard in the DBVS Phase 1 staging tank is evaluated in RPP-CALC-23740, *Steady-State Flammability Evaluation of the Time to 25% and 100% of the Lower Flammability Limit on Demonstration Bulk Vitrification Systems Using Tank Waste of 241-S-109*. The evaluation assumed this nominal 1,100 gal capacity double-wall tank is fabricated from cross-linkable polyethylene (i.e., no hydrogen generation from corrosion), has an open passive breathing path with no isolation valve, and has a primary tank total enclosed volume of approximately 1,250 gal with an overflow line at approximately 850 gal. The results of the RPP-CALC-23740 evaluation showed that the flammable gas concentration in the tank headspace cannot approach 100% of the LFL. The frequency of a flammable gas deflagration due to the steady-state accumulation of flammable gas was, therefore, qualitatively determined to be "extremely unlikely." In addition, the steady-state flammable gas hazard from a postulated primary tank waste leak into the annulus was qualitatively determined to be "extremely unlikely" because there is no hydrogen generation from corrosion and the annulus is open to the atmosphere.

Induced and spontaneous GRE flammable gas hazards are also qualitatively determined to be "extremely unlikely." The basis for this determination is that the waste retrieved from SST 241-S-109 is not expected to contain solids. This precludes the formation of a settled solids layer in the DBVS Phase 1 staging tank where significant quantities of flammable gases could be retained that if released could achieve a flammable gas concentration in the tank headspace $\geq$ 100% of the LFL. Even without the cyclonic solids separator required by the DBVS *Permit for Dangerous and or Mixed Waste Research, Development, and Demonstration* (Permit No. WA 7890008967), solids are not expected in the retrieved SST 241-S-109 waste because the waste retrieval pumps are located within a saltwell screen and above the bottom sludge layer in the tank. In addition, the SST 241-S-109 retrieval process of dissolving saltcake with water distributed over the tank waste surface limits the solids in the retrieved waste.

For the reasons described in Section 2.2.2.12.1, the consequences of a flammable gas deflagration in the aboveground DBVS Phase 1 staging tank are qualitatively determined to be bounded by the representative SST flammable gas deflagration accident. The ULD and SOF values for the SST 241-S-109 waste in the Phase 1 staging tank versus those for representative SST flammable gas deflagration (see Section 2.2.1) are shown in Table 2-41. Note that the ULD and SOF values for the SST 241-S-109 waste in Table 2-41 do not consider planned pretreatment by selective dissolution to reduce the ^{137}Cs concentration or dilution with water that is inherent in the saltcake dissolution waste retrieval method.

Table 2-41. Representative Single-Shell Tank Flammable Gas Deflagration Accident Versus Single-Shell Tank 241-S-109 Waste Unit Liter Doses and Sum of Fractions Values. (2 sheets)

	Representative SST Flammable Gas Deflagration Accident	**SST 241-S-109**[a,b]
ULD (Sv/L)	1.0E+05	7.8E+01
SOF Value:		
TEEL-1	3.71E+09	7.97E+08
TEEL-2	6.28E+08	1.18E+08
TEEL-3	9.8E+07	7.03E+06

Table 2-41. Representative Single-Shell Tank Flammable Gas Deflagration Accident Versus Single-Shell Tank 241-S-109 Waste Unit Liter Doses and Sum of Fractions Values. (2 sheets)

Notes:
[a]RPP-5924, 2003, *Radiological Source Terms for Tank Farms Safety Analysis*, Rev. 4, CH2M HILL Hanford Group, Inc., Richland, Washington.
[b]RPP-8369, 2003, *Chemical Source Terms for Tank Farms Safety Analyses*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland Washington.
SOF = sum of fractions.
SST = single-shell tank.
ULD = unit liter dose.

Tables 2-42 and 2-43 show the resultant risk bins for steady-state and GRE flammable gas deflagrations in the DBVS Phase 1 staging tank, respectively, based on the above estimated frequencies and consequences.

Table 2-42. Risk Bins for a Steady-State Flammable Gas Deflagration in the Demonstration Bulk Vitrification System Phase 1 Staging Tank.

Receptor	Frequency	Consequence	Risk bin
Onsite radiological	Extremely Unlikely	Moderate	III
Onsite toxicological		Moderate	III
Offsite toxicological		Low	IV

Table 2-43. Risk Bins for a Gas Release Event Flammable Gas Deflagration in the Demonstration Bulk Vitrification System Phase 1 Staging Tank.

Receptor	Frequency	Consequence	Risk bin
Onsite radiological	Extremely Unlikely	Moderate	III
Onsite toxicological		Moderate	III
Offsite toxicological		Low	IV

2.2.2.12.3 Demonstration Bulk Vitrification System

The DBVS is a full-scale research and development facility to demonstrate bulk vitrification as a method for disposing low-activity waste (LAW) from the tank farms. The DBVS receives waste from SST 241-S-109 and converts it into immobilized glass for disposal at the Integrated Disposal Facility (IDF).

In the DBVS process, SST 241-S-109 waste is transferred into three double-wall waste staging tanks (approximately 18,000 gal) for process feed, storage, and sampling. From the waste staging tanks, the waste is fed into a waste dryer along with soil and additives necessary for vitrification. The waste in the waste dryer is dried under a vacuum using steam heat. The dried waste is then pneumatically transferred from the waste dryer to an In-Container Vitrification

(ICV)[2] container where the waste is vitrified by joule heating with installed electrodes. Off-gases from the ICV container during melting are treated prior to release to the atmosphere. Secondary waste generated by the off-gas treatment system and condensate recovered from the waste dryer vacuum exhaust are collected and shipped to the Effluent Treatment Facility (ETF).

The DBVS aboveground tanks where flammable gas hazards are possible include the waste staging tanks, the waste dyer, and condensate recovery system, off-gas treatment system, and secondary waste storage system tanks (i.e., the condensate receiver tank, condensate holding tanks, scrubber tanks, scrubber bleed tanks, and Tri-Mer effluent tanks). The frequency, consequences, and risk bins for flammable gas deflagrations in these DBVS tanks are presented below.

Waste Staging Tanks

The potential for a steady-state flammable gas hazard in the DBVS waste staging tanks is evaluated in RPP-CALC-23740. The evaluation assumed these double-wall tanks are carbon steel, but with the interior of the primary tank coated to prevent hydrogen generation from the corrosion of carbon steel. The primary waste staging tank is also assumed to have an open passive breathing path with no isolation valve. The results of the RPP-CALC-23740 evaluation show that with barometric breathing the flammable gas concentration can not achieve 100% of the LFL accept when the tank is > 98% full. The normal waste staging tank operating volume is approximately 13,000 gal (the volume of waste feed required for one ICV container) versus the approximate 18,000 gal tank capacity (at overflow). The frequency of a significant flammable gas deflagration due to the steady-state accumulation of flammable gas was, therefore, qualitatively determined to be "extremely unlikely." Because the carbon steel surfaces of the inner and outer annulus walls are carbon steel, the steady-state flammable gas hazard from a postulated primary tank waste leak into the annulus, the subsequent accumulation of flammable gas to 100% of the LFL, and ignition was qualitatively determined to be "unlikely."

Induced and spontaneous GRE flammable gas hazards in the DBVS waste staging tanks are qualitatively determined to be "extremely unlikely." The basis for this determination is that the waste retrieved from SST 241-S-109 is not expected to contain solids. This precludes the formation of a settled solids layer in the waste staging tanks where significant quantities of flammable gases could be retained that if released could achieve a flammable gas concentration in the tank headspace $\geq$ 100% of the LFL. Even without the cyclonic solids separator required by the environmental management program, solids are not expected in the retrieved SST 241-S-109 waste because the waste retrieval pumps are located within a saltwell screen and above the bottom sludge layer in the tank. In addition, the SST 241-S-109 retrieval process of dissolving saltcake with water distributed over the tank waste surface limits the solids in the retrieved waste. The waste transferred into the waste staging tanks is also sampled to verify that it does not exceed the 3% solids limit established in DBVS Permit No. WA 7890008967.

[2] ICV (In-Container Vitrification) is a trademark of AMEC, Inc., London, England.

For the reasons described in Sections 2.2.2.12.1 and 2.2.2.12.2, the consequences of a flammable gas deflagration in an aboveground DBVS waste staging tank are qualitatively determined to be bounded by the representative SST flammable gas deflagration accident.

Based on the above estimated frequencies and consequences, Tables 2-44, 2-45, and 2-46 show the resultant risk bins for steady-state flammable gas deflagrations in the DBVS waste staging primary tank and waste staging tank annulus, and GRE flammable gas deflagrations in the DBVS waste staging tanks, respectively.

Table 2-44. Risk Bins for a Steady-State Flammable Gas Deflagration in a Demonstration Bulk Vitrification System Waste Staging Tank.

Receptor	Frequency	Consequence	Risk bin
Onsite radiological	Extremely Unlikely	Moderate	III
Onsite toxicological		Moderate	III
Offsite toxicological		Low	IV

Table 2-45. Risk Bins for a Steady-State Flammable Gas Deflagration in a Demonstration Bulk Vitrification System Waste Staging Tank Annulus.

Receptor	Frequency	Consequence	Risk bin
Onsite radiological	Unlikely	Moderate	II
Onsite toxicological		Moderate	II
Offsite toxicological		Low	III

Table 2-46. Risk Bins for a Gas Release Event Flammable Gas Deflagration in a Demonstration Bulk Vitrification System Waste Staging Tank.

Receptor	Frequency	Consequence	Risk bin
Onsite radiological	Extremely Unlikely	Moderate	III
Onsite toxicological		Moderate	III
Offsite toxicological		Low	IV

Waste Dryer

The potential for a steady-state flammable gas hazard in the DBVS waste dryer is also evaluated in RPP-CALC-23740. The RPP-CALC-23740 evaluation assumed the waste dryer is stainless steel (i.e., limited hydrogen generation from corrosion) and performed parametric analyses assuming:

- Waste dryer fill fractions ranging from 0.1 to 0.9 (nominal case is 0.5)

- Percent water in the waste of 100% (bounding case), 10% (off-normal case), 2% (nominal case)
- Ambient waste temperature (77 °F) and elevated temperatures ranging from 140 °F (nominal case) up to 200 °F (bounding case).

During normal operation when steam is supplied to heat the waste, the waste dryer is under a vacuum and flammable gases can not accumulate in the headspace. (Note: Until the waste water content reaches zero, the present of moisture would also preclude a flammable gas deflagration.) But even assuming zero airflow at reasonably conservative off-normal conditions (e.g., 0.8 fill fraction, 10% water, and 160 °F), the time to achieve 100% of the LFL is approximately 250 days; an unrealistic scenario. At ambient temperature, 100% of the LFL can not be achieved assuming barometric breathing. If zero airflow is assumed at ambient temperature, the time to 100% of the LFL for bounding conditions (0.9 fill fraction and 100% water) is more than 1.5 yr. Based on the RPP-CALC-23740 results, the frequency of a steady-state flammable gas deflagration in the waste dryer is qualitatively determined to be "extremely unlikely." The frequency of a GRE flammable gas deflagration is also determined to be "extremely unlikely" because waste conditions required for flammable gas retention (i.e., undisturbed solids saturated with liquid) are not expected and the long time required in an off-normal condition to generate sufficient retained flammable gas to create a potential GRE hazard.

Based on an "extremely unlikely" frequency and the consequences of the bounding representative SST flammable gas deflagration accident, Table 2-47 shows the resulting risk bins for a flammable gas deflagration in the DBVS waste dryer.

Table 2-47. Risk Bins for a Flammable Gas Deflagration in the Demonstration Bulk Vitrification System Waste Dryer.

Receptor	Frequency	Consequence	Risk bin
Onsite radiological	Extremely Unlikely	Moderate	III
Onsite toxicological		Moderate	III
Offsite toxicological		Low	IV

Condensate Recovery System, Off-gas Treatment System, and Secondary Waste Storage System Tanks

Condensate from the waste dryer vacuum exhaust that is collected in the condensate recovery system condensate receiver tank and stored in two secondary waste storage system condensate holding tanks is expected to have radionuclide and chemical concentrations below those of waste classified as Waste (L). As described in RPP-13750, *Waste Transfer Leaks Technical Basis Document*, this will be verified during DBVS startup testing using SST 241-S-109 waste stimulant. Based on the condensate being below the Waste (L) criteria, the estimated frequency and consequences of a flammable gas deflagration in the condensate receiver tank or condensate holding tanks are qualitatively determined to be "unlikely" and "low," respectively.

Although the radionuclide concentration in the two off-gas treatment system scrubber tanks and secondary waste storage system scrubber bleed tanks (2) and Tri-Mer effluent tanks (2) is expected to be below the Waste (L) criteria (RPP-13750), the chemical concentration may exceed the toxicological criteria for Waste (L). However, based on the "low" estimated toxicological consequences of postulated off-gas treatment system leak accidents in RPP-13750, the consequences of a flammable gas deflagration in an off-gas treatment system tank is qualitatively determined to be "low." The frequency of an off-gas treatment system tank flammable gas deflagration is qualitatively determined to be "unlikely" because of the low expected hydrogen generation rates from radiolysis and thermolytic decomposition.

Table 2-48 shows the resulting risk bins for flammable gas deflagrations in condensate recovery system, off-gas treatment system, and secondary waste storage system tanks.

Table 2-48. Risk Bins for a Flammable Gas Deflagration in a Demonstration Bulk Vitrification System Condensate Recovery System, Off-Gas Treatment System, or Secondary Waste Storage System Tank.

Receptor	Frequency	Consequence	Risk bin
Onsite radiological	Unlikely	Low	III
Onsite toxicological		Low	III
Offsite toxicological		Low	III

Other Potential DBVS Flammable Gas Hazards

Because of the small hydrogen generation rate for dried waste (RPP-CALC-23740), the frequency of a flammable gas deflagration is qualitatively determined to be "extremely unlikely" in the piping and components of the dried waste transfer system (DWTS) used to pneumatically transfer the dried waste from the waste dryer to the ICV container and in the ICV container. The consequences of a flammable gas deflagration in the DWTS or ICV container is qualitatively determined to be bounded by the representative SST flammable gas deflagration accident. This is conservative, but accounts for the disperability of dried waste. Table 2-49 shows the resulting risk bins.

Table 2-49. Risk Bins for a Flammable Gas Deflagration in the Dried Waste Transfer System or In-Container Vitrification Container.

Receptor	Frequency	Consequence	Risk bin
Onsite radiological	Extremely Unlikely	Moderate	III
Onsite toxicological		Moderate	III
Offsite toxicological		Low	IV

Note: The frequency and consequences of a flammable gas deflagration in an ICV container post-melt are "beyond extremely unlikely" and "low" because all the water and organics are driven off during melting and because of the stabilized glass form, respectively.

The frequency, consequences, and risk bins for potential flammable gas hazards in DBVS waste-intruding equipment, if any and waste transfer lines are addressed in Sections 2.1.2.5 and 2.1.2.10, respectively. Risk binning for potential flammable gas hazards in DBVS waste transfer-associated structures (i.e., waste staging tank valve secondary containment housings, waste transfer pump skid, and waste dryer ISO container), are addressed in RPP-13354.

3.0 CONTROL SELECTION

A series of six formal control decision meetings were held to select safety-significant SSCs and/or TSRs for risk bins I and II flammable gas hazardous conditions during the initial DSA development. The control decision meetings were organized to address separately the steady-state and GRE flammable gas hazards. Attendance sheets are provided in Appendix C. Subsequently, control decision meetings have been held to support amendments to the DSA and TSRs (see Appendix D).

Controls were selected in accordance with control decision criteria established in:

- Title 10, *Code of Federal Regulations*, Part 830, Subpart B, "Nuclear Safety Management" (10 CFR Part 830)
- DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*
- DOE G 421.1-2, *Implementation Guide for Use in Developing Documented Safety Analyses to Meet Subpart B of 10 CFR 830*
- DOE G 423.1-1, *Implementation Guide for Use in Developing Safety Requirements*
- Klein and Schepens (2003), "Replacement of Previous Guidance Provided by RL and ORP."

The control decision preference applied at the meetings can be summarized as follows:

1. Preventive controls over mitigative controls.
2. Passive controls over active controls.
3. Engineering controls over administrative controls.
4. Controls with the highest reliability.
5. Controls closest to the hazard.

The cost of implementation and maintenance of available controls was also considered as part of control selection.

Table 3-1 provides a summary of the selected TSRs and their associated safety function. Human factors checklists for flammable gas accident controls are included in Appendix E. Defense-in-depth features have also been identified for some of the flammable gas representative hazardous conditions, and are described in RPP-14821, *Technical Basis Document for Defense-in-Depth Features*. Facility worker flammable gas hazardous conditions are evaluated for controls as documented in RPP-14286, *Facility Worker Technical Basis Document.*

Table 3-1. Summary of Technical Safety Requirements for Flammable Gas Accidents. (3 sheets)

Technical safety requirement	Safety function
Transfer Leak Detection Systems	To ensure the operability of the transfer leak detection systems, thus decreasing the frequency of a flammable gas accident (Note: The safety function of the safety-significant transfer leak detection systems is to detect the accumulation of waste leaked into a waste transfer-associated structure and to provide an alarm signal to initiate operator response, thus decreasing the frequency of a flammable gas accident)
DST Primary Ventilation Systems (Steady-State Controls)	To ensure the DST primary ventilation system is operable, thus decreasing the frequency of a flammable gas accident (Note: The safety function of the safety-significant DST primary ventilation systems is to maintain the concentration of flammable gases from steady-state releases below the LFL in the DST headspace, thus decreasing the frequency of a flammable gas accident)
SST Passive Ventilation Systems (Steady-State Controls)	To maintain the concentration of flammable gases from steady-state releases below the LFL in the SST headspace, thus decreasing the frequency of a flammable gas accident
Flammable Gas Controls – Steady-state hazard controls for non-DST/SST tank farm facilities	To decrease the frequency of a flammable gas accident
Flammable Gas Controls – Spontaneous gas release hazard controls	To decrease the frequency of a flammable gas accident
Flammable Gas Controls – Induced gas release hazard controls	To decrease the frequency of a flammable gas accident
Flammable Gas Controls – Waste-intruding equipment	To reduce the frequency of ignition sources, thus decreasing the frequency of a flammable gas accident
Flammable Gas Controls – Ignition source control requirements	To reduce the frequency of ignition sources, thus decreasing the frequency of a flammable gas accident
Flammable Gas Controls – DST and SST time to LFL determination	To ensure DST and SST waste conditions and characteristics are maintained within the analyzed conditions for the steady-state controls, thus decreasing the frequency of a flammable gas accident
Flammable Gas Controls – Waste gel prevention	To prevent the formation of waste gel, thus decreasing the frequency of a flammable gas accident

Table 3-1. Summary of Technical Safety Requirements for Flammable Gas Accidents. (3 sheets)

Technical safety requirement	Safety function
Emergency Preparedness	To verify that DST primary ventilation systems can perform their safety function following significant, relevant natural events (e.g., seismic events, high wind), thus decreasing the frequency of a flammable gas accident To decrease the consequences of a seismically-induced GRE flammable gas accident To take action for waste leaks into waste transfer-associated structures, DCRTs, active catch tanks, or DST or DBVS waste staging tank annuli to maintain the flammable gas concentration in the structures, DCRTs, active catch tanks, or DST or DBVS waste staging tank annuli below the LFL or to reduce the frequency of ignition sources, thus deceasing the frequency of a flammable gas accident.
Fire Protection	To protect vehicle fuel systems from leaks caused by collisions with tank structures and to prevent fuel leaks or spills into tanks during fueling activities, thus decreasing the frequency of a flammable as accident.
Transfer Controls – Operating Requirements • Material balance	To detect a waste leak or misroute into the annulus of a DST and alert operators to take actions, thus decreasing the frequency of a flammable gas accident
• DCRT and active catch tank level monitoring	To detect a waste leak into a DCRT or an active catch tank and alert operators to take actions, thus decreasing the frequency of a flammable gas accident
• Transfer leak alarm monitoring and response	To initiate operator response upon transfer leak detection system alarms, thus decreasing the frequency of a flammable gas accident
DBVS waste staging tank annulus leak detection systems	To ensure the operability of the DBVS waste staging tank annulus leak detection systems, thus decreasing the frequency of a flammable gas accident (Note: The safety function of the DBVS waste staging tank annulus leak detection systems is to detect a primary waste staging tank leak into the annulus and to provide an alarm signal to initiate operator response, thus decreasing the frequency of a flammable gas accident)
Design Features: • DBVS Phase 1 staging tank	The important attributes of the DBVS Phase 1 staging tank are cross-linkable polyethylene construction that prevents hydrogen generation by corrosion, a passive breathing path with no valve (primary tank and annulus), and a total enclosed primary tank volume of approximately 1,250 gal with an overflow line at approximately 850 gal
Design Features (also designated as safety-significant SSCs): • DBVS waste staging tanks	The safety function of the DBVS waste staging tanks is to maintain important design attributes that decrease the frequency of a flammable gas accident. These important design attributes are a passive breathing path with no valve and interior coating of the primary tank that prevents hydrogen generation by corrosion.
Design Features (also designated as safety-significant SSCs): • DBVS waste dryer	The safety function of the DBVS waste dryer is to maintain the important design attributes that decrease the frequency of a flammable gas accident. The important design attribute is construction from stainless steel that minimizes hydrogen generation by corrosion.

