**This document was too large to scan
as a single document. It has
been divided into smaller sections.**

Section 1 of 2

Document Information			
Document #	HNF-3737	Revision	1
Title	TANK 241SY101 SAFETY BASIS FOR REMEDIATION ACTIVITIES & OPERATIONS BEFORE CLOSURE OF THE UNREVIEWED SAFETY QUESTION ON WASTE SURFACE CHANGE		
Date	10/28/99		
Originator	FEIN KO,RYAN GW,SHULTZ MV,VANKEUREN JC,GRIGSBY JM,KRIPPS LJ	Originator Co.	FDNW,OTHER
Recipient		Recipient Co.	
References			
Keywords			
Projects			
Other Information			

ENGINEERING CHANGE NOTICE

1. ECN 655903

Page 1 of 2

Proj.
ECN

HMLM0231 108976/BB20

2. ECN Category (mark one)		3. Originator's Name, Organization, MSIN, and Telephone No.		4. USQ Required?	5. Date
Supplemental ☐		G. W. Ryan, Safety Analysis & Nuclear Engineering, B4-47, 376-5114		☒ Yes ☐ No	10/22/1999
Direct Revision ☒		6. Project Title/No./Work Order No.		7. Bldg./Sys./Fac. No.	8. Approval Designator
Change ECN ☐		Tank 241-SY-101 Remediation Operations and Activities		241-SY Farm/200W	SQ
Temporary ☐		9. Document Numbers Changed by this ECN (Includes sheet no. and rev.)		10. Related ECN No(s).	11. Related PO No.
Standby ☐		HNF-3737, Rev. 0		N/A	N/A
Supersedeure ☐		12a. Modification Work		12d. Restored to Original Condition (Temp. or Standby ECNs only)	
Cancel/Void ☐		12b. Work Package No.		12c. Modification Work Completed	
		N/A		N/A	
		Design Authority/Cog. Engineer Signature & Date		Design Authority/Cog. Engineer Signature & Date	
13a. Description of Change					
HNF-3737, which contains the "Contractor prudent controls to safely operate Tank 241-SY-101 crust growth remediation actions" is being revised to:					
<ul style="list-style-type: none"> - clearly define the scope of HNF-3737 in Section 3.0; - include a description of the hazard analysis activities performed for back dilution that are documented in HNF-4891, Hazard Evaluation for Back-Dilution of Tank 241-SY-101 Waste (Section 3.1); - include controls for the initial back dilution following the first waste transfer from Tank 241-SY-101; - modify the Safety-Class siphon break safety function; - include text additions to discuss operational features of the siphon break; - more clearly define the applicability of specific controls when water sources are connected to Tank 241-SY-101; - add a BIO/FSAR cross-reference listing in Section 1.1; - modify the Mixer Pump Operability and Performance Monitoring control; and - include controls to prevent crust sinkage. 					
13b. Design Baseline Document? ☐ Yes ☒ No					
Release Instructions- Replace all pages of Revision 0 with Revision 1 (provided by this ECN).					
14a. Justification (mark one)		14b. Justification Details			
Criteria Change ☒		To support the first Tank 241-SY-101 waste transfer, controls for the initial back dilution are being incorporated into HNF-3737. Additional changes included in this revision to HNF-3737 are detailed in Block 13a.			
Design Improvement ☐					
Environmental ☐					
Facility Deactivation ☐					
As-Found ☐					
Facilitate Const. ☐					
Const. Error/Omission ☐		USQ # TF-99-0782 Rev. 0			
Design Error/Omission ☐		KN			
15. Distribution (Include name, MSIN, and no. of copies)					
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Page 2 of 2

1. ECN (use no. from pg. 1)

655903

16. Design Verification Required

☐ Yes
☒ No

17. Cost Impact

ENGINEERING

Additional ☐ \$ N/A
Savings ☐ \$ N/A

CONSTRUCTION

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Savings ☐ \$ N/A

18. Schedule Impact (days)

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Delay ☐ N/A

19. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 13. Enter the affected document number in Block 20.

SDD/DD	☐	Seismic/Stress Analysis	☐	Tank Calibration Manual	☐
Functional Design Criteria	☐	Stress/Design Report	☐	Health Physics Procedure	☐
Operating Specification	☐	Interface Control Drawing	☐	Spares Multiple Unit Listing	☐
Criticality Specification	☐	Calibration Procedure	☐	Test Procedures/Specification	☒
Conceptual Design Report	☐	Installation Procedure	☐	Component Index	☐
Equipment Spec.	☐	Maintenance Procedure	☒	ASME Coded Item	☐
Const. Spec.	☐	Engineering Procedure	☐	Human Factor Consideration	☐
Procurement Spec.	☐	Operating Instruction	☐	Computer Software	☐
Vendor Information	☐	Operating Procedure	☒	Electric Circuit Schedule	☐
OM Manual	☐	Operational Safety Requirement	☐	ICRS Procedure	☐
FSAR/SAR	☐	IEFD Drawing	☐	Process Control Manual/Plan	☐
Safety Equipment List	☒	Cell Arrangement Drawing	☐	Process Flow Chart	☐
Radiation Work Permit	☐	Essential Material Specification	☐	Purchase Requisition	☐
Environmental Impact Statement	☐	Fac. Proc. Samp. Schedule	☐	Tickler File	☐
Environmental Report	☐	Inspection Plan	☐	Alarm Response	☒
Environmental Permit	☐	Inventory Adjustment Request	☐		☐

20. Other Affected Documents: (NOTE: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

Document Number/Revision	Document Number/Revision	Document Number/Revision
TO-430-100	ARP-T-431-350A	6-FCD-454
TO-430-190	ARP-T-431-350B	6-FCD-473
OTP-440-003	HNF-IP-1266	
ARP-T-431-0401	HNF-4531	

21. Approvals

Signature	Date	Signature	Date
Design Authority <i>[Signature]</i>	<i>18 Oct 99</i>	Design Agent	
Cog. Eng. <i>[Signature]</i>	<i>10/18/99</i>	PE	
Cog. Mgr. <i>[Signature]</i>	<i>10/18/99</i>	QA	
QA <i>[Signature]</i>	<i>10/18/99</i>	Safety	
Safety <i>[Signature]</i>	<i>10/18/99</i>	Design	
Environ. <i>[Signature]</i>	<i>10/19/99</i>	Environ.	
Other <i>[Signature]</i>	<i>10/19/99</i>	Other	
Reg. Comp. Suppt <i>[Signature]</i>	<i>10/18/99</i>		
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SST Eng. <i>[Signature]</i>	<i>10/19/99</i>		
SY-101 Proj. Mgr. <i>[Signature]</i>	<i>10/18/99</i>		
Rad. Con. <i>[Signature]</i>	<i>10/18/99</i>		
Proc. Eng. <i>[Signature]</i>	<i>10/18/99</i>		
EDW Nuc. Sfty <i>[Signature]</i>	<i>N/A</i>		

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Signature or a Control Number that tracks the Approval Signature

ADDITIONAL

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SY-101 Project Files (10)	G1-45	X
TWRS S & L Project Files (4)	R1-44	X
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DOE/RL Reading Room	H2-53	X

Tank 241-SY-101 Safety Basis for Remediation Activities and Operations Before Closure of the Unreviewed Safety Question on Waste Surface Change

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Abstract: This document contains the safety basis for Tank 241-SY-101 remediation activities and operations until closure of the Unreviewed Safety Question (USQ) related to waste surface level changes. Also summarized in this document are the new Technical Safety Requirement (TSR)-level controls that will be implemented as prudent contractor controls required for safe operation and new safety structures, systems, and components (SSCs).

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Tank 241-SY-101 Safety Basis for Remediation Activities and Operations Before Closure of the Unreviewed Safety Question on Waste Surface Change

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LIST OF TERMS

AB	Authorization Basis
AC	Administrative Control
ALARA	As Low As Reasonably Achievable
AWF	Aging Waste Facility
BD GRE	buoyant displacement gas release event
BIO	Basis for Interim Operation
CAM	continuous air monitor
CGM	combustible gas monitor
DOE	U.S. Department of Energy
DST	double-shell tank
EPDM	ethylene propylene diene monomer
FSAR	final safety analysis report
HEPA	high-efficiency particulate air (filter)
LCO	Limiting Condition for Operation
LCS	Limiting Control Setting
LFL	Lower Flammability Limit
MMA	mechanical mitigation arm
OGT	overground transfer (line)
PHMC	Project Hanford Management Contract
PPP	pre-fabricated pump pit
PRC	Plant Review Committee
RAPID	Respond and Pump In Days
REG	risk evaluation guideline
SC	Safety-Class
SEL	safety equipment list
SL	Safety Limit
SR	surveillance requirement
SS	Safety-Significant
SSC	structure, system, and component
TRG	Test Review Group
TSR	Technical Safety Requirement
TWRS	Tank Waste Remediation System ^a
USQ	Unreviewed Safety Question

^a The U.S. Department of Energy-Richland Operations Office recently changed the title of the Tank Waste Remediation System (TWRS) to River Protection Project (RPP). References in this document to TWRS should be considered equivalent to RPP.

1.0 SUMMARY AND CONCLUSIONS

The safety basis for Tank 241-SY-101 remediation activities and operations until closure of the Unreviewed Safety Question (USQ) related to waste surface level changes is described in this document. For Tank 241-SY-101, all remediation activities and operations are reviewed to determine whether they could pose new hazards or require new or different controls not included in the *Tank Waste Remediation System Basis for Interim Operation* (BIO) (HNF-SD-WM-BIO-001) safety analysis. This safety review specifically considers the issues regarding waste surface level changes identified in the open USQ on Tank 241-SY-101.

For non-flammable gas hazards, the safety basis generally is provided in the BIO. For flammable gas hazards and for specific aspects of activities to remediate the surface-level-rise condition in Tank 241-SY-101, additional hazard and accident analyses have been required and have resulted in additional controls. The methodologies for performing the additional hazard and accident analyses and for making supplemental control decisions are described in the BIO.

A summary of the new controls for Tank 241-SY-101 remediation activities and operations is presented in Table 1. These controls include new Safety-Class and Safety-Significant structures, systems, and components (SSCs) and new Technical Safety Requirement (TSR)-level controls that as a result of direction received from the U.S. Department of Energy (DOE) (French 1999) will be implemented as prudent contractor controls required for safe operation. The new controls in Table 1, together with the applicable controls from the BIO and supplemental controls and operating restrictions directed by DOE (Wagoner 1998 and French 1999), ensure the continued safe management of the stored waste in Tank 241-SY-101.

1.1 BIO/FSAR CROSS-REFERENCE LISTING

Upon transition to the *Tank Waste Remediation System Final Safety Analysis Report* (FSAR) (HNF-SD-WM-SAR-067), the BIO will be superceded. The cross-reference listing provided below allows the reader to determine the equivalent FSAR section or table for each BIO section or table cited in this document.

<u>BIO Section or Table Cited</u>	<u>Equivalent FSAR Section or Table</u>
5.3.2.1	3.3.2.4.1
5.3.2.2	3.3.2.4.2
5.3.2.3	3.3.2.4.3
5.3.2.7	3.3.2.4.7
5.3.2.11	3.3.2.4.11
5.3.2.12	3.3.2.4.12
5.3.2.13	3.4.2.1
5.3.2.14	3.4.2.2
5.3.2.15	3.4.2.4
5.3.2.16	3.4.2.5
5.3.2.18	3.4.2.7
5.3.2.19	3.4.2.8

<u>BIO Section or Table Cited</u>	<u>Equivalent FSAR Section or Table</u>
5.3.2.20	3.4.2.9
5.3.2.21	3.4.2.10
5.3.2.22	3.4.2.11
5.3.2.23	3.4.2.12
5.4	3.3.1.5 and the Hazard Analysis Database for specific hazardous conditions
Table 6.1	Table 3.3.2.3.2-1
Appendix B	Chapter 2.0

Table 1. New Controls for Tank 241-SY-101 Remediation Activities and Operations. (9 sheets)

Analyzed Accident	Safety Structures, Systems, and Components		Technical Safety Requirement ^a	Comments ^b
	Description	SC SS		
Flammable Gas Deflagrations	Siphon break in Tank 241-SY-102 drop leg	X		Siphon break: The safety function of the siphon break is to prevent the siphoning of waste from Tank 241-SY-101 to Tank 241-SY-102 when the waste transfer pump is not operating and there is no dilution water flow to the transfer pump.
	Tank 241-SY-101 waste transfer flow totalizer	X		Tank 241-SY-101 waste transfer flow totalizer: The safety function of the Tank 241-SY-101 waste transfer flow totalizer is to provide the volume of material transferred from Tank 241-SY-101 to Tank 241-SY-102 (waste plus dilution water) for implementation of the Tank 241-SY-101 Waste Transfer Control.
	Dilution water flow totalizer	X		Dilution water flow totalizer: The safety function of the dilution water flow totalizer is to provide dilution water data for implementation of the Tank 241-SY-101 Waste Transfer Control.
			AC: Tank 241-SY-101 Mixer Pump Operation and Performance Monitoring	<p>Program key elements are:</p> <ul style="list-style-type: none"> Mixer pump operating parameters (e.g., pump motor current, pump discharge pressure) identified by the Test Review Group (TRG) shall be monitored during mixer pump operation, and the mixer pump shall be shutdown if limits established by the TRG to prevent pump damage are exceeded. Mixer pump performance (e.g., pump motor current, pump discharge pressure, waste thermocouple response) shall be monitored, and the TRG shall review the data quarterly for signs of degradation that could affect continued control of gas retention at depth and prevention of buoyant displacement gas release events (BD GREs).

Table 1. New Controls for Tank 241-SY-101 Remediation Activities and Operations. (9 sheets)

Analyzed Accident	Safety Structures, Systems, and Components		Technical Safety Requirement ^a	Comments ^b
	Description	SC SS		
Flammable Gas Deflagrations (Continued)			AC: Tank 241-SY-101 Back Dilution Control	<ul style="list-style-type: none"> The TRG shall direct corrective actions to restore mixer pump operation and performance, as necessary. If following the first waste transfer back dilution of the Tank 241-SY-101 waste with water is required to restore mixer pump operation or performance (e.g., to raise the crust), back dilution shall be in accordance with the requirements of the Tank 241-SY-101 Back Dilution Control (see below). <p>Program key elements are:</p> <ul style="list-style-type: none"> Following the first Tank 241-SY-101 waste transfer, the maximum quantity of water that can be added on top of the waste shall be 30,000 gallons. Following the first Tank 241-SY-101 waste transfer, the quantity of back dilution water that can be added low in the tank (i.e., via the Tank 241-SY-101 mixer pump burrowing ring or the waste transfer pump) shall be limited to ensure that the crust does not sink. The maximum quantity of back dilution water that can be added low in the tank following the first waste transfer shall be determined by Process Engineering and reviewed and approved by the PRC. Back dilution water additions to Tank 241-SY-101 waste shall be monitored and limited to the maximum quantities specified above.

