CH2M HILL ENGINEERING CHANGE NOTICE

Page 1 of 2 ☒ DM ☐ FM ☐ TM

1a. ECN 722867 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 02/17/05

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 ECN 722499 R0 ECN 722868 R0

8. Title General revision of RPP-13470	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-13470, Rev 1	13. Safety Designation ☐ SC ☐ SS ☐ GS ☒ N/A	14. Expedited/Off-Shift ECN? ☐ Yes ☒ No

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-13470, "Offsite Radiological Consequence Analysis for the Bounding Flammable Gas Accident," has undergone a general revision to incorporate changes required by Rev. 4-A to RPP-5926, "Steady-State Flammable Gas Release Rate Calculation and Lower Flammability Level Evaluation for Hanford Tank Waste."

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

RPP-13470 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-13470 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		
E. C. Heubach II	S7-90		
L. J. Kripps	S7-90		
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J. Shuen	H6-60		

Release Stamp

DATE: HANFORD RELEASE STA: 4 ID: 2

FEB 18 2005

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1a. ECN 722867 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
NONE			

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

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

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

28. Approvals

Facility/Project Signatures		Date	A/E Signatures	Date
Design Authority			Originator/Design Agent	
Resp. Engineer	LJ Kripps [signature]	2/17/05	Professional Engineer	
Resp. Manager	JM Grigsby [signature]	2/17/05	Project Engineer	
Quality Assurance			Quality Assurance	
IS&H Engineer			Safety	
NS&L Engineer	LJ Kripps [signature]	2/17/05	Designer	
Environ. Engineer			Environ. Engineer	
Engineering Checker	EC Heubach III [signature]	02/17/05	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				

RPP-13470, Rev. 2

Offsite Radiological Consequence Analysis for the Bounding Flammable Gas Accident

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

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Key Words: Accident, calculation, consequence, double-shell tank (DST), tank, evaluation guidelines, flammable gas, offsite, radiological, single-shell tank (SST)

Abstract: This document quantifies the offsite radiological consequences of the bounding flammable gas accident for comparison with the 25 rem Evaluation Guideline established in DOE-STD-3009, Appendix A. The bounding flammable gas accident is a detonation in a SST. The calculation applies reasonably conservative input parameters in accordance with guidance in DOE-STD-3009, Appendix A.

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Tank Farm Contractor (TFC) RECORD OF REVISION

(1) Document Number: RPP-13470

Page 1

(2) Title
Offsite Radiological Consequence Analysis for the Bounding Flammable Gas Accident

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 #636617	CA Carro	JM Grigsby 03/19/03
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RPP-13470
Revision 2

Offsite Radiological Consequence Analysis for the Bounding Flammable Gas Accident

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

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

CH2MHILL
Hanford Group, Inc.

P.O. Box 1500
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DDT	deflagration-to-detonation transition
DST	double-shell tank
SST	single-shell tank
TNT	trinitrotoluene
ULD	unit-liter dose

1.0 PURPOSE

The purpose of this analysis is to calculate the offsite radiological consequence of the bounding flammable gas accident. DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*, requires the formal quantification of a limited subset of accidents representing a complete set of bounding conditions. The results of these analyses are then evaluated to determine if they challenge the DOE-STD-3009-94, Appendix A, "Evaluation Guideline," of 25 rem total effective dose equivalent in order to identify and evaluate safety-class structures, systems, and components.

The bounding flammable gas accident is a detonation in a single-shell tank (SST). A detonation versus a deflagration was selected for analysis because the faster flame speed of a detonation can potentially result in a larger release of respirable material. A detonation in an SST versus a double-shell tank (DST) was selected as the bounding accident because the estimated respirable release masses are the same and because the doses per unit quantity of waste inhaled are greater for SSTs than for DSTs. Appendix A contains a DST analysis for comparison purposes.

2.0 ASSUMPTIONS

1. A detonation is assumed to occur in an SST.

   For a detonation to occur, the flammable gas concentration must be greater than or equal to the detonable or deflagration-to-detonation transition (DDT) limit and an ignition source must be present. Combustion limits for detonations and DDTs have been evaluated for tank waste flammable gas mixtures. As documented in WHC-SD-WM-RPT-281, *Deflagration and Detonation Hazards in Hanford Tank Farm Facilities*, detonations and DDTs can occur at a flammable gas concentration on the order of 8% to 14% hydrogen.

   The waste stored within tank farm facilities is capable of generating flammable gases (primarily hydrogen) to varying degrees depending on the type, amount, geometry, and condition of the waste. In RPP-5926, *Steady-State Flammable Gas Release Rate Calculation and Lower Flammability Level Evaluation for Hanford Tank Waste*, the steady-state flammable gas concentration in SSTs is calculated. Two off-normal ventilation conditions, i.e., barometric breathing and zero ventilation, are considered. Under barometric breathing conditions, in which air flows into and out of the tanks due solely to barometric pressure variations, the maximum calculated steady-state hydrogen concentration in an SST is < 8 % hydrogen, which is the most conservative detonable limit.

   Under zero ventilation conditions, in which the SSTs are essentially modeled as sealed pressure vessels, 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.

Given the detonable limit is reached, a detonation can occur if an ignition source is present. The direct initiation of a detonation requires an ignition source of high energy, high power, or large size (i.e., 4.6 kJ for a stoichiometric hydrogen/air mixture, which is roughly equal to 1 g of high explosive). Such strong ignition sources have been judged to be incredible for in-tank ignition sources (LA-UR-92-3196, *A Safety Assessment for Proposed Mixer Pump Operations to Mitigate Episodic Gas Releases in Tank 241-SY-101: Hanford Site, Richland, Washington*).