Table 3-1. Summary of Technical Safety Requirements for Flammable Gas Accidents. (3 sheets)

Technical safety requirement	Safety function

Notes:
DBVS = Demonstration Bulk Vitrification System.
DCRT = double-contained receiver tank.
DST = double-shell tank.
GRE = gas release event.
HEPA = high-efficiency particulate air (filter).
LFL = lower flammability limit.
SSC = structures, systems, and components.
SST = single-shell tank.

3.1 CONTROL SELECTION FOR THE STEADY-STATE FLAMMABLE GAS HAZARD

This section addresses control selection for the steady-state flammable gas hazard. Two documents, i.e., RPP-5926 and RPP-8050, analyze the flammable gas hazard in selected tank farm facilities and were used in support of the control selection process. These documents calculate the times to 25% and 100% of the LFL based on assumptions and input parameters related to waste characteristics and tank ventilation conditions. The sensitivity of the assumptions and input parameters used in these documents was assessed to determine whether or not protection of a given assumption or input parameter was required. Tables 3-2 and 3-3 present the results of the assessment for RPP-5926 and RPP-8050, respectively.

Table 3-2. Sensitivity of Control Decision Analytical Assumptions and Input Parameters. (3 sheets)

Analysis assumption (AA)/input parameter and basis	Assumption type	Sensitivity	Need to protect AA	Protection basis
Input Parameter: DST and SST tank waste characteristics. Based on best-basis inventory data. The tank waste characteristics used in RPP-5926 include: (1) concentration of total organic carbon, nitrate ion, nitrite ion, and aluminate in the liquid phase (2) cesium and strontium concentration (3) weight-percent water	Best estimate	(1) TOC data are used as an indicator of organic species because *organic species provide the source term for thermolysis and* organic radiolysis. Nitrate and nitrite concentrations are used to estimate the scavenger effects for radiolysis of pure water. Aluminate is a catalyst in the thermal-chemical reaction and its *concentration is used in the thermolysis rate calculation.* (2) Cesium and strontium concentrations are used to estimate the head load of the tank waste, which is the power source for both water and organic radiolysis. (3) Weight-percent water data are used to estimate the liquid fraction of the waste because the model considers gas generation reactions occur more effectively in the liquid phase. Tank waste characteristics are based on best-basis inventory data. New sampling results or changes in tank waste inventories could result in different characteristics and potentially higher flammable gas generation rates than currently analyzed in RPP-5926, which forms the basis for surveillance frequencies and action statement completion times.	Yes	USQ Process
Input Parameter: Tank waste volume and densities. Based on best-basis inventory data.	Best estimate	The tank waste volume and densities are used to calculate the total mass of waste and to estimate wetted surface area for calculating corrosion rates. Increasing the total mass of waste and increasing the wetted surface area increases the flammable gas generation rate. The tank waste volume also determines the tank headspace volume. Increasing the waste volume decreases the headspace volume such that the LFL is reached in a shorter period of time. Tank waste volume and densities are based on best-basis inventory data. New sampling results or changes in tank waste inventories (i.e., waste transfers into DSTs) could result in larger waste volumes and wetted surface areas than are currently analyzed in RPP-5926.	Yes	TFC Procedures

Table 3-2. Sensitivity of Control Decision Analytical Assumptions and Input Parameters. (3 sheets)

Analysis assumption (AA)/input parameter and basis	Assumption type	Sensitivity	Need to protect AA	Protection basis
Input Parameter: Initial tank waste temperature. For SSTs, based on SACS, applied maximum tank waste temperatures over a 1-yr period (to cover seasonal effects). For DSTs, based on maximum tank waste temperature over a 1-yr period plus 5 °C is applied to account for potential increasing temperature trends.	Best estimate	The tank waste temperature is needed to calculate the radiolysis G value and to account for the Arrhenius behavior of the thermolysis rate. The sensitivity of this assumption is a function of the tank waste characteristics. Higher initial tank waste temperatures could result in higher flammable gas generation rates than currently analyzed in RPP-5926, which forms the basis for surveillance frequencies and action statement completion times.	Yes	TFC Procedures
Assumption: RPP-5926 assumes a 10,000 gal water addition to DSTs and 100-series SSTs and 1,000 gal for 200-series SSTs. This is intended to account for routine activities that add water to DSTs and SSTs (e.g., transfer line flushes, rinsing of equipment).	Reasonably conservative	The addition of water reduces the tank headspace volume such that the LFL is reached in a shorter period of time. Additions greater than 10,000 gal (1,000 gal for 200-series SSTs) will require an evaluation of the tank end-state to ensure surveillance frequencies and action statement completion times are still limiting	Yes	TFC Procedures
Assumption: For DSTs, it is assumed that the tank waste temperature increases on loss of ventilation due to loss of cooling provided by the ventilation. Analyses in RPP-5926 base this temperature rise on modeling assumptions applied to the tank bump accident analysis.	Reasonably conservative	Only a factor for high heat load tanks.	No	N/A
Assumption: It is assumed that zero ventilation conditions exist in SSTs and DSTs (DSTs are normally provided with active ventilation and SSTs are normally provided with passive ventilation). RPP-5926 analyzes two off normal conditions, barometric breathing and zero ventilation. The zero ventilation condition results in the most limiting times to LFL.	Bounding (theoretical facility configuration)	N/A	No	N/A

Table 3-2. Sensitivity of Control Decision Analytical Assumptions and Input Parameters. (3 sheets)

Analysis assumption (AA)/input parameter and basis	Assumption type	Sensitivity	Need to protect AA	Protection basis

Notes:

RPP-5926, 2005, *Steady-State Flammable Gas Release Rate Calculation and Lower Flammability Level Evaluation for Hanford Tank Waste*, Rev. 4-A, CH2M HILL Hanford Group, Inc., Richland, Washington.

AA = analysis assumption.
DST = double-shell tank.
LFL = lower flammability limit.
N/A = not applicable.
SACS = Surveillance Analysis Computer System.
SST = single-shell tank.
TFC = Tank Farm Contractor.
TOC = total organic carbon.
USQ = unreviewed safety question.

Table 3-3. Sensitivity of Control Decision Analytical Assumptions and Input Parameters. (2 sheets)

Analysis assumption (AA)/input parameter and basis	Assumption type	Sensitivity	Need to protect AA	Protection basis
Active Catch Tanks				
Assumption: For active catch tanks, RPP-8050 assumes barometric breathing.	Reasonably Conservative	Under zero ventilation conditions, *small volumes of waste will* eventually reach the LFL.	Yes	TFC Procedures
Assumption: For active catch tanks, RPP-8050 assumes a maximum fill fraction of 0.80 in the calculation that uses current liquid waste content to derive the hydrogen generation rate.	Reasonably Conservative	Higher fill fractions will decrease the time to LFL and/or allow the flammable gas concentration to reach the LFL with barometric breathing. (Note: Based on environmental requirements to maintain active catch tank space available for waste transfers, the allowable operational fill volume for active catch tanks *is limited to 80%, except for catch tanks* 241-A-350 and 241-AZ-151, where the normal limit is 70%.)	Yes	TFC Procedures
Inactive Miscellaneous Underground Storage Tanks				
The IMUST flammability analysis presented in RPP-8050 was not directly used to support the control decision process. Therefore, the control decisions are not sensitive to the analysis assumptions.				
Double-Shell Tank Annuli				
Assumption: It is assumed that barometric breathing conditions exist in DST annuli.	Reasonably conservative	Under the barometric breathing assumption, it takes *> 30,000 gal of waste in the annulus to reach 100%* of the LFL. Under zero ventilation conditions, small volumes of waste will eventually reach the LFL. However, calculations indicate that under zero ventilation conditions the time to reach 100% of the LFL for small waste leaks (i.e., 8,000 gal) is very long (e.g., > 4 yr). Therefore, even under zero flow conditions, the volume of waste required to present a flammable gas hazard is detectable by tank level monitoring.	No	N/A
Assumption: It is assumed *that the* waste in the annulus is comprised of raw waste, i.e., that the liquids and *solids are present in the annulus in* the same ratio as in the tank.	*Reasonably* conservative	*If a higher* percentage of sludge was present in the annulus, the times to LFL would be shortened if the hydrogen generation rate due to radiolysis is higher for the sludge than for the supernatant	No	N/A

Table 3-3. Sensitivity of Control Decision Analytical Assumptions and Input Parameters. (2 sheets)

Analysis assumption (AA)/input parameter and basis	Assumption type	Sensitivity	Need to protect AA	Protection basis
Double-Contained Receiver Tank				
Assumption: It is assumed that zero ventilation conditions exist in DCRTs. DCRTs are normally *provided with active ventilation.* RPP-8050 analyzes a zero ventilation condition that results in the most limiting times to LFL.	Bounding (theoretical facility configuration)	N/A	No	N/A
Assumption: In RPP-8050, the unit flammable gas generation rate of waste in the DCRTs is based on sample data and/or best-basis inventory data.	Best estimate	Purge air at a flow rate of 2 ft^3/hr for DCRT 244-BX and 1 ft^3/hr for DCRTs 244-S and 244-TX is adequate to maintain flammable gas concentrations below 25% of the LFL based on assumed tank waste characteristics. The DCRTs are being taken out of service and there are no planned waste transfers to DCRTs.	Yes	TFC Procedures
Assumption: In RPP-8050, DCRTs are assumed to be 80% full.	Reasonably conservative	If the tanks are more than 80% full, the times to 100% of the LFL assuming zero ventilation decrease, e.g.: 244-BX: 80% full = 331 days to the LFL, 90% = 148 days to the LFL	Yes	TFC Procedures

Notes:

RPP-5926, 2005, *Steady-State Flammable Gas Release Rate Calculation and Lower Flammability Level Evaluation for Hanford Tank Waste*, Rev. 4-A, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-8050, 2005, *Lower Flammability Limit Calculation for Catch Tanks, IMUST, DST Annuli, Pit Structures and Double-Contained Receiver Tanks in Tank Farms at the Hanford Site*, Rev. 4-A, CH2M HILL Hanford Group, Inc., Richland, Washington.

AA = analysis assumption.
DCRT = double-contained receiver tank.
DST = double-shell tank.
IMUST = inactive miscellaneous underground storage tank.
LFL = lower flammability limit.
N/A = not applicable.
SST = single-shell tank.
TFC = Tank Farm Contractor.

The following sections present the proposed and selected controls for the steady-state flammable gas hazard associated with DSTs, DST annuli, SSTs, DCRTs, active catch tanks, inactive tanks, Diversion Box 6241-A/Vent Station 6241-V, gasoline, waste-intruding equipment, and SST retrieval/closure aboveground tanks.

3.1.1 Double-Shell Tanks

3.1.1.1 Proposed Controls to Prevent DST Steady-State Flammable Gas Accidents

Option 1. Specifically credit active headspace ventilation systems with maintaining flammable gas concentrations < 25% of the LFL.

- Designate DST active ventilation systems as safety-significant SSCs.
- Prepare a limiting condition for operation (LCO) with defined mode and process area applicability, surveillance frequencies, required actions, and action statement completion times.
- Surveillance frequencies and action statement completion times based on times to 100% of the LFL as calculated in RPP-5926.

This is essentially the control strategy that has been previously applied. Flammable gas monitoring data collected to date document that active ventilation maintains steady-state flammable gas concentrations well below 25% of the LFL.

Option 2. Credit headspace ventilation (either passive or active) with maintaining flammable gas concentrations < 25% of the LFL, verify adequacy of ventilation via flammable gas monitoring.

- Prepare an administrative control (AC) TSR (e.g., flammable gas control program) requiring periodic monitoring of tank headspace to verify flammable gas concentrations are < 25% of the LFL.
- Key program elements of the AC would identify required actions and completion times if concentrations > 25% of the LFL were detected.
- Alternatively, key program elements could be documented in HNF-IP-1266, *Tank Farms Operations Administrative Controls*.
- No specific ventilation system configuration explicitly credited, therefore, no SSCs are designated as safety-significant. As documented in RPP-5926, some DSTs do not reach 100% of the LFL under barometric breathing conditions, passive ventilation is adequate to maintain some DSTs below 25% of the LFL.

Option 3. Provide active headspace ventilation to maintain flammable gas concentrations < 25% of the LFL or periodically monitor to verify that the flammable gas concentration is < 25% of the LFL.

This is a combination of Options 1 and 2, does not require performance of periodic monitoring if active ventilation systems are operable, and does not require active ventilation if periodic monitoring verifies flammable gas concentrations are < 25% of the LFL.

Option 4. Perform periodic monitoring to verify the flammable gas concentration is < 25% of the LFL and credit active ventilation as being available.

- Prepare an AC TSR requiring periodic monitoring of the tank headspace to verify flammable gas concentrations are < 25% of the LFL.
- Prepare an LCO requiring the active ventilation system to be operable. Define operable as "capable of providing adequate ventilation."

This option is analogous to the control strategy previously applied to the DST 241-AY-102 annulus ventilation system.

Option 5. Credit passive ventilation with maintaining flammable gas concentrations < 25% of the LFL.

- Maintain a defined passive ventilation flow path.
- Perform periodic flammable gas monitoring to collect sufficient data to verify that passive ventilation is adequate to maintain flammable gas concentrations < 25% of the LFL, subsequently eliminate monitoring requirement.

Option 6. Follow the National Fire Protection Association (NFPA) code requirements (e.g., < 25% of the LFL, explosion proof equipment, no ignition sources in the tank).

Option 7. Credit standby active ventilation (either permanently installed or portable).

3.1.1.2 Proposed Controls to Protect Double-Shell Tank Analytical Assumptions

Flammable gas generation rates and flammability evaluations documented in RPP-5926 are based on best-basis inventory (BBI) data as of a specific date. Waste transfers, water additions, and chemical additions can potentially increase flammable gas generation rates and reduce the headspace volume in which flammable gases collect. The analyses in RPP-5926 also base the tank waste temperature on historical data. The following options were discussed relative to possible controls to protect key analytical assumptions regarding waste volume and characteristics.

Option 1. Evaluate each planned waste transfer, water addition, or chemical addition to determine impact on RPP-5926 analyses.

- Prepare an AC TSR requirement to verify prior to waste transfers or chemical additions that the minimum time from 25% to 100% of the LFL remains greater than the bounding condition analyzed in RPP-5926.

This is essentially the control strategy that has been previously applied with the requirement being a key element of the waste compatibility program.

Option 2. Periodically evaluate DSTs to verify that times in RPP-5926 remain bounding.

The following options were discussed relative to possible controls to protect key analytical assumptions regarding tank waste temperature (note: mixer pump operation is not currently authorized):

Option 1. Periodically review tank waste temperature data to detect increasing tank waste temperature trends.

- Prepare an AC TSR requirement to periodically review tank waste temperature data.

Option 2. Specifically credit DST ventilation systems with maintaining tank waste temperatures within analyzed values.

- Designate DST ventilation systems as safety-significant SSCs.
- Prepare an LCO with defined mode and process area applicability, surveillance frequencies, required actions, and action statement completion times.

Option 3. Revise RPP-5926, calculate flammable gas generation rates based on steady-state tank waste temperatures assuming no ventilation.

- Radiolysis and thermolysis function of the waste temperature to the third power.
- Will result in shorter times to 25% and 100% of the LFL with corresponding impacts to periodic monitoring frequencies, surveillances frequencies, and action statement completion times.

3.1.1.3 Selected Controls to Prevent Double-Shell Tank Steady-State Flammable Gas Accidents

The selected control to prevent steady-state flammable gas deflagrations in DSTs is an LCO requiring the primary tank ventilation system to be operable (i.e., operating) except for outages not to exceed 24 hr. It was the consensus of the control decision team that primary tank ventilation systems should be designated as safety-significant SSCs. The selected control requires the following surveillances: (1) surveillances to verify the primary tank ventilation system is operable (this could be accomplished in different ways at different DST tank farms depending on the ventilation system design), or (2) periodic monitoring of the flammable gas concentration to verify it is ≤ 25% of the LFL. It was the consensus of the control decision team that instruments used to perform flammable gas monitoring should not be safety-significant SSCs but should meet the requirements of the AC addressing tank farm installed instrumentation.

3.1.1.4 Selected Controls to Protect Double-Shell Tank Analytical Assumptions

The selected control to protect analytical assumptions is an AC addressing DST time to LFL determinations.

The selected control requires periodic (not to exceed annually) confirmation of the completion times and surveillance frequencies associated with the DST ventilation LCO.

3.1.2 Double-Shell Tank Annuli

As discussed in Section 2.1.2.3, waste can conceivably enter a DST annulus in two ways: (1) a leak from the primary tank, or (2) a misrouting of a waste transfer into the annulus. The following sections address controls for leaks from the primary tank. Controls to prevent the misrouting of waste are documented in RPP-13750 (i.e., material balance).

3.1.2.1 Proposed Controls to Prevent Double-Shell Tank Annuli Steady-State Flammable Gas Accidents

Option 1. Specifically credit the annulus leak detection system (either conductivity probe or buoyancy type instrument) or the annulus continuous air monitor (CAM) system with detecting the presence of waste in the annulus.