Table 1. New Controls for Tank 241-SY-101 Remediation Activities and Operations. (9 sheets)

Analyzed Accident	Safety Structures, Systems, and Components			Technical Safety Requirement ^a	Comments ^b
	Description	SC	SS		
Flammable Gas Deflagrations (Continued)				AC: Tank 241-SY-101 Ignition Controls	Program key elements of the ignition controls of TSR AC 5.10 shall be implemented for Tank 241-SY-101. The Flammable Gas Ignition Control (AC 5.10.2c) shall be implemented with Tank 241-SY-101 treated as if it were a flammable gas Facility Group 1 tank.
				AC: Tank 241-SY-101 Flammable Gas Monitoring Controls	<p>Program key elements are:</p> <ul style="list-style-type: none"> • The manned work activity controls of TSR AC 5.11.2a shall be implemented for Tank 241-SY-101 with Tank 241-SY-101 treated as if it were a flammable gas Facility Group 1 tank. • Prior to initiating and during unmanned waste disturbing operations and activities, continuous flammable gas monitoring of the tank dome space is required. Waste disturbing operations and activities shall be stopped if the flammable gas concentration is > 25% of the Lower Flammability Limit (LFL)

Table 1. New Controls for Tank 241-SY-101 Remediation Activities and Operations. (9 sheets)

Analyzed Accident	Safety Structures, Systems, and Components			Technical Safety Requirement	Comments
	Description	SC	SS		
Flammable Gas Deflagrations (Continued)					<ul style="list-style-type: none"> When water sources are connected to equipment for operations and activities that could add water to Tank 241-SY-101, continuous flammable gas monitoring of the tank dome space is required. This requirement does not apply when the RAPID Mitigation System water support skid is the only water source connected to the tank and the water support skid is not connected to the service water system. Water sources are not considered to be connected if they are disconnected by a removal of piping (i.e., air gap) or installation of a blind flange. Note that closed valves do not disconnect water sources. Water sources shall be immediately isolated if the flammable gas concentration is > 25% of the LFL. Isolation requires a shutoff valve in the line from the water source to be closed. If it cannot be verified that the valve is not leaking through, the water line shall be disconnected. <p>Note: For manned work activity controls and the unmanned operations controls in Tank 241-SY-101, 25% of the LFL is defined as 25% of the LFL as measured by a combustible gas monitor or, if measuring hydrogen only, as 7,500 ppm hydrogen.</p>

Table 1. New Controls for Tank 241-SY-101 Remediation Activities and Operations. (9 sheets)

Analyzed Accident	Safety Structures, Systems, and Components		Technical Safety Requirement ^a	Comments ^b
	Description	SC	SS	
Flammable Gas Deflagrations (Continued)			AC: Tank 241-SY-101 Waste Transfer Control	<p>Program key elements are:</p> <ul style="list-style-type: none"> For the first waste transfer from Tank 241-SY-101, the quantity of waste transferred shall be limited. The maximum quantity of waste that can be transferred shall be calculated so that back dilution of the Tank 241-SY-101 waste with water following the first waste transfer can raise the base of the crust to at least 295 inches from the bottom of the tank without the crust sinking. The maximum quantity of waste transferred shall account for waste that could be siphoned from Tank 241-SY-101 after the waste transfer pump is turned off until dilution water flow to the transfer pump is stopped (e.g., the dilution water supply is disconnected). (Note that closed valves do not ensure that the dilution water flow is stopped.) The maximum quantity of waste transferred in the first waste transfer shall be determined by Process Engineering and reviewed and approved by the PRC. The first waste transfer from Tank 241-SY-101 shall be monitored and limited to the maximum quantity established above.

Table 1. New Controls for Tank 241-SY-101 Remediation Activities and Operations. (9 sheets)

Analyzed Accident	Safety Structures, Systems, and Components		Technical Safety Requirement ^a	Comments ^b
	Description	SC SS		
Spray Leak in Structure or from Overground Transfer Line	Prefabricated Pump Pit (PPP)	X -	None	PPP: The safety function of the PPP is to knock down spray and limit release of aerosols to the environment. The PPP shall be designed to withstand design basis high wind and associated missiles.
	OGT encasement and connections	X -		OGT Encasement and Connections: The safety function of the OGT encasement and connections is to confine a leak from the primary piping and ensure that the leak is directed to the riser 241-SY-102-007 drop leg enclosure or to the PPP which contain leak detection systems. The OGT encasement and connections shall be designed to withstand (1) the maximum pressure resulting if the drain to Tank 241-SY-102 is plugged and the waste backs up the OGT encasement to the PPP and (2) design basis high wind, but not the associated missiles.
	Riser 241-SY-102-007 drop leg enclosure	X -		Riser 241-SY-102-007 Drop Leg Enclosure: Same as OGT encasement and connections except that the riser 241-SY-102-007 drop leg enclosure shall be designed to withstand missiles associated with the design basis high wind.

Table 1. New Controls for Tank 241-SY-101 Remediation Activities and Operations. (9 sheets)

Analyzed Accident	Safety Structures, Systems, and Components		Technical Safety Requirement ^a	Comments ^b
	Description	SC	SS	
Surface Leak Resulting in Pool	Prefabricated Pump Pit (PPP)	X	X	<p>PPP: The <i>Safety-Class safety function</i> of the PPP is to provide an intact boundary for the leaked waste, and when leak detector alarms and appropriate operator response times to shut off the transfer pump are credited, to prevent premature PPP overflow and the formation of a surface pool. The <i>Safety-Significant safety function</i> of the PPP, including cover, is to limit release of aerosols generated by splatter inside the PPP, and limit shine and skyshine dose to onsite receptors. The PPP shall be designed to withstand the design basis high wind and associated missiles.</p>
	OGT encasement and connections	X	-	<p>OGT encasement and connections: The safety function of the OGT encasement and connections is to provide secondary confinement for a leak from the primary line and route the leak to the riser 241-SY-102-007 drop leg enclosure or to the PPP which contain leak detection systems. The OGT encasement and connections shall be designed to withstand (1) the maximum pressure resulting if the drain to Tank 241-SY-102 is plugged and the waste backs up the OGT encasement to the PPP and (2) design basis high wind, but not the associated missiles.</p>
	Riser 241-SY-102-007 drop leg enclosure	X	-	<p>Riser 241-SY-102-007 drop leg enclosure: Same as OGT encasement and connections except that the riser 241-SY-102-007 drop leg enclosure shall be designed to withstand missiles associated with the design basis high wind.</p>
	Tank 241-SY-101 waste transfer flow totalizer	-	X	<p>Tank 241-SY-101 waste transfer flow totalizer: The safety function of the Tank 241-SY-101 waste transfer flow totalizer is to provide the volume of material transferred from Tank 241-SY-101 to Tank 241-SY-102 (waste plus dilution water) for implementation of the TSR AC 5.12 Transfer Controls material balance requirements.</p>

Table 1. New Controls for Tank 241-SY-101 Remediation Activities and Operations. (9 sheets)

Analyzed Accident	Safety Structures, Systems, and Components			Technical Safety Requirement ^a	Comments ^b
	Description	SC	SS		
Mixing of Incompatible Material – Toxic Vapor Generation	241-SY Tank Farm primary tank ventilation system	-	X	AC: 241-SY Tank Farm primary tank ventilation system	<p>241-SY Tank Farm primary tank ventilation system: The safety function of the 241-SY Tank Farm primary tank ventilation system is to provide an elevated release (versus a ground-level release) of ammonia from 241-SY Tank Farm tanks. The primary tank ventilation system for the 241-SY Tank Farm ensures an elevated release of ammonia by maintaining a vacuum in the vapor spaces of Tanks 241-SY-101, -102, and -103 and exhausting through a stack.</p> <p>Ammonia monitoring systems: The safety function of the Tank 241-SY-101 ammonia monitoring system is to measure the ammonia concentration in the Tank 241-SY-101 vapor space and alarm at 3000 ppm. The safety function of the 241-SY Tank Farm primary tank ventilation exhaust ammonia monitoring system is to measure the ammonia concentration in the 241-SY Tank Farm ventilation exhaust and alarm at 1000 ppm.</p> <p>Ensures operation of the 241-SY Tank Farm primary tank ventilation system during <i>global waste disturbing</i> operations and activities in Tank 241-SY-101. TSR LCO 3.2.1 satisfies this requirement for ammonia releases.</p>
	Ammonia monitoring systems (Tank 241-SY-101 and 241-SY Tank Farm primary tank ventilation exhaust)	-	X		

Table 1. New Controls for Tank 241-SY-101 Remediation Activities and Operations. (9 sheets)

Analyzed Accident	Safety Structures, Systems, and Components		Technical Safety Requirement ^a	Comments ^b
	Description	SC	SS	
Mixing of Incompatible Material – Toxic Vapor Generation (continued)			AC: Ammonia monitoring (Tank 241-SY-101 and 241-SY Tank Farm primary tank ventilation exhaust)	<p>The program key elements are:</p> <ul style="list-style-type: none"> During <i>global waste disturbing</i> operations and activities in Tank 241-SY-101 (except waste transfers) and when water sources are connected to equipment for operations and activities that could add water to Tank 241-SY-101, monitor the ammonia concentration in the tank vapor space or in the 241-SY Tank Farm primary tank ventilation exhaust and, if the ammonia concentration reaches 3000 ppm or 1000 ppm, respectively, stop <i>global waste disturbing</i> operations and activities in the tank and isolate all sources of water to the tank. This requirement does not apply when the RAPID Mitigation System water support skid is the only water source connected to the tank and the water support skid is not connected to the service water system. During Tank 241-SY-101 waste transfers, monitor the ammonia concentration in the 241-SY Tank Farm primary tank ventilation exhaust and, if the ammonia concentration reaches 1000 ppm, stop the waste transfer and isolate all sources of water to Tank 241-SY-101. <p>Note: See HNF-SD-WM-TSR-006 for the definition of <i>global waste disturbing</i>.</p>

^aAs a result of direction received from the U.S. Department of Energy, Office of River Protection (French 1999), new TSR-level controls for Tank 241-SY-101 remediation activities will be imposed as prudent contractor controls necessary for safe operation.

^bThe safety function for a Safety-Class or Safety-Significant SSC states the preventive and/or mitigative safety function(s) that the safety SSC is required to meet. Unless specifically stated in the safety function, the safety SSC is not required to perform its safety function during or following design basis natural phenomena (e.g., seismic events, high winds and associated missiles).

French, R. T., 1999, *Contract Number DE-AC06-96RL13200 – Submittal of Updated Unreviewed Safety Question (USQ) Evaluation and Supplemental Controls for Tank 241-SY-101*, (Letter 99-TSD-051 to R. D. Hanson, FDH), U.S. Department of Energy, Office of River Protection, Richland, Washington.

PRC = Plant Review Committee

RAPID = Respond and Pump In Days.

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2.0 INTRODUCTION

The safety basis for Tank 241-SY-101 facilities and operations is described in this document. The BIO (HNF-SD-WM-BIO-001) is generally referenced as the safety basis for non-flammable gas hazards. The BIO originally referenced *A Safety Assessment for Proposed Pump Mixing Operations to Mitigate Episodic Gas Releases in Tank 241-SY-101* (LA-UR-92-3196) for the safety analysis and TSR-level controls for Tank 241-SY-101 flammable gas hazards. However, because of the unexplained rise in the surface level of Tank 241-SY-101, which is the subject of an open USQ, the safety analysis and derived controls in the BIO and LA-UR-92-3196 do not fully address current tank hazards and planned remediation activities and operations. This document, therefore, provides the additional safety analysis and supplemental controls required for the continued safe management of the stored waste in Tank 241-SY-101 until closure of the USQ on waste surface change.

This introduction provides background on the current Tank 241-SY-101 condition and the evolution of the USQ related to waste surface level change. It also provides an overview of the activities to remediate the surface level rise in Tank 241-SY-101 and to close the associated USQ. The safety analysis of Tank 241-SY-101 remediation activities and operations is described in Section 3.0. The safety analysis includes hazard and accident analyses and provides the basis for controls required for the protection of the public, onsite worker, facility worker, and the environment. Section 4.0 contains a summary of the operational controls for Tank 241-SY-101 based on the existing safety analysis from the BIO and the new safety analysis contained in Section 3.0. References are listed in Section 5.0. Supporting technical information describing Tank 241-SY-101 remediation systems and equipment, and detailed results of the hazard and accident analyses and control decisions, are provided in appendixes.

2.1 BACKGROUND

Tank 241-SY-101 is a double-shell tank (DST) with a nominal storage capacity of 3.8 million liters (1 million gallons) and a maximum storage capacity of 4.4 million liters (1.16 million gallons). Construction of Tank 241-SY-101 was completed in 1976. A description of Tank 241-SY-101 structures and systems is contained in BIO Appendix B.

Tank 241-SY-101 contains approximately 3.8 million liters (1 million gallons) of the most highly concentrated radioactive waste stored in the DSTs at the Hanford Site. The first waste put into Tank 241-SY-101 came from the first double-shell slurry campaign using the 242-S Evaporator in 1977. Double-shell slurry is a concentrated waste that was produced by the 242-S and the 242-A Evaporators; it is high in sodium hydroxide, sodium nitrate, and sodium aluminate. Tank 241-SY-101 received subsequent transfers of double-shell slurry and concentrated complexant waste, an evaporator product similar to double-shell slurry (although not as concentrated) that contained significant organic complexant concentrations. The last slurry transfer into Tank 241-SY-101 was in November 1980.

Degradation of organic complexants and radiolysis of water in the Tank 241-SY-101 waste generates a flammable mixture of gases that includes hydrogen, nitrogen, nitrous oxide, and ammonia. Until 1993, the waste in Tank 241-SY-101 retained the gas and periodically released large volumes in sudden, buoyant displacement gas release events (BD GREs). These periodic BD GREs occurred approximately every 100 days. In July 1993, a mixer pump was installed in Tank 241-SY-101. Operation of the mixer pump has prevented the periodic, large BD GREs by inducing a more continuous release of gas.

Since September of 1996, the waste surface level in Tank 241-SY-101 has been rising in a manner inconsistent with previous behavior. The waste surface level changes resulted in DOE declaring a USQ in February 1998 (Kinzer 1998). Table 2 is a summary of DOE actions that have occurred since declaration of the original USQ.

Table 2. Summary of DOE Actions Related to the Unreviewed Safety Question on Tank 241-SY-101 Waste Surface Level Changes.

February 1998	A USQ was declared by DOE as a result of waste surface level changes in Tank 241-SY-101 (Kinzer 1998).
March 1998	The TWRS Authorization Basis was amended by DOE to authorize use of operational judgment regarding pump operation if the Tank 241-SY-101 waste level were determined to exceed 402 in. (Wagoner 1998a).
October 1998	The Tank 241-SY-101 waste level limits of 406 and 422 in. were suspended, and supplemental controls for mixer pump operation and other activities were approved by DOE (Wagoner 1998b).
April 1999	A revision to the USQ to reflect the results of waste characterization and analysis performed to understand level growth mechanisms and potential hazards was approved by DOE. In addition, DOE directed the imposition of a flammable gas monitoring control and additional prudent contractor controls necessary for safe operation (French 1999).

French, R. T., 1999, *Contract Number DE-AC06-96RL13200 – Submittal of Updated Unreviewed Safety Question (USQ) Evaluation and Supplemental Controls for Tank 241-SY-101*, (Letter 99-TSD-051 to R. D. Hanson, FDH, April 27), U.S. Department of Energy, Office of River Protection, Richland, Washington.

Kinzer, J. E., 1998, *Contract Number DE-AC06-96RL13200 – Declaration of an Unreviewed Safety Question (USQ) Related to Waste Surface Level Changes in Tank 241-SY-101*, (Letter 98-WSD-040 to H. J. Hatch, FDH, February 26), U.S. Department of Energy, Office of Tank Waste Remediation Systems, Richland, Washington.