In contrast to detonations, deflagrations (and thus DDTs) can be ignited with very small energy sources on the order of 0.01 mJ (PNNL-13269, *Overview of Flammability of Gases Generated in Hanford Waste Tanks*). However, a DDT requires a geometry or configuration conducive to flame acceleration (e.g., confinement, obstructions). An evaluation of the geometry of SSTs concluded that, given the DDT hydrogen concentration limit is reached, a DDT is possible but not likely (WHC-SD-WM-RPT-281).

In summary, detonations in SSTs are conceivable. Based on an evaluation of the conditions required to reach the detonation or DDT combustion limits and the likelihood of ignition sources, the frequency of such an event has been qualitatively determined to be "beyond extremely unlikely" (RPP-13510, *Flammable Gas Technical Basis Document*). However, when analyzing operational accidents for comparison to the DOE-STD-3009-94, Appendix A, "Evaluation Guideline," there is no predetermined frequency cutoff value.

2. A detonation is assumed to result in a partial dome collapse.

   A panel of experts was convened to evaluate the structural response of SSTs 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 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 (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. 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, the DELPHI Panel concluded there is no reason to expect complete dome collapse.

3. The respirable material released from the tank is assumed to be saltcake solids.

   The SST waste phases include supernatant, saltcake solids and interstial liquids, and sludge. These waste phases are stratified within the tanks due to density differences and process histories with the sludge at the bottom, covered by saltcake (if present), covered by supernatant (if present). Note that not all tanks contain all waste phases.

As will be discussed in Section 4.1, detonations resulting in partial dome collapse generate airborne material primarily by aerodynamic entrainment and by suspension caused by falling debris. Both of these phenomena impact the surface layer of the waste. Depending on the SST, the surface layer of waste could be supernatant, saltcake, or sludge. The respirable material released is assumed to be saltcake solids because, as will be discussed in Section 4.4, saltcake solids have, in general, the highest unit-liter dose (ULD) of the waste phases potentially impacted by a detonation.

3.0 METHODOLOGY

The radiological consequence calculation method is described in RPP-13482, *Atmospheric Dispersion Coefficients and Radiological and Toxicological Exposure Methodology for Use in Tank Farms*. The offsite dose is calculated using Equation 3-1:

$$D = Q \, x \, \frac{\chi}{Q'} \, x \, BR \, x \, ULD \qquad (3\text{-}1)$$

where:

D = committed effective dose equivalent to the receptor, sieverts (Sv)
Q = respirable tank waste released, L
χ/Q' = integrated atmospheric dispersion coefficient, s/m^3
BR = breathing rate, m^3/s
ULD = unit-liter dose, Sv/L.

Given the dose in sieverts, the dose in rem is calculated by multiplying by a conversion factor of 100 rem/Sv.

4.0 INPUT DATA

The following sections provide the data and the associated bases for input to Equation 3-1. As stated in DOE-STD-3009-94, Appendix A, offsite radiological consequence calculations are to be based on reasonably conservative estimates of the various input parameters.

4.1 LITERS OF RESPIRABLE TANK WASTE RELEASED

It is estimated that 100 kg of respirable saltcake would be released by a detonation in an SST that results in partial dome collapse. This estimate is based on information contained in HNF-2577, *Flammable Gas Project Expert Elicitation Results for Hanford Site Double-Shell Tanks*, and other flammable gas consequence assessments, as described below.

Considerable uncertainty exists in estimating the mass and particle size distribution of tank waste that would become airborne given a detonation in an SST. To date, SST flammable gas accident analyses have evaluated deflagrations and have, in general, estimated airborne releases based on aerodynamic entrainment and, in cases where partial dome collapse was postulated, by the impact of concrete masses on the waste surface.

In WHC-SD-TWR-RTP-003, a deflagration in an SST that results in dome cracking and spalling (but not dome collapse) is analyzed. The quantity of airborne material generated by aerodynamic entrainment is estimated by applying airborne release fraction and respirable fraction values in DOE-HDBK-3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, for a dry powder at wind speeds up to 20 mi/h (8.94 m/s). The airborne material generated by spalled concrete is estimated based on the energy density of the falling concrete and total mass of tank waste affected. The quantity of respirable material generated by the two mechanisms is approximately 6 g and 4 kg, respectively.

In WHC-SD-WM-TI-753, *Summary of Flammable Gas Hazards and Potential Consequences in Tank Waste Remediation System Facilities at the Hanford Site*, a deflagration in an SST is estimated to generate approximately 3 kg of respirable material due to entrainment at a flame speed of 10 m/s. This estimate was based on earlier work, documented in LA-UR-92-3196, Appendix D, which estimates that approximately 5 kg of respirable tank waste would be entrained at a flame speed of 100 m/s. The release of respirable material due to partial dome collapse would be additive to these values.

In HNF-SD-WM-ES-412, *Safety Controls Optimization by Performance Evaluation (SCOPE) Expert Elicitation Results for Hanford Site Single-Shell Tanks*, an expert elicitation process was used to estimate the mass of respirable material suspended by a deflagration in an SST that causes dome failure. Seven different experts applied various modeling techniques to generate a best estimate of the mass of respirable material suspended and an associated uncertainty distribution. As a point of reference, the seven median estimates (i.e., the true value is equally as likely to be greater than or less than the estimate) range in value from 0.3 kg to 300 kg with an aggregate median value of 6 kg. For the dome failure scenario, HNF-SD-WM-ES-412 assumes 100% of the material suspended is released.