- Designate these systems as safety-significant SSCs.
- Prepare an LCO with defined mode and process area applicability, surveillance frequencies, required actions, and action statement completion times.
- Surveillance frequencies and action statement completion times based on time to 100% of the LFL as calculated by RPP-8050.

This option is essentially the control strategy that has been previously applied.

Option 2. Same as Option 1, but specifically credit the annulus leak detection system only.

This option was the control strategy agreed upon at control decision meetings held in May 2001 in support of control optimization efforts.

Option 3. Provide annulus leak detection to detect presence of waste in annulus, periodically verify that the system is operable and not alarming.

- Prepare an AC TSR requiring periodic verification.
- Key program elements of the AC would identify required actions and completion times if the leak detection system was inoperable or alarming.
- Alternatively, key program elements could be documented in HNF-IP-1266.

Option 4. Credit the environmental protection/regulatory compliance program.

- Consent decree establishes regulatory requirements for primary tank leak detection that include both the conductivity probe or buoyancy type instruments and the annulus CAM system.

Option 5. Periodically monitor the flammable gas concentration in the annulus.

Option 6. Periodically monitor the primary tank level.

3.1.2.2 Proposed Controls to Protect Double-Shell Tank Annuli Analytical Assumptions

It was proposed, and the control decision team concurred, that a control to protect analytical assumptions was not required. This decision was based on the fact that assumptions related to waste types and volumes in RPP-8050 are reasonably conservative, and that calculations assuming zero ventilation show that, for relatively small leaks (i.e., approximately 8,000 gal), the times to LFL are sufficiently long (i.e., > 4 yr) that the zero ventilation condition can reasonably be disregarded.

3.1.2.3 Selected Controls to Prevent Double-Shell Tank Annuli Steady-State Flammable Gas Accidents

The selected control to prevent steady-state flammable gas accidents in DST annuli is either the implementation of a concentration control point of ≤ 25% of the LFL or the implementation of ignition controls at all times. If selected, flammable gas concentration controls shall be monitored on a frequency to ensure that appropriate actions are taken for conditions > 25% of the LFL.

Any combination of controls may be used to remain ≤ 25% of the LFL. Based on calculations in RPP-8050, given barometric breathing conditions, one acceptable means of meeting the concentration control point is primary tank waste level monitoring.

3.1.3 Single-Shell Tanks

3.1.3.1 Proposed Controls to Prevent Single-Shell Tank Steady-State Flammable Gas Accidents

Option 1. Specifically credit passive ventilation systems (i.e., breather filter isolation valve open) with maintaining flammable gas concentrations < 25% of the LFL.

- Designate SST passive ventilation systems (i.e., isolation valves) as safety-significant SSCs.

- Prepare an LCO with defined mode and process area applicability, surveillance frequencies, required actions, and action statement completion times.

- Surveillance frequencies and action statement completion times based on time to 100% of the LFL as calculated by RPP-5926.

This is essentially the control strategy that has been previously applied. Flammable gas monitoring data collected to date documents passive ventilation maintains steady-state flammable gas concentrations well below 25% of the LFL.

Option 2. This option is the same as Option 1, but without designating isolation valve as a safety-significant SSC.

- The requirement is simply that the valve be open thereby providing a known pathway for passive ventilation.

Option 3. Specifically credit passive ventilation systems (i.e., breather filter isolation valve open) with maintaining flammable gas concentrations < 25% of the LFL.

- Prepare an AC TSR (e.g., flammable gas control program) requiring periodic verification that the breather filter isolation valve is open.
- Key program elements of the AC would identify required actions and completion times if isolation valve found closed.
- Alternatively, key program elements could be documented in HNF-IP-1266.

Option 4. Credit headspace ventilation (either passive or barometric breathing) with maintaining flammable gas concentrations < 25% of the LFL, verify adequacy of ventilation via flammable gas monitoring.

- Prepare an AC TSR (e.g., flammable gas control program) requiring periodic monitoring of tank headspace to verify flammable gas concentrations are < 25% of the LFL.
- Key program elements of the AC would identify required actions and completion times if concentrations > 25% of the LFL were detected.
- Alternatively, key program elements could be documented in HNF-IP-1266.

Option 5. Provide passive headspace ventilation to maintain flammable gas concentrations < 25% of the LFL <u>or</u> periodically monitor the flammable gas concentration to verify the flammable gas concentration is < 25% of the LFL.

- This is a combination of Options 1 and 4, and does not require performance of periodic monitoring if passive ventilation systems are operable (e.g., isolation valve open).

Option 6. Re-analyzed flammability taking credit for hydrogen diffusion through the concrete dome.

- Calculations could potentially demonstrate that 100% of the LFL cannot be reached even under zero ventilation conditions.

3.1.3.2 Proposed Controls to Protect Single-Shell Tank Analytical Assumptions

At the control decision meeting, it was proposed that no protection of analytical assumptions was required because the analysis in RPP-5926 assumes zero ventilation, and because there are no currently authorized activities that could result in an increase in the flammable gas generation rate. It was subsequently proposed that SSTs be periodically evaluated to verify that times in RPP-5926 remain bounding.

3.1.3.3 Selected Controls to Prevent Single-Shell Tank Steady-State Flammable Gas Accidents

The selected control to prevent steady-state flammable gas deflagrations in SSTs is an LCO requiring either that the HEPA breather filter isolation valve is open or verification that the tank headspace flammable gas concentration is ≤ 25% of the LFL. It was the consensus of the control decision team that the isolation valve should not be designated as a safety-significant SSC as the requirement was simply that the valve be open. It was further discussed that the valve may be closed for planned activities (e.g., maintenance, filter testing) for a time period judged to be a small fraction of the time required for the flammable gas concentration to increase by 25% of the LFL. The selected control requires only one surveillance, i.e, verification that the valve is open (i.e., the valve handle is in the fully open position) or verification that the flammable gas concentration is ≤ 25% of the LFL. The frequency of performing this surveillance should be based on the time it takes for the flammable gas concentration to increase by 25% of the LFL (as documented in RPP-5926).

3.1.3.4 Selected Controls to Protect Single-Shell Tank Analytical Assumptions

The selected control requires periodic (not to exceed annually) confirmation of the completion times and surveillance frequencies associated with the SST ventilation LCO.

3.1.4 Double-Contained Receiver Tanks

3.1.4.1 Proposed Controls to Prevent Double-Contained Receiver Tank Steady-State Flammable Gas Accidents

Option 1. Specifically credit DCRT purge air systems with maintaining flammable gas concentrations < 25% of the LFL.

- Designate DCRT purge air systems as safety-significant SSCs.
- Prepare an LCO with defined mode and process area applicability, surveillance frequencies, required actions, and action statement completion times.
- Surveillance frequencies and action statement completion times based on time to 100% of the LFL as calculated by RPP-4941.

This is essentially the control strategy that has been previously applied.

Option 2. Credit purge air systems with maintaining flammable gas concentrations < 25% of the LFL.

- Prepare an AC TSR (e.g., flammable gas control program) requiring periodic verification that the inlet air supply is adequate.
- Key program elements of the AC would identify required actions and completion times if isolation valve found closed.
- Alternatively, key program elements could be documented in HNF-IP-1266.

Option 3. Credit purge air systems or passive ventilation with maintaining flammable gas concentrations < 25% of the LFL, verify adequacy of ventilation via flammable gas monitoring.

- Prepare an AC TSR (e.g., flammable gas control program) requiring periodic monitoring of DCRT headspace to verify flammable gas concentrations are < 25% of the LFL.
- Key program elements of the AC would identify required actions and completion times if concentrations > 25% of the LFL were detected.
- Alternatively, key program elements could be documented in HNF-IP-1266.

3.1.4.2 Proposed Controls to Protect Double-Contained Receiver Tank Analytical Assumptions

At the control decision meeting, it was proposed that no protection of analytical assumptions was required because the assumptions in RPP-4941, *Methodology for Predicting Flammable Gas Mixtures in Double-Contained Receiver Tanks*, related to waste characteristics and volumes were reasonably conservative, and because no efforts have been made to isolate the tanks such that the barometric breathing assumption was reasonable. It was subsequently proposed that calculations in RPP-4941 be replaced with new calculations documented in RPP-8050 that assume zero ventilation and apply revised waste compositions. It was further proposed that the assumed waste level in the tanks (which affects both the flammable gas generation rate and headspace volume) be protected.

3.1.4.3 Selected Controls to Prevent Double-Contained Receiver Tank Steady-State Flammable Gas Accidents

The selected control to prevent steady-state flammable gas accidents in DCRTs is either the implementation of a concentration control point of ≤ 25% of the LFL or the implementation of ignition controls at all times. If selected, flammable gas concentration controls shall be monitored on a frequency to ensure that appropriate actions are taken for conditions > 25% of the LFL.

Any combination of controls may be used to remain ≤ 25% of the LFL. One acceptable means of meeting the concentration control point is to provide a purge airflow rate of 2 ft^3/h to DCRT

244-BX and 1 ft^3/h to DCRTs 244-S and 244-TX. Calculations in RPP-8050 demonstrate that these rates are adequate to maintain flammable gas concentrations below 25% of the LFL. It was also the consensus that the DCRT purge air systems be designated as safety-significant for this control. The safety function of the DCRT purge air system is to maintain the concentration of flammable gas from steady-state releases below the LFL in the DCRT headspace, thus decreasing the frequency of a flammable gas accident.

3.1.4.4 Selected Controls to Protect Double-Contained Receiver Tank Analytical Assumptions

No controls were selected to protect analytical assumptions, but Table 3-3 identifies analytical assumptions that are protected by TFC procedures.

3.1.5 Active Catch Tanks

3.1.5.1 Proposed Controls to Prevent Active Catch Tank Steady-State Flammable Gas Accidents

Option 1. Periodically monitor the waste level in catch tanks.

- Establish an AC TSR (e.g., catch tank level monitoring program) that requires periodic monitoring of waste levels.
- If the level exceeds that at which flammable gas could accumulate to 100% of the LFL, then periodically monitor flammable gas concentration to verify < 25% of the LFL or take actions that prevent the flammable gas concentration from exceeding the LFL (e.g., provide active ventilation, transfer waste out of tank).

This was the control strategy agreed upon at control decision meetings held in May 2001 in support of control optimization efforts.

Option 2. Provide adequate ventilation (either active or passive) to maintain flammable gas concentrations < 25% of the LFL.

- Designate ventilation systems as safety-significant SSCs.
- Prepare an LCO with defined mode and process area applicability, surveillance frequencies, required actions, and action statement completion times.
- Surveillance frequencies and action statement completion times based on time to 100% of the LFL as calculated by RPP-8050.

Option 3. Periodically monitor the flammable gas concentration to verify concentrations are < 25% of the LFL.

- Prepare an AC TSR requiring periodic monitoring of tank headspace to verify flammable gas concentrations are < 25% of the LFL.

- Key program elements of the AC would identify required actions and completion times if concentrations > 25% of the LFL were detected.
- Alternatively, key program elements could be documented in HNF-IP-1266.

3.1.5.2 Proposed Controls to Protect Active Catch Tank Analytical Assumptions

At the control decision meeting, it was proposed that no protection of analytical assumptions was required because the analysis in RPP-8050 related to waste characteristics and volumes were reasonably conservative, and because no efforts have been made to isolate the tanks such that the barometric breathing assumption was reasonable. It was subsequently proposed that the barometric breathing assumption be protected. If less than barometric breathing is provided, the LFL could be reached for lower waste levels.

3.1.5.3 Selected Controls to Prevent Active Catch Tank Steady-State Flammable Gas Accidents

The selected control to prevent steady-state flammable gas accidents in active catch tanks is either the implementation of a concentration control point of ≤ 25% of the LFL or the implementation of ignition controls at all times. Any combination of controls may be used to remain ≤ 25% of the LFL. Flammable gas concentration controls shall be monitored on a frequency to ensure that appropriate actions are taken for conditions > 25% of the LFL.

3.1.5.4 Selected Controls to Protect Active Catch Tank Analytical Assumptions

No controls were selected to protect analytical assumptions, but Table 3-3 identifies analytical assumptions that are protected by TFC procedures.

3.1.6 Inactive Tanks

3.1.6.1 Proposed Controls to Prevent Inactive Tank Steady-State Flammable Gas Accidents

Option 1. Provide (or verify) adequate ventilation to maintain flammable gas concentrations < 25% of the LFL.

- Designate ventilation systems as safety-significant SSCs.
- Prepare LCOs with defined mode and process area applicability, surveillance frequencies, required actions, and action statement completion times.
- Surveillance frequencies and action statement completion times to be based on time to 100% of the LFL.

This option requires flammability evaluations to define adequate ventilation.

Option 2. Apply ignition source controls and monitor the flammable gas concentration to verify concentrations are < 25% of the LFL.

- Apply ignition source controls to permanently installed equipment and activity-related equipment and material (until entry monitoring requirements are satisfied).

- Prepare an AC TSR requiring monitoring of tank headspace to verify flammable gas concentrations are < 25% of the LFL prior to commencing manned work activities.

- Key program elements of the AC would identify required actions and completion times if concentrations > 25% of the LFL were detected.

- Alternatively, key program elements could be documented in HNF-IP-1266.

Option 3. Require adequate ventilation or apply ignition and monitoring controls as compensatory measures until ventilation is provided or verified.

3.1.6.2 Proposed Controls to Protect Inactive Tank Analytical Assumptions

At the control decision meeting, it was proposed that no protection of analytical assumptions was required because the proposed controls were not based on any specific analyses. It was subsequently proposed that transfers of any material into or within the 244-CR Vault be prohibited to protect the assumption that the tanks in the vault are inactive.

3.1.6.3 Controls Selected to Prevent Inactive Tank Steady-State Flammable Gas Accidents

The selected control to prevent steady-state flammable gas accidents in inactive tanks is either the implementation of a concentration control point of ≤ 25% of the LFL or the implementation of ignition controls at all times. Any combination of controls may be used to remain ≤ 25% of the LFL. The flammable gas concentrations controls shall be monitored on a frequency to ensure that appropriate actions are taken for conditions > 25% of the LFL.

3.1.6.4 Controls Selected to Protect Inactive Tank Analytical Assumptions

No controls were selected to protect analytical assumptions.

3.1.7 Diversion Box 6241-A/Vent Station 6241-V

As discussed in Section 2.2.2.10, a flammable gas hazard potentially exists in Diversion Box 6241-A and Vent Station 6241-V given a transfer line failure that results in the accumulation of a large volume of waste. It was proposed, and the control decision team concurred, that transfer controls for the detection of waste leaks (as documented in RPP-13750) coupled with an AC emergency preparedness program requirement to take corrective actions given a leak is detected, adequately controls the flammable gas hazard in these structures. Although the risk binning was specific to Diversion Box 6241-A and Vent Station 6241-V, the control decision team determined that the transfer leak controls and emergency preparedness program requirement should be applied to all waste transfer-associated structures.

3.1.8 Gasoline Fuel

3.1.8.1 Proposed Controls to Prevent Gasoline Fuel Steady-State Flammable Gas Accidents

Option 1. Establish vehicle controls.

- Prepare an AC TSR that:

  1. Limits vehicle access within tank farms to those vehicles with protected fuel systems.

  2. Requires physical barriers to be established around tank structures located outside of tank farm boundaries and limits access inside physical barriers to vehicles with protected fuel systems.

  3. Establishes speed limits within tank farms.

This is essentially the control strategy that has been previously applied.

Option 2. Prevent vehicles from entering tank farms.

3.1.8.2 Proposed Controls to Protect Gasoline Fuel Analytical Assumptions

It was proposed, and the control decision team concurred, that no protection of analytical assumptions was required because both gasoline and diesel fuels were considered, and because the capacity of the fuel tank is assumed to provide sufficient fuel to reach flammable concentrations.

3.1.8.3 Selected Controls to Prevent Gasoline Fuel Steady-State Flammable Gas Accidents

The control selected to prevent flammable gas deflagrations in DSTs and SSTs resulting from vehicle gasoline spills is a fire protection program that: (1) limits access inside tank farm boundaries to vehicles with protected fuel systems, and (2) requires physical barriers around tank structures located outside tank farm boundaries; access inside the physical barriers is limited to vehicles with protected fuel systems. The fire protection program also controls the storage, transport, and transfer of flammable or combustible liquids or fuels within the tank farm boundaries and within the physical barriers established around tank structures outside tank farm boundaries.

The control decision team discussed what constitutes a "physical barrier." Acceptable examples include chain-link fencing, metal interlocking rail systems, concrete or concrete fill piping posts, concrete barriers, etc. The purpose of the barriers is to restrict vehicle access, not necessarily to prevent it under all conceivable scenarios.

The control decision team also determined that physical barriers are not required for RCTS Diversion Box 6241-A and Vent Station 6241-V because these structures are of a size and construction that a vehicle impact would not result in an accumulation of fuel within one of the structures.

3.1.9 Waste-Intruding Equipment

As discussed in Section 2.1.2.5, the risk binning team qualitatively determined that a deflagration in waste-intruding equipment could result in significant facility worker consequences (i.e., a prompt fatality or serious injuries or significant radiological or chemical exposures). Although worker safety is addressed in a separate document, i.e., RPP-14286, the control decision team selected as a control an AC requiring the application of ignition controls at all times inside waste-intruding equipment. This control is applicable to waste-intruding equipment in all waste containing structures (e.g., SSTs, DSTs, DCRTs, IMUSTs).

3.1.10 Single-Shell Tank Retrieval/Closure Aboveground Tanks

3.1.10.1 Single-Shell Tank Vacuum Retrieval Systems

A steady-state flammable gas hazard could occur in the vacuum retrieval system slurry tank and water separator if waste remained in the vessels for extended durations. An existing TSR established for controlling steady-state flammable gas hazards in non-DST/SST tank farm facilities applies to the vacuum retrieval system slurry tank and water separator. This control requires either flammable gas concentration controls with a control point of $\leq$ 25% of the LFL or ignition controls. The selected control for the vacuum retrieval system slurry tank and water separator is ignition controls. Flammable gas concentration controls (i.e., active ventilation, flammable gas monitoring) were considered, but not selected because ignition controls are judged to be sufficient for preventing a steady-state flammable gas accident in the vacuum retrieval system slurry tank and water separator.

3.1.10.2 Demonstration Bulk Vitrification System Phase 1 Staging Tank

No controls for steady-state flammable gas hazards are required for the DBVS Phase 1 staging tank because the flammable gas concentration can not achieve 100% of the LFL without controls (i.e., risk bin III or IV). However, to protect the assumption of the steady-state flammable gas evaluation, this aboveground tank is identified as a Design Feature with the important attributes of cross-linkable polyethylene construction that prevents hydrogen generation by corrosion, a passive breathing path with no valve (primary tank and annulus), and a total enclosed primary tank volume of approximately 1,250 gal with an overflow line at approximately 850 gal.