Wagoner, J. D., 1998a, *Contract Number DE-AC06-96RL13200 – Further Direction Regarding Tank 241-SY-101 Unreviewed Safety Question (USQ)* (Letter 98-WSD-043 to H. J. Hatch, FDH, March 5), U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Wagoner, J. D., 1998b, *Contract Number DE-AC06-96RL13200 – Supplemental Controls for Continued Operations in Tank 241-SY-101* (Letter 98-SCD-140 to R. D. Hanson, FDH, October 22), U.S. Department of Energy, Richland Operations Office, Richland, Washington.

With the approval of the revised waste surface change USQ (French 1999), it was recognized that the hazards in Tank 241-SY-101 are increasing and the frequencies and consequences of potential accidents are increased over those previously accepted by DOE. In addition, it was recognized that these increased risks cannot be acceptably quantified at this time. In view of the urgent need to mitigate the growing hazards with Tank 241-SY-101, DOE authorized the conduct of activities which exceed previously accepted risk, so long as an operational restriction specified by DOE is imposed (i.e., prohibiting discretionary activities when flammable gas concentrations in the dome space exceed 25% of the LFL), and the contractor imposes additional prudent controls necessary to safely conduct such operations (French 1999).

2.2 PLANNED REMEDIATION ACTIVITIES

Following the declaration of the USQ on Tank 241-SY-101 waste surface level change in February 1998, a remediation plan was developed (*Tank 241-SY-101 Surface-Level-Rise Remediation Project Plan*, HNF-3824). The plan requires a series of Tank 241-SY-101 waste transfers followed by back dilution with water, and temporary measures for near-term crust mitigation. These remediation activities are in addition to continued mixer pump operation and other Tank 241-SY-101 operations described in the BIO that are required for the continued safe management of the stored waste in this tank.

The plan for remediation of the waste surface level condition in Tank 241-SY-101 is to transfer waste from Tank 241-SY-101 to Tank 241-SY-102, followed by back dilution with water into Tank 241-SY-101 as required. Waste transfer remediates the surface level rise condition by lowering the waste level. Back dilution with water dissolves the crust. Waste transfer and back dilution also could remediate the BD GRE issue in Tank 241-SY-101.

The waste will be transferred from Tank 241-SY-101 to Tank 241-SY-102 in increments (followed by back dilution with water). The first waste transfer will be approximately 380,000 to 570,000 liters (100,000 to 150,000 gallons) of waste. The plan for subsequent Tank 241-SY-101 waste transfers includes options for a total of 1.1×10^6 to 1.9×10^6 liters (300,000 to 500,000 gallons) of waste transferred out of the tank. The temporary system to transfer waste from Tank 241-SY-101 to Tank 241-SY-102 is described in Appendix A. The system consists of a waste transfer pump installed in Tank 241-SY-101; an aboveground pre-fabricated pump pit (PPP) housing the mounting for the transfer pump, piping connections, and valves; a dedicated overground transfer (OGT) line (ethylene propylene diene monomer [EPDM] hose in a hose); and a Tank 241-SY-102 drop leg assembly, which includes a riser extension enclosure and a siphon break.

Following waste transfers, water will be added to Tank 241-SY-101 (i.e., back dilution). The quantity of water is expected to be approximately equal to the quantity of waste transferred. Options for adding back dilution water include adding the water low in the tank (e.g., via the Tank 241-SY-101 mixer pump burrowing ring or the waste transfer pump), adding water on top of the crust (e.g., via a 1-inch vent line from the PPP piping manifold to the tank 241-SY-101 dome space in riser 241-SY-101-007), or adding water within or near the base of the crust (e.g., via a water lance).

The remediation plan for Tank 241-SY-101 also includes near-term options such as a water and/or mechanical system to reduce the thickness and gas content in a localized area of the crust before the waste transfer. Near-term crust mitigation actions are temporary because they do not alter the crust-forming mechanisms. Based on past observations, a water jet or spray will dissolve an area of the crust providing a leak path for trapped gas. Dissolution of the crust with localized water additions also can mitigate crust impact with sensitive in-tank equipment. A mechanical system will release gas directly from a local volume of waste by breaking up the crust.

Two methods for near-term crust mitigation are planned; one using a 42-inch water lance and one using a mechanical mitigation arm (MMA). The water lance is an existing system used during installation of the Tank 241-SY-101 mixer pump. Appendix V of LA-UR-92-3196 contains a description of the 42-inch water lance. The MMA is described in Appendix A.

3.0 SAFETY ANALYSIS

The safety analysis of Tank 241-SY-101 remediation activities and operations either is referenced or described in this section. The safety analysis includes hazard and accident analyses. It provides the basis for controls required for the protection of the public, onsite worker, facility worker, and the environment.

For Tank 241-SY-101, all remediation activities and operations are reviewed to determine whether the activities could pose new hazards or require new or different controls not included in the BIO safety analysis. This safety review specifically considers the issues regarding waste surface level change identified in the USQ Determination (TF-97-0975, Rev. 3). In general, potential hazardous conditions and postulated accidents for Tank 241-SY-101 remediation actions and operations are addressed by the BIO safety analysis. When Tank 241-SY-101 remediation activities and operations are identified as not clearly covered by the BIO safety analysis, additional hazard and accident analyses are performed and supplemental controls are derived, if necessary. Derived supplemental controls may include Safety-Class and Safety-Significant SSCs, TSRs (or prudent contractor controls necessary for safe operation), controls providing defense-in-depth, and controls specifically designed for environmental protection. The methodologies for performing additional hazard and accident analyses, and making decisions regarding supplemental controls are the same as those described in the BIO.

Note: The scope of the hazard analysis, accident analysis, and the derived engineered and administrative controls in this section cover Tank 241-SY-101 waste transfers and near-term crust mitigation activities (i.e., water lance and MMA) described in Section 2.2. The hazard analysis in Section 3.1 covers all options under consideration for back dilution water additions, but the accident analysis in Section 3.2 and the engineered and administrative controls in Section 3.3 only cover the initial back dilution of Tank 241-SY-101 waste following the first waste transfer. Additional analyses and controls may be required for subsequent back dilutions.

3.1 HAZARD ANALYSIS

The hazard analysis of TWRS facilities and operations presented in BIO Section 5.2 generally encompasses Tank 241-SY-101 facilities and operations. To understand the potential causes and new hazards resulting from the Tank 241-SY-101 waste surface level change and to assess Tank 241-SY-101 remediation activities and operations, the following new hazard analyses have been performed.

- *Hazard Evaluation for Tank 241-SY-101 Waste Surface Level Growth (HNF-3645)*
- *Hazard Evaluation for Transfer of Waste from Tank 241-SY-101 to Tank 241-SY-102, (HNF-3966)*
- *Hazard Evaluation for Back-Dilution of Tank 241-SY-101 Waste (HNF-4891)*

HNF-3645 documents the results of a hazard identification and evaluation performed on the Tank 241-SY-101 waste surface level growth phenomenon. The purpose was to identify potential hazardous conditions associated with the waste surface level growth issue and to estimate the potential risk that these hazardous conditions represent. The results identify the need for additional information and analysis of potential flammable gas retention and release mechanisms from the growing crust. The results support the development of plans to remediate the waste surface level rise condition and resolve and close the USQ. The results also support the required review of Tank 241-SY-101 remediation activities and operations to determine the need for additional hazard and accident analyses and supplemental controls.

The results of the hazard analysis for the transfer of waste from Tank 241-SY-101 to Tank 241-SY-102 to remediate Tank 241-SY-101 waste surface level rise are documented in HNF-3966. This hazard evaluation was performed to support the design of the waste transfer system and to determine if additional accident analyses and supplement controls were needed. The hazardous conditions with the potential for consequences affecting the offsite public (S3) or onsite workers (S2) were found to be represented by the following existing representative accidents in the BIO.

- Fire in Contaminated Area
- Mixing of Incompatible Material – Toxic Vapor Generation
- Tank Failure Due to Excessive Loads
- Flammable Gas Deflagrations
- Surface Leak Resulting in Pool
- Spray Leak in Structure or from Overground Waste Transfer Line
- Spray Leak from Underground Transfer Lines

Additional accident analyses were required for postulated Tank 241-SY-101 flammable gas accident scenarios and for postulated ammonia releases in Tank 241-SY-101 and Tank 241-SY-102. Accident analyses also were required to demonstrate that postulated unmitigated and mitigated spray and pool leaks for the Tank 241-SY-101 waste transfer were enveloped by the BIO accident analysis. A review of the anticipated hazardous conditions with facility worker consequences (F3, S1) and hazardous conditions with potentially significant environmental consequences (E2 and E3) identified that no additional controls were required for the Tank 241-SY-101 waste transfer to protect the facility worker or the environment (i.e., existing controls from the BIO safety analysis, and new controls derived from this Tank 241-SY-101 safety analysis to protect the public and onsite workers, acceptably protect facility workers and the environment).

The results of the hazard analysis for the back dilution of Tank 241-SY-101 waste are documented in HNF-4891. The hazard analysis was performed to identify potential hazardous conditions and their sensitivity to back dilution variables (e.g., location of the water addition, water temperature, rate of water addition) and Tank 241-SY-101 conditions. Based on the

hazard analysis, additional analyses were identified to support control decisions for back dilution (see Section 3.2).^a The back dilution hazardous conditions with the potential for consequences affecting the offsite public (S3) or onsite workers (S2) were found to be represented by the following existing representative accidents in the BIO.

- Mixing of Incompatible Material – Toxic Vapor Generation
- Flammable Gas Deflagrations
- Surface Leak Resulting in Pool
- HEPA Filter Failure – Exposure to High Temperature or Pressure

A review of the one anticipated hazardous condition with facility worker consequences (F3, S1) and hazardous conditions with potentially significant environmental consequences (E2 and E3) identified that no additional controls were required for back dilution of Tank 241-SY-101 waste to protect the facility worker or the environment (i.e., existing controls from the BIO safety analysis, and new controls derived from this Tank 241-SY-101 safety analysis to protect the public and onsite workers, acceptably protect facility workers and the environment).

The safety review of near-term remediation activities with the 42-inch water lance and the MMA determined that non-flammable gas hazards for these activities are acceptably enveloped by the existing BIO safety analysis and controls. Additional analysis of flammable gas hazards and supplemental controls for these near-term mitigation activities are addressed in Section 3.2.4. The LA-UR-92-3196 safety analyses in Appendix V and Addendum 2 for the 42-inch water lance and the void fraction instrument, respectively, were used to support the safety review.

Although the safety analysis in LA-UR-92-3196 for Tank 241-SY-101 mixer pump operation is no longer completely applicable given the waste surface level change in the tank, the existing TSR-level controls (i.e., Level I controls), as modified by DOE in Wagoner 1998b, are considered necessary and sufficient to control gas retention at depth and prevent BD GREs. The Level II and III controls identified in Section 6 of LA-UR-92-3196 also continue to be implemented, except where modifications are approved by the Test Review Group (TRG).

3.2 ACCIDENT ANALYSIS

This section summarizes the results of the accident analysis performed for Tank 241-SY-101 remediation activities and operations. The purpose of the accident analysis is to quantify the accident frequency and consequences of scenarios and to identify the associated necessary and sufficient set of controls that ensure safe operation. This section summarizes the accident analysis and/or identifies the controls for those representative accidents that represent hazardous conditions identified in the hazard analysis of Tank 241-SY-101 remediation activities and

^aNote: Analyses necessary to derive controls for the initial back dilution of Tank 241-SY-101 waste following the first waste transfer have been completed (see Section 3.2). Additional analyses and controls may be required for subsequent back dilutions.

operations. The remaining representative accidents in BIO Section 5.3, including the controls required to prevent or mitigate the accidents, are valid when applicable to Tank 241-SY-101.

The general calculation methods used for quantifying the radiological and toxicological consequences of postulated Tank 241-SY-101 accidents in this section are the same as those summarized in BIO Section 5.3.1. Consequence calculation methods specific to individual accidents are described in the referenced appendix for the corresponding accident.

3.2.1 HEPA Filter Failure – Exposure to High Temperature or Pressure

The hazard analysis of Tank 241-SY-101 remediation activities and operations identified a hazardous condition involving an increased vapor space loading of radioactive or toxic aerosols due to a high pressure spray of water directed at the crust in Tank 241-SY-101. This hazardous condition is represented by the HEPA Filter Failure – Exposure to High Temperature or Pressure accident. The controls for this hazardous condition are the same as those derived from the BIO safety analysis. See BIO Section 5.3.2.2 and TSR Limiting Condition for Operation (LCO) 3.1.4 and Administrative Control (AC) 5.18 for ventilation system continuous air monitor (CAM) interlock system controls and for HEPA filter controls, respectively. BIO Section 5.3.2.2 also identifies defense-in-depth controls.

3.2.2 Fire In Contaminated Area

For Tank 241-SY-101 remediation activities and operations, a specific hazardous condition identified is a flammable gas deflagration in the PPP. Consistent with the BIO safety analysis, postulated flammable gas deflagrations in waste transfer-associated structures are represented by the Fire in Contaminated Area accident because this accident bounds the potential accident consequences. The controls for the PPP are based on the established controls for preventing flammable gas deflagrations (e.g., ignition controls, flammable gas monitoring controls), and controls for identifying waste leaks (e.g., leak detection systems, waste transfer material balances), and responding to identified leaks (i.e., emergency preparedness response procedures).

3.2.3 Mixing of Incompatible Material — Toxic Vapor Generation

The potential for ammonia releases was identified in the hazard analysis of Tank 241-SY-101 remediation activities and operations as well as in the mixer pump safety assessment (LA-UR-92-3196). Hazardous conditions including ammonia release are represented by the Mixing of Incompatible Materials – Toxic Vapor Generation accident. The representative accident analyzed in the BIO (see BIO Section 5.3.2.11) showed that onsite and offsite ammonia concentrations were below risk evaluation guidelines (REGs), and no controls were identified other than the Industrial Hygiene Program as a defense-in-depth control. This representative accident, however, does not bound the potential consequences for hazardous conditions postulated for Tank 241-SY-101. The analysis of postulated ammonia releases for Tank 241-SY-101 described in Appendix E are summarized in this section, along with controls derived to protect onsite workers.

Chemical reactions and radiolysis that are occurring within the waste in Tank 241-SY-101 produce ammonia. Ammonia is soluble in tank waste liquids and Tank 241-SY-101 has a high ammonia concentration in the waste (0.25 g-moles/L). In addition, the gas bubbles retained within the waste, and in particular the crust of Tank 241-SY-101, contain about 12% to 14% ammonia by volume. The ammonia retained in bubbles and in solution in the waste provides a large reservoir, which, if released, can present a toxic gas exposure hazard.

As an indication of the possible magnitude of ammonia exposures, ammonia released during BD GREs that occurred before installation and operation of the mixer pump produced concentrations in the headspace as high as 13,000 ppm. Operation of the mixer pump has mitigated BD GREs. However, ammonia may be released because of waste disturbing operations such as mixer pump operation, crust-disturbing activities, waste transfers to Tank 241-SY-102, or back dilution of Tank 241-SY-101 waste.

Ammonia releases that might occur during the disturbance of gas retained at depth (in settled solids at the bottom of Tank 241-SY-101) are analyzed in LA-UR-92-3196. Cases analyzed include equipment installation and removal, and operation of the mixer pump. As indicated in LA-UR-92-3196, Table 5-20, ammonia concentrations at the 100 m receptor (often listed as the SY-Farm in consequence tables in LA-UR-92-3196) range from 23 to 333 ppm. Although concluded to be acceptable in LA-UR-92-3196 based on the assigned frequencies and exposure limits used in that analysis, the exposures for several of the cases would not be within REGs as described in the BIO.