In HNF-2577, an expert elicitation process was again used to estimate the mass of respirable material released by a deflagration in a DST that causes dome failure. Nine different experts applied various modeling techniques to estimate the respirable mass of material released and an associated uncertainty distribution. The nine median estimates range in value from 0.2 kg to 50 kg with an aggregate median value of approximately 1 kg. These estimates are lower than those for a deflagration in an SST because the DST expert panel determined that it is unacceptably conservative to assume that all of the material suspended is released, as such an assumption does not account for suspended waste falling back into the tank or on the ground in the immediate vicinity of the tank, nor does it account for coarse filtering of the waste as the gases vent through the tank overburden (HNF-2577).

The analyses summarized above address a deflagration versus a detonation, the difference being the speed at which the flame front moves as the gas burns. In a deflagration, the combustion front travels at speeds on the order of 10 to 55 m/s (WHC-SD-WM-TI-753, LA-UR-92-3196), whereas a detonation combustion front travels at supersonic speeds ranging up to 2,000 m/s for a stoichiometric hydrogen/air mixture (HNF-2577). 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. For a detonation, the median estimates range from 0.5 kg to 400 kg with an aggregate median value of 7 kg. These values are approximately an order-of-magnitude greater than the deflagration estimates.

Based on the above evaluations, a value of 100 kg is selected as being a reasonably conservative estimate of the mass of respirable material released given a detonation in an SST. In reference to the expert elicitation aggregate curve for a detonation in a DST (reproduced as Figure 4-1), this value encompasses the majority of release estimates. Two individuals (Experts 1 and 4) estimated higher releases. Expert 1 estimated the release by assuming aerosol densities ranging from 10 to 1,000 g/m^3. These are extremely high mass loadings for air and considerable particle agglomeration and deposition would occur as the resultant plume was transported downwind. Expert 4 estimated the release by applying a trinitrotoluene (TNT)-equivalent model in which 1 g of material is released per gram of TNT equivalent. This approach, as discussed in DOE-HDBK-3010-94, is conservative.

For input to Equation 3-1, the 100 kg value must be converted to liters. As stated in Chapter 2.0, it is assumed that the material released is comprised of SST saltcake solids. Based on best-basis inventory 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. The saltcake with the applicable ULD (see Section 4.4) is associated with SST 241-TX-118. This saltcake has a corresponding density of approximately 1.8 g/ml.[1] The volume of respirable material released is therefore 56 L, which is rounded to 60 L.