3.1.10.3 Demonstration Bulk Vitrification System

Based on the results of the risk binning for postulated DBVS flammable gas accidents, controls are required for steady-state flammable gas hazards caused by waste leaks from the primary waste staging tank into the annulus and waste leaks into DBVS waste transfer-associated structures. An existing TSR established for controlling steady-state flammable gas hazards in non-DST/SST tank farm facilities applies to the DBVS waste staging tank annulus and waste transfer-associated structures. This control requires either flammable gas concentration controls with a control point of < 25% of the LFL or ignition controls.

The selected controls for the DBVS waste staging tank annulus are safety-significant waste staging tank annulus leak detection systems and an associated TSR to ensure their operability. The safety function of the DBVS waste staging tank annulus leak detection systems is to detect a primary waste staging tank leak into the annulus and to provide an alarm signal to initiate operator response, thus decreasing the frequency of a flammable gas accident. The emergency preparedness program is also credited as a TSR-level control to ensure that actions (e.g., remove waste, provide ventilation, flammable gas monitoring, de-energize ignition sources) are taken to prevent a flammable gas deflagration. (Note: The capability to perform flammable gas monitoring of the DBVS waste staging tank annulus is also required to implement actions required by the existing TSR in the event of a primary waste staging tank leak.)

The selected controls for DBVS waste transfer-associated structures are the same as for tank farm waste transfer-associated structures (i.e., safety-significant transfer leak detection systems and TSRs to ensure their operability and alarm monitoring, and the emergency preparedness program) (see Section 3.1.7).

In addition, to protect assumptions of the steady-state flammable gas evaluation, the DBVS waste staging tanks and waste dryer are identified as passive safety-significant SSCs (i.e., Design Features). The safety function of the DBVS waste staging tanks and waste dryer is to maintain the important design attributes that decrease the frequency of a flammable gas accident. The important design attributes of the DBVS waste staging tanks are a passive breathing path with no valve and interior coating of the primary tank that prevents hydrogen generation by corrosion. The important design attribute of the DBVS waste dryer is construction from stainless steel that minimizes hydrogen generation by corrosion.

3.2 CONTROL SELECTION FOR THE GAS RELEASE EVENT FLAMMABLE GAS HAZARD

The GRE hazard has been extensively investigated in support of watch list tank closure and control optimization efforts. Several technical documents have been prepared that form the basis for understanding the GRE hazard and selecting controls. These documents include:

- RPP-7771, *Flammable Gas Safety Issue Resolution*
- RPP-6655, *Data Observations on Double-Shell Flammable Gas Watch List Tank Behavior*
- RPP-7249, *Data and Observations of Single-Shell Flammable Gas Watch List Tank Behavior*
- RPP-10006, *Methodology and Calculations for the Assignment of Waste Groups for the Large Underground Waste Storage Tanks at the Hanford Site*

- RPP-10007, *Flammable Gas Release Calculational Methodology and Results for Active Catch Tanks and DCRTs*
- PNNL-13781, *Effects of Globally Waste-Disturbing Activities on Gas Generation, Retention, and Release in Hanford Waste Tanks*
- PNNL-13782, *Analysis of Induced Gas Releases During Retrieval of Hanford Double-Shell Tank Waste*
- PNNL-14271, *Flammable Gas Release Estimates for Modified Sluicing Retrieval of Waste from Selected Single-Shell Tanks.*

RPP-10006 is a key document in that it estimates the quantity of retained gas in DSTs and SSTs and consequently the quantity available for release given either a spontaneous or induced GRE. The sensitivity of the assumptions and input parameters used in RPP-10006 were assessed to determine whether or not protection of the assumptions or input parameters was required. Table 3-4 presents the results of the assessment.

Table 3-4. Sensitivity of Control Decision Analytical Assumptions and Input Parameters. (2 sheets)

Analysis assumption (AA)/input parameter and basis	**Assumption Type**	**Sensitivity**	**Need to Protect AA**	**Protection Basis**
100% of retained gas is released. If less than 100% of the retained gas is released, the waste group of a given tank could decrease from A to B, A to C, or B to C.	Bounding (theoretical maximum)	N/A	No	N/A
Tank waste information has a degree of uncertainty associated with its value. To account for this uncertainty in the data, values used in RPP-10006 have been assigned distributions and a statistical calculation method applied (i.e., Monte Carlo methodology). Waste groups are designated based on the 95th *confidence level.* Parameters include: • Height of wetted non-convective layer • Void fraction of wetted non-convective layer • Tank vapor space volume • Neutral buoyancy of wetted *non-convective layer* • Yield stress of wetted non-convective layer • Height of convective layer • Specific gravity of convective layer • Hydrogen generation rate • Temperature of wetted non-convective layer • Volume of retained gas that is hydrogen • Retained gas pressure	Reasonably conservative	Small variations in the value of a given tank waste characteristic or tank condition are accounted for by the Monte Carlo analysis. A significant variation in a given parameter has the potential to change waste groups. Therefore, waste transfers must be *evaluated to determine if the end state of the tank results in a* change in waste group. Additionally, relatively small variations in a large number of parameters could potentially result in a change in waste groups.	Yes	TFC Procedures

Table 3-4. Sensitivity of Control Decision Analytical Assumptions and Input Parameters. (2 sheets)

Analysis assumption (AA)/input parameter and basis	**Assumption Type**	**Sensitivity**	**Need to Protect AA**	**Protection Basis**

Notes:

RPP-10006, 2004, *Methodology and Calculations for the Assignment of Waste Groups for the Large Underground Waste Storage Tanks at the Hanford Site*, Rev. 4, CH2M HILL Hanford Group, Inc., Richland, Washington.

AA = analysis assumption.
N/A = not applicable.
TSR = technical safety requirement.

In contrast to other control decision meetings, at the GRE flammable gas hazard control decision meetings various control options were not presented and discussed by the control decision team. Instead, a relatively mature control strategy, developed over several years and based upon the technical reports listed in Section 3.2, was presented to the team for consideration, refinement, and concurrence.

3.2.1 Single-Shell Tank and Double-Shell Tank Waste Group Designation Definitions

The following waste group designation definitions are from RPP-10006.

Waste Group A: Tanks with a potential spontaneous buoyant displacement gas release event (BDGRE) flammable gas hazard in addition to a potential induced GRE flammable gas hazard. That is, tanks that are:

1. Conservatively estimated to contain sufficient retained gas to achieve 100% of the LFL if all of the retained gas is released into the tank headspace, and
2. Determined or predicted to exhibit spontaneous BDGRE behavior.

Waste Group B: Tanks with a potential induced GRE flammable gas hazard, but no potential spontaneous BDGRE flammable gas hazard. That is, tanks that are conservatively estimated to contain sufficient retained gas to achieve 100% of the LFL if all of the retained gas is released into the tank headspace, but are not Waste Group A tanks (see above).

Note: Potential induced GRE flammable gas hazards exist in Waste Group B (and A) tanks only for specific operations that can release the retained gas in the tank at a rate and quantity that results in reaching 100% of the LFL in the tank headspace.

Waste Group C: Tanks with no potential GRE flammable gas hazard. That is, tanks that are conservatively estimated to contain insufficient retained gas to achieve 100% of the LFL even if all of the retained gas is released into the tank headspace.

3.2.2 Single-Shell Tank and Double-Shell Tank Waste Group Designation Selection Criteria

The selection criteria for determining waste group designations A, B, and C for DSTs and SSTs are shown in Table 3-5. The waste group selection methodology is described in RPP-10006.

A controlled list of waste group designations for DSTs and SSTs are maintained based on the Table 3-5 criteria and the methodology documented in RPP-10006.

Table 3-5. Criteria for Tank Waste Group Designation.

<table>
<tr><th>Criteria</th><th>Tank waste characteristics</th><th>Waste group</th></tr>
<tr><td>1</td><td>The volume of retained gas in the solids saturated with liquid is insufficient to make the tank headspace flammable if the gas contained therein is all released into the tank headspace.</td><td>If Criterion 1 is met, then designate the tank as Waste Group C.</td></tr>
<tr><td colspan="3">If Criterion 1 is not met, then go to Criterion 2</td></tr>
<tr><td>2</td><td>The depth of the liquid layer over the settled solids does not provide sufficient potential energy to create the possibility of a gas release during a buoyant displacement event.
The criterion is: The Energy Ratio is < 3.</td><td>If Criterion 1 is not met but Criterion 2 is met, then designate the tank as Waste Group B.</td></tr>
<tr><td colspan="3">If Criteria 1 and 2 are not met, then go to Criterion 3</td></tr>
<tr><td>3</td><td>The tank waste characteristics do not create the possibility of a buoyant displacement event.
The criterion is: The Buoyancy Ratio is < 1.</td><td>If Criteria 1 and 2 are not met but Criterion 3 is met, then designate the tank as Waste Group B.
If Criteria 1, 2, and 3 are not met, then designate the tank as Waste Group A.</td></tr>
</table>

3.2.3 Spontaneous Gas Release Hazard Controls

The control selected for the spontaneous GRE hazard is the application of ignition controls at all times in the tank headspace and in connected enclosed spaces directly above any tank farm facility that can spontaneously release sufficient gas to achieve a flammable gas concentration ≥ 100% of the LFL.

3.2.4 Induced Gas Release Hazard Controls

The control selected for the induced GRE hazard is the implementation of a flammable gas concentration control point of ≤ 25% of the LFL for all tank farm facilities during activities that can induce a gas release which can achieve 100% of the LFL without the use of flammable gas concentration controls. Flammable gas concentration controls shall be monitored on a sufficient frequency to ensure that appropriate actions are taken for conditions > 25% of the LFL.

Any combination of flammable gas concentration controls may be used to maintain the flammable gas concentration ≤ 25% of the LFL. Flammable gas concentration controls are to be documented in a process control plan such that the flammable gas concentration is maintained ≤ 25% of the LFL. A process control plan is not required for saltwell pumping based on operational experience.

3.2.5 Ignition Source Controls

Both the steady-state and GRE flammable gas hazard controls strategies include the application of ignition controls. A control was selected requiring the establishment of ignition source control requirements consistent with National Fire Protection Association (NFPA) requirements. The TFC Chief Engineer shall be the approval authority for equivalency.

3.2.6 Waste Gel

One additional flammable gas release event control is required to prevent waste gel formation in the tank farms (e.g., phosphate precipitation as trisodium phosphate dodecahydrate [Na_3PO_4•$12H_2O$•$0.25NaOH$]). As described in RPP-23584, *Safety Evaluation of Waste Gel in the Tank Farms*, waste gel prevention is required because of uncertainty concerning flammable gas retention and release behavior in a waste gel layer and, therefore, in the applicability of the spontaneous and induced GRE models that provide the basis for the flammable gas release hazard controls presented in the following sections. The control requires that waste conditions are maintained to prevent the precipitation of a gel (i.e., that waste conditions are maintained below the solubility limit of components of the waste that could precipitate as a gel).

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4.0 RISK BINNING RESULTS WITH CONTROLS

Tables 4-1 and 4-2 present the risk bin results applying the controls identified in Chapter 3.0. Results are presented for the DST and SST representative accidents and those associated hazardous conditions that were risk bins I or II without controls. In general, the controls are qualitatively credited with reducing the accident frequency by one frequency bin, i.e., from "anticipated" to "unlikely," or from "unlikely" to "extremely unlikely."

Taking credit for the reduction in frequency reduces the risk bins to either Risk Bin III or Risk Bin IV with four exceptions: (1) a headspace deflagration in a DST due to an induced GRE; (2) a headspace deflagration in an SST due to an induced GRE; (3) a steady-state flammable gas deflagration in an inactive tank; and (4) a steady-state flammable gas deflagration in the vacuum retrieval system slurry tank and water separator. In all four cases, except for IMUSTs that are steel tanks and that were sealed when interim stabilized where the risk bin remains I, the combination of an "unlikely" frequency and a "moderate" onsite radiological and/or toxicological consequence results in Risk Bin II.

For operationally induced GREs in DSTs and SSTs, the control strategy requires the implementation of a concentration control point of ≤ 25% of the LFL during those activities that can induce a gas release which can achieve 100% of the LFL. This control requires flammable gas concentration controls (e.g., active or manually configured passive ventilation, process controls, flammable gas monitoring and proceduralized actions) monitored on a sufficient frequency to ensure that appropriate actions are taken for conditions > 25% of the LFL. Such actions include stopping the activities and removing ignition sources. This combination of controls and actions provides multiple layers of defense against a headspace deflagration.

For steady-state flammable gas deflagrations in inactive tanks, the selected control is the implementation of ignition controls and flammable gas entry monitoring requirements established by the industrial safety program. For IMUSTs that are steel tanks and that were sealed when interim stabilized in the mid-1980s, the risk bin remains I (i.e., "anticipated" frequency and "moderate" onsite radiological and toxicological consequences) even with controls. This is judged to be an acceptable risk until ventilation or diffusion is verified to prevent the steady-state flammable gas hazard.

For steady-state flammable gas deflagrations in the SST vacuum retrieval system slurry tank and water separator, the selected control is the implementation of ignition controls. Ignition controls are judged to be acceptable because ignition sources are limited and the conditions required for a flammable gas hazard (i.e., prolonged shutdown of vacuum retrieval system operations without draining the slurry tank or water separator) are not expected.

Table 4-1. Double-Shell Tank Flammable Gas Risk Binning Results With Controls.

Postulated accident	Frequency	Consequences			Risk bin		
		Onsite radiological	Offsite toxicological	Onsite toxicological	Onsite radiological	Offsite toxicological	Onsite toxicological
Representative Accident 04: Headspace deflagration due to steady-state accumulation of flammable gas or a spontaneous GRE	EU	L	L	M	IV	IV	III
Headspace deflagration due to an induced GRE	U	L	L	M	III	III	II
Annulus deflagration	EU	L	L	M	IV	IV	III
Gasoline fuel deflagration	EU	L	L	M	IV	IV	III

Notes:

EU = extremely unlikely.
GRE = gas release event.
L = low.
M = moderate.
U = unlikely.

Table 4-2. Single-Shell Tank Flammable Gas Risk Binning Results with Controls.

Postulated accident	Frequency	Consequences			Risk bin		
		Onsite radiological	Offsite toxicological	Onsite toxicological	Onsite radiological	Offsite toxicological	Onsite toxicological
Representative Accident 05: Headspace deflagration due to steady-state accumulation of flammable	EU	M	L	M	III	IV	III
Headspace deflagration due to an induced GRE	U	M	L	M	II	III	II
Deflagration in a double-contained receiver tank	EU	M	L	M	III	IV	III
Deflagration in an active catch tank	EU	M	L	M	III	IV	III
Deflagration in an inactive tank	A*	M	L	M	I*	III	I*
Deflagration in a diversion box/vent station	EU	M	L	M	III	IV	III
Gasoline fuel deflagration	EU	M	L	M	III	IV	III
Deflagration in SST retrieval/closure aboveground tanks (SST vacuum retrieval system slurry tank and water separator)	U	M	L	M	II	III	II

Notes:

*The frequency is "anticipated" and the risk bin is I for IMUSTs that are steel tanks and that were sealed when interim stabilized in the mid-1980s.

A = anticipated.
EU = extremely unlikely.
GRE = gas release event.
IMUST = inactive miscellaneous underground storage tank.
L = low.
M = moderate.
U = unlikely.

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APPENDIX A

RISK BINNING MEETING ATTENDEES DURING INITIAL DOCUMENTED SAFETY ANALYSIS DEVELOPMENT

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APPENDIX A

RISK BINNING MEETING ATTENDEES DURING INITIAL DOCUMENTED SAFETY ANALYSIS DEVELOPMENT

Flammable Gas Risk Binning Meeting
July 8, 2002

Name	Organization	Telephone Number
Craig Conn	CHG NS&L	372-2646
Geoff Gelhaus	ORP Tech Ops	539-1922
Joseph Bevelacqua	ORP	376-8443
Cliff Hampton	CHG OPS	~~32~~ 372-0571
Larry Kripps	NS&L	376-1061
Milton Shultz	NS&L	372-3740
Matthew Tiffany	Sys Eng	373-2148
Steve Fowler	CHG SO	376-0688
Richard DeBurk	CHG Safety	372-1158
Brad Smith	NS&L	376-1907
Rich Schlosser	Des Eng	372-3659
Bob Carrell	ORP support	521-6421
Rick Hvolgelat	Safety	372-1151
Robert Shepard	L+A	521-2680
Yusuf Noorani	ORP	372-2018
Steve Fischetti	HPMC	528-5007
Dennis Irby	ORP	376-5652
Delmar Noyes	ORP	376-5166

Flammable Gas Risk Bin Meeting
July 9, 2002

Name	Organization	Telephone Number
Craig Carro	CHG NS+L	372-2646
Geoff Gelhaus	ORP	539-7989
Ed Ford	CHG NS&L	373-1296
MILTON SHULTZ	CHG NS&L	372-3740
CLIFF HAMPTON	CHG OPS	372-0566
Ralph Broz	CHG Rad Con	372-0852 !
Bob Carrell	ORP support	521-6421
Yusuf NooRani	ORP	372-2013
Joseph Bevelacqua	ORP	376-8443
LAWRENCE O. KRIPPS	NS&L	376-1061
Rich Schlosser	CHG Design Eng'g	375-3659
Matt Tiffany	CHG System Eng	373-2148
Robert Shepard	ORP	521-2680
Steve Fischetti	ORP	528-5007
C. Brad Evans	CHG	373-2754
BRAD SMITH	CHG	376 1907

APPENDIX B

RADIOLOGICAL AND TOXICOLOGICAL CONSEQUENCE SCOPING CALCULATIONS FOR FLAMMABLE GAS ACCIDENTS

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APPENDIX B

RADIOLOGICAL AND TOXICOLOGICAL CONSEQUENCE SCOPING CALCULATIONS FOR FLAMMABLE GAS ACCIDENTS

This appendix contains scoping calculations performed to support the qualitative assignment of consequence levels (i.e., low, moderate, or high). Consequence levels are combined with frequency estimates to determine the risk bin of a given hazardous condition.

Scoping calculations were performed to estimate the onsite radiological consequences and onsite and offsite toxicological consequences for headspace deflagrations in double-shell tanks (DST) and single-shell tanks (SST), and for a headspace detonation in a DST. Scoping calculations for a detonation in an SST were not performed as such an event was qualitatively determined by the risk binning team to be "beyond extremely unlikely."

B.1 DOUBLE-SHELL TANK DEFLAGRATION

B.1.1 INPUT PARAMETERS

B.1.1.1 Quantity of Respirable Material Released

The radiological and toxicological consequences of a headspace deflagration in a DST are a function of the quantity of tank waste released by the deflagration, which in turn is a function of the tank failure mode. As documented in WHC-SD-TWR-RPT-003, *DELPHI Expert Panel Evaluation of Hanford High Level Waste Tank Failure Modes and Release Quantities*, at internal pressures in the range of 55 to 60 lb/in^2 gauge the steel liner of a DST primary tank will fail along a transition weld located at a 6 ft radius from the dome center. The energy of the high-pressure air at failure is such that part of the concrete and soil overburden above the center 6-ft radius of the primary tank could blow out. At pressures below 55 to 60 lb/in^2 gauge, the primary tank could bulge, lifting the entire concrete dome and side walls. At still lower pressures, there may be no tank damage because the pressure could be relieved through the primary tank ventilation system and other pathways (e.g., via risers).