Operation of the mixer pump has prevented significant gas retention at depth. In addition, Level I controls for mixer pump operation to mitigate flammable gas deflagrations also work to mitigate ammonia releases. These include the requirement for the primary tank ventilation system to be operable, and ammonia monitoring with manual mixer pump shut down. The controls for ammonia releases to mitigate toxic exposures during mixer pump operation and during equipment installation and removal are shown in Tables 4 and 5. Because mixer pump operation and equipment installation or removal can induce gas releases (from gas retained at depth) and create high ammonia concentrations in Tank 241-SY-101, and there are no significant ammonia releases in the other two SY-Farm tanks (except during waste transfers from Tank 241-SY-101 to Tank 241-SY-102, described later), ammonia monitoring in the dome space of 241-SY-101 with manual shutdown of the mixer pump if concentrations reach 3,000 ppm (current Level I control for mixer pump operation to mitigate flammable gas deflagrations) is adequate. Thus, primary tank ventilation and ammonia monitoring controls address ammonia releases from settled solids (gas retained at depth) during equipment installation and removal operations as well as during mixer pump operation. Therefore, the basis for the primary tank ventilation and ammonia monitoring controls for mixer pump operation has been expanded to add control of toxic exposure due to ammonia release during equipment installation and removal as well as during mixer pump operation. Control of ammonia releases is in addition to control of flammable gas deflagrations.

In addition to gas released from the settled solids, ammonia release can result from gas release from the crust or ammonia evaporation from the waste liquid if it is exposed to headspace air. Therefore, ammonia exposures were analyzed by calculating the concentration in the headspace and at the ventilation stack due to crust disturbance, crust dissolution, or waste transfer into Tank 241-SY-102. Ammonia is released with flammable gases as bubbles are released from the

waste. Ammonia also evaporates from the waste if ammonia-rich liquids are exposed to air. Stack concentrations consider the combined ammonia that may be released from Tank 241-SY-101, Tank 241-SY-102, and Tank 241-SY-103.

3.2.3.1 Ammonia Exposure Due to Crust Disturbance in Tank 241-SY-101. As described in Section 3.2.4, "Flammable Gas Deflagrations," gases retained in the crust may be released by crust disturbances (bubble slurry flow). Such a bubble slurry release has been conservatively postulated during deployment of the 42-inch water lance through the crust in Tank 241-SY-101. In addition, ammonia can evaporate from the waste surface if fresh liquid waste is exposed to the air in the dome space. Ammonia concentrations in the headspace of Tank 241-SY-101 were calculated by summing the contribution from bubble release and evaporation for Tank 241-SY-101 remediation activities and operations. The concentration at the primary tank ventilation exhaust stack was then calculated based on the ammonia concentrations and ventilation flow rate from all three tanks in the 241-SY Tank Farm. The peak 15 min average concentration at the 100 m onsite receptor was then calculated, assuming no controls, based on worst-case (i.e., ground-level release) atmospheric dispersion.

Ammonia release mechanisms and resulting concentrations for various representative activities are shown in Table 3. The peak 15 min average concentration is compared with the REG. The ammonia exposure is assumed to be an anticipated event; therefore, the REG is based on an ERPG-1 value (BIO Section 5.3.1), which is 25 ppm for ammonia.

As indicated in Table 3, the concentration, without controls, exceeds the REG at the 100 m onsite receptor location for activities that can cause bubble slurry flow through a hole in the crust (i.e., 42-inch water lance), which causes fresh liquid waste to flow across the waste surface. This fresh waste surface allows for a large-scale evaporation of ammonia into the dome space air.^a

The release of ammonia through the primary tank ventilation system exhaust stack, rather than as a ground-level release, reduces the concentration at the 100 m receptor below REGs (see Table 3). This control is implemented by ensuring the primary tank ventilation system is operating during 42-inch water lance operations (i.e., TSR LCO 3.2.1). In addition, ammonia monitoring is required. Because crust disturbing operations and activities can create high ammonia concentrations in Tank 241-SY-101 and there are no significant ammonia releases in the other two SY-Farm tanks (except during waste transfers from Tank 241-SY-101 to Tank 241-SY-102, described later), ammonia monitoring in the dome space of Tank 241-SY-101 with shutdown of the crust disturbing operation or activity if concentrations reach 3,000 ppm is adequate. Alternately, the ammonia can be monitored at the primary tank ventilation exhaust stack with shutdown of the waste disturbing activity or operation if concentrations reach 1,000 ppm. These limits provide ample margin to a stack concentration of 4,150 ppm which is the stack concentration that produces 25 ppm (REG) at the 100 m receptor under worst-case (fumigation) dispersion conditions. These controls were selected to mitigate this accident scenario (see Appendix F). An essential assumption is that the primary tank ventilation system

^a Actual measurements of ammonia concentrations during deployment of the MMA and 42-inch water lance show that the calculated ammonia concentrations in Table 3 (and Table 6) are very conservative. Measured ammonia concentrations from MMA deployments on May 20 and 26, 1999 and deployment of the 42-inch water lance (cruciform lance) on September 10, 1999 are provided in Appendix F, Enclosure 15 – Part 18.

exhausts through the existing stack. Safety SSCs and contractor-imposed prudent controls to safely operate the 42-inch water lance are shown in Table 4 and Table 5, respectively.

Table 3. Ammonia Exposures Caused By Crust Disturbing Activities in Tank 241-SY-101.^a

Activity	Release Mechanisms	Dome Concentration (ppm)	Stack Concentration (ppm)	Peak 15 min. average concentration at 100 m (ppm)	REG for anticipated events (ppm)
Without Controls					
Mechanical Mitigation Arm	Evaporation from a 4 m dia. wet surface	1600	850	12 ^a	25 (ERPG-1) ^c
42-in. Water Lance	Bubble slurry flow – bubble release and evaporation	6400	3400	47 ^a	25 (ERPG-1)
With Controls					
42-in. Water Lance	Bubble slurry flow – bubble release and evaporation	6400	3400	20 ^b	25 (ERPG-1)

^a Actual measurements of ammonia concentrations during deployment of the MMA and 42-inch water lance show that the calculated ammonia concentrations in this table are very conservative.

^b Ground-level release

^c Elevated release from the primary tank ventilation exhaust stack assuming fumigation which is the limiting atmospheric dispersion condition

^d AIHA, 1998, *Emergency Response Planning Guidelines*, American Industrial Hygiene Association, Akron, Ohio.

REG = risk evaluation guideline

3.2.3.2 Ammonia Exposure During Waste Transfer from Tank 241-SY-101 to Tank 241-SY-102. Gas release mechanisms that are postulated to occur during the waste transfer include:

- Gas release caused by dissolution of the crust in Tank 241-SY-101 as a result of an inadvertent water addition (e.g., the waste transfer stops but in-line dilution water continues to be added at the transfer pump suction which remains in Tank 241-SY-101 and floats up to the bottom of the crust)
- Evaporation of ammonia in Tank 241-SY-102 from the transferred waste (from the falling waste column, from splashing, from the disturbed portion of the waste surface, and from the rest of the waste surface)
- Ammonia release caused by a GRE in Tank 241-SY-103.

Table 4. Safety Structures, Systems, and Components for Ammonia Releases for Tank 241-SY-101 Remediation Activities and Operations.

Structures, Systems, and Components	Classification		Safety Function	Comments
	SC	SS		
241-SY Tank Farm primary tank ventilation system	-	X	Provide an elevated release (versus a ground-level release) of ammonia from 241-SY Tank Farm tanks.	The primary tank ventilation system for the 241-SY Tank Farm ensures an elevated release of ammonia by maintaining a vacuum in the vapor spaces of Tanks 241-SY-101, -102, and -103 and exhausting through a stack.
Ammonia monitoring system:				
Tank 241-SY-101	-	X	Measure the ammonia concentration in the Tank 241-SY-101 vapor space and alarm at 3000 ppm.	
241-SY Tank Farm primary tank ventilation exhaust	-	X	Measure the ammonia concentration in the 241-SY Tank Farm primary tank ventilation exhaust and alarm at 1000 ppm.	

SC = Safety-Class

SS = Safety-Significant

Table 5. Technical Safety Requirements (and Prudent Contractor Controls Necessary for Safe Operation) for Ammonia Releases for Tank 241-SY-101
Remediation Activities and Operations. (2 sheets)

Control	Safety Function	Comments
241-SY Tank Farm primary tank ventilation system	Ensures operation of the 241-SY Tank Farm primary tank ventilation system during <i>global waste disturbing</i> operations and activities in Tank 241-SY-101.	<p>The primary tank ventilation system for the 241-SY Tank Farm provides an elevated release of ammonia by maintaining a vacuum in the vapor spaces of Tanks 241-SY-101, -102, and -103 and exhausting through a stack.</p> <p>This TSR-level control for ammonia releases is an expansion of the basis of TSR LCO 3.2.1. Action statement A.1 of LCO 3.2.1 requires that all <i>waste disturbing</i> operations and activities be stopped when the primary tank ventilation system is not operating. This satisfies the safety function for ammonia releases.</p> <p>See HNF-SD-WM-TSR-006 for the definition of <i>waste disturbing</i> and <i>global waste disturbing</i>.</p>
Ammonia Monitoring	During <i>global waste disturbing</i> operations and activities in Tank 241-SY-101 (except waste transfers – see below) and when water sources are connected to equipment for operations and activities that could add water to Tank 241-SY-101, monitor the ammonia concentration in the tank vapor space <u>or</u> in the 241-SY Tank Farm primary tank ventilation exhaust and, if the ammonia concentration reaches 3000 ppm or 1000 ppm, respectively, stop <i>global waste disturbing</i> operations and activities in the tank and isolate all sources of water to the tank. This requirement does not apply when the RAPID Mitigation System water support skid is the only water source connected to the tank <u>and</u> the water support skid is not connected to the service water system.	<p>Stopping <i>global waste disturbing</i> operations and activities in Tank 241-SY-101 eliminates these causes of ammonia releases. Isolating sources of water to Tank 241-SY-101 prevents water additions (intentional or inadvertent) that can cause ammonia releases from the waste.</p> <p>See HNF-SD-WM-TSR-006 for the definition of <i>global waste disturbing</i></p>

Table 5. Technical Safety Requirements (and Prudent Contractor Controls Necessary for Safe Operation) for Ammonia Releases for Tank 241-SY-101
Remediation Activities and Operations. (2 sheets)

Control	Safety Function	Comments
Ammonia Monitoring (Continued)	During Tank 241-SY-101 waste transfers, monitor the ammonia concentration in the 241 SY Tank Farm primary tank ventilation exhaust and, if the ammonia concentration reaches 1000 ppm, stop the waste transfer and isolate all sources of water to Tank 241-SY-101.	

HNF-SD-WM-TSR-006, 1999, *Tank Waste Remediation System Technical Safety Requirements*, Rev. 0-U, Fluor Daniel Hanford, Inc., Richland, Washington.

RAPID = Respond and Pump In Days.

The peak calculated ammonia concentration in the tank headspace, at the primary tank ventilation exhaust stack, and at the 100 m onsite receptor, are shown in Table 6 for each individual release mechanism and for the combined releases. Without controls, the concentration at the 100 m onsite receptor exceeds the REG conservatively assuming the postulated combined ammonia release is an anticipated event (10^{-2} to 10^0 per year). Controls selected to mitigate the consequences of ammonia release during Tank 241-SY-101 waste transfers (see Appendix F) include:

- Requiring the primary tank ventilation system to be operating during the waste transfer and ensuring that the release of ammonia is through the primary tank ventilation exhaust stack, rather than a ground-level release;
- Monitoring ammonia concentration at the primary tank ventilation exhaust stack and stopping waste transfer and water additions to Tank 241-SY-101 if concentrations reach 1000 ppm. Ammonia monitoring at the primary tank ventilation exhaust stack is required to monitor the combined releases from all the SY-Farm tanks.

Table 6. Ammonia Exposure due to Waste Transfer from
Tank 241-SY-101 to Tank 241-SY-102. (2 sheets)

Source tank	Release Mechanisms	Peak Dome Concentration (ppm)	Peak Stack Concentration (ppm)	Peak 15 min. average concentration at 100 m (ppm)	REG for anticipated events (ppm)
Without Controls					
241-SY-101	Crust dissolution	20,700	11,000	151 ^a	25 (ERPG-1) ^b
241-SY-102	Evaporation from transferred waste	62,300	14,700	201 ^a	25 (ERPG-1)
241-SY-103	BD GRE	850	200	3 ^a	25 (ERPG-1)
Total combined	All	--	25,900	355 ^a	25 (ERPG-1)
With Controls					
241-SY-101	Crust dissolution	20,700	11,000	7 ^c	25 (ERPG-1)
241-SY-102	Evaporation from transferred waste	11,100 ^d	2,600	2 ^c	25 (ERPG-1)
241-SY-103	BD GRE	850	200	<1	25 (ERPG-1)
Total combined	All	--	13,800	9 ^c	25 (ERPG-1)

^aGround-level release

^bAIHA, 1998, *Emergency Response Planning Guidelines*, American Industrial Hygiene Association, Akron, Ohio.

^cElevated release from the primary tank ventilation exhaust stack. Fumigation conditions were not assumed because of the unlikely coincidence of these conditions for the meteorological peak stack concentration.

^dTank 241-SY-102 dome concentration at the time of the peak dome concentration in Tank 241-SY-101 which results in the peak combined stack concentration.

As shown in Table 6, with these controls, the concentration at the 100 m onsite receptor is below the REG for the individual release events and for the combined release event. Fumigation conditions were not assumed because of the unlikely coincidence of these meteorological

conditions with the peak stack concentration for this bounding postulated accident scenario.^a If fumigation conditions were assumed, the peak 15 minute average ammonia concentration at 100 m is 83 ppm, which is below the REG for an unlikely event (i.e., ERPG-2) of 200 ppm for ammonia. Safety SSCs and contractor imposed prudent controls to safely transfer waste from Tank 241-SY-101 to Tank 241-SY-102 are shown in Table 4 and Table 5, respectively. In addition, the Tank 241-SY-102 drop leg and an associated Tank 241-SY-102 waste level control are defense-in-depth controls that ensure that waste transferred from Tank 241-SY-101 discharges below the Tank 241-SY-102 waste surface. This reduces ammonia releases by minimizing the surface area of Tank 241-SY-101 waste exposed to air in Tank 241-SY-102 caused by falling waste, splashing, waste surface disturbance, and poor mixing with Tank 241-SY-102 waste.

3.2.3.3 Ammonia Exposure During Back Dilution of Tank 241-SY-101 Waste. The hazard analysis of back dilution of Tank 241-SY-101 waste identified the potential for ammonia releases resulting from crust disturbance, crust dissolution, and from the waste surface if fresh liquid waste is exposed to the air in the tank dome space. These potential ammonia releases are generally encompassed by the analyses in Sections 3.2.3.1 and 3.2.3.2, and, therefore, the ammonia controls in Tables 4 and 5 acceptably prevent or mitigate postulated ammonia releases from back dilution.

The only potential hazardous condition with ammonia releases that could possibly exceed those evaluated in Sections 3.2.3.1 and 3.2.3.2 is a sudden “roll over” of the crust which rapidly exposes fresh liquid waste to the air in the tank dome space. The cause of this hazardous condition is water additions on top of the crust that thin and weaken the crust. The Tank 241-SY-101 back dilution control derived for flammable gas deflagration hazards prevents this event by restricting the quantity of water that can be added on top of the crust following the first waste transfer to 30,000 gallons (see Section 3.2.5 and Table 9).