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

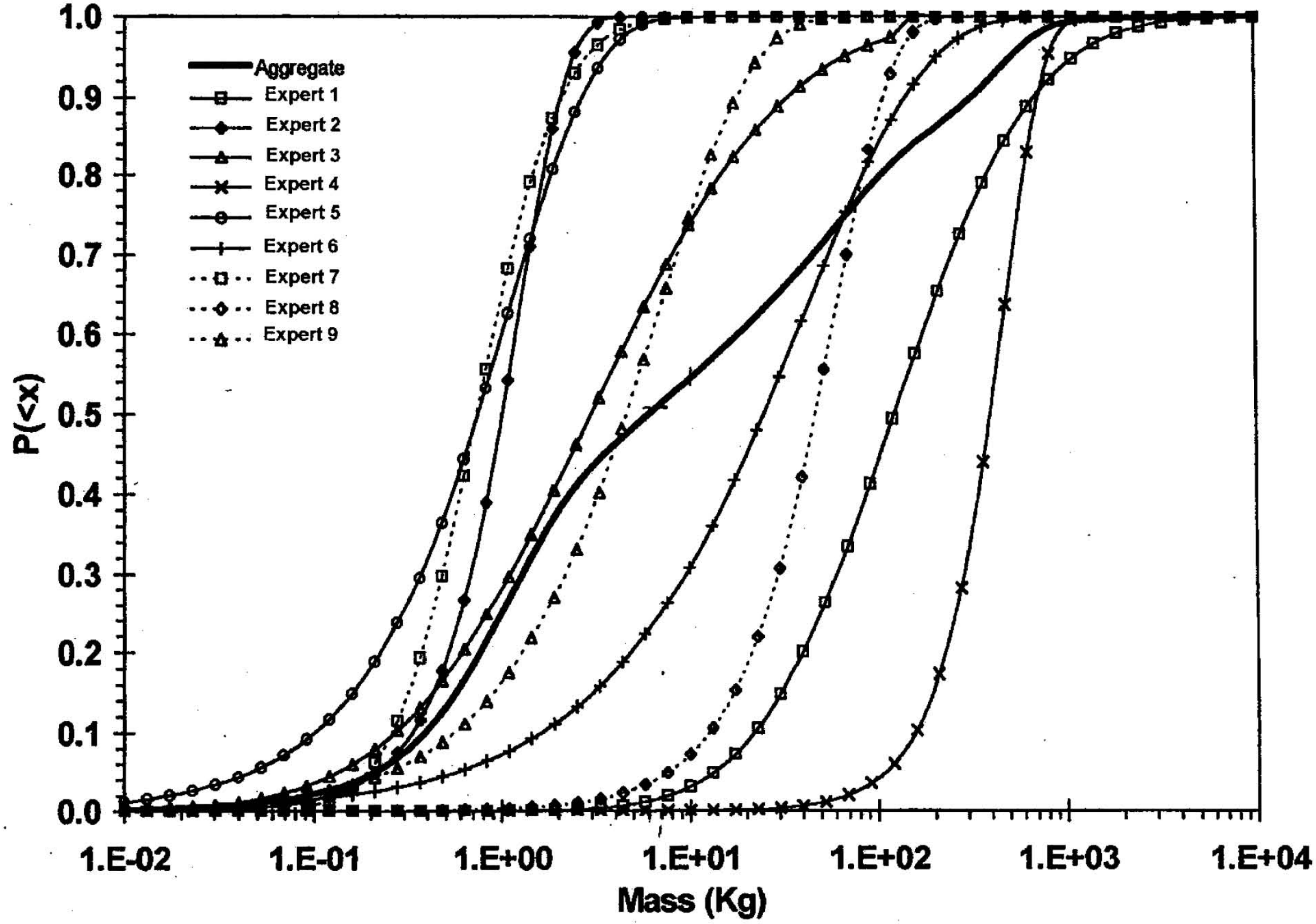

Figure 4-1. Aggregate Curve for Detonation in a Double-Shell Tank.

In estimating the liters of respirable material released, consideration was given to additional releases associated with ex-tank material potentially impacted by the detonation (e.g., contamination in a connected waste transfer-associated structure) and additional releases from secondary events potentially initiated by the detonation (e.g., waste transfer leak). Based on a review of relevant accident analyses (Appendix B), it was concluded that such additional releases would be insignificant relative to the 60 L estimate.

4.2 INTEGRATED ATMOSPHERIC DISPERSION COEFFICIENT

The integrated atmospheric dispersion coefficient is 2.22×10^{-5} s/m^3. The assumptions, input parameters, and derivation of this value are documented in RPP-13482.

4.3 BREATHING RATE

The breathing rate is 3.33×10^{-4} m^3/s. As described in RPP-13482, this value is applicable to offsite calculations for accidents with acute releases (i.e., the release occurs in less than 24 hr).

4.4 UNIT-LITER DOSE

As described in the following paragraphs, a ULD of $1.6 \times 10^{+5}$ Sv/L has been selected for use in calculating the offsite radiological consequences of an SST detonation.

The ULDs are derived in RPP-5924, *Radiological Source Terms for Tank Farms Safety Analysis*, for each waste phase in each tank. For the 149 SSTs, ULDs ranged in value from 1.8×10^{-1} Sv/L (associated with 8 kL of liquid in SST 241-T-201) to $1.9 \times 10^{+5}$ 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 $1.6 \times 10^{+5}$ Sv/L and SST 241-TX-118 can reach the LFL and detonable limits assuming zero ventilation conditions.

5.0 CALCULATIONS

Using Equation 3-1 and the input data provided in Chapter 4.0, the offsite radiological consequence of a detonation in an SST is calculated as follows.

$$D(Sv) = 60(L) x 2.22x10^{-5}(s/m^3) x 3.33x10^{-4}(m^3/s) x 1.6x10^{+5}(Sv/L)$$

$$D(Sv) = 7.1x10^{-2}$$

$$D(rem) = 7.1x10^{-2}(Sv) x 1x10^{+2}(rem/Sv)$$

$$D(rem) = 7.1$$

where D = committed effective dose equivalent to the receptor.

6.0 RESULTS

The offsite radiological consequence of a detonation in an SST that results in partial dome collapse is calculated to be 7.1 rem, which is rounded to 7 rem.

7.0 CONCLUSIONS

The calculated offsite radiological consequence of the bounding flammable gas accident does not challenge the DOE-STD-3009-94, Appendix A, "Evaluation Guideline." The bounding flammable gas accident is a detonation in an SST. The offsite radiological consequence is calculated to be 7 rem, which is less than the 25 rem Evaluation Guideline.

The conclusion that the bounding flammable gas accident does not challenge the Evaluation Guideline takes into consideration the conservative nature of the analysis. The sensitivity of the calculated consequence to assumptions and input parameters is evaluated in Table 7-1. It is concluded that no technical safety requirements are required to protect the assumptions and parameters used in the analysis.

Table 7-1. Sensitivity of the Bounding Offsite Radiological Consequence Analysis to Assumptions and Input Parameters. (3 sheets)

Assumption/Input Parameter and Basis	Assumption Type	Sensitivity	Need to Protect AA	Protection Basis
Ignition of flammable gas results in a detonation. A detonation of flammable gas represents the bounding accident phenomenology. The higher flame speed associated with a detonation versus a deflagration results in a larger suspension of respirable material.	Bounding (phenomenology)	N/A	No	N/A
Detonation results in partial dome collapse. Based on structural evaluation documented in WHC-SD-TWR-RPT-003.	Bounding (phenomenology)	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 is not expected based on existing stress analyses.	No	N/A
Material released is saltcake solids.	Bounding	Saltcake solids have the highest ULD with the exception of the sludge in SST 241-AX-104. SST 241-AX-104 cannot reach the LFL even under zero ventilation conditions due to diffusion through the SST concrete dome (RPP-5926).	No	N/A
100 kg of respirable saltcake is released (60 L applying a density of approximately 1.8 g/ml).	Reasonably conservative	The offsite radiological consequence is directly proportional to the respirable release. A release of 100 kg has been judged to be a reasonably conservative value based on a review of various approaches to modeling the respirable release from a detonation that results in dome collapse.	No	N/A
The density of the saltcake is approximately 1.8 g/ml. Based on reported density of saltcake with the applicable ULD. Density taken from RPP-5926, Table A-1 for waste type T2-SltCk (solid).	Best estimate	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 70 L versus 60 L. Holding all other input parameters constant, the offsite consequence increases from 7.1 rem to 8.3 rem.	No	N/A