Considerable uncertainty exists in estimating the mass and particle size distribution of tank waste that would become airborne given a deflagration in a DST.

Table B-1 summarizes the estimated quantities of respirable material released assuming no tank damage, dome failure, and dome collapse based on various modeling techniques. The risk binning team judged that Case 4 provided the most robust release estimate as it represented the aggregate best estimate of 9 subject matter experts. The respirable material released from the tank is assumed to be supernatant. DST waste phases include supernatant, saltcake liquids and solids, and sludge liquids and solids. These waste phases are stratified within the tanks due to density differences and process histories with the sludge at the bottom, covered by saltcake, covered typically by supernatant (some DSTs have a floating crust layer that covers, or partially covers, the supernatant).

Table B-1. Respirable Releases as a Function of Double-Shell Tank Failure Scenario.

Case	DST failure scenario	Respirable release (L) DST supernatant
1	No tank damage-1	0.39
2	No tank damage-2	0.3
3	Dome failure-1	0.7
4	Dome failure-2	0.7
5	Dome collapse	4.3

Note:

DST = double-shell tank.

Case 1 assumes a deflagration occurs that pressurizes but does not damage the tank, i.e., there is no dome failure or collapse. The 0.39 L value is derived from WHC-SD-WM-TI-753, *Summary of Flammable Gas Hazards and Potential Consequences in Tank Waste Remediation System Facilities at the Hanford Site.* A pressure of 60 lb/in^2 gauge is assumed based on the predicted pressures at which DST primary tank failure occurs. It is assumed that the headspace inventory consists of 0.13 L due to aerodynamic entrainment (dry powder correlation at a 20 m/s flame speed) and a precombustion headspace loading of 0.39 L. The ventilation system loading contributes 0.001 L to the release (note that RPP-13437, *Technical Basis Document for Ventilation System Filtration Failures Leading to an Unfiltered Release*, calculates a contribution of 0.018 from the ventilation system, but the analysis is not sensitive to this difference). At a pressure of 60 lb/in^2 gauge, approximately 75% of the material in the headspace will be released via unfiltered pathways as the headspace blows down and returns to atmospheric pressure. The respirable release is thus:

$$[0.75 \times (0.13 + 0.39) + 0.001]\text{L} = 0.39 \text{ L DST supernatant.}$$

Case 2 also assumes a deflagration occurs that pressurizes but does not damage the tank. The 0.3 value is derived from HNF-2577, *Flammable Gas Project Expert Elicitation Results for Hanford Site Double-Shell Tanks*. In HNF-2577, an expert elicitation process was used to estimate the mass of respirable material suspended in the headspace of a DST by a deflagration that causes high-efficiency particulate air (HEPA) failure but that does not cause dome failure. Nine different experts applied various modeling techniques to estimate the respirable mass of material released and an associated uncertainty distribution. The aggregate median value was approximately 0.4 kg. Based on best-basis inventory (BBI) data as reported in RPP-5926, *Steady-State Flammable Gas Release Rate Calculation and Lower Flammability Level Evaluation for Hanford Tank Waste*, Table A-1, the density of DST supernatant ranges from 1.1 g/ml to 1.5 g/ml. The DST supernatant with the highest applicable unit-liter dose (ULD) (see Section B.1.1.3) is associated with DST 241-AN-107. The supernatant in this tank has a density of approximately 1.4 g/ml. Applying this density yields a respirable release of approximately 0.3 L.

Case 3 is based on evaluations contained in WHC-SD-TWR-RPT-003 and assumes a pressure high enough to open the tank in a "can-opener" manner and blow much of the debris and soil overburden off the opened center region of the dome. Material sources included the inventory of material present in the tank headspace at all times, airborne activity from activities being performed in the tank at the time of a deflagration, liquid splashed from the impact of the solid debris on the liquid surface, and liquid sheared from the surface by aerodynamic entrainment. The estimated total amount of material to be released was 0.2 kg. Because of a lack of a dynamic model and other assumptions and uncertainties, WHC-SD-TWR-RPT-003 estimates the uncertainty on this value to be at least a factor of 2 to 5 for an upper estimate of 1 kg or, applying a density of 1.4 g/ml, 0.7 L of DST supernatant.

Case 4 is based on HNF-2577 wherein the expert elicitation process also estimated the respirable release from a DST headspace deflagration that causes dome failure. The aggregate median value was approximately 1.0 kg, or, applying a density of 1.4 g/ml, 0.7 L of DST supernatant.

Case 5 assumes complete collapse of the dome. As in Case 1, the dome collapse scenario assumes an aerodynamic entrainment of 0.13 L, a precombustion headspace loading of 0.39 L, and a ventilation system loading of 0.001 L. An additional 3.8 L of respirable material is assumed to be suspended by the complete collapse of the dome based on calculations in WHC-SD-WM-CN-051, *The Effects of Load Drop and Uniform Load and Concentrated Loads on Waste Tanks*. In WHC-SD-WM-CN-051, the tank overburden is credited with reducing the respirable release by a factor of 10. However, because some of the overburden may be expelled by the deflagration, this factor is not credited. The total release is the sum of these contributors or 4.3 L of DST supernatant.

B.1.1.2 Atmospheric Dispersion Coefficients and Breathing Rate

Atmospheric dispersion coefficients to be used in safety basis documents for tank farm facilities are documented in RPP-13482, *Atmospheric Dispersion Coefficients and Radiological and Toxicological Exposure Methodology for Use in Tank Farms*.

The overall 95th percentile, ground level, point source release χ/Q' values are shown in Table B-2.

Table B-2. Dispersion Coefficients for 200 Area Tank Farms.

Receptor location	1-hr χ/Q' (s/m^3)	Maximum puff χ/Q (1/m^3)
100 m (i.e., onsite)	3.28 E-2	8.88 E-3
Site Boundary (i.e., offsite)	2.22 E-5	5.06 E-8

RPP-13482, Appendix H, "Special χ/Qs and χ/Q's for Puff Releases Due to Rapid Venting of Underground Tank," calculates a series of χ/Qs and χ/Q's for the rapid venting of a large underground waste tank where the release is modeled as a semi-ellipsoidal puff on the ground above the tank. These atmospheric dispersion coefficients were specifically developed to account for the pressurized release associated with a flammable gas deflagration. The continuous release χ/Q's for a range of pressures are shown in Table B-3.

Table B-3. Continuous Release 1-hr χ/Q's for the Rapid Venting of a Double-Shell Tank.

Initial Pressure (lb/in^2 gauge)	χ/Q' (s/m^3)	
	Onsite	Offsite
5	1.06E-2	2.18E-5
15	7.35E-3	2.18E-5
45	3.73E-3	2.15E-5
60	2.97E-3	2.14E-5

For radiological consequence calculations, a breathing rate of 3.33×10^{-4} m^3/s is used. 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 (ICRP).

B.1.1.3 Unit-Liter Dose

ULDs are documented in RPP-5924, *Radiological Source Terms for Tank Farms Safety Analysis.* A ULD of 1.0×10^3 Sv/L was used to calculate the radiological consequences. This ULD, specific to DST 241-AN-107, is the bounding ULD value reported in RPP-5924 for DST supernatant based on ICRP-68, *Dose Coefficients for Intakes of Radionuclides by Workers—Replacement of ICRP Publication 61*, dose conversion factors.

B.1.1.4 Sum of Fractions Values

Sum of fractions (SOF) values are documented in RPP-8369, *Chemical Source Terms for Tank Farms Safety Analyses.* Toxicological consequences are based on application of the following Temporary Emergency Exposure Limit (TEEL) SOF values:

- TEEL-1 = 2.75×10^9
- TEEL-2 = 3.46×10^8
- TEEL-3 = 1.27×10^7.

These are the highest reported values for DST liquids as documented in RPP-8369.

B.1.2 ONSITE RADIOLOGICAL CONSEQUENCES

The onsite radiological consequences were calculated in accordance with the methodology described in RPP-13482, Chapter 4.0, "Radiological Dose Calculations."

The consequences are shown in Table B-4 for application of both the ground level, point source and rapid venting (i.e., volume release) atmospheric dispersion coefficients. For the "no tank damage" failure mode volume release calculations, it was assumed that the deflagration results in a pressurization of 15 lb/in^2 gauge. For the dome failure and dome collapse failure modes, a pressure of 45 lb/in^2 gauge was conservatively assumed. The calculations are provided in Attachment B-1.

Table B-4. Onsite Radiological Consequences of a Double-Shell Tank Headspace Deflagration.

Case	DST failure scenario	Dose (rem)	
		Ground level/point source	Volume release
Case 1	No tank damage-1	0.4	0.1
Case 2	No tank damage-2	0.3	0.07
Case 3	Dome failure-1	0.8	0.09
Case 4	Dome failure-2	0.8	0.09
Case 5	Dome collapse	4.7	0.5

Note:

DST = double-shell tank.

B.1.3 ONSITE AND OFFSITE TOXICOLOGICAL CONSEQUENCES

The onsite and offsite toxicological consequences were calculated in accordance with the methodology described in RPP-13482, Chapter 5.0, "Toxicological Exposure Calculations."

The onsite consequences are shown in Table B-5 for application of both the ground level, point source and rapid venting (i.e., volume release) atmospheric dispersion coefficients. For the "no tank damage" failure mode volume release calculations, it was assumed that the deflagration results in a pressurization of 15 lb/in^2 gauge. For the dome failure and dome collapse failure modes, a pressure of 45 lb/in^2 gauge was conservatively assumed. A release duration of 60 sec was used in conjunction with the continuous release χ/Q's. The calculations are provided in Attachment B-1.

Table B-5. Onsite Toxicological Consequences of a Double-Shell Tank Headspace Deflagration.

Case	DST failure scenario	Sum of fractions	
		Ground level/ Point source	Volume release
Case 1	No tank damage-1	74 (TEEL-2)	17 (TEEL-2)
		2.7 (TEEL-3)	0.6 (TEEL-3)
Case 2	No tank damage-2	57 (TEEL-2)	13 (TEEL-2)
		2.1 (TEEL-3)	0.5 (TEEL-3)
Case 3	Dome failure-1	130 (TEEL-2)	15 (TEEL-2)
		4.9 (TEEL-3)	0.6 (TEEL-3)
Case 4	Dome failure-2	130 (TEEL-2)	15 (TEEL-2)
		4.9 (TEEL-3)	0.6 (TEEL-3)
Case 5	Dome collapse	810 (TEEL-2)	92 (TEEL-2)
		30 (TEEL-3)	3.4 (TEEL-3)

Notes:

DST = double-shell tank.

TEEL = Temporary Emergency Exposure Limit.

Table B-6 presents the offsite toxicological consequences. The consequences were calculated using the maximum puff atmospheric dispersion coefficient for a ground level, point source release. Calculations were not performed for a volume release as the associated atmospheric dispersion coefficients are essentially the same. The calculations are provided in Attachment B-1.

Table B-6. Offsite Toxicological Consequences of a Double-Shell Tank Headspace Deflagration.

Case	DST failure scenario	Sum of fractions
Case 1	No tank damage-1	0.05 (TEEL-1)
Case 2	No tank damage-2	0.04 (TEEL-1)
Case 3	Dome failure-1	0.1 (TEEL-1)
Case 4	Dome failure-2	0.1 (TEEL-1)
Case 5	Dome collapse	0.6 (TEEL-1)

Notes:

DST = double-shell tank.

TEEL = Temporary Emergency Exposure Limit.

B.2 SINGLE-SHELL TANK DEFLAGRATION

B.2.1 INPUT PARAMETERS

B.2.1.1 Quantity of Respirable Material Released

As was the case with DSTs, the radiological and toxicological consequences of a headspace deflagration in an SST are a function of the quantity of tank waste released by the deflagration, which in turn is a function of the tank failure mode. As documented in WHC-SD-WR-RPT-003, at internal pressures in the range of 11 to 15 lb/in^2 gauge some cracking of the concrete tank dome with distributed pressure venting and overstressing of rebar is predicted. This failure would lead to self-venting through the soil overburden. Given a very rapid, high pressure transient (e.g., up to 44 lb/in^2 gauge), the pressure may not have time to vent. At pressures significantly greater than 11 to 15 lb/in^2 gauge, the center portion of the dome to a radial distance of 2 to 20 ft, along with the soil overburden, would likely be blown out. The tank could open in a "can-opener" manner. Fall back of debris would be limited to the ejected dome material and soil adjacent to the failed portion of the dome. Based on existing stress analyses, WHC-SD-TWR-RPT-003 concludes there is no reason to expect complete dome collapse.

Table B-7 summarizes the estimated quantities of respirable material released assuming a cracked concrete dome, no tank damage, and partial dome collapse based on various modeling techniques. The risk binning team judged that Case 5 provided the most robust release estimate as it represented the aggregate best estimate of 7 subject matter experts. The respirable material released from the tank is assumed to be saltcake. SST waste phases include supernatant, saltcake liquids and solids, and sludge liquids and solids. These waste phases are stratified within the tanks due to density differences and process histories with the sludge at the bottom, covered by saltcake, covered by supernatant (if present).

Table B-7. Respirable Release as a Function of Single-Shell Tank Failure Scenario.

Case	SST failure scenario	Respirable release (L) SST solids
1	Cracked dome-1	0.011
2	Cracked dome-2	0.6
3	No tank damage	0.12
4	Dome collapse-1	4
5	Dome collapse-2	3.3

Note:

SST = single-shell tank.

Case 1 is based on analyses in WHC-SD-TWR-RPT-003. The assumed material sources included the inventory of material present in the tank headspace at all times plus that caused by activities in the tank, material suspended by the deflagration, and material made airborne by the impact of concrete spalled from the interior of the dome. The material released during the deflagration is split between unfiltered paths (through open risers including the lifting of cover blocks) and the cracks that develop in the dome. The material released through dome cracks is filtered by flow through the soil overburden. The estimated total respirable release for this case ranged up to 20 g, or 0.011 L assuming a saltcake density of 1.8 g/ml. Based on BBI data as reported in RPP-5926, Table A-1, the density of saltcake solids ranges from 1.4 g/ml to 1.9 g/ml. As discussed in Section B.2.1.3, the radiological consequence calculations are based on the saltcake ULD for SST 241-TX-118. The saltcake has a density of approximately 1.8 g/ml.[3]

Case 2 is also based on WHC-SD-TWR-RPT-003 which states that releases should be "less than 1 kg" based on the calculated releases and a review of the associated uncertainties. A release of 1 kg of saltcake corresponds to 0.6 L applying a density of 1.8 g/ml.

Case 3 assumes a deflagration occurs that pressurizes but does not damage the tank; i.e., there is no cracking of the concrete dome. The release, therefore, occurs via unfiltered pathways (e.g., failed HEPA filters) versus partial filtering through the soil overburden. The 0.12 L value is derived from WHC-SD-WM-TI-753. For this analysis, a pressure of 15 lb/in^2 gauge is assumed based on the predicted pressures at which SST dome cracking occurs. The headspace inventory consists of 0.033 L due to aerodynamic entrainment (dry powder correlation at 10 m/s flame speed) and a precombustion headspace loading of 0.21 L. The ventilation system loading contributes 0.0001 L (passive ventilation) to the release (note that RPP-13437 calculates a higher contribution from the ventilation system, however, the analysis is not sensitive to this difference). At a pressure of 15 lb/in^2 gauge, 50% of the material in the headspace will be released via unfiltered pathways as the headspace blows down and returns to atmospheric pressure. The respirable release is thus:

$$[0.50 \times (0.033 + 0.21) + 0.0001]\text{L} = 0.12 \text{ L saltcake.}$$

Case 4 assumes complete collapse of the dome. As in Case 3, the dome collapse scenario assumes an aerodynamic entrainment of 0.033 L, a precombustion headspace loading of 0.21 L, and a ventilation system loading of 0.0001 L. An additional 3.8 L of respirable material is assumed to be suspended by the complete collapse of the dome based on calculations in WHC-SD-WM-CN-051. The total release is the sum of these contributors or 4.0 L of saltcake.

Case 5 also assumes a deflagration that causes collapse of the dome. The 3.3 L value is derived from HNF-SD-WM-ES-412, *Safety Controls Optimization by Performance Evaluation (SCOPE) Expert Elicitation Results for Hanford Site Single-Shell Tanks*. In HNF-SD-WM-ES-412, an expert elicitation process was used to estimate the mass of respirable material suspended by a deflagration that causes the dome to collapse. Seven different experts applied various modeling techniques to estimate the respirable mass of material released and an associated uncertainty distribution. The aggregate median value was approximately 6 kg, or 3.3 L applying a density of 1.8 g/ml.

[3] The SST 241-TX-118 saltcake waste type with the highest ULD is T2-SltCk (solid).

B.2.1.2 Atmospheric Dispersion Coefficients and Breathing Rate

The overall 95th percentile, ground level, point source release χ/Q' values were previously provided in Table B-2. RPP-13482, Appendix H, "Special χ/Qs and $\chi/Q's$ for Puff Releases Due to Rapid Venting of Underground Tank," calculates a series of χ/Qs and $\chi/Q's$ for the rapid venting of a large underground waste tank where the release is modeled as a semi-ellipsoidal puff on the ground above the tank. The continuous release $\chi/Q's$ for a range of pressures are shown in Table B-8.

Table B-8. Continuous Release 1-hr χ/Q 's for the Rapid Venting of a Single-Shell Tank.

Initial pressure (lb/in^2 gauge)	χ/Q' (s/m^3)	
	Onsite	Offsite
15	4.88E-3	2.16E-5
44	2.06E-3	2.10E-5

For radiological consequence calculations, a breathing rate of 3.33×10^{-4} m^3/s is used (see Section B.1.1.2).

B.2.1.3 Unit-liter Dose

The ULDs are derived in RPP-5924 for each waste phase in each tank. For the 149 SSTs, ULDs ranged in value from 1.9×10^{-1} Sv/L (associated with 8 kL of liquid in SST 241-T-201) to 1.4×10^{5} Sv/L (associated with 28 kL of sludge in SST 241-AX-104). SST 241-AX-104 sludge, which has the highest SST waste ULD, was not selected because even under zero ventilation conditions the headspace in this SST cannot reach the LFL due to diffusion through the concrete dome (RPP-5926, Table 4-5). Therefore, SST 241-TX-118 saltcake was selected because it has the second highest SST waste ULD of 1.0×10^{5} Sv/L and SST 241-TX-118 can reach the LFL and detonable limits assuming zero ventilation conditions.

B.2.1.4 Sum of Fractions Values

SOF values are documented in RPP-8369. Toxicological consequences are based on application of the following TEEL SOF values:

- TEEL-1 = 3.71×10^{9}
- TEEL-2 = 6.28×10^{8}
- TEEL-3 (100-series) = 9.80×10^{7}
- TEEL-3 (200-series) = 3.39×10^{8}

These are the highest SST liquids or solids SOF values reported in RPP-8369 with the exception of the 241-C Tank Farm 200-series tanks. These relatively small (i.e., 50,000 gal) tanks only contain from 800 to 2,600 gal of waste and are judged not to present a significant flammable gas hazard. Calculations are performed for two TEEL-3 values, one for 100-series SSTs and one for 200-series SSTs.