3.2.4 Tank Failure Due to Excessive Loads

The hazard analysis of Tank 241-SY-101 remediation activities and operations identified hazardous conditions involving dropping equipment or overloading Tank 241-SY-101 structures. These hazardous conditions are represented by the Tank Failure Due to Excessive Loads accident. The controls for these hazardous conditions are the same as those derived from the BIO safety analysis. See BIO Section 5.3.2.13 and TSR Administrative Control (AC) 5.16 for dome loading controls. BIO Section 5.3.2.13 also identifies defense-in-depth controls.

^a The bounding postulated accident scenario with controls conservatively calculates that a 60 gpm transfer of undiluted waste from Tank 241-SY-101 results in ammonia releases in Tank 241-SY-102 that exceed a 1,000 ppm ammonia concentration at the 241-SY Tank Farm primary tank ventilation exhaust stack. With the ammonia monitoring control, the waste transfer pump is shutdown 30 minutes after detecting the 1,000 ppm ammonia concentration. At this time dilution water is assumed to inadvertently continue to be added to Tank 241-SY-101. The added water dissolves the crust and releases ammonia into Tank 241-SY-101. The peak ammonia concentration at the stack occurs when the ammonia concentration in Tank 241-SY-101 peaks from crust dissolution and is added to the ammonia released from the Tank 241-SY-101 waste transferred to Tank 241-SY-102 and the ammonia from a GRE occurring in Tank 241-SY-103.

3.2.5 Flammable Gas Deflagrations

The USQ regarding waste surface level change in Tank 241-SY-101 identifies the following four factors that could adversely affect the flammable gas risk as originally analyzed in the BIO (and its reference to LA-UR-92-3196).

- The head space volume available to dilute released gases or absorb combustion energy in case of a deflagration event is decreasing.
- The waste crust is retaining a significant amount of gas, and gas retention in the crust cannot be controlled by operation of the mixer pump, as is the case with gas retention at depth (in settled solids at the bottom of the tank).
- Gas release mechanisms, unique to the gas retention in the crust, have been postulated that may result in flammable conditions.
- Crust growth creates the potential for interference with equipment important to safety. Most notably, continued growth of the crust thickness and/or lowering of the crust as the result of waste transfer out of Tank 241-SY-101 could cause the bottom of the crust to encroach on the mixer pump suction inlet, thus degrading pump effectiveness at mitigating gas retention at depth.

Postulated flammable gas deflagrations associated with Tank 241-SY-101, therefore, have been reevaluated to address these factors. The flammable gas accident analysis is described in Appendix C and summarized in this section along with controls to prevent or mitigate potential flammable gas hazards and postulated accidents.

3.2.5.1 Steady-State Accumulation of Flammable Gas Resulting in a Deflagration. One postulated flammable gas accident scenario analyzed in the BIO is a loss of ventilation that allows flammable gases to accumulate, over time, to a concentration that is above the lower flammability limit (LFL). With an ignition source present, a deflagration results. This postulated accident is prevented by the existing TSR LCO 3.2.1 that requires the primary tank ventilation system to be operating.

Flammable gas risk for this scenario has been reevaluated by analyzing the impact of a reduced headspace volume on steady-state accumulation of flammable gas following a loss of ventilation. The analysis documented in Hu (1999) shows that the transient time to 25% of the LFL is not decreased from the 7 days as described in the bases to TSR LCO 3.2.1. The analysis applies to a waste level of 460 inches. The conclusion is that the existing control is still adequate.

3.2.5.2 Release of Gas from the Crust Results in a Deflagration. One new postulated accident scenario in Tank 241-SY-101 involves a gas release from the crust at a sufficient rate and in a sufficient quantity to create flammable conditions in the tank headspace. An ignition source is assumed to be present, causing a deflagration. Existing Authorization Basis level controls include only ventilation, which can reduce the time at risk. Ventilation cannot prevent flammable conditions. Operation of the mixer pump can prevent gas retention at depth, but it cannot prevent gas accumulation in the crust.

Gas release mechanisms from Tank 241-SY-101 crust were evaluated and credible mechanisms for significant release were identified and concluded to be adequately represented by crust disturbance events and crust dissolution events. Gas release rates and quantities were estimated based on experiments and analytical models. Gas releases were then evaluated using a headspace mixing and flammability model, and it was determined that flammable conditions might be created.

Qualitative assessment of the frequency of a deflagration resulted in the conclusion that the frequency may be increased over that described in LA-UR-92-3196 (see TF-97-0975, Rev. 3). In addition, TF-97-0975, Rev. 3, concluded that consequences might also be increased because of the reduced headspace volume. Therefore, the consequences of deflagrations were assessed in a more quantitative manner. The details of the analysis of deflagrations resulting from crust gas release are described in Appendix C.

Gas release rates and quantities were represented by two conservative cases: (1) a crust disturbance that resulted in bubble slurry flow up through a hole in the crust and to the crust surface and (2) gas release caused by dissolution of waste solids in the crust bubble slurry layer, which releases the retained gas. The representative case for bubble slurry flow assumes a bubble slurry layer thickness of 0.5 m, a void fraction of 0.6 and a crust hole 2 m in diameter. The resulting gas release is 51 m³ (See Appendix C, Section C2.2 and Appendix C, Attachment 2). The representative case for crust dissolution assumes a water addition rate of 70 gpm below the crust, an unlimited water supply, and a bubble slurry layer thickness of 0.5 m, with a void fraction of 0.6. The resulting gas release is 160 m³ at a release rate of 0.042 m³/s (See Appendix C, Section C2.2 and Appendix C, Attachment 1).

Note: Although these two postulated accident scenarios were developed for Tank 241-SY-101 waste transfers, they generally encompass potential flammable gas releases from the back dilution of the Tank 241-SY-101 waste with water. The only possible exception is a sudden release of flammable gas in the bubble slurry layer caused by a sudden "roll over" of the crust. Crust roll over could result if water additions on top of the crust thin and weaken the crust. To address this specific potential hazardous condition, the quantity of water that can be initially added on top of the crust following the first waste transfer will be limited to 30,000 gallons (see Table 9). Based on the analysis in PNNL-13066, *Buoyant Response of the SY-101 Crust to Transfer and Back Dilution*, 30,000 gallons should dissolve the upper layers of the crust (i.e., the top, dry freeboard and the wet clay layers), but the crust thickness will remain well above where experience has shown the crust to be very stable.

Headspace gas concentrations resulting from these postulated releases were compared with the LFL. Transient local conditions in the mixing zone just above the waste surface and in a stratified layer at the top of the tank dome were evaluated as well as concentrations following complete mixing in the tank dome space (Appendix C, Attachment F).

The gas release rate during bubble slurry flow is sufficiently high that transient local flammable conditions can be attained in the mixing zone just above the waste surface and in a stratified layer at the top of the tank dome space. However the total quantity of gas released is insufficient to maintain flammable conditions once the dome space becomes well mixed (Appendix C, Attachment F).

Gas release caused by bubble slurry dissolution, on the other hand, is too slow to create transient local flammable conditions in the mixing zone or in a stratified layer. However, the gas release is large enough to overcome the dilution provided by ventilation flow and eventually will exceed the LFL (headspace well mixed) (Appendix C, Attachment F).

The consequences of a deflagration in Tank 241-SY-101 vary based on the quantity of flammable gas involved and the headspace volume available (which affects the gas concentration and the air mass available to absorb the energy). Waste material can be released to the environment because of (1) entrainment from the waste surface by the turbulence created in the headspace gases and subsequent venting during pressure blow-down and (2) suspension from the waste surface caused by impact from falling debris if the tank structure fails.

Deflagration consequences were assessed in two ways. (1) The consequences were compared with those described in LA-UR-92-3196. The quantity of gas available to burn was compared with the quantity assumed to burn in LA-UR-92-3196, accounting for the reduced headspace available because of crust growth. (2) The consequences were calculated using the refined safety analysis methodology being developed for Flammable Gas Safety Issue resolution.

In the first method, the ratio of the flammable gas release volume to available headspace volume was compared with this ratio from LA-UR-92-3196. If the ratio for the crust gas release is less than that analyzed in LA-UR-92-3196, the consequences of a deflagration caused by the crust release will be less than those described in LA-UR-92-3196. The results are summarized in Table 7, which show that the consequences of a deflagration resulting from crust disturbance (bubble slurry flow) are less than those calculated in LA-UR-92-3196 (i.e., the ratio of gas release volume to available headspace volume is less than the reference case). However, the consequences of a deflagration resulting from a gas release caused by crust dissolution may exceed those described in LA-UR-92-3196 (i.e., the ratio of gas release volume to available headspace volume is greater than the reference case) (see Appendix C, Section C2.4).

The results using the second method, the refined safety analysis, are also shown in Table 7 (last two columns). The 95-percentile dose consequences are less than the consequences for the reference case from LA-UR-92-3196. Therefore, it is concluded from the refined safety analysis that consequences for crust gas releases are unlikely to exceed those described in LA-UR-92-3196.

Because crust gas retention and release increases the likelihood of a flammable gas deflagration in Tank 241-SY-101 and could result in consequences that are similar to or may exceed those in LA-UR-92-3196, controls are needed to manage the flammable gas hazard risk. Based on the consequences shown in Table 7 and an anticipated frequency of occurrence without controls, the risk exceeds the REGs for onsite workers and because of uncertainties could approach the REGs for the offsite public. The controls listed in Table 8 and 9 include ignition source controls and flammable gas monitoring controls, as well as the existing ventilation control. This three-pronged control strategy (ventilation, ignition source controls, and monitoring) is designed to prevent flammable gas deflagrations. Provisions for ventilation serve to reduce the time at risk when concentrations exceed the LFL. Flammable gas monitoring requirements serve to prevent or halt operations and activities when the margin of safety is considered to be insufficient (i.e., conditions are such that the flammable gases exist in concentrations greater than 25% of the LFL). Ignition controls serve to eliminate, to the greatest extent practical, ignition

sources. This three-pronged control strategy is assumed to be effective in preventing either the accumulation of flammable gases where ignition sources are present or in eliminating ignition sources where flammable gas may be present. Therefore, the deflagration is assumed to be prevented because of the absence of an ignition source.

Table 7. Deflagration Consequence Assessment Results.

Case	Gas Release (m ³)	Headspace Volume (m ³)	Ratio ^a	Onsite Dose (rem)	Offsite Dose (rem)
LA-UR-92-3196 (Reference Case)	245	1218 ^b	0.20	17 ^c	0.014 ^c
Crust disturbance (bubble slurry flow)	51	566 ^d	0.09	6 ^e	0.006 ^e
Crust dissolution	160	566 ^d	0.28	4 ^e	0.004 ^e

LA-UR-92-3196, 1996, *A Safety Assessment for Proposed Pump Mixing Operations to Mitigate Episodic Gas Releases in Tank 241-SY-101: Hanford Site, Richland, Washington, Rev. 14a*, Los Alamos National Laboratory, Los Alamos, New Mexico.

^aRatio of gas release volume to available headspace volume

^bBased on a waste level of 398 in.

^cDoses based on waste release quantities from LA-UR-92-3196, Tank 241-SY-101 specific Unit Liter Dose, and BIO dispersion and health effects

^dBased on a waste level of 460 in.

^eDoses based on 95-percentile values as calculated using the refined safety analysis methodology BIO = *Tank Waste Remediation System Basis for Interim Operation* (HNF-SD-WM-BIO-001)

Buoyant Displacement Gas Release Event. Settled solids in the bottom of Tank 241-SY-101 have a demonstrated capacity to retain gas. Gas retention can result in naturally occurring BD GREs. The mixer pump mitigates gas retention at depth and thus prevents BD GREs. Operation of the mixer pump, however, also can induce a gas release if some gas retention at depth occurs before mixer pump operation. Mixer pump operating instructions, therefore, are included in the Authorization Basis controls for this tank. These are the Level I controls from LA-UR-92-3196 as modified by DOE (Wagoner 1998b). These operating restrictions are aimed at preventing mixer pump-induced GREs that exceed a defined allowable volume as well as restricting mixer pump operation to tank conditions for which there is an acceptable operating history relative to gas retention at depth. The bases for these operating restrictions and controls are described in LA-UR-92-3196, Appendix R and Wagoner (1998b).

As described in TF-97-0975, Rev. 3, the retained gas in the crust may add to the gas release during a BD GRE and thus increase the consequences. Qualitative assessment of this scenario concluded that the mixer pump is continuing to prevent BD GREs. The presence of the growing crust, however, may increase the probability of a failure of the mixer pump by encroaching on the mixer pump suction. Although level rise remediation actions will eliminate the crust encroachment hazard in the long term, waste transfers performed as an interim step during crust growth remediation actions may increase the likelihood of crust encroachment by lowering the

crust level closer to the mixer pump suction. Controls were selected to manage this risk by monitoring mixer pump operation and performance (see Table 9 and Appendix F). Mixer pump operating parameters identified by the Test Review Group (TRG) will be monitored during mixer pump operation, and the mixer pump will be shutdown if limits established by the TRG to prevent pump damage are exceeded. Mixer pump performance (e.g., pump motor current, pump discharge pressure, waste thermocouple response) will also be monitored and reviewed by the TRG at least quarterly for signs of degradation caused by crust encroachment. If needed, actions would be taken to move the crust away from the mixer pump suction (e.g., adding water back to the tank) to restore mixer pump operation or performance (i.e., its ability to control gas retention at depth and to prevent BD GREs).

For the first waste transfer, additional controls were selected to ensure that corrective action to raise the crust can be taken to restore mixer pump operation or performance, if needed (see Tables 8 and 9 and Appendix F). These controls are required because the analysis of crust buoyancy in PNNL-13066 shows that the crust could sink and prevent mixer pump operation/performance if the first waste transfer and subsequent back dilution with water lowers the specific gravity of the Tank 241-SY-101 slurry below the specific gravity of the crust. Based on operating experience, the mixer pump has operated and performed to control gas retention at depth and prevent BD GREs with the base of the crust as low as 295 inches from the bottom of the tank. Therefore, the maximum quantity of waste transferred for the first Tank 241-SY-101 transfer is limited so that back dilution can raise the base of the crust back to at least 295 inches without the crust sinking. The quantity of back dilution water that can be added following the first waste transfer is also limited to ensure that the crust does not sink (see Table 9). The maximum quantities of waste transferred and back dilution water added low in the tank (i.e., via the mixer pump burrowing ring or waste transfer pump) are determined prior to the first waste transfer and subsequent back dilution by Process Engineering based on the crust buoyancy model in PNNL-13066 and current Tank 241-SY-101 conditions. The maximum allowed waste transfer and low back dilution quantities will be reviewed and approved by the Plant Review Committee (PRC). For example, the results of the PNNL-13066 crust model for current tank conditions would allow a first waste transfer of at least 100,000 gallons with no top back dilution and a safety margin for uncertainties of approximately 37%. With a top back dilution of 20,000 gallons, the crust model would allow a 150,000 gallon waste transfer with a safety margin of approximately 40%. Both examples assume the water added low in the tank is via the mixer pump burrowing ring.

The Tank 241-SY-101 waste transfer flow totalizer and the dilution water flow totalizer will be used to monitor and limit the waste transfer and are designated Safety-Class SSCs. Back dilution water additions will be monitored and limited by the Safety-Class dilution water flow totalizer or other instrumentation that meets the requirements of TSR AC 5.19, *Process Instrumentation and Measuring and Test Equipment*.