Table 7-1. Sensitivity of the Bounding Offsite Radiological Consequence Analysis to Assumptions and Input Parameters. (3 sheets)

Assumption/Input Parameter and Basis	**Assumption Type**	**Sensitivity**	**Need to Protect AA**	**Protection Basis**
The ULD is 1.6 x 10^{+5} Sv/L. Value for tank 241-TX-118 as documented in RPP-5924.	Bounding	The offsite radiological consequence is directly proportional to the ULD. A ULD of 1.6 x 10^{+5} Sv/L has been judged to be reasonably conservative. This is the second highest ULD reported in RPP-5924 for SSTs. The highest ULD (1.9 x 10^{+5} Sv/L) is associated with SST 241-AX-104, which cannot reach the LFL even under zero ventilation conditions due to diffusion through the SST concrete dome (RPP-5926) Applying the 241-AX-104 ULD, the dose increases from 7.1 to 8.4 rem.	No	N/A
The integrated atmospheric dispersion coefficient is 2.22 x 10^{-5} s/m^3 (RPP-13482).	Reasonably conservative	No anticipated effect on consequence level. This atmospheric dispersion coefficient is based on 95% meteorology, which is recommended for conservative analysis.	No	N/A
A breathing rate of 3.33 x 10^{-4} m^3/s was used to estimate the radiological consequences. This is the breathing rate associated with light activity (i.e., it is an 8-hr average which assumes 2.5 hr of sitting and 5.5 hr of light exercise) as derived by the International Commission on Radiological Protection (RPP-13482).	Reasonably conservative	This is a standard analysis assumption	No	N/A

Table 7-1. Sensitivity of the Bounding Offsite Radiological Consequence Analysis to Assumptions and Input Parameters. (3 sheets)

Assumption/Input Parameter and Basis	Assumption Type	Sensitivity	Need to Protect AA	Protection Basis

Notes:

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-13482, 2005, *Atmospheric Dispersion Coefficients and Radiological and Toxicological Exposure Methodology for Use in Tank Farms*, Rev. 3, 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 = assumption analysis.
N/A = not applicable.
SST = single-shell tank.
ULD = unit-liter dose.

8.0 REFERENCES

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

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

HNF-2577, 1998, *Flammable Gas Project Expert Elicitation Results for Hanford Site Double-Shell Tanks*, Rev. 0, CH2M HILL Hanford Group, Inc., 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, CH2M HILL Hanford Group, Inc., Richland, Washington.

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RPP-13482, 2005, *Atmospheric Dispersion Coefficients and Radiological and Toxicological Exposure Methodology for Use in Tank Farms*, Rev. 3, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-13510, 2005, *Flammable Gas Technical Basis Document*, Rev. 3, CH2M HILL Hanford Group, Inc., 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.

WHC-SD-WM-RPT-281, 1996, *Deflagration and Detonation Hazards in Hanford Tank Farm Facilities*, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

APPENDIX A

OFFSITE RADIOLOGICAL CONSEQUENCE OF A DOUBLE-SHELL TANK DETONATION

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APPENDIX A

OFFSITE RADIOLOGICAL CONSEQUENCE OF A DOUBLE-SHELL TANK DETONATION

A.1 PURPOSE

This appendix calculates the offsite radiological consequences of a detonation in a double-shell tank (DST). The calculation uses the same methodology as applied to single-shell tanks (SST). The atmospheric dispersion coefficient and breathing rate remain the same. Differences include the liters of respirable material released and the applicable unit-liter dose (ULD).

A.2 ASSUMPTIONS

1. A detonation is assumed to occur in a DST.

   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. Under barometric breathing conditions, hydrogen concentrations in excess of the detonable limit of 8% can be reached in some of the 28 DSTs based on the analyzed tank waste volumes and characteristics.

2. The detonation is assumed to result in partial dome collapse.

   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.

3. The respirable material released from the tank is assumed to be supernatant.

   The 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 by supernatant. Some DSTs have a floating crust layer that covers, or partially covers, the supernatant. This crust is comprised of solids (primarily saltcake) with a high void fraction such that the density of the crust is less than that of the supernatant.

   As discussed in Section 4.1 of the main document, detonations resulting in partial dome collapse generate airborne material primarily by aerodynamic entrainment and by suspension caused by falling debris. These phenomena impact the surface layer of the waste, which in the case of DSTs, is either supernatant or a floating crust layer. The respirable material released is assumed to be supernatant. The sensitivity of the analysis to this assumption is examined via a second calculation in which it is assumed that the respirable material released is comprised entirely of saltcake solids.

A.3 METHODOLOGY

The methodology is the same as shown in Chapter 3.0 of the main document.

A.4 INPUT VALUES

As stated in DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses,* Appendix A, offsite radiological consequence calculations are to be based on reasonably conservative estimates of the various input parameters.

A.4.1 Liters of Respirable Material Released

It is estimated that 100 kg of respirable material would be released by a detonation in a DST that results in partial dome collapse. The basis for this value is the same as given in Section 4.1 of the main document.