B.2.2 ONSITE RADIOLOGICAL CONSEQUENCES

The onsite radiological consequences were calculated in accordance with the methodology described in RPP-13482, Chapter 4.0, "Radiological Dose Calculations."

The consequences are shown in Table B-9 for application of both the ground level, point source and rapid venting (i.e., volume release) atmospheric dispersion coefficients. For the "cracked dome" and "no tank damage" failure mode volume release calculations, it was assumed that the deflagration results in pressurization of 15 lb/in^2 gauge. For the dome collapse failure modes, a pressure of 44 lb/in^2 gauge was assumed. The calculations are provided in Attachment B-1.

Table B-9. Onsite Radiological Consequences of a Single-Shell Tank Headspace Deflagration.

Case	SST failure scenario	Dose (rem)	
		Ground level/point source	Volume release
Case 1	Cracked dome-1	1.2	0.2
Case 2	Cracked dome-2	66	9.8
Case 3	No tank damage	13	2.0
Case 4	Dome collapse-1	440	27
Case 5	Dome collapse-2	360	23

Note:

SST = single-shell tank.

B.2.3 ONSITE AND OFFSITE TOXICOLOGICAL CONSEQUENCES

The onsite and offsite toxicological consequences were calculated in accordance with the methodology described in RPP-13482, Chapter 5.0, "Toxicological Exposure Calculations."

The onsite consequences are shown in Table B-10 for application of both the ground level, point source and rapid venting (i.e., volume release) atmospheric dispersion coefficients. For the "cracked dome" and "no tank damage" failure mode volume release calculations, it was assumed that the deflagration results in pressurization of 15 lb/in^2 gauge. For the dome collapse failure modes, a pressure of 44 lb/in^2 gauge was assumed. A release duration of 60 sec was used in conjunction with the continuous release χ/Q's. The calculations are provided in Attachment B-1.

Table B-10. Onsite Toxicological Consequences of a Single-Shell Tank Headspace Deflagration.

Case	SST failure scenario	Sum of fractions*	
		Ground level/point source	Volume release
Case 1	Cracked dome-1	3.8 (TEEL-2)	0.6 (TEEL-2)
		0.6 (TEEL-3)	0.1 (TEEL-3)
Case 2	Cracked dome-2	210 (TEEL-2)	31 (TEEL-2)
		32 (TEEL-3)	4.8 (TEEL-3)
Case 3	No tank damage	41 (TEEL-2)	6.1 (TEEL-2)
		6.4 (TEEL-3)	1.0 (TEEL-3)
Case 4	Dome collapse-1	1,400 (TEEL-2)	86 (TEEL-2)
		210 (TEEL-3)	13 (TEEL-3)
Case 5	Dome collapse-2	1,100 (TEEL-2)	71 (TEEL-2)
		180 (TEEL-3)	11 (TEEL-3)

Notes:

*TEEL-3 values are for 100-series SSTs.

SST = single-shell tank.

TEEL = Temporary Emergency Exposure Limit.

Table B-11 presents the offsite toxicological consequences. The consequences were calculated using the maximum puff atmospheric dispersion coefficient for ground level, point source release. Calculations were not performed for a volume release as the associated atmospheric dispersion coefficients are essentially the same. The calculations are provided in Attachment B-1.

Table B-11. Offsite Toxicological Consequences of a Single-Shell Tank Headspace Deflagration.

Case	SST Failure Scenario	Sum-of-Fractions
Case 1	Cracked dome-1	0.002 (TEEL-1)
Case 2	Cracked dome-2	0.1 (TEEL-1)
Case 3	No tank damage	0.02 (TEEL-1)
Case 4	Dome collapse-1	0.8 (TEEL-1)
Case 5	Dome collapse-2	0.6 (TEEL-1)

Notes:

SST = single-shell tank.

TEEL = Temporary Emergency Exposure Limit.

B.3 DOUBLE-SHELL TANK DETONATION

B.3.1 INPUT PARAMETERS

The input parameters for a detonation in a DST are the same as for a deflagration except for the quantity of respirable material released. The difference between a detonation and a deflagration is the speed of the flame front of the burning gases. For detonations, the flame front moves at supersonic speeds. These higher flame speeds can result in a greater suspension of tank waste.

In HNF-2577, the expert elicitation process was also used to estimate the mass of respirable material released from a DST detonation that causes dome failure. The aggregate median value was approximately 7 kg. Applying a density of 1.4 g/ml yields a respirable release of approximately 5 L.

B.3.2 ONSITE RADIOLOGICAL CONSEQUENCES

The onsite radiological consequences were calculated in accordance with the methodology described in RPP-13482, Chapter 4.0, "Radiological Dose Calculations."

The consequences are shown in Table B-12 for application of both the ground level, point source and rapid venting (i.e., volume release) atmospheric dispersion coefficient. For a detonation, a pressure of 45 lb/in^2 gauge was conservatively assumed. The calculation is provided in Attachment B-1.

Table B-12. Onsite Radiological Consequences of a Double-Shell Tank Headspace Detonation.

Respirable release	Dose (rem)	
	Ground level/point source	Volume release
5 L	5.5	0.6

B.3.3 ONSITE AND OFFSITE TOXICOLOGICAL CONSEQUENCES

The onsite and offsite toxicological consequences were calculated in accordance with the methodology described in RPP-13482, Chapter 5.0, "Toxicological Exposure Calculations."

The onsite consequences are shown in Table B-13 for application of both the ground level, point source and rapid venting (i.e., volume release) atmospheric dispersion coefficients. For a detonation, a pressure of 45 lb/in^2 gauge was conservatively assumed. A release duration of 60 sec was used in conjunction with the continuous release χ/Q's. The calculations are provided in Attachment B-1.

Table B-13. Onsite Toxicological Consequences of a Double-Shell Tank Headspace Detonation.

Respirable release	Sum of fractions	
	Ground level/point source	Volume release
5 L	950 (TEEL-2)	110 (TEEL-2)
	35 (TEEL-3)	3.9 (TEEL-3)

Note:

TEEL = Temporary Emergency Exposure Limit.

Table B-14 presents the offsite toxicological consequences. The consequences were calculated using the maximum puff atmospheric dispersion coefficient for ground level, point source release. The calculation is provided in Attachment B-1.

Table B-14. Offsite Toxicological Consequences of a Double-Shell Tank Headspace Detonation.

Respirable release	Sum of fractions
5 L	0.7 (TEEL-1)

Note:

TEEL = Temporary Emergency Exposure Limit.

B.4 REFERENCES

HNF-2577, 1998, *Flammable Gas Project Expert Elicitation Results for Hanford Site Double-Shell Tanks*, Rev. 0, Duke Engineering and Services Hanford, Richland, Washington.

HNF-SD-WM-ES-412, 1997, *Safety Controls Optimization by Performance Evaluation (SCOPE) Expert Elicitation Results for Hanford Site Single-Shell Tanks*, Rev. 0, Duke Engineering and Services Hanford, Inc., Richland, Washington.

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WHC-SD-WM-CN-051, 1996, *The Effects of Load Drop and Uniform Load and Concentrated Loads on Waste Tanks*, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

WHC-SD-WM-TI-753, 1996, *Summary of Flammable Gas Hazards and Potential Consequences in Tank Waste Remediation System Facilities at the Hanford Site*, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

WHC-SD-TWR-RPT-003, 1996, *DELPHI Expert Panel Evaluation of Hanford High Level Waste Tank Failure Modes and Release Quantities*, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

ATTACHMENT B1

CONSEQUENCE CALCULATIONS

Double-Shell Tank Deflagration Onsite Radiological Consequences

Release quantities

Case 1	No tank damage-1	0.39 L
Case 2	No tank damage-2	0.3 L
Case 3	Dome failure-1	0.7 L
Case 4	Dome failure-2	0.7 L
Case 5	Dome collapse	4.3 L

ULD = $1.0 \times 10^{+3}$ Sv/L (241-AN-107, supernatant)

Apply Standard, ground level release χ/Q:

Case 1

$$D(rem) = 0.39(L)\ 3.28x10^{-2}(s/m^3)\ 3.33x10^{-4}(m^3/s)\ 1.0x10^{+3}(Sv/L)1.0x10^{+2}(rem/Sv)$$

$$D(rem) = 4.3x10^{-1}$$

rounded to:

$$D(rem) = 0.4$$

Case 2

$$D(rem) = 0.3(L)\ 3.28x10^{-2}(s/m^3)\ 3.33x10^{-4}(m^3/s)\ 1.0x10^{+3}(Sv/L)1.0x10^{+2}(rem/Sv)$$

$$D(rem) = 3.3x10^{-1}$$

rounded to:

$$D(rem) = 0.3$$

Case 3

$$D(rem) = 0.7(L)\ 3.28x10^{-2}(s/m^3)\ 3.33x10^{-4}(m^3/s)\ 1.0x10^{+3}(Sv/L)1.0x10^{+2}(rem/Sv)$$

$$D(rem) = 7.6x10^{-1}$$

rounded to:

$$D(rem) = 0.8$$

Case 4

$$D(rem) = 0.7(L)\ 3.28x10^{-2}(s/m^3)\ 3.33x10^{-4}(m^3/s)\ 1.0x10^{+3}(Sv/L)1.0x10^{+2}(rem/Sv)$$

$$D(rem) = 7.6x10^{-1}$$

rounded to:

$$D(rem) = 0.8$$

Case 5

$$D(rem) = 4.3(L)\ 3.28x10^{-2}(s/m^3)\ 3.33x10^{-4}(m^3/s)\ 1.0x10^{+3}(Sv/L)1.0x10^{+2}(rem/Sv)$$

$$D(rem) = 4.7x10^{+0}$$

$$D(rem) = 4.7$$

Apply volumetric χ/Q

Case 1 Assume 15 lb/in^2 gauge

$$D(rem) = 0.39(L)\ 7.35x10^{-3}(s/m^3)\ 3.33x10^{-4}(m^3/s)\ 1.0x10^{+3}(Sv/L)1.0x10^{+2}(rem/Sv)$$

$$D(rem) = 9.5x10^{-2}$$

rounded to:

$$D(rem) = 0.1$$

Case 2 Assume 15 lb/in^2 gauge

$$D(rem) = 0.3(L)\ 7.35x10^{-3}(s/m^3)\ 3.33x10^{-4}(m^3/s)\ 1.0x10^{+3}(Sv/L)1.0x10^{+2}(rem/Sv)$$

$$D(rem) = 7.3x10^{-2}$$

rounded to:

$$D(rem) = 0.07$$

Case 3 Assume 45 lb/in^2 gauge

$$D(rem) = 0.7(L)\ 3.73x10^{-3}(s/m^3)\ 3.33x10^{-4}(m^3/s)\ 1.0x10^{+3}(Sv/L)1.0x10^{+2}(rem/Sv)$$

$$D(rem) = 8.7x10^{-2}$$

rounded to:

$$D(rem) = 0.09$$

Case 4 Assume 45 lb/in^2 gauge

$$D(rem) = 0.7(L)\ 3.73x10^{-3}(s/m^3)\ 3.33x10^{-4}(m^3/s)\ 1.0x10^{+3}(Sv/L)1.0x10^{+2}(rem/Sv)$$

$$D(rem) = 8.7x10^{-2}$$

rounded to:

$$D(rem) = 0.09$$

Case 5 Assume 45 lb/in^2 gauge

$$D(rem) = 4.3(L)\ 3.73x10^{-3}(s/m^3)\ 3.33x10^{-4}(m^3/s)\ 1.0x10^{+3}(Sv/L)1.0x10^{+2}(rem/Sv)$$

$$D(rem) = 5.3x10^{-1}$$

rounded to:

$$D(rem) = 0.5$$

Single-Shell Tank Deflagration Onsite Radiological Consequences

Release quantities

Case 1	Cracked dome - 1	0.011 L
Case 2	Cracked dome - 2	0.6 L
Case 3	No tank damage	0.12 L
Case 4	Dome collapse - 1	4 L
Case 5	Dome collapse - 2	3.3 L

ULD = 1.0 x 10^{+5} Sv/L (241-TX-118, saltcake solids)

Apply Standard, ground level release χ/Q:

Case 1

$$D(rem) = 0.011(L)\ 3.28x10^{-2}(s/m^3)\ 3.33x10^{-4}(m^3/s)\ 1.0x10^{+5}(Sv/L)1.0x10^{+2}(rem/Sv)$$

$$D(rem) = 1.2x10^{+0}$$

$$D(rem) = 1.2$$

Case 2

$$D(rem) = 0.6(L)\ 3.28x10^{-2}(s/m^3)\ 3.33x10^{-4}(m^3/s)\ 1.0x10^{+5}(Sv/L)1.0x10^{+2}(rem/Sv)$$

$$D(rem) = 6.6x10^{+1}$$

$$D(rem) = 66$$

Case 3

$$D(rem) = 0.12(L)\ 3.28x10^{-2}(s/m^3)\ 3.33x10^{-4}(m^3/s)\ 1.0x10^{+5}(Sv/L)1.0x10^{+2}(rem/Sv)$$

$$D(rem) = 1.3x10^{+1}$$

$$D(rem) = 13$$

Case 4

$$D(rem) = 4(L)\ 3.28x10^{-2}(s/m^3)\ 3.33x10^{-4}(m^3/s)\ 1.0x10^{+5}(Sv/L)1.0x10^{+2}(rem/Sv)$$

$$D(rem) = 4.37x10^{+2}$$

rounded to:

$$D(rem) = 440$$

Case 5

$$D(rem) = 3.3(L)\ 3.28x10^{-2}(s/m^3)\ 3.33x10^{-4}(m^3/s)\ 1.0x10^{+5}(Sv/L)1.0x10^{+2}(rem/Sv)$$

$$D(rem) = 3.60x10^{+2}$$

$$D(rem) = 360$$

Apply volumetric χ/Q

Case 1 Assume 15 lb/in² gauge

$$D(rem) = 0.011(L)\ 4.88x10^{-3}(s/m^3)\ 3.33x10^{-4}(m^3/s)\ 1.0x10^{+5}(Sv/L)1.0x10^{+2}(rem/Sv)$$

$$D(rem) = 1.8x10^{-1}$$

rounded to:

$$D(rem) = 0.2$$

Case 2 Assume 15 lb/in² gauge

$$D(rem) = 0.6(L)\ 4.88x10^{-3}(s/m^3)\ 3.33x10^{-4}(m^3/s)\ 1.0x10^{+5}(Sv/L)1.0x10^{+2}(rem/Sv)$$

$$D(rem) = 9.8x10^{+0}$$

$$D(rem) = 9.8$$

Case 3 Assume 15 lb/in² gauge

$$D(rem) = 0.12(L)\ 4.88x10^{-3}(s/m^3)\ 3.33x10^{-4}(m^3/s)\ 1.0x10^{+5}(Sv/L)1.0x10^{+2}(rem/Sv)$$

$$D(rem) = 2.0x10^{+0}$$

$$D(rem) = 2.0$$

Case 4 Assume 44 lb/in² gauge

$$D(rem) = 4(L)\ 2.06x10^{-3}(s/m^3)\ 3.33x10^{-4}(m^3/s)\ 1.0x10^{+5}(Sv/L)1.0x10^{+2}(rem/Sv)$$

$$D(rem) = 2.7x10^{+1}$$

$$D(rem) = 27$$

Case 5 Assume 44 lb/in² gauge

$$D(rem) = 3.3(L)\ 2.06x10^{-3}(s/m^3)\ 3.33x10^{-4}(m^3/s)\ 1.0x10^{+5}(Sv/L)1.0x10^{+2}(rem/Sv)$$

$$D(rem) = 2.3x10^{+1}$$

$$D(rem) = 23$$

Double-Shell Tank Deflagration Offsite Toxicological Consequences

Release quantities

Case 1	No tank damage-1	0.39 L
Case 2	No tank damage-2	0.3 L
Case 3	Dome failure -1	0.7 L
Case 4	Dome failure-2	0.7 L
Case 5	Dome collapse	4.3 L

Apply χ/Q for "puff" release = 5.06×10^{-8} 1/m³

(Note: corresponding volumetric χ/Q about the same, 4.8 - 4.9 x 10^{-8} 1/m³)

SOF for TEEL-1: $2.75 \times 10^{+9}$ (241-AN-103, liquids)

Case 1

$$SOF = 0.39(\text{L})\ 0.001(\text{m}^3/\text{L})\ 5.06x10^{-8}(1/\text{m}^3)\ 2.75x10^{+9}$$

$$SOF = 5.4x10^{-2}$$

rounded to:

$$SOF = 0.05$$

Case 2

$$SOF = 0.3(L)\ 0.001(m^3/L)\ 5.06x10^{-8}(1/\text{m}^3)\ 2.75x10^{+9}$$

$$SOF = 4.2x10^{-2}$$

rounded to:

$$SOF = 0.04$$

Case 3

$$SOF = 0.7(L)\ 0.001(m^3/L)\ 5.06x10^{-8}(1/m^3)\ 2.75x10^{+9}$$

$$SOF = 9.7x10^{-2}$$

rounded to:

$$SOF = 0.1$$

Case 4

$$SOF = 0.7(L)\ 0.001(m^3/L)\ 5.06x10^{-8}(1/\text{m}^3)\ 2.75x10^{+9}$$

$$SOF = 9.7x10^{-2}$$

rounded to:

$$SOF = 0.1$$

Case 5

$$SOF = 4.3(L)\ 0.001(m^3/L)\ 5.06x10^{-8}(1/\text{m}^3)\ 2.75x10^{+9}$$

$$SOF = 6.0x10^{-1}$$

$$SOF = 0.6$$

Single-Shell Tank Deflagration Offsite Toxicological Consequences

Release quantities

Case 1	Cracked dome – 1	0.011 L
Case 2	Cracked dome – 2	0.6 L
Case 3	No tank damage	0.12 L
Case 4	Dome collapse-1	4 L
Case 5	Dome collapse-2	3.3 L

Apply χ/Q for "puff" release = 5.06 x 10^{-8} 1/m^3

(Note: corresponding volumetric χ/Q about the same, 4.8 - 4.9 x 10^{-8} 1/m^3)

SOF for TEEL-1: 3.71 x 10^{+9} (241-A-106, liquids)

Case 1

$$SOF = 0.011(L)\,0.001(m^3/L)\,5.06x10^{-8}(1/m^3)\,3.71x10^{+9}$$

$$SOF = 2.1x10^{-3}$$

rounded to:

$$SOF = 0.002$$

Case 2

$$SOF = 0.6(L)\,0.001(m^3/L)\,5.06x10^{-8}(1/m^3)\,3.71x10^{+9}$$

$$SOF = 1.1x10^{-1}$$

rounded to:

$$SOF = 0.1$$

Case 3

$$SOF = 0.12(L)\,0.001(m^3/L)\,5.06x10^{-8}(1/m^3)\,3.71x10^{+9}$$

$$SOF = 2.3x10^{-2}$$

rounded to:

$$SOF = 0.02$$

Case 4

$$SOF = 4(L)\ 0.001(m^3/L)\ 5.06x10^{-8}(1/m^3)\ 3.71x10^{+9}$$

$$SOF = 7.5x10^{-1}$$

rounded to:

$$SOF = 0.8$$

Case 5

$$SOF = 3.3(L)\ 0.001(m^3/L)\ 5.06x10^{-8}(1/m^3)3.71x10^{+9}$$

$$SOF = 6.2x10^{-1}$$

rounded to:

$$SOF = 0.6$$

Double-Shell Tank Deflagration Onsite Toxicological Consequences

Release quantities

Case 1	No tank damage-1	0.39 L
Case 2	No tank damage-2	0.3 L
Case 3	Dome failure -1	0.7 L
Case 4	Dome failure-2	0.7 L
Case 5	Dome collapse	4.3 L