To prevent inadvertent siphoning of waste from Tank 241-SY-101 to Tank 241-SY-102, the siphon break in the Tank 241-SY-102 drop leg is designated a Safety-Class SSC and the quantity of waste that could be siphoned after the waste transfer pump is turned off and before the dilution water flow to the transfer pump is stopped will be accounted for in the maximum first waste transfer limit. The analysis of potential siphon flows is contained in HNF-4359, *Engineering Design Calculations for the SY-101 RAPID Mitigation Project*.

Table 8. Safety Structures, Systems, and Components for Flammable Gas Deflagrations for Tank 241-SY-101 Remediation Activities and Operations. (2 sheets)

Structures, Systems, and Components	Classification		Safety Function	Comments
	SC	SS		
*Primary tank leak detection system	X		Provide indication that corrective action is required to avoid accumulation and deflagration of waste gas in the annulus space.	-
The SSCs listed below are required to implement the LA-UR-92-3196 (Rev. 14a) Level I controls for Tank 241-SY-101:				Refer to LA-UR-92-3196, Rev. 14a, and Wagoner 1998b.
*1. Mixer Pump	X		1. Reduce the frequency of a flammable gas deflagration by mixing, releasing flammable gases generated and trapped in the waste.	
*2. Hydrogen Monitor	X		2. Provide indication and alarm for hydrogen gas concentration in the Tank 241-SY-101 vapor space to the operations staff. Provide interlock to stop mixer pump operation if the hydrogen concentration reaches 0.75% (7,500 ppm) by volume.	
*3. Level Monitoring System	X		3. Provide indication of tank level which directs operation of the mixer pump.	
*4. Pressure Monitoring System	X		4. Provide indication and alarm for tank dome pressure. Provide interlock to stop mixer pump operation on high pressure.	
*5. Ventilation Flowmeter	X		5. Provide indication and alarm for ventilation flow rate. Provide interlocks to stop mixer pump operation on high or low flow rate.	
*6. SY-101 ammonia detection systems	X		6. Detect ammonia in the tank headspace/exhaust gas and alarm on the data acquisition system (DACS) when a high level of ammonia exists.	
*7. SY-101 temperature monitoring system	X		7. Provide indication and alarm for tank waste temperature. Provide interlock to stop mixer pump operation on high temperature.	
*Primary tank ventilation system	X		Maintain flammable gas concentrations in tank dome space, due to steady state releases, below 25% of the LFL.	-

Table 8. Safety Structures, Systems, and Components for Flammable Gas Deflagrations for Tank 241-SY-101 Remediation Activities and Operations. (2 sheets)

Structures, Systems, and Components	Classification		Safety Function	Comments
	SC	SS		
<i>Siphon break in Tank 241-SY-102 drop leg</i>	X		<i>Prevent the siphoning of waste from Tank 241-SY-101 to Tank 241-SY-102 when the waste transfer pump is not operating and there is no dilution water flow to the transfer pump.</i>	-
<i>Tank 241-SY-101 waste transfer flow totalizer</i>	X		<i>Provide the volume of material transferred from Tank 241-SY-101 to Tank 241-SY-102 (waste plus dilution water) for implementation of the Tank 241-SY-101 Waste Transfer Control.</i>	-
<i>Dilution water flow totalizer</i>	X		<i>Provide dilution water data for implementation of the Tank 241-SY-101 Waste Transfer Control.</i>	-

LA-UR-92-3196, 1996, *A Safety Assessment for Proposed Pump Mixing Operations to Mitigate Episodic Gas Releases in Tank 241-SY-101: Hanford Site, Richland, Washington*, LA-UR-92-3196, Rev. 14a, Los Alamos National Laboratory, Los Alamos, New Mexico.

Wagoner, J. D., 1998b, *Contract Number DE-AC06-96RL13200 – Supplemental Controls for Continued Operations in Tank 241-SY-101* (Letter 98-SCD-140 to R. D. Hanson, Fluor Daniel Hanford, Inc., October 22), U.S. Department of Energy, Richland Operations Office, Richland, Washington.

*Existing control

Note: New controls appear in ***bold italics***.

SC = Safety-Class

SS = Safety-Significant

Table 9. Technical Safety Requirements (and Prudent Contractor Controls Necessary for Safe Operation) for Flammable Gas Deflagrations for Tank 241-SY-101 Remediation Activities and Operations. (6 sheets)

Control	Safety Function	Comments
*DST and AWF Tank Ventilation (LCO 3.2.1)	Assure that steady state release of flammable gas does not accumulate in flammable concentrations in vapor spaces of DST and AWF tanks.	--
*Primary tank leak detection system	Provides indication of leakage in the annulus so action can be taken to prevent the steady state flammable gas accumulation from reaching the Lower Flammability Limit (LFL)	--

Table 9. Technical Safety Requirements (and Prudent Contractor Controls Necessary for Safe Operation) for Flammable Gas Deflagrations for Tank 241-SY-101
Remediation Activities and Operations. (6 sheets)

Control	Safety Function	Comments
*Flammability Controls (i.e., LA-UR-92-3196 Level I mixer pump controls, including supplemental controls, and mixer pump replacement control) (AC 5.9)	Assure effective mitigation and safe operations of Tank 241-SY-101 with respect to flammable gas hazards [i.e., gas retention at depth and buoyant displacement gas release events (BD GREs)].	Refer to LA-UR-92-3196, Rev. 14a, and Wagoner 1998b.
<i>Tank 241-SY-101 Mixer Pump Operation and Performance Monitoring (Prudent contractor control necessary for safe operation)</i>	<i>Identify and prevent or mitigate conditions that could damage or degrade Tank 241-SY-101 mixer pump operation or performance caused by interaction of the pump and the crust to ensure that the safety function of the mixer pump (control gas retention at depth and prevent BD GREs) is maintained.</i>	<p><i>Program key elements are:</i></p> <ul style="list-style-type: none"> <i>Mixer pump operating parameters (e.g., pump motor current, pump discharge pressure) identified by the Test Review Group (TRG) shall be monitored during mixer pump operation, and the mixer pump shall be shutdown if limits established by the TRG to prevent pump damage are exceeded.</i> <i>Mixer pump performance (e.g., pump motor current, pump discharge pressure, waste thermocouple response) shall be monitored, and the TRG shall review the data quarterly for signs of degradation that could affect continued control of gas retention at depth and prevention of BD GREs.</i> <i>The TRG shall direct corrective actions to restore mixer pump operation and performance, as necessary (e.g., add water). If following the first waste transfer back dilution of the Tank 241-SY-101 waste with water is required to restore mixer pump operation or performance (e.g., to raise the crust), back dilution shall be in accordance with the requirements of the Tank 241-SY-101 Back Dilution Control.</i>

Table 9. Technical Safety Requirements (and Prudent Contractor Controls Necessary for Safe Operation) for Flammable Gas Deflagrations for Tank 241-SY-101 Remediation Activities and Operations. (6 sheets)

Control	Safety Function	Comments
<i>Tank 241-SY-101 Back Dilution Control (Prudent contractor control necessary for safe operation)</i>	<p><i>Limit the quantity of back dilution water that can be added to the Tank 241-SY-101 waste following the first waste transfer to:</i></p> <ol style="list-style-type: none"> <i>1. Prevent a crust "roll over" that could cause a sudden release of flammable gas (including ammonia) for top water additions</i> <i>2. Prevent the crust from sinking to ensure that the mixer pump continues to perform its safety function (control gas retention at depth and prevent BD GREs) for low tank water additions</i> 	<p><i>Program key elements are:</i></p> <ul style="list-style-type: none"> <i>Following the first Tank 241-SY-101 waste transfer, the maximum quantity of water that can be added on top of the waste shall be 30,000 gallons.</i> <i>Following the first Tank 241-SY-101 waste transfer, the quantity of back dilution water that can be added low in the tank (i.e., via the Tank 241-SY-101 mixer pump burrowing ring or the waste transfer pump) shall be limited to ensure that the crust does not sink. The maximum quantity of back dilution water that can be added low in the tank following the first waste transfer shall be determined by Process Engineering and reviewed and approved by the PRC.</i> <i>Back dilution water additions to Tank 241-SY-101 waste shall be monitored and limited to the maximum quantities specified above.</i>
<i>Ignition controls (Prudent contractor control necessary for safe operation)</i>	<i>Prevent the ignition of flammable gases that may be present.</i>	<i>Program key elements of the ignition controls of TSR AC 5.10 shall be implemented for Tank 241-SY-101. The Flammable Gas Ignition Controls (AC 5.10.2c) shall be implemented with Tank 241-SY-101 treated as if it were a flammable gas Facility Group 1 tank.</i>
<i>Flammable gas monitoring control (DOE directed control in French 1999)</i>	<i>Ensures flammable conditions are not present in the Tank 241-SY-101 dome space when discretionary activities are being performed. This reduces the frequency of flammable gas deflagrations.</i>	<i>DOE directed Fluor Daniel Hanford to "impose an operational restriction that requires verification that flammable gas concentrations in the dome space do not exceed 25% of the LFL before commencing any discretionary activities. Further, when unanticipated exceedences of the 25% LFL limit occur, all discretionary activities will be halted until the tank dome space is below 25% of the LFL." This control is conservatively implemented by the flammable gas monitoring controls listed below.</i>

Table 9. Technical Safety Requirements (and Prudent Contractor Controls Necessary for Safe Operation) for Flammable Gas Deflagrations for Tank 241-SY-101 Remediation Activities and Operations. (6 sheets)

Control	Safety Function	Comments
<i>Flammable Gas Monitoring Controls (Prudent contractor control necessary for safe operation)</i>	<i>Ensures flammable conditions caused by steady-state accumulation or as a results of a recent gas release event are not present in the work space before and during manned work activities and ensures that flammable conditions are not produced by waste intrusive activities in Tank 241-SY-101. This reduces the frequency of flammable gas deflagrations.</i>	<p>Program key elements are:</p> <ul style="list-style-type: none"> • <i>The manned work activity controls of TSR AC 5.11.2a shall be implemented for Tank 241-SY-101 with Tank 241-SY-101 treated as if it were a flammable gas Facility Group 1 tank.</i> • <i>Prior to initiating and during unmanned waste disturbing operations and activities, continuous flammable gas monitoring of the tank dome space is required. Waste disturbing operations and activities shall be stopped if the flammable gas concentration is > 25% of the LFL.</i> • <i>When water sources are connected to equipment for operations and activities that could add water to Tank 241-SY-101, continuous flammable gas monitoring of the tank dome space is required. This requirement does not apply when the RAPID Mitigation System water support skid is the only water source connected to the tank <u>and</u> the water support skid is not connected to the service water system. Water sources are not considered to be connected if they are disconnected by a removal of piping (i.e., air gap) or installation of a blind flange. Note that closed valves do not disconnect water sources. Water sources shall be immediately isolated if the flammable gas concentration is > 25% of the LFL. Isolation requires a shutoff valve in the line from the water source to be closed. If it cannot be verified that the valve is not leaking through, the water line shall be disconnected.</i> <p>Note: <i>For manned work activity controls and the unmanned operations controls in Tank 241-SY-101, 25% of the LFL is defined as 25% of the LFL as measured by a combustible gas monitor or, if measuring hydrogen only, as 7,500 ppm hydrogen.</i></p>

Table 9. Technical Safety Requirements (and Prudent Contractor Controls Necessary for Safe Operation) for Flammable Gas Deflagrations for Tank 241-SY-101 Remediation Activities and Operations. (6 sheets)

Control	Safety Function	Comments
<i>Tank 241-SY-101 Waste Transfer Control (Prudent contractor control necessary for safe operation)</i>	<i>Limit the quantity of waste transferred from Tank 241-SY-101 to ensure that the mixer pump continues to perform its safety function (control gas retention at depth and prevent BD GREs)</i>	<p><i>Program key elements are:</i></p> <ul style="list-style-type: none"> <i>For the first waste transfer from Tank 241-SY-101, the quantity of waste transferred shall be limited. The maximum quantity of waste that can be transferred shall be calculated so that back dilution of the Tank 241-SY-101 waste with water following the first waste transfer can raise the base of the crust to at least 295 inches from the bottom of the tank without the crust sinking. The maximum quantity of waste transferred shall account for waste that could be siphoned from Tank 241-SY-101 after the waste transfer pump is turned off until dilution water flow to the transfer pump is stopped (e.g., the dilution water supply is disconnected). (Note that closed valves do not ensure that the dilution water flow is stopped.) The maximum quantity of waste transferred in the first waste transfer shall be determined by Process Engineering and reviewed and approved by the PRC.</i> <i>The first waste transfer from Tank 241-SY-101 shall be monitored and limited to the maximum quantity established above.</i>
*Excavation Controls (AC 5.17)	Reduce the likelihood of inadvertently intruding any structure potentially containing flammable gas to prevent ignition of flammable gases.	-
*HEPA Filter Controls (AC 5.18)	Reduce consequences from a possible HEPA filter failure by limiting the inventory available for release.	-

Table 9. Technical Safety Requirements (and Prudent Contractor Controls Necessary for Safe Operation) for Flammable Gas Deflagrations for Tank 241-SY-101 Remediation Activities and Operations. (6 sheets)

Control	Safety Function	Comments
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LA-UR-92-3196, 1996, *A Safety Assessment for Proposed Pump Mixing Operations to Mitigate Episodic Gas Releases in Tank 241-SY-101: Hanford Site, Richland, Washington*, LA-UR-92-3196, Rev. 14a, Los Alamos National Laboratory, Los Alamos, New Mexico.

Wagoner, J. D., 1998b, *Contract Number DE-AC06-96RL13200 – Supplemental Controls for Continued Operations in Tank 241-SY-101* (Letter 98-SCD-140 to R. D. Hanson, Fluor Daniel Hanford, Inc., October 22), U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Note: New controls appear in ***bold italics***.

*Existing control

BD GRE= buoyant displacement gas release event

HEPA = high-efficiency particulate air (filter)

PRC = Plant Review Committee

Safety Controls for Flammable Gas Deflagrations. DOE and the PHMC Team have acknowledged that the hazards in Tank 241-SY-101 are increasing and that the frequencies and consequences of potential accidents are increased over those previously accepted by DOE. The PHMC Team has specified controls by following the safety analysis and control selection process described in the BIO. These controls include: (1) applicable TSRs, (2) supplemental controls directed by DOE in Wagoner (1998b); (3) the operating restriction directed by DOE in French (1999); and (4) Contractor-imposed prudent controls necessary to safely operate as required by DOE in French (1999).

The safety SSCs selected for flammable gas deflagrations in Tank 241-SY-101 are shown in Table 8. TSRs and prudent controls to safely operate for flammable gas deflagrations in Tank 241-SY-101 are listed in Table 9.

In addition, a defense-in-depth item was selected to monitor with a video camera during waste transfers and during activities that could involve crust disturbance or dissolution to detect significant unexpected events.

LA-UR-92-3196 Level II and Level III controls are still applicable under the authority of the PHMC Team's Test Review Group (TRG). The TRG may approve revisions to the Level II controls. The requirement to notify DOE of changes to Level II controls was suspended by French 1999.

3.2.6 Surface Leak Resulting in Pool

The hazard analysis of Tank 241-SY-101 waste transfers identified hazardous conditions involving waste leaks resulting in a surface pool similar to those identified in the BIO hazard analysis. These hazardous conditions are represented by the Surface Leak Resulting in Pool accident in BIO Section 5.3.2.18. To assure that the unmitigated and mitigated risk of Tank 241-SY-101 waste transfer pool leaks are encompassed by the BIO accident analysis, the

parameters of the Tank 241-SY-101 waste transfer were compared with the key parameters of the Surface Leak Resulting in Pool accident analysis. Appendix B presents the results of this comparison and an analysis of parameter differences. The conclusion of Appendix B is that the frequency and consequences of a pool leak that might occur during Tank 241-SY-101 waste transfers are enveloped by the BIO accident analysis. This conclusion is also valid for two hazardous conditions identified for back dilution that are represented by the Surface Leak Resulting in Pool accident.