For input to Equation 3-1 of the main document, the 100 kg value must be converted to liters. As stated in Section A.2, it is assumed that the material released is DST supernatant. Based on best-basis inventory data as reported in RPP-5926, 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 ULD (see Section A.4.4) is associated with DST 241-AN-107. This supernatant has a density of approximately 1.4 g/ml. The volume of respirable material released is therefore 71 L, which is rounded to 70.

The highest DST saltcake ULD (see Section A.4.4) is also associated with DST 241-AN-107. This saltcake has a density of approximately 1.5 g/ml. The volume of respirable material released is therefore 67 L, which is rounded to 70 L.

A.4.2 Integrated Atmospheric Dispersion Coefficient

The integrated atmospheric dispersion coefficient is 2.22×10^{-5} s/m^3 (RPP-13482, *Atmospheric Dispersion Coefficients and Radiological and Toxicological Exposure Methodology for Use in Tank Farms*).

A.4.3 Breathing Rate

The breathing rate is 3.33×10^{-4} m^3/s (RPP-13482).

A.4.4 Unit Liter Dose

A ULD of 1.5 x 10^{+3} Sv/L has been selected for use in calculating the offsite radiological consequences of a DST detonation. This is the highest DST supernatant ULD derived in RPP-5924, *Radiological Source Terms for Tank Farms Safety Analysis.*

As stated in Section A.2, some DSTs have a floating crust layer comprised primarily of saltcake. The ULDs for these crusts have not been calculated. The highest DST saltcake ULD derived in RPP-5924 is 2.7 x 10^{+3} Sv/L.

A.5 CALCULATIONS

Using Equation 3-1 in Chapter 5.0 of the main document and the input data provided in Section A.4, the offsite radiological consequence of a DST detonation resulting in a release of 70 L of supernatant is calculated as follows:

$$D(Sv) = 70(L)\, 2.22x10^{-5}(s/m^3)\, 3.33x10^{-4}(m^3/s)\, 1.5x10^{+3}(Sv/L)$$

$$D(Sv) = 7.8x10^{-4}$$

$$\text{D(rem)} = 7.8x10^{-4}\,(\text{Sv})\, x 1x10^{+2}\,(\text{rem/Sv})$$

$$D(rem) = 7.8x10^{-2}$$

Using Equation 3-1 and the input data provided in Section A.4, the offsite radiological consequence of a DST detonation resulting in a release of 70 L of saltcake is calculated as follows:

$$D(Sv) = 70(L)\, 2.22x10^{-5}(s/m^3)\, 3.33x10^{-4}(m^3/s)\, 2.7x10^{+3}(Sv/L)$$

$$D(Sv) = 1.4x10^{-3}$$

$$D(rem) = 1.4x10^{-3}(Sv)\, x 1x10^{+2}(rem/Sv)$$

$$D(rem) = 1.4x10^{-1}$$

A.6 RESULTS

The offsite radiological consequence of a detonation in a DST that results in a release of 70 L of supernatant is calculated to be 7.8 x 10^{-2} rem, which is rounded to 0.08 rem.

The offsite radiological consequence of a detonation in a DST that results in a release of 70 L of saltcake is calculated to be 0.14 rem, which is rounded to 0.1 rem.

A.7 CONCLUSIONS

The calculated offsite radiological consequences of a DST detonation resulting in a respirable release of supernatant or saltcake are approximately equal (0.08 rem versus 0.1 rem). Additionally, the consequences are significantly less than the bounding offsite consequence calculated for a detonation in an SST (i.e., 7 rem).

A.8 REFERENCES

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

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-13482, 2005, *Atmospheric Dispersion Coefficients and Radiological and Toxicological Exposure Methodology for Use in Tank Farms*, Rev. 3, 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.

APPENDIX B

EVALUATION OF ADDITIONAL RELEASES

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APPENDIX B

OFFSITE CONSEQUENCES OF POTENTIAL ADDITIONAL RELEASES

B.1 PURPOSE

The bounding flammable gas accident is a detonation in a single-shell tank (SST). An offsite radiological consequence of 7 rem has been calculated based on the detonation resulting in a release of 60 L of respirable material. This release is associated with the waste stored within the tank. The purpose of this appendix is to evaluate the potential for an increase in consequences due to additional releases associated with ex-tank waste material potentially impacted by the detonation and additional releases from secondary events potentially initiated by the detonation.

Ex-tank material potentially impacted by the detonation refers to waste that may be present in (a) ventilation system ducting and filters, or (b) waste transfer-associated structures connected to the tank in which the detonation occurs. Secondary events potentially initiated by the detonation include a fire in waste transfer-associated structures and a waste transfer leak.

Consideration was also given to a detonation initiating an organic solvent fire. The number of SSTs and double-shell tanks (DST) that may contain separable solvent is not known. Not all of the tanks received solvents and most of the solvents that were sent to the tanks have evaporated or undergone chemical degradation to form organic species that would not be susceptible to organic solvent fire. Even if present, liquid organic solvent is difficult to ignite as discussed in HNF-4240, *Organic Solvent Topical Report.* For an organic solvent fire to occur, the detonation would have to heat the solvent above its flash point (i.e., heat the solvent sufficiently to drive off enough solvent vapors to reach the flammability limit), and an ignition source would need to be present. A detonation, which occurs in less than a second, does not represent the type of sustained energy source required to initiate an organic solvent fire.