SOF for TEEL-2: $3.46 \times 10^{+8}$ (241-AN-103, liquids)

SOF for TEEL-3: $1.27 \times 10^{+7}$ (241-AN-103, liquids)

Release duration = 60 sec

Continuous release ground level point source χ/Q

Case 1

$$SOF_{TEEL-2} = \frac{[0.39(L)0.001(m^3/L)]}{60(s)} 3.28x10^{-2}(s/m^3)3.46x10^{+8}$$

$$SOF_{TEEL-2} = 7.4x10^{+1}$$

$$SOF_{TEEL-2} = 74$$

$$SOF_{TEEL-3} = \frac{[0.39(L)0.001(m^3/L)]}{60(s)} 3.28x10^{-2}(s/m^3)1.27x10^{+7}$$

$$SOF_{TEEL-3} = 2.7x10^{+0}$$

$$SOF_{TEEL-3} = 2.7$$

Case 2

$$SOF_{TEEL-2} = \frac{[0.3(L)0.001(m^3/L)]}{60(s)} 3.28x10^{-2}(s/m^3)3.46x10^{+8}$$

$$SOF_{TEEL-2} = 5.7x10^{+1}$$

$$SOF_{TEEL-2} = 57$$

$$SOF_{TEEL-3} = \frac{[0.3(L)0.001(m^3/L)]}{60(s)} 3.28x10^{-2}(s/m^3)1.27x10^{+7}$$

$$SOF_{TEEL-3} = 2.1x10^{+0}$$

$$SOF_{TEEL-3} = 2.1$$

Case 3

$$SOF_{TEEL-2} = \frac{[0.7(L)0.001(m^3/L)]}{60(s)} 3.28x10^{-2}(s/m^3)3.46x10^{+8}$$

$$SOF_{TEEL-2} = 1.3x10^{+2}$$

$$SOF_{TEEL-2} = 130$$

$$SOF_{TEEL-3} = \frac{[0.7(L)0.001(m^3/L)]}{60(s)} 3.28x10^{-2}(s/m^3)1.27x10^{+7}$$

$$SOF_{TEEL-3} = 4.9x10^{+0}$$

$$SOF_{TEEL-3} = 4.9$$

Case 4

$$SOF_{TEEL-2} = \frac{[0.7(L)0.001(m^3/L)]}{60(s)} 3.28x10^{-2}(s/m^3)3.46x10^{+8}$$

$$SOF_{TEEL-2} = 1.3x10^{+2}$$

$$SOF_{TEEL-2} = 130$$

$$SOF_{TEEL-3} = \frac{[0.7(L)0.001(m^3/L)]}{60(s)} 3.28x10^{-2}(s/m^3)1.27x10^{+7}$$

$$SOF_{TEEL-3} = 4.9x10^{+0}$$

$$SOF_{TEEL-3} = 4.9$$

Case 5

$$SOF_{TEEL-2} = \frac{[4.3(L)0.001(m^3/L)]}{60(s)} 3.28x10^{-2}(s/m^3)3.46x10^{+8}$$

$$SOF_{TEEL-2} = 8.1x10^{+2}$$

$$SOF_{TEEL-2} = 810$$

$$SOF_{TEEL-3} = \frac{[4.3(L)0.001(m^3/L)]}{60(s)} 3.28x10^{-2}(s/m^3)1.27x10^{+7}$$

$$SOF_{TEEL-3} = 3.0x10^{+1}$$

$$SOF_{TEEL-3} = 30$$

Continuous release volumetric χ/Q

Case 1 Assume 15 lb/in^2 gauge

$$SOF_{TEEL-2} = \frac{[0.39(L)0.001(m^3/L)]}{60(s)} 7.35x10^{-3}(s/m^3)3.46x10^{+8}$$

$$SOF_{TEEL-2} = 1.7x10^{+1}$$

$$SOF_{TEEL-2} = 17$$

$$SOF_{TEEL-3} = \frac{[0.39(L)0.001(m^3/L)]}{60(s)} 7.35x10^{-3}(s/m^3)1.27x10^{+7}$$

$$SOF_{TEEL-3} = 6.1x10^{-1}$$

rounded to:

$$SOF_{TEEL-3} = 0.6$$

Case 2 Assume 15 lb/in^2 gauge

$$SOF_{TEEL-2} = \frac{[0.3(L)0.001(m^3/L)]}{60(s)} 7.35x10^{-3}(s/m^3)3.46x10^{+8}$$

$$SOF_{TEEL-2} = 1.3x10^{+1}$$

$$SOF_{TEEL-2} = 13$$

$$SOF_{TEEL-3} = \frac{[0.3(L)0.001(m^3/L)]}{60(s)} 7.35x10^{-3}(s/m^3)1.27x10^{+7}$$

$$SOF_{TEEL-3} = 4.7x10^{-1}$$

rounded to:

$$SOF_{TEEL-3} = 0.5$$

Case 3 Assume 45 lb/in^2 gauge

$$SOF_{TEEL-2} = \frac{[0.7(L)0.001(m^3/L)]}{60(s)} 3.73x10^{-3}(s/m^3)3.46x10^{+8}$$

$$SOF_{TEEL-2} = 1.5x10^{+1}$$

$$SOF_{TEEL-2} = 15$$

$$SOF_{TEEL-3} = \frac{[0.7(L)0.001(m^3/L)]}{60(s)} 3.73x10^{-3}(s/m^3)1.27x10^{+7}$$

$$SOF_{TEEL-3} = 5.5x10^{-1}$$

rounded to:

$$SOF_{TEEL-3} = 0.6$$

Case 4 Assume 45 lb/in^2 gauge

$$SOF_{TEEL-2} = \frac{[0.7(L)0.001(m^3/L)]}{60(s)} 3.73x10^{-3}(s/m^3)3.46x10^{+8}$$

$$SOF_{TEEL-2} = 1.5x10^{+1}$$

$$SOF_{TEEL-2} = 15$$

$$SOF_{TEEL-3} = \frac{[0.7(L)0.001(m^3/L)]}{60(s)} 3.73x10^{-3}(s/m^3)1.27x10^{+7}$$

$$SOF_{TEEL-3} = 5.5x10^{-1}$$

$$SOF_{TEEL-3} = 0.6$$

Case 5 Assume 45 lb/in^2 gauge

$$SOF_{TEEL-2} = \frac{[4.3(L)0.001(m^3/L)]}{60(s)} 3.73x10^{-3}(s/m^3)3.46x10^{+8}$$

$$SOF_{TEEL-2} = 9.2x10^{+1}$$

$$SOF_{TEEL-2} = 92$$

$$SOF_{TEEL-3} = \frac{[4.3(L)0.001(m^3/L)]}{60(s)} 3.73x10^{-3}(s/m^3)1.27x10^{+7}$$

$$SOF_{TEEL-3} = 3.4x10^{+0}$$

$$SOF_{TEEL-3} = 3.4$$

Single-Shell Tank Deflagration Onsite Toxicological Consequences

Release quantities

Case 1	Cracked dome-1	0.011 L
Case 2	Cracked dome-2	0.6 L
Case 3	No tank damage	0.12 L
Case 4	Dome collapse-1	4 L
Case 5	Dome collapse-2	3.3 L

SOF for TEEL-2: 6.28 x 10^{+8} (241-A-102, solids)

SOF for TEEL-3 (100-series): 9.80 x 10^{+7} (241-T-112, solids)

SOF for TEEL-3 (200-series): 3.39 x 10^{+8} (241-T-202, solids)

Release duration = 60 sec

Continuous release ground level point source χ/Q (200-series TEEL-3 values and results shown in brackets)

Case 1

$$SOF_{TEEL-2} = \frac{[0.011(L)0.001(m^3/L)]}{60(s)} 3.28x10^{-2}(s/m^3)6.28x10^{+8}$$

$$SOF_{TEEL-2} = 3.8x10^{+0}$$

$$SOF_{TEEL-2} = 3.8$$

$$SOF_{TEEL-3} = \frac{[0.011(L)0.001(m^3/L)]}{60(s)} 3.28x10^{-2}(s/m^3)9.80x10^{+7}[3.39x10^{+8}]$$

$$SOF_{TEEL-3} = 5.9x10^{-1}[2.0x10^{+0}]$$

rounded to:

$$SOF_{TEEL-3} = 0.6[2.0]$$

Case 2

$$SOF_{TEEL-2} = \frac{[0.6(L)0.001(m^3/L)]}{60(s)} 3.28x10^{-2}(s/m^3)6.28x10^{+8}$$

$$SOF_{TEEL-2} = 2.1x10^{+2}$$

$$SOF_{TEEL-2} = 210$$

$$SOF_{TEEL-3} = \frac{[0.6(L)0.001(m^3/L)]}{60(s)} 3.28x10^{-2}(s/m^3)9.80x10^{+7}[3.39x10^{+8}]$$

$$SOF_{TEEL-3} = 3.2x10^{+1}m[1.1x10^{+2}]$$

$$SOF_{TEEL-3} = 32[110]$$

Case 3

$$SOF_{TEEL-2} = \frac{[0.12(L)0.001(m^3/L)]}{60(s)} 3.28x10^{-2}(s/m^3)6.28x10^{+8}$$

$$SOF_{TEEL-2} = 4.1x10^{+1}$$

$$SOF_{TEEL-2} = 41$$

$$SOF_{TEEL-3} = \frac{[0.12(L)0.001(m^3/L)]}{60(s)} 3.28x10^{-2}(s/m^3)9.80x10^{+7}[3.39x10^{+8}]$$

$$SOF_{TEEL-3} = 6.4x10^{+0}[2.2x10^{+1}]$$

$$SOF_{TEEL-3} = 6.4[22]$$

Case 4

$$SOF_{TEEL-2} = \frac{[4(L)0.001(m^3/L)]}{60(s)} 3.28x10^{-2}(s/m^3)6.28x10^{+8}$$

$$SOF_{TEEL-2} = 1.4x10^{+3}$$

$$SOF_{TEEL-2} = 1,400$$

$$SOF_{TEEL-3} = \frac{[4(L)0.001(m^3/L)]}{60(s)} 3.28x10^{-2}(s/m^3)9.80x10^{+7}[3.39x10^{+8}]$$

$$SOF_{TEEL-3} = 2.1x10^{+2}[7.4x10^{+2}]$$

$$SOF_{TEEL-3} = 210[740]$$

Case 5

$$SOF_{TEEL-2} = \frac{[3.3(L)0.001(m^3/L)]}{60(s)} 3.28x10^{-2}(s/m^3)6.28x10^{+8}$$

$$SOF_{TEEL-2} = 1.1x10^{+3}$$

$$SOF_{TEEL-2} = 1,100$$

$$SOF_{TEEL-3} = \frac{[3.3(L)0.001(m^3/L)]}{60(s)} 3.28x10^{-2}(s/m^3)9.80x10^{+7}[3.39x10^{+8}]$$

$$SOF_{TEEL-3} = 1.8x10^{+2}[6.1x10^{+2}]$$

$$SOF_{TEEL-3} = 180[610]$$

Continuous release volumetric χ/Q

Case 1 Assume 15 lb/in^2 gauge

$$SOF_{TEEL-2} = \frac{[0.011(L)0.001(m^3/L)]}{60(s)} 4.88x10^{-3}(s/m^3)6.28x10^{+8}$$

$$SOF_{TEEL-2} = 5.6x10^{-1}$$

rounded to:

$$SOF_{TEEL-2} = 0.6$$

$$SOF_{TEEL-3} = \frac{[0.011(L)0.001(m^3/L)]}{60(s)} 4.88x10^{-3}(s/m^3)9.80x10^{+7}[3.39x10^{+8}]$$

$$SOF_{TEEL-3} = 8.8x10^{-2}[3.0x10^{-1}]$$

rounded to:

$$SOF_{TEEL-3} = 0.1[0.3]$$

Case 2 Assume 15 lb/in^2 gauge

$$SOF_{TEEL-2} = \frac{[0.6(L)0.001(m^3/L)]}{60(s)} 4.88x10^{-3}(s/m^3)6.28x10^{+8}$$

$$SOF_{TEEL-2} = 3.1x10^{+1}$$

$$SOF_{TEEL-2} = 31$$

$$SOF_{TEEL-3} = \frac{[0.6(L)0.001(m^3/L)]}{60(s)} 4.88x10^{-3}(s/m^3)9.80x10^{+7}[3.39x10^{+8}]$$

$$SOF_{TEEL-3} = 4.8x10^{+0}[1.7x10^{+1}]$$

$$SOF_{TEEL-3} = 4.8[17]$$

Case 3 Assume 15 lb/in^2 gauge

$$SOF_{TEEL-2} = \frac{[0.12(L)0.001(m^3/L)]}{60(s)} 4.88x10^{-3}(s/m^3)6.28x10^{+8}$$

$$SOF_{TEEL-2} = 6.1x10^{+0}$$

$$SOF_{TEEL-2} = 6.1$$

$$SOF_{TEEL-3} = \frac{[0.12(L)0.001(m^3/L)]}{60(s)} 4.88x10^{-3}(s/m^3)9.80x10^{+7}[3.39x10^{+8}]$$

$$SOF_{TEEL-3} = 9.6x10^{-1}[3.3x10^{+0}]$$

$$SOF_{TEEL-3} = 1.0[3.3]$$

Case 4 Assume 44 lb/in^2 gauge

$$SOF_{TEEL-2} = \frac{[4(L)0.001(m^3/L)]}{60(s)} 2.06x10^{-3}(s/m^3)6.28x10^{+8}$$

$$SOF_{TEEL-2} = 8.6x10^{+2}$$

$$SOF_{TEEL-2} = 86$$

$$SOF_{TEEL-3} = \frac{[4(L)0.001(m^3/L)]}{60(s)} 2.06x10^{-3}(s/m^3)9.80x10^{+7}[3.39x10^{+8}]$$

$$SOF_{TEEL-3} = 1.3x10^{+1}[4.7x10^{+1}]$$

$$SOF_{TEEL-3} = 13[47]$$

Case 5 Assume 44 lb/in^2 gauge

$$SOF_{TEEL-2} = \frac{[3.3(L)0.001(m^3/L)]}{60(s)} 2.06x10^{-3}(s/m^3)6.28x10^{+8}$$

$$SOF_{TEEL-2} = 7.1x10^{+1}$$

$$SOF_{TEEL-2} = 71$$

$$SOF_{TEEL-3} = \frac{[3.3(L)0.001(m^3/L)]}{60(s)} 2.06x10^{-3}(s/m^3)9.80x10^{+7}[3.39x10^{+8}]$$

$$SOF_{TEEL-3} = 1.1x10^{+1}[3.8x10^{+1}]$$

$$SOF_{TEEL-3} = 11[38]$$

Double-Shell Tank Detonation Consequences

Release quantity = 5 L

Onsite Radiological Consequences

Apply standard, ground level release χ/Q:

$$D(rem) = 5(L)\ 3.28x10^{-2}(s/m^3)\ 3.33x10^{-4}(m^3/s)\ 1.0x10^{+3}(Sv/L) 1.0x10^{+2}(rem/Sv)$$

$$D(rem) = 5.5x10^{+0}$$

$$D(rem) = 5.5$$

Apply volumetric χ/Q, assume 45 lb/in^2 gauge

$$D(rem) = 5(L)\ 3.73x10^{-3}(s/m^3)\ 3.33x10^{-4}(m^3/s)\ 1.0x10^{+3}(Sv/L) 1.0x10^{+2}(rem/Sv)$$

$$D(rem) = 6.2x10^{-1}$$

rounded to:

$$D(rem) = 0.6$$

Offsite Toxicological Consequences:

$$SOF = 5(L)\ 0.001(m^3/L)\ 5.06x10^{-8}(1/m^3)\ 2.75x10^{+9}$$

$$SOF = 6.9x10^{-1}$$

rounded to:

$$SOF = 0.7$$

Onsite Toxicological Consequences:

Continuous release ground level point source χ/Q

$$SOF_{TEEL-2} = \frac{[5(L)0.001(m^3/L)]}{60(s)} 3.28x10^{-2}(s/m^3)3.46x10^{+8}$$

$$SOF_{TEEL-2} = 9.5x10^{+2}$$

$$SOF_{TEEL-2} = 950$$

$$SOF_{TEEL-3} = \frac{[5(L)0.001(m^3/L)]}{60(s)} 3.28x10^{-2}(s/m^3)1.27x10^{+7}$$

$$SOF_{TEEL-3} = 3.5x10^{+1}$$

$$SOF_{TEEL-3} = 35$$

Continuous release volumetric χ/Q, assume 45 lb/in^2 gauge

$$SOF_{TEEL-2} = \frac{[5(L)0.001(m^3/L)]}{60(s)} 3.73x10^{-3}(s/m^3)3.46x10^{+8}$$

$$SOF_{TEEL-2} = 1.1x10^{+2}$$

$$SOF_{TEEL-2} = 110$$

$$SOF_{TEEL-3} = \frac{[5(L)0.001(m^3/L)]}{60(s)} 3.73x10^{-3}(s/m^3)1.27x10^{+7}$$

$$SOF_{TEEL-3} = 3.9x10^{+0}$$

$$SOF_{TEEL-3} = 3.9$$

APPENDIX C

CONTROL DECISION MEETING ATTENDEES DURING INITIAL DOCUMENTED SAFETY ANALYSIS DEVELOPMENT

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APPENDIX C

CONTROL DECISION MEETING ATTENDEES DURING INITIAL DOCUMENTED SAFETY ANALYSIS DEVELOPMENT

FLAMMABLE GAS STEADY STATE HAZARDS
CONTROL DECISION MEETING ATTENDANCE
AUGUST 28, 2002

Name	Knowledge Area(s) Represented (see below)	Organization	Telephone Number
Geoffrey Gellhaus	1,2,4,6,7,8	ORP-Support	375-1417
Jon C Gaisbush		CHG-ADI	373-0468
Rick Huckfeldt		Safety	372-3217
Bill Cowley	1,2	NS&L	376-4567
Patricia Kabagel	4	DST Engr.	372-0036
LISA DOMNOSKE-RAUCH	2,3,4	DST SYS ENG	376-9346
Wylie Lee Walker	1234 10	NucSfty&Lic DSA	
MARC A. DANNA	1,2,3,6,7,9,10,13	NS+L-DSA	373-4045
Michael C. Jones	5	CHG-CPO	373-5630
Dan K Ahrens	5	CHG-CPO	373-2809
BRAD SMITH	1,2,4,5,6,7,9,10,11,12, 13,14, [redacted] 17,18,19,20, 23	NS&L	376-1907

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

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FLAMMABLE GAS STEADY STATE HAZARDS
CONTROL DECISION MEETING ATTENDANCE
AUGUST 28, 2002