The controls identified in BIO Section 5.3.2.18 for a surface leak resulting in pool, including safety SSCs, TSRs, and defense-in-depth controls, apply to Tank 241-SY-101 remediation activities and operations (see the applicable controls in BIO Tables 5.3.2.18-3, -4, and -5). There are, however, several unique aspects of the Tank 241-SY-101 waste transfer system that required control decisions (see Appendix F). The control decisions included defining the safety functions of the PPP, the overground transfer line, and the riser 241-SY-102-007 drop leg enclosure, all of which had characteristics different from any safety SSC in the BIO. The required safety functions of these special Tank 241-SY-101 waste transfer structures for pool leaks are provided in Table 10. In addition, to implement the material balance requirements of TSR AC 5.12, the Tank 241-SY-101 waste transfer flow totalizer was designated as a Safety-Significant SSC (see Table 10).

Another unique aspect of the Tank 241-SY-101 waste transfer system is the possibility of limited siphoning of waste from Tank 241-SY-101 to Tank 241-SY-102 if there is dilution water flow to the waste transfer pump even though the transfer pump is not operating (HNF-4359). As a result, prevention of an inadvertent waste transfer requires removing the motive power (i.e., electric power) to the waste transfer pump and either stopping the dilution water flow to the waste transfer pump or shutting off the waste transfer pump discharge flow. For purposes of implementing the TSR AC 5.20, "Administrative Lock Program" for Tank 241-SY-101 remediation activities and operations, both of these actions are required.

Table 10. Surface Leak Resulting in Pool Accident Safety Functions for the Tank 241-SY-101 Waste Transfer Pre-fabricated Pump Pit, Overground Transfer Line, Riser 241-SY-102-007 Drop Leg Enclosure, and Flow Totalizer.

Structures, Systems, and Components	Classification		Safety Function	Comments
	SC	SS		
Pre-fabricated Pump Pit (PPP)*	X	X	<p>The Safety-Class safety function of the PPP is to provide an intact boundary for the leaked waste, and when leak detector alarms and appropriate operator response times to shut off the transfer pump are credited, to prevent premature PPP overflow and the formation of a surface pool.</p> <p>The Safety-Significant safety function of the PPP, including cover, is to limit release of aerosols generated by splatter inside the PPP, and limit shine and skyshine dose to onsite receptors.</p>	The PPP shall be designed to withstand design basis high wind and associated missiles.
Overground transfer line (OGT) encasement and connections*	X		Provide secondary confinement for leaks from the primary line and route the leak to the riser 241-SY-102-007 drop leg enclosure or to the PPP which contain leak detection systems.	The OGT encasement and connections shall be designed to withstand (1) the maximum pressure resulting if the drain to Tank 241-SY-102 is plugged and the waste backs up the OGT encasement to the PPP and (2) design basis high wind, but not the associated missiles.
Riser 241-SY-102-007 drop leg enclosure*	X		Same as OGT encasement and connections.	Comments for OGT encasement and connections above also apply to the riser 241-SY-102 drop leg enclosure, except that it shall be designed to withstand missiles associated with the design basis high wind.
Tank 241-SY-101 waste transfer flow totalizer		X	Provide volume of material transferred from Tank 241-SY-101 to Tank 241-SY-102 (waste plus dilution water) for implementation of the TSR AC 5.12 Transfer Controls material balance requirements.	-

*Additional temporary shielding and administrative controls shall be used to maintain facility worker radiation exposures ALARA.

ALARA= As Low As Reasonably Achievable

SC = Safety-Class

SS = Safety-Significant

3.2.7 Spray Leak in Structure or From Overground Waste Transfer Lines

The potential hazardous conditions for Tank 241-SY-101 waste transfers involving spray leaks are similar to those identified in the BIO hazard analysis. These hazardous conditions are represented by the Spray Leak in Structure or From Overground Waste Transfer Lines and are addressed in BIO Section 5.3.2.20. To assure that the unmitigated and mitigated risk of Tank 241-SY-101 waste transfer spray leaks are encompassed by the BIO accident analysis, the parameters of the Tank 241-SY-101 waste transfer were compared with the key parameters of the BIO accident analysis. Appendix B presents the results of this comparison and an analysis of parameter differences. The conclusion of Appendix B is that the frequency and consequences of a spray leak that might occur during Tank 241-SY-101 waste transfers are enveloped by the BIO accident analysis.

The controls identified in BIO Section 5.3.2.20 for a spray leak, including safety SSCs, TSRs, and defense-in-depth controls, apply to the Tank 241-SY-101 waste transfer (see the applicable controls in BIO Tables 5.3.2.20-3, -4, and -5). However, several unique aspects of the Tank 241-SY-101 waste transfer system required control decisions (see Appendix F). The control decisions included defining the safety functions of the PPP, the overground transfer line, and the riser 241-SY-102-007 drop leg enclosure, all of which have characteristics different from any safety SSC in the BIO. The required safety functions of these special Tank 241-SY-101 waste transfer structures for spray leaks are provided in Table 11.

Another unique aspect of the Tank 241-SY-101 waste transfer system is the possibility of limited siphoning of waste from Tank 241-SY-101 to Tank 241-SY-102 if there is dilution water flow to the waste transfer pump even though the transfer pump is not operating (HNF-4359). As a result, prevention of an inadvertent waste transfer requires removing the motive power (i.e., electric power) to the waste transfer pump and either stopping the dilution water flow to the waste transfer pump or shutting off the waste transfer pump discharge flow. For purposes of implementing the TSR AC 5.20, "Administrative Lock Program" for Tank 241-SY-101 remediation activities and operations, both of these actions are required.

3.2.8 Spray Leak from Underground Waste Transfer Lines

Excavation activities required by Tank 241-SY-101 remediation activities and operation could damage a waste transfer line, resulting in a waste leak. This hazardous condition is represented in the BIO safety analysis by the Spray Leak from Underground Waste Transfer Lines accident. Preventive and mitigative controls for this postulated accident are described in BIO Section 5.3.2.21 and contained in TSR AC 5.17. The requirement to perform material balances during waste transfers is a defense-in-depth control for this postulated accident (see BIO Section 5.3.2.21).

Table 11. Spray Leak Accident Safety Functions for the Tank 241-SY-101 Waste Transfer Prefabricated Pump Pit, Overground Transfer Line, and the Riser 241-SY-102-007 Drop Leg Enclosure.

Structures, Systems, and Components*	Classification		Safety Function	Comments
	SC	SS		
Pre-fabricated Pump Pit (PPP)	X		Knock down spray and limit release of aerosols to the environment.	The PPP shall be designed to withstand design basis high wind and associated missiles.
Overground transfer line (OGT) encasement and connections	X		Confine a leak from the primary piping and ensure that the leak is directed to the riser 241-SY-102-007 drop leg enclosure or to the PPP which contain leak detection systems.	The OGT encasement and connections shall be designed to withstand (1) the maximum pressure resulting if the drain to Tank 241-SY-102 is plugged and the waste backs up the OGT encasement to the PPP and (2) design basis high wind, but not the associated missiles.
Riser 241-SY-102-007 drop leg enclosure	X		Same as OGT encasement and connections.	Comments for OGT encasement and connections above are also applicable to the riser 241-SY-102 drop leg enclosure, except that it shall be designed to withstand missiles associated with the design basis high wind.

*Additional temporary shielding and administrative controls shall be used to maintain facility worker radiation exposures ALARA.

ALARA = As Low As Reasonably Achievable

SC = Safety-Class

SS = Safety-Significant

3.3 ENGINEERED AND ADMINISTRATIVE CONTROLS

The criteria used for the control decisions in the BIO and in this safety basis document for Tank 241-SY-101 remediation activities and operations are described in BIO Section 5.4. BIO Section 5.4 also identifies the controls for the individual hazardous conditions identified for TWRS facilities and operations. Appendix G identifies the controls for the individual hazardous conditions identified for Tank 241-SY-101 waste transfers in HNF-3966 and HNF-3645 and for back dilution of Tank 241-SY-101 waste in HNF-4891. The tables in Appendix G include the following.

- **Public and Onsite Worker Protection.** Table G1 identifies the safety SSCs and TSRs (or prudent contractor controls necessary for safe operation) for hazardous conditions with significant consequences to the public (S3) and onsite workers (S2). The table is organized by the representative accidents analyzed in Section 3.2, with the represented hazardous conditions listed following each representative accident.

- **Facility Worker Protection.** Table G2 identifies the safety SSCs and TSRs (or prudent contractor controls necessary for safe operation) for anticipated hazardous conditions with significant consequences to facility workers (F3, S1).
- **Environmental Protection.** Table G3 identifies controls for hazardous conditions with the potential for significant environmental consequences (E3 or E2).

Additional controls that provide defense-in-depth for Tank 241-SY-101 remediation activities and operations are identified in Section 3.2.

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4.0 OPERATIONAL CONTROLS

Controls that define the operating envelope for Tank 241-SY-101 remediation activities and operations are summarized in Table 12. The basis for these controls is the safety analysis identified or described in Section 3. These operational controls provide the operating restrictions and administrative controls that are necessary to preserve the validity of the safety analysis assumptions and to ensure that Tank 241-SY-101 remediation activities and operations are conducted within the required conditions bounded by the analysis. The existing controls identified for Tank 241-SY-101 from the BIO are implemented through HNF-SD-WM-TSR-006. New controls identified for Tank 241-SY-101 remediation activities and operations as prudent controls required for safe operation are implemented through HNF-IP-1266, *Tank Farms Operations Administrative Controls*. Safety SSCs are identified in the TWRS Safety Equipment List (SEL).

Table 12. Technical Safety Requirement Cross-Reference for Tank 241-SY-101. (10 sheets)

Analyzed Accident	Safety Structures, Systems, and Components			Technical Safety Requirement	Derivation Basis
	Description	SC	SS		
Nuclear Criticality	The controls for this accident that have been established in HNF-SD-WM-BIO-001 for further details of the controls.			HNF-SD-WM-BIO-001 and HNF-SD-WM-TSR-006 apply to Tank 241-SY-101. See Section 5.3.2.1 and Table 6-1 of HNF-SD-WM-BIO-001.	
HEPA Filter Failure-Exposure to High Temperature or Pressure	The controls for this accident that have been established in HNF-SD-WM-BIO-001 and HNF-SD-WM-TSR-006 apply to Tank 241-SY-101. See Section 5.3.2.2 and Table 6-1 of HNF-SD-WM-BIO-001 for further details of the controls. Section 3.2.1 of this document provides additional discussion of how the established controls apply to the specific Tank 241-SY-101 hazardous conditions represented by this accident.				
Fire in Contaminated Area	The technical basis for the controls documented in Table 6-1 of HNF-SD-WM-BIO-001 is in Section 5.3.2.3 of HNF-SD-WM-BIO-001. See Section 3.2.2 of this document for a discussion of the specific controls credited for Tank 241-SY-101 hazardous conditions represented by this accident.				
Evaporator Dump	This accident does not apply to Tank 241-SY-101.				
Steam Intrusion From Interfacing Systems	This accident does not apply to Tank 241-SY-101.				
Leak from Railcar/Tank Trailer	This accident does not apply to Tank 241-SY-101.				
Subsurface Leak Remaining Subsurface	The controls for this accident that have been established in HNF-SD-WM-BIO-001 and HNF-SD-WM-TSR-006 apply to Tank 241-SY-101. See Section 5.3.2.7 and Table 6-1 of HNF-SD-WM-BIO-001 for further details of the controls.				
Unplanned Excavation/Drilling in Crib/Ditch/Pond	This accident does not apply to Tank 241-SY-101.				
Caustic Spray Leak	This accident does not apply to Tank 241-SY-101.				
Sodium Fire	This accident does not apply to Tank 241-SY-101.				

Table 12. Technical Safety Requirement Cross-Reference for Tank 241-SY-101. (10 sheets)

Analyzed Accident	Safety Structures, Systems, and Components			Technical Safety Requirement	Derivation Basis
	Description	SC	SS		
Mixing of Incompatible Material-Toxic Vapor Generation	241-SY Tank Farm primary tank ventilation system	-	X	SL: None required LCS: None required LCO: None required AC: 241-SY Tank Farm primary tank ventilation system	<p>In HNF-SD-WM-BIO-001, Section 5.3.2.11, the unmitigated offsite and onsite radiological and toxicological dose consequences are below the risk guidelines so no controls are required to prevent or mitigate the accident scenario or protect the offsite public, onsite worker, or facility worker. No controls were necessary to mitigate the risk from this accident.</p> <p>For Tank 241-SY-101 waste transfers, however, controls have been established to protect the onsite worker from postulated ammonia releases. These controls are shown in the previous columns and are discussed in detail in Section 3.2.3 of this document.</p> <p><i>Ensures operation of the 241-SY Tank Farm primary tank ventilation system during global waste disturbing operations and activities in Tank 241-SY-101. TSR LCO 3.2.1 satisfies this requirement for ammonia releases.</i></p>
	Ammonia monitoring systems (Tank 241-SY-101 and 241-SY Tank Farm primary tank ventilation exhaust)	-	X	AC: Ammonia monitoring (Tank 241-SY-101 and 241-SY Tank Farm primary tank ventilation exhaust)	<p>The program key elements are:</p> <ul style="list-style-type: none"> During global waste disturbing operations and activities in Tank 241-SY-101 (except waste transfers) and when water sources are connected to equipment for operations and activities that could add water to Tank 241-SY-101, monitor the ammonia concentration in the tank vapor space or in the 241-SY Tank Farm primary tank ventilation exhaust and, if the ammonia concentration reaches 3000 ppm or 1000 ppm, respectively, stop global waste disturbing operations and activities in the tank and isolate all sources of water to the tank. This requirement does not apply when the RAPID Mitigation System water support skid is the only water source connected to the tank and the water support skid is not connected to the service water system. During Tank 241-SY-101 waste transfers, monitor the ammonia concentration in the 241-SY Tank Farm primary tank ventilation exhaust and, if the ammonia concentration reaches 1000 ppm, stop the waste transfer and isolate all sources of water to Tank 241-SY-101. <p><i>Note: See HNF-SD-WM-TSR-006 for the definition of global waste disturbing.</i></p>
Mixing of Incompatible Material-Tank Pressurization					<p>The controls for this accident that have been established in HNF-SD-WM-BIO-001 and HNF-SD-WM-TSR-006 apply to Tank 241-SY-101. See Section 5.3.2.12 and Table 6-1 of HNF-SD-WM-BIO-001 for further details of the controls.</p>

Table 12. Technical Safety Requirement Cross-Reference for Tank 241-SY-101. (10 sheets)