B.2 ESTIMATED OFFSITE CONSEQUENCES

B.2.1 Damage to Ventilation System Ducting and Filters

All 149 SSTs are provided with passive ventilation systems consisting of a single high-efficiency particulate air (HEPA) filter mounted on a riser. Thirteen SSTs in the 241-SX Tank Farm are also connected to an active ventilation system with multiple HEPA filters that may be operated. These ventilation systems contain varying quantities of tank waste that have accumulated over years of operation. Portable exhausters with HEPA filters are also installed and operated on SSTs to support retrieval activities. Given a detonation in an SST, it is expected that the associated ventilation system would pressurize resulting in damage to the HEPA filter(s) and a partial release of accumulated material.

The quantities of respirable material released from ventilation systems due to pressurization events are estimated in RPP-13437, *Technical Basis Document for Ventilation System Filtration Failure Leading to an Unfiltered Release*. The material at risk for each system is estimated and the respirable release is calculated by applying an airborne release fraction (ARF) of 2×10^{-6} and a respirable fraction (RF) of 1. These ARF/RF values are taken from DOE-HDBK-3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, for shock effects on HEPA filters. The highest calculated release, associated with the 241-SX Tank Farm active ventilation system, is 2.6×10^{-5} L. Using Equation 3-1 in Chapter 5.0 of the main document and assuming the material is saltcake solids with a unit-liter dose (ULD) of $1.6 \times 10^{+5}$, the release results in an offsite radiological consequence of 3.1×10^{-6} rem, which is rounded to 3×10^{-6} rem. This consequence is judged to be insignificant relative to the 7 rem consequence calculated in Chapter 5.0 of the main document.

B.2.2 Pressurization of a Waste Transfer-Associated Structure

Waste transfer-associated structures (e.g., pump pits) communicate with tank headspaces via drain lines and risers. Given a detonation in an SST, it is expected that connected structures would pressurize. As a result of past operations, varying quantities of residual tank waste are present in waste transfer-associated structures as surface contamination. Pressurization of these structures could therefore result in a release of respirable material. These releases are judged to be bounded by the release resulting from a flammable gas deflagration occurring directly in a structure.

A flammable gas deflagration in a waste transfer-associated structure is analyzed in RPP-13354, *Technical Basis for the Release from Contaminated Facility Representative Accident and Associated Represented Hazardous Conditions*. The analysis assumes that the equivalent of 42 L of waste accumulates on the floor of the structure and applies an ARF of 5×10^{-3} and an RF of 0.3 to calculate a respirable release of 6.3×10^{-2} L. The ARF/RF values are taken from DOE-HDBK-3010-94, which indicates that the blast effects on solid noncombustible unyielding contaminated surfaces are bounded by the venting of pressurized gas over solids. Using Equation 3-1 and a ULD of $1.6 \times 10^{+5}$, a release of 6.3×10^{-2} L results in an offsite radiological consequence of 7.5×10^{-3} rem, which is rounded to 8×10^{-3} rem. This consequence is judged to be insignificant relative to the 7 rem consequence calculated in Chapter 5.0.

B.2.3 Damage to a Waste Transfer-Associated Structure

A detonation in an SST is assumed to result in partial dome collapse. As discussed in Chapter 2.0 of the main document, at pressures significantly greater than 11 to 15 lb/in^2 gauge, the center region of an SST dome along with the soil overburden would likely be blown out. For a waste transfer-associated structure located on or near the center region of the dome, such a failure mode could result in physical damage (e.g., collapse of wall or cover block) that releases respirable material.

Physical damage to waste transfer-associated structures is analyzed in RPP-13354. The analysis assumes that the equivalent of 42 L of waste accumulates on the floor of the structure and applies an ARF of 1×10^{-3} and an RF of 1.0 to calculate a respirable release of 4.2×10^{-2} L. The

ARF/RF values are taken from DOE-HDBK-3010-94 for shock suspension of surface contamination. Using Equation 3-1 and a ULD of 1.6 x 10^{+5}, a release of 4.2 x 10^{-2} L results in an offsite radiological consequence of 5.0 x 10^{-3} rem. This consequence is judged to be insignificant relative to the 7 rem consequence calculated in Chapter 5.0.

B.2.4 Fire in a Waste Transfer-Associated Structure

Conceivably, a detonation in an SST could initiate a fire in a waste transfer-associated structure as a result of hot gases contacting combustible materials. As previously stated, varying quantities of residual tank waste are present in waste transfer-associated structures as a result of past operations. A fire in a structure could therefore result in a release of respirable material.

A fire in a waste transfer-associated structure is analyzed in RPP-13354. The analysis assumes that the equivalent of 42 L of waste accumulates on the floor of the structure and applies an ARF of 2 x 10^{-1} and an RF of 0.3 to calculate a respirable release of 2.5 L. The ARF/RF values are taken from DOE-HDBK-3010-94 for thermal stress on an aqueous solution or air-dried salts under gasoline fire on a surface that is a strong conductor of heat. Using Equation 3-1 and a ULD of 1.6 x 10^{+5}, the release results in an offsite radiological consequence of 3.0 x 10^{-1}. Using thermally lofted atmospheric dispersion coefficient of 3.74 x 10^{-6} s/m^3 for a fire in a waste transfer-associated structure (see RPP-13482, Appendix G), the offsite radiological consequence is 5.0 x 10^{-2} rem. This consequence is judged to be insignificant relative to the 7 rem consequence calculated in Chapter 5.0.