Name	Knowledge Area(s) Represented (see below)	Organization	Telephone Number
Craig Carro	1, 2, 3, 6, 7, 9	NS&L	372-2646
MILTON V SHULTZ	1, 2, 3, 6, 7, 9, 10	NS&L	372-3740
JOSEPH J BEVELACQUA	1-23	ORP	376-8443
CLIFFORD HAMPTON	5	CHG	2-0566
David Shuford	4, 20, 21, 23	CHG/SE	372-0703
TODD Blaak	4	CHG/SYS Eng	373-3880
Chuck Scaief	4, 8	CHG	376-0491
TROY FARRIS	4, 5	CHG	3-4373
Mark Sautman		DNFSB	373-0101
Jennifer Stewart	1, 7, 9	NS&L/FFS	376-5633
Brad Evans	1, 2, 3, 6, 7, 9, 10	NS&L/NSS	373-2754
[illegible]	4-5	CHG	373-1938
Curt Reichmuth	5	CHG SST [illegible]	376-4796

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

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FLAMMABLE GAS GRE HAZARDS
CONTROL DECISION MEETING ATTENDANCE
AUGUST 29, 2002

Name	Knowledge Area(s) Represented (see below)	Organization	Telephone Number
MILTON V. SHULTZ	1, 2, 3, 4, 7, 9, 10	CHG - NS&L	372-3740
Jennifer L. Stewart	1, 7, 9	FFS - NS+L	376-5633
MARC A. DANNA	1, 2, 3, 6, 7, 9, 10	NS+L	373-4045
Willie Lee Walker	1 2 3 4 10	NS&L	
Rick Huckfeldt		Safety	372-3212
Jon C Geisbush		CHG/AD1	373 0406
Geoffrey Gelhaus	1, 2, 4, 6, 7, 8, 18	ORP - Support	375-1417
Patricia Kabage	4	DST Engr.	372-0036
LISA DIMNOSKE-RAUCH	2, 4	DST SYS ENG	376-9886
Blaine Barton	22	Process Control	376-5118
R. Frank Frost	5	FWS (CPO)	544-8606
CLIFF HAMPTON	5, 13 9	OPS	2-0566

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

FLAMMABLE GAS GRE HAZARDS
CONTROL DECISION MEETING ATTENDANCE
AUGUST 29, 2002

Name	Knowledge Area(s) Represented (see below)	Organization	Telephone Number
Craig Carro	1, 2, 3, 6, 7, 9		
Joseph Bevelacqua	1- 23	ORP	376-8443
Lawrence J. Kripps	1,2,3,6,7,9,10	NSL	376-1061
BRAD SMITH	1 -23	NSTL	376 1907
Mark Roberts	4, 20, 21	M+RE	376-4852
Todd Blaak	4	DST SYS ENG	373-3880
Ron W Reed	8	Des Engr	373-5546
Bruce E. Wells	3, 4	PNNL	375-6671
T R Farris	4	CHG / Sys. E	3-4393
R H Koon	4, 5	CHG	373 1938
Brad Evans	1, 2, 3, 6, 7, 9, 10		
James Fuhardy	5,	Operations, CHG	373-4517
Yusuf Nuri	1-23	DOE	372-2...

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

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FLAMMABLE GAS STEADY STATE HAZARDS
CONTROL DECISION MEETING ATTENDANCE
SEPTEMBER 4, 2002

Name	Knowledge Area(s) Represented (see below)	Organization	Telephone Number
Craig Carro	1, 2, 3, 6, 7, 9	NS + L	372-2646
MILTON V. SHULTZ	1, 2, 3, 6, 7, 9, 10	NS & L	372-3740
LAWRENCE T. KRIAK	1, 2, 3, 6, 7, 9, 10		
CLIFF HAMPTON		OPS	20565
Jennifer Stewart	1, 7, 9	NS&L / FFS	376-5633
Dan Harris	5	CPO - ops	373-2809

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

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**FLAMMABLE GAS STEADY STATE HAZARDS
CONTROL DECISION MEETING ATTENDANCE
SEPTEMBER 4, 2002**

Name	Knowledge Area(s) Represented (see below)	Organization	Telephone Number
Geoffrey Gelhaus	1,2,4,6,7,8,18	ORP Support	375-1417
Robert Carrell	2 3 6 7 9 10	ORP Support	521-6421
LEE M LIVESEY	12	TFC RAD CON	531-5637
Wylie LeuWalker	1 2 3 4 9 10	NS&L	373-9045
Michael C Jones	5	CHG/CPO	373-5630
Brad Evans	1,2,3,6,7,9,10	CHG NS&L	373-2754
BRAD SMITH	ALL	CHG NS&L	376 1907
Paul Kison	4,5	CHG/SSTSE	373 1938
CRAIG GROENDYKE	2,3,6,7,9,10	ORP	376-9811
Mark Roberts	4,20,21	CHG	376-4852
Mark Sautman		DNFSB	373-0101

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

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FLAMMABLE GAS GRE HAZARDS
CONTROL DECISION MEETING ATTENDANCE
SEPTEMBER 5, 2002

Name	Knowledge Area(s) Represented (see below)	Organization	Telephone Number
MILTON V. SHULTZ	1, 2, 3, 6, 7, 9, 10	NS&L	372-3740
Jennifer L. Stewart	1, 7, 9	NS&L / FFS	376-5633
LAWRENCE J. KRIPPS	1, 2, 3, 6, 7, 9, 10		
Craig Carro	1, 2, 3, 6, 7, 9, 10	NS&L	372-2646
Rick Hockfeldt		Safety	372-3212
CRAIG GROENDYKE	2, 3, 6, 7, 9, 10	ORP	376-9811
Bert Wells	2, 3	PNNL	375-6671
CHUCK STEWART	2, 3,	PNNL	372-4678
Blaine Barton	22	Process Eng	376-5118
James Fluharty	5	NCO	376-4517
LISA DOMNOSKE-RAUCH	4	DST SYS ENG	376-9886
TODD BLANK	4	DST SYS ENG	373-3880

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

FLAMMABLE GAS GRE HAZARDS
CONTROL DECISION MEETING ATTENDANCE
SEPTEMBER 5, 2002

Name	Knowledge Area(s) Represented (see below)	Organization	Telephone Number
Mark Roberts	4, 20, 21	CHG	376-4852
MARC A. DANNA	1, 2, 3, 6, 7, 9, 10	NS+L	373-4045
Willie Lea Walker	1.2.3.4. 9.10	NS&L	373-9045
Robert Carrell	2 3 6 7 9 10		
BRAD SMITH		NSL	376 1907
Cliff Hamilton		OPS	2-0566
Patricia Kabage	4	DST Engr.	372-0036
Geoffrey Gellman		ORP-Sup	375-1417

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

FLAMMABLE GAS HAZARDS
CONTROL DECISION MEETING ATTENDANCE
SEPTEMBER 12, 2002

Name	Knowledge Area(s) Represented (see below)	Organization	Telephone Number
Ed Ford	1,2,3,7,9,12	CHG NS&L	373-1296
Jennifer Stewart	1,7,9	NS&L/EFS	376-5633
[illegible] Walker	1234 9 10	NS&L DSA	373-9045
Tom Tre[illegible]	1,2,3,4,5,9,10	NS&L	373-1342
MARC DANNA	1,2,3,6,7,9,10	NS+L	373-4045
Curt Reichmuth	5	SST OPS	376-4796
TR FARRIS	4	SYSTEM ENGR.	3-4393
Bob Carrell	2 3 6 7 9 10	ORP support	521-6421
Linda Quarles		ISM Review Team	
Patricia Kabage	4	DST Sys. Engr	372-0036
CHUCK STEWART	2,3,6	PNNL	372-4678
Blaine Barton	22	Process Control	376-5118
LISA O[illegible]-RACH	4,2	DST SYS ENG	376-9856
Geoffrey Gelhaus		ORP-Sup.	375-1417

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

FLAMMABLE GAS HAZARDS
CONTROL DECISION MEETING ATTENDANCE
SEPTEMBER 12, 2002

Name	Knowledge Area(s) Represented (see below)	Organization	Telephone Number
MILTON V. SHULTZ	1, 2, 3, 6, 7, 9, 10	CHG - NS&L	372-3740
Craig Carrero	1, 2, 3, 6, 7, 9, 10	"	372-2646
LAWRENCE T. KRIPPS	1, 2, 3, 6, 7, 9, 10	NS+L	376-1061
James Fruhauf	5	CHG-CPO	376-4557
Mark Roberts	4, 20, 21	CHG - M+RE	376-4852
Rick Hutfeldt		Safety	372-3212
Joseph Bendecgue	1 - 23	ORP	376-4443
CRAIG GROENDYKE	1, 2, 3, 6, 7, 9, 10	ORP	376-9811
DENNIS IRBY	16 - OBSERVER	ORP	376-5652
C HAMPTON	YES	CHG OPS	322-0566
David Shuford	4, 5, 10, 20, 23	CHG - M&RE	372-0703

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

Focused Flammable Gas Hazard
Control Decision Meeting Attendance
October 24, 2002

Name	Knowledge Area(s) Represented (see below)	Organization	Telephone Number
Craig Corro	1, 2, 3, 6, 7, 9	NS&L	372-2641
RON FRINK	5	SST OPS	373-0778
CRAIG GROENDYKE		ORP	376-9811
Bob Carrell	1 2 3 6 7 8 9 10	ORP Support	947-6421
Ed Ford	1 2 3 6 7 9	NS&L	373-1246
MARC DANNA	1, 2, 3, 6, 7, 9, 10, 13	NS&L	373-4045
Jennifer Stewart	1, 7, 9	NS&L	376-5633
Mark Sautman		DNFSB	373-0101
Joseph Bavelacqua		DOE	376-8443
LAWRENCE T. KRIM	1, 2 [illegible]	NS&L	376-1061
Donald R Jones	5	Transfers	372-2988
MARK HASTY	5, 9, 13	OPS	373-9378
C HAMILTON		OPS	372-0565

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

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APPENDIX D

ATTENDEES AT RISK BINNING AND CONTROL DECISION MEETINGS SUBSEQUENT TO INITIAL DOCUMENTED SAFETY ANALYSIS DEVELOPMENT

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APPENDIX D

ATTENDEES AT RISK BINNING AND CONTROL DECISION MEETINGS SUBSEQUENT TO INITIAL DOCUMENTED SAFETY ANALYSIS DEVELOPMENT

Subsequent to the flammable gas accident risk binning team meetings and control decision meetings conducted to support the initial development of RPP-13033, *Tank Farms Documented Safety Analysis* (DSA) (see Appendices A and C), risk binning and/or control decision meetings have been held to support amendments to the DSA addressing flammable gas accidents. Attendees at these meetings are attached as follows.

- Attendees at the risk binning/control decision meeting held on October 24, 2004, for the single-shell tank 241-S-109 waste retrieval system for the Demonstration Bulk Vitrification System.
- Attendees at the Demonstration Bulk Vitrification System flammable gas accident (risk binning and) control decision meeting held on November 9, 2004.

References

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

SINGLE-SHELL TANK 241-S-109 RISK BINNING/CONTROL DECISION MEETING ATTENDANCE LIST

October 25, 2004		
Attendees:		
<u>CH2M HILL</u>	<u>MSIN</u>	<u>OTHER</u>
JA Bewick	S7-24	JR Buchanan R1-82
JF Bores	S7-07	CE Hanson S7-70
DW Hamilton	T4-67	JL Mauss R3-27
EC Heubach II	S7-90	TE Rainey S7-12
GP Janicek	S7-12	
LJ Kripps	S7-90	
CR Reichmuth	S7-20	
KR Sandgren	S7-90	
DH Shuford	T4-67	
MV Shultz	S7-90	
BD Zimmerman	S5-24	
<u>DOE</u>		
MA Sautman	A5-17	

CONTROL DECISION MEETING ATTENDANCE

Meeting Subject: Flammable Gas Accident during DBVS Operations

Meeting Date: 11/9/04

Name	Organization	Telephone
Mark Hasty	CH2M HILL Closure Project	373-9378
David Shuford	CH2M HILL DBVS	372-0703
K. J. McCracken	DMJM	375-7875
Dick Whitehurst	DMJM	375-7883
John Harris	CH2M HILL NS&L	372-1237
Stephen Primo	CH2M HILL	373-2031
Lawrence J. Kripps	CH2M HILL	376-1061
George Janicek	CH2M HILL - DA	376-2225
D. W. Hamilton	CH2M HILL	376-2425
John Guberski	CH2M HILL	376-5084
John Hammer	AMEC	942-1114 Ext 203
Mark Sautman	DNFSB Site Rep	373-0101
Mike Grigsby	CH2M HILL	372-1907

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APPENDIX E

HUMAN FACTORS CHECKLISTS

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APPENDIX E

HUMAN FACTORS CHECKLISTS

Human factors checklists were not prepared during initial development of RPP-13033, *Tank Farms Documented Safety Analysis* (DSA), although human interactions required to implement selected controls were considered during control decision meetings and in technical reviews of the technical safety requirements. A human factors checklist was also not prepared for single-shell tank vacuum retrieval system flammable gas controls. However, the selected ignition controls to prevent steady-state flammable gas hazards in the vacuum retrieval system slurry tank and water separator do not require human interaction to implement. The following human factors checklists developed based on control decision meeting discussions are attached:

- Human Factors Checklist for Demonstration Bulk Vitrification System Flammable Gas Accidents.

HUMAN FACTORS CHECKLIST

Hazard Analysis Title:	Demonstration Bulk Vitrification System (DBVS) Flammable Gas Accidents
Documented Safety Analysis Section Number:	RPP-23429, *Preliminary Documented Safety Analysis for the Demonstration Bulk Vitrification System*, Section 3.3.2.4.1, "Flammable Gas Accidents"

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: ______ Print ______ Signature ______ Date Peer Reviewer: ______ Print ______ Signature ______ 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.

APPENDIX F

PEER REVIEW CHECKLIST

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APPENDIX F

PEER REVIEW CHECKLIST

NS&L CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: RPP-13510, Rev. 4

Scope of Review (e.g., document section or portion of calculation): Changes that result from revising document to Rev. 4

Yes	No*	NA	
☒	☐	☐	1. Previous reviews are complete and cover the analysis, up to the scope of this review, with no gaps. *Explanation:
☒	☐	☐	2. Problem is completely defined. *Explanation:
☒	☐	☐	3. Accident scenarios are developed in a clear and logical manner. *Explanation:
☒	☐	☐	4. Analytical and technical approaches and results are reasonable and appropriate. *(ORP QAPP criterion 2.8)* *Explanation:
☒	☐	☐	5. Necessary assumptions are reasonable, explicitly stated, and supported. *(ORP QAPP criterion 2.2)* *Explanation:
☐	☐	☒	6. Computer codes and data files are documented. *Explanation: No computer codes used in the revision
☒	☐	☐	7. Data used in calculations are explicitly stated. *Explanation:
☒	☐	☐	8. Bases for calculations, including assumptions and data, are consistent with the supported safety basis document (e.g., the Tank Farms Documented Safety Analysis). *Explanation:
☒	☐	☐	9. Data were checked for consistency with original source information as applicable. *(ORP QAPP criterion 2.9)* *Explanation:
☒	☐	☐	10. For both qualitative and quantitative data, uncertainties are recognized and discussed, as appropriate. *(ORP QAPP criterion 2.17)* *Explanation:
☒	☐	☐	11. Mathematical derivations were checked including dimensional consistency of results. *(ORP QAPP criterion 2.16)* *Explanation:
☒	☐	☐	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. *Explanation:
☐	☐	☒	13. Spreadsheet results and all hand calculations were verified. *Explanation: No spreadsheets were used in the revision
☒	☐	☐	14. Calculations are sufficiently detailed such that a technically qualified person can understand the analysis without requiring outside information. *(ORP QAPP criterion 2.5)* *Explanation:
☐	☐	☒	15. Software input is correct and consistent with the document reviewed. *Explanation: No software used in the revision
☐	☐	☒	16. Software output is consistent with the input and with the results reported in the document reviewed. *Explanation: No software used in the revision
☐	☐	☒	17. Software verification and validation are addressed adequately. *(ORP QAPP criterion 2.6)* *Explanation: No software used in the revision
☒	☐	☐	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)* *Explanation:
☒	☐	☐	19. Safety margins are consistent with good engineering practices. *Explanation:
☒	☐	☐	20. Conclusions are consistent with analytical results and applicable limits. *Explanation:
☒	☐	☐	21. Results and conclusions address all points in the purpose. *(ORP QAPP criterion 2.3)* *Explanation:
☐	☐	☒	22. All references cited in the text, figures, and tables are contained in the reference list. *Explanation:

WJL / 3-2-05
Initials/Date

Form Current To 12/08/2004

NS&L CHECKLIST FOR TECHNICAL PEER REVIEW

Yes	No*	NA*	
☐	☐	☒	23. Reference citations (e.g., title and number) are consistent between the text callout and the reference list. *Explanation:
☐	☐	☒	24. Only released (i.e., not draft) references are cited. *(ORP QAPP criterion 2.1)* *Explanation:
☐	☐	☒	25. Referenced documents are retrievable or otherwise available. *Explanation:
☐	☐	☒	26. The most recent version of each reference is cited, as appropriate. *(ORP QAPP criterion 2.1)* *Explanation:
☐	☐	☒	27. There are no duplicate citations in the reference list. *Explanation:
☐	☐	☒	28. Referenced documents are spelled out (title and number) the first time they are cited. *Explanation:
☐	☐	☒	29. All acronyms are spelled out the first time they are used. *Explanation:
☐	☐	☒	30. The Table of Contents is correct. *Explanation:
☒	☐	☐	31. All figure, table, and section callouts are correct. *Explanation:
☒	☐	☐	32. Unit conversions are correct and consistent. *Explanation:
☒	☐	☐	33. The number of significant digits is appropriate and consistent. *Explanation:
☐	☐	☒	34. Chemical reactions are correct and balanced. *Explanation: No chemical reactions are specified in the revision
☐	☐	☒	35. All tables are formatted consistently and are free of blank cells. *Explanation:
☒	☐	☐	36. The document is complete (pages, attachments, and appendices) and in the proper order. *Explanation:
☐	☐	☒	37. The document is free of typographical errors. *Only the section(s) being reviewed was checked for typographical errors.* *Explanation:
☒	☐	☐	38. The tables are internally consistent. *Explanation:
☐	☐	☒	39. The document was prepared in accordance with HNF-2353, Section 4.3, Attachment B, "Calculation Note Format and Preparation Instructions." *Explanation:
☒	☐	☐	40. Impacted documents are appropriately identified in Blocks 7 and 25 of the Engineering Change Notice (form A-6003-563.1). *Explanation:
☐	☐	☒	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. *Explanation: Only one peer reviewer
☒	☐	☐	**Concurrence**

W.L. Cowley *W. L. Cowley* — 3/2/05

Reviewer (Printed Name and Signature) — Date

* If No is chosen, an explanation must be provided on this form.

Additional explanation: Items 22 through 30, 35, 37, and 39 are checked by the technical editor.

Form Current To 12/08/2004

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: RPP-13510 Rev 4

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)*
[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

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

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

Technical Edit