B.2.5 Waste Transfer Leak

Damage to a waste transfer-associated structure resulting from a detonation was discussed in Section B.2.3. If a transfer were taking place at the time of the detonation, additional respirable material could be generated due to damaged transfer piping or piping connections.

The offsite radiological consequences of an ex-tank waste transfer leak directly into the soil is analyzed in RPP-14499, *Offsite Radiological Consequence Analysis for the Waste Transfer Leak.* The calculated offsite dose for the bounding waste transfer leak (large break) assuming the waste contains 25 vol% solids is 5.5 x 10^{-1} rem, which is rounded to 6 x 10^{-1} rem. This consequence is judged to be insignificant relative to the 7 rem consequence calculated in Chapter 5.0.

B.3 SINGLE-SHELL TANK CONCLUSIONS

The bounding flammable gas accident is a detonation in an SST. An offsite radiological consequence of 7 rem has been calculated based on the detonation resulting in a release of 60 L of respirable material. Additional respirable releases associated with ex-tank waste material potentially impacted by the detonation and additional releases from secondary events potentially initiated by the detonation have been evaluated. The additional releases analyzed include those potentially resulting from damage to ventilation system ducting and filters; pressurization, physical damage, and fire in waste transfer-associated structures; and a waste transfer leak. As show in Table B-1, the offsite radiological consequence associated with these events, if all were to occur, is 0.7 rem. This additional consequence is judged to be insignificant relative to the 7 rem consequence that directly results from the detonation.

Table B-1. Summary of Offsite Consequences.

SST detonation contributing event	Dose (rem)
Damage to ventilation system ducting and filters	3 E-6
Pressurization of a waste transfer-associated structure	8 E-3
Damage to a waste transfer-associated structure	5 E-3
Fire in a waste transfer-associated structure	5 E-2
Waste transfer leak	6 E-1
Total	0.663 which is rounded to 0.7

Notes:
SST = single-shell tank.

B.4 DOUBLE-SHELL TANK CONSIDERATIONS

Appendix A of the main document analyzes the offsite radiological consequence of a detonation in a DST. Two calculations are performed. One assumes the respirable material released is supernatant, the other assumes the material is saltcake. The calculated consequences are approximately equal to each other (i.e., 0.08 rem assuming supernatant versus 0.1 rem assuming saltcake) and are bounded by the consequence calculated for a detonation in an SST (i.e., 7 rem).

The evaluations of potential additional consequences contained in Sections B.2.1 through B.2.4 for SSTs reasonably bound DSTs because the respirable releases remain unchanged except for ventilation system ducting and filters and because the SST ULD is greater (i.e., 1.6 x 10^{+5} Sv/L for SST saltcake versus 1.5 x 10^{+3} Sv/L and 2.7 x 10^{+3} Sv/L for DST supernatant and saltcake, respectively). Release volumes from the ventilation system for the aging waste facilities (DSTs 241-AY-101, 241-AY-102, 241-AZ-101,and 241-AZ-102) are approximately a factor of two higher, but there is no significant increase in consequences because the DST supernatant and saltcake ULDs are approximately factors of 100 and 60 lower, respectively. The evaluation contained in Section B.2.5 is bounding for all waste transfers and, therefore, is also applicable if a detonation were to occur in a DST. The additional consequence of 0.7 rem from Table B-1 is greater than the 0.1 rem dose that results directly from the DST detonation (assuming a floating crust layer). However, the cumulative dose of 0.8 rem does not challenge the 25 rem Evaluation Guideline (DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analyses*, Appendix A, "Evaluation Guideline").

B.5 REFERENCES

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

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

HNF-4240, 2000, *Organic Solvent Topical Report*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-13354, 2004, *Technical Basis for the Release from Contaminated Facility Representative Accident and Associated Represented Hazardous Conditions*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-13437, 2005, *Technical Basis Document for Ventilation System Filtration Failure Leading to an Unfiltered Release*, Rev. 1, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-14499, 2004, *Offsite Radiological Consequence Analysis for the Waste Transfer Leak*, Rev. 3, CH2M HILL Hanford Group, Inc., Richland, Washington.

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APPENDIX C

PEER REVIEW CHECKLIST

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APPENDIX C

PEER REVIEW CHECKLIST

NS&L CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: RPP-13470, Offsite Radiological Consequence Analysis For the Bounding Flammable Gas Accident., Rev. 2.

Scope of Review (e.g., document section or portion of calculation): Changes that move document from Rev. 1 to Rev.2

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:
☒	☐	☐	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:
☒	☐	☐	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:
☐	☐	☒	16. Software output is consistent with the input and with the results reported in the document reviewed. *Explanation:
☐	☐	☒	17. Software verification and validation are addressed adequately. *(ORP QAPP criterion 2.6)* *Explanation:
☒	☐	☐	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:
☐	☒	☐	23. Reference citations (e.g., title and number) are consistent between the text callout

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NS&L CHECKLIST FOR TECHNICAL PEER REVIEW

Page 2 of 2

Yes	No*	NA*	
			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:
☐	☒	☐	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:
☒	☐	☐	**Concurrence**

W.L. Cowley [signature] Feb. 16, 2005

Reviewer (Printed Name and Signature) Date

* If No is chosen, an explanation must be provided on this form.

Additional explanation: Items 22 through 31, and 35 through 39 are reviewed by the technical editor.

Form Current To 12/08/2004

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: RPP-13470, Rev. 2

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.

LA

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] 2/15/05
Reviewer (Printed Name and Signature) Date

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

Technical Edit