Analyzed Accident	Safety Structures, Systems, and Components			Technical Safety Requirement	Derivation Basis
	Description	SC	SS		
Tank Failure Due to Excessive Loads	The controls for this accident that have been established in HNF-SD-WM-BIO-001 and HNF-SD-WM-TSR-006 apply to Tank 241-SY-101. See Section 5.3.2.13 and Table 6-1 of HNF-SD-WM-BIO-001 for further details of the controls. Section 3.2.4 of this document provides additional discussion of how the established controls apply to the specific Tank 241-SY-101 hazardous conditions represented by this accident.				
Flammable Gas Deflagrations	DST/AWF ventilation*	X		SL: None required LCS: None required LCO: 3.2.1 DST and AWF Tank Ventilation Systems*	Shown here and in the preceding columns are existing controls (denoted by an asterisk [*]) and additional prudent contractor controls necessary for safe operation (denoted by text shown in <i>bold italics</i>). The technical basis for existing controls is provided in Section 5.3.2.14 and Appendix E of HNF-SD-WM-BIO-001. Similarly, the technical basis for new prudent contractor controls is provided in Section 3.2.5 of this document. LCO 3.2.1 PREVENTIVE: On DSTs and AWF tanks, active ventilation system operation prevents a steady state flammable gas accumulation from reaching the lower flammability limit. LCO 3.2.6 MITIGATIVE: The primary tank leak detection system (conductivity probes or CAMs) provides indication of leakage in the annulus so action can be taken to prevent the steady state flammable gas accumulation from reaching the LFL. AC 5.9 PREVENTIVE: Tank 241-SY-101 controls are in accordance with LANL requirements to control the potential for flammable gas deflagrations as modified by Wagoner (1998b). AC (241-SY-101 Ignition Controls) PREVENTIVE: <i>Controls prevent the ignition of flammable gases that may be present.</i>
	Primary tank leak detection systems*	X		LCO: 3.2.6 Primary Tank Leak Detection Systems*	
	Tank 241-SY-101 mixer pump*	X		AC: 5.9 Flammability Controls* - 241-SY-101 tank controls 241-SY-101 Ignition Controls 241-SY-101 Flammable Gas Monitoring Controls	
	Tank 241-SY-101 hydrogen monitor*	X		AC: 241-SY-101 Mixer Pump Operation and Performance Monitoring 241-SY-101 Back Dilution Control	
	Tank 241-SY-101 level monitoring system*	X		AC: 5.12 Transfer Controls* -Waste compatibility controls	
	Tank 241-SY-101 pressure monitoring system*	X		AC: 241-SY-101 Waste Transfer Control 5.14 Emergency Preparedness*	
	Tank 241-SY-101 ventilation flowmeter*	X		AC: Response procedures 5.17 Excavation Controls*	
	Tank 241-SY-101 ammonia detection systems*	X		AC: 5.18 HEPA Filter Controls* - Periodic radiation surveillance - Replacement based on accumulation	
	Tank 241-SY-101 temperature monitoring systems*	X		AC: 5.19 Process Instrumentation and Measuring and Test Equipment*	
	Siphon Break in Tank 241-SY-101 drop leg	X			
	Dilution Water Flow Totalizer	X			
	Tank 241-SY-101 waste transfer flow totalizer	X			

Table 12. Technical Safety Requirement Cross-Reference for Tank 241-SY-101. (10 sheets)

Analyzed Accident	Safety Structures, Systems, and Components			Technical Safety Requirement	Derivation Basis
	Description	SC	SS		
Flammable Gas Deflagrations (continued)					<p>AC (241-SY-101 Flammable Gas Monitoring Controls) PREVENTIVE:</p> <p>Controls ensure flammable conditions caused by steady-state accumulation or as a result of a recent gas release event are not present in the work space before and during manned work activities and ensures that flammable conditions are not produced by waste intrusive activities in Tank 241-SY-101. This reduces the frequency of flammable gas deflagrations.</p> <p>AC (241-SY-101 Mixer Pump Operation and Performance Monitoring) PREVENTIVE:</p> <p>Controls are in place to identify and prevent or mitigate conditions that could damage or degrade Tank 241-SY-101 mixer pump operation and performance caused by interaction of the pump and the crust to ensure that the safety function of the mixer pump (control gas retention at depth and prevent buoyant displacement GREs) is maintained.</p> <p>AC (241-SY-101 Back Dilution Control) PREVENTIVE:</p> <p>Controls limit the quantity of dilution water that can be added to Tank 241-SY-101 following the first waste transfer. These controls ensure that the crust does not sink and cause mixer pump operation or performance issues of generate high concentrations of flammable or toxic gas in the Tank 241-SY-101 dome space.</p> <p>AC 5.12 MITIGATIVE:</p> <p>Controls ensure final tank states remain within analyzed topography of the flammable gas deflagration accident.</p>

Table 12. Technical Safety Requirement Cross-Reference for Tank 241-SY-101. (10 sheets)

Analyzed Accident	Safety Structures, Systems, and Components			Technical Safety Requirement	Derivation Basis
	Description	SC	SS		
Flammable Gas Deflagrations (continued)					<p>AC (241-SY-101 Waste Transfer Control) PREVENTIVE:</p> <p><i>Controls limit the quantity of waste transferred from Tank 241-SY-101 to ensure that waste conditions can be restored (e.g., by back dilution), if needed, such that the mixer pump continues to perform its safety function (control gas retention at depth and prevent buoyant displacement GREs).</i></p> <p>AC 5.14 MITIGATIVE:</p> <p>Controls mitigate the consequences of a flammable gas deflagration.</p> <p>AC 5.17 PREVENTIVE:</p> <p>Controls prevent ignition of flammable gases by reducing the likelihood of inadvertently intruding any structure potentially containing flammable gas.</p> <p>AC 5.18 MITIGATIVE:</p> <p>HEPA filter and pre-filter monitoring and replacement at ≤ 200 mm/m/h protects against exceeding the source term assumptions in the analysis by limiting the accumulation on the filter and thereby limiting inventory available for release.</p> <p>AC 5.19 PREVENTIVE:</p> <p>Controls ensure that instrumentation used to monitor the concentration of flammable gases is maintained.</p>
Organic Solvent Fire				The controls for this accident that have been established in HNF-SD-WM-BIO-001 and HNF-SD-WM-TSR-006 apply to Tank 241-SY-101. See Section 5.3.2.15 and Table 6-1 of HNF-SD-WM-BIO-001 for further details of the controls.	
In-Tank Fuel Fire/Deflagration				The controls for this accident that have been established in HNF-SD-WM-BIO-001 and HNF-SD-WM-TSR-006 apply to Tank 241-SY-101. See Section 5.3.2.16 and Table 6-1 of HNF-SD-WM-BIO-001 for further details of the controls.	
Organic Salt-Nitrate Reaction				This accident does not apply to Tank 241-SY-101.	

Table 12. Technical Safety Requirement Cross-Reference for Tank 241-SY-101. (10 sheets)

Analyzed Accident	Safety Structures, Systems, and Components			Technical Safety Requirement	Derivation Basis
	Description	SC	SS		
Surface Leak Resulting in Pool	Transfer leak detection systems*	X		SL: None required LCS: None required LCO: 3.1.1 Transfer System Covers and Entry Doors*	Shown here and in the preceding columns are existing controls (denoted by an asterisk (*)) and additional prudent contractor controls necessary for safe operation (denoted by text shown in <i>bold italics</i>). The technical basis for existing controls is provided in Section 5.3.2.18 of HNF-SD-WM-BIO-001. Similarly, the technical basis for the new prudent contractor controls is provided in Section 3.2.6 of this document. LCO 3.1.1 MITIGATIVE: Covers and entry doors for transfer-associated structures mitigate releases of hazardous material when transferring waste by stopping a leak from aerosolizing outside the transfer-associated structures. LCO 3.1.2 PREVENTIVE: Flushing system pressure switches and associated interlocks with waste transfer pumps or alarm response are used to stop inadvertent waste flow into flushing systems in transfer-associated structures that do not have covers. This prevents potential leaks from developing outside the transfer path. The pressure switches and associated interlocks or alarm response also prevent radioactive material from contaminating the service water supply system. LCO 3.1.3 MITIGATIVE: The leak detection systems detect leaks from the primary waste transfer system piping and either automatically stops the waste transfer or provides an alarm to initiate operator action. Stopping the transfer when a leak is detected minimizes the potential consequences from a continued leak.
	Primary tank leak detection systems*	X		LCO: 3.1.2 Service Water Pressure Detection Systems*	
	Pressure switch interlocks or alarms (water service lines)*	X		LCO: 3.1.3 Transfer Leak Detection Systems* LCO: 3.2.6 Primary Tank Leak Detection Systems*	
	Tank level detection systems*		X	AC: 5.12 Transfer Controls* - Material balance - Monitor interconnected tanks for level increase	
	Transfer system covers*	X		- Configuration management - Use of concrete shielding system or vehicle restrictions around OGT lines - Jumper leak testing	
	Service water flow totalizers*		X	- Caps/blanks on open nozzles 5.14 Emergency Preparedness*	
	OGT encasement and connections	X		- Response procedures 5.20 Transfer pump administrative lock controls*	
	Pre-fabricated Pump Pit	X	X	5.21 Tank service water intrusion monitoring program*	
	Riser 241-SY-102 drop leg enclosure	X		AC: 5.22 Transfer system Cover removal controls*	
	Tank 241-SY-101 waste transfer flow totalizer		X		

Table 12. Technical Safety Requirement Cross-Reference for Tank 241-SY-101. (10 sheets)

Analyzed Accident	Safety Structures, Systems, and Components			Technical Safety Requirement	Derivation Basis
	Description	SC	SS		
Surface Leak Resulting in Pool (continued)					<p>LCO 3.2.6 MITIGATIVE:</p> <p>The primary tank leak detection system detects leakage in the annulus of the DSTs so action can be taken to terminate the leakage before it overflows and forms a surface pool.</p> <p>AC 5.12 MITIGATIVE:</p> <p>Performing a material balance during waste transfers identifies discrepancies in the amount of material transferred which indicates a potential leak or misrouting.</p> <p>Monitoring the tanks interconnected to the transfer route helps to detect any misroutes or leakage.</p> <p>Use of the concrete shielding system or vehicle restrictions around the OGT lines are used to protect the OGT lines from external events such as a vehicle accident that may damage the transfer line and result in a leak.</p> <p>The leak test when jumpers are installed ensures proper installation to prevent a misalignment of the jumper or prevent the jumper from falling off during a transfer resulting in a leak.</p> <p>AC 5.14 MITIGATIVE:</p> <p>In the event that a leak occurs, emergency response procedures provide direction to minimize the consequences of the leak and to implement recovery activities.</p> <p>AC 5.20 PREVENTIVE:</p> <p>Placing an administrative lock on an active transfer pump that is physically connected to a waste transfer system, minimizes the potential for an inadvertent pump start that could result in the unplanned transfer of waste. See Section 3.2.6 for a discussion of how this control applies to the siphon break, which is part of the system used for Tank 241-SY-101 remediation activities and operations.</p>

Table 12. Technical Safety Requirement Cross-Reference for Tank 241-SY-101. (10 sheets)

Analyzed Accident	Safety Structures, Systems, and Components			Technical Safety Requirement	Derivation Basis
	Description	SC	SS		
Surface Leak Resulting in Pool (continued)					AC 5.21 MITIGATIVE: The tank service water intrusion monitoring program is used to provide indication of service water leaks having the potential to cause tank intrusion. Service water flow totalizer monitoring or the tank level detection system provides alternate means of indicating service water intrusion. AC 5.22 MITIGATIVE: The transfer system cover removal controls provide compensatory measures for cover removal during waste transfers.
Subsurface Leak Resulting in Pool	The controls for this accident that have been established in HNF-SD-WM-BIO-001 and HNF-SD-WM-TSR-006 apply to Tank 241-SY-101. See Section 5.3.2.19 and Table 6-1 of HNF-SD-WM-BIO-001 for further details of the controls.				
Spray Leak in Structure or from Overground Waste Transfer Line	Transfer system covers*	X		SL: None required	Shown here and in the preceding columns are existing controls (denoted by an asterisk [*]) and additional prudent contractor controls necessary for safe operation (denoted by text shown in <i>bold italics</i>). The technical basis for existing controls is provided in Section 5.3.2.20 of HNF-SD-WM-BIO-001. Similarly, the technical basis for new controls is provided in Section 3.2.7 of this document. LCO 3.1.1 MITIGATIVE: Covers and entry doors for transfer-associated structures mitigate spray leak events when transferring waste by stopping a leak from aerosolizing outside the transfer-associated structures. LCO 3.1.2 PREVENTIVE: Flushing system pressure switches and associated interlocks with waste transfer pumps or alarm response are used to stop inadvertent waste flow into flushing systems in transfer-associated structures that do not have covers. This prevents potential leaks from developing outside the transfer path. The pressure switches and associated interlocks or alarm response also prevent radiological material from contaminating the service water supply system. LCO 3.1.4 MITIGATIVE: The ventilation CAM interlock detects increasing radiological effluent releases and stops the ventilation exhaust fan on DSTs. Stopping the exhaust fan protects against the continued unfiltered release of radiological and toxicological materials following the breach of the filter.
	Pressure switch interlocks or alarms (water service lines)*	X		LCS: None required	
	Ventilation CAM interlock systems	X		LCO: 3.1.1 Transfer System Covers and Entry Doors*	
	Backflow prevention devices*		X	LCO: 3.1.2 Service Water Pressure Detection Systems*	
	OGT encasement and connections	X		LCO: 3.1.4 Ventilation Stack CAM Interlock Systems*	
	Pre-fabricated pump pit	X		AC: 5.12 Transfer Controls*	
Riser 241-SY-102 drop leg enclosure	X		- Configuration management - Use of concrete shielding system or vehicle restrictions around OGT lines AC: 5.18 HEPA Filter Controls* - Periodic radiation surveillance - Replacement based on accumulation AC: 5.20 Transfer pump administrative lock controls* AC: 5.22 Transfer system cover removal controls*		

Table 12. Technical Safety Requirement Cross-Reference for Tank 241-SY-101. (10 sheets)

Analyzed Accident	Safety Structures, Systems, and Components			Technical Safety Requirement	Derivation Basis
	Description	SC	SS		
Spray Leak in Structure or from Overground Waste Transfer Line (continued)					<p>AC 5.12 PREVENTIVE/MITIGATIVE:</p> <p>The independent verification of the selected transfer path and configuration management of the alignment of the jumpers and valves used in the transfer help to prevent a misroute. Monitoring the tanks interconnected to the transfer route helps to detect any misroutes or leakage.</p> <p>Use of the concrete shielding system or vehicle restrictions around the OGT lines are used to protect the OGT lines from external events such as a vehicle accident that may damage the transfer line and result in a leak.</p> <p>AC 5.18 MITIGATIVE:</p> <p>HEPA filter and pre-filter monitoring and replacement at ≤ 200 mrem/h) protects against exceeding the source term assumptions in the analysis by limiting the accumulation on the filter and thereby limiting inventory available for release.</p> <p>AC 5.20 PREVENTIVE:</p> <p>Placing an administrative lock on an active transfer pump that is physically connected to a waste transfer system minimizes the potential for an inadvertent pump start that could result in the unplanned transfer of waste. See Section 3.2.7 for a discussion of how this control applies to the siphon break, which is part of the system used for Tank 241-SY-101 remediation activities and operations.</p> <p>AC 5.22 MITIGATIVE:</p> <p>The transfer system cover removal controls provide compensatory measures for cover removal during waste transfers.</p>
Spray Leak from Underground Waste Transfer Lines				The controls for this accident that have been established in HNF-SD-WM-BIO-001 and HNF-SD-WM-TSR-006 apply to Tank 241-SY-101. See Section 5.3.2.21 and Table 6-1 of Section 3.2.8 of this document provides additional discussion of how the established controls apply to the specific Tank 241-SY-101 hazardous conditions represented by this accident.	
Tank Bump				The controls for this accident that have been established in HNF-SD-WM-BIO-001 and HNF-SD-WM-TSR-006 apply to Tank 241-SY-101. See Section 5.3.2.22 and Table 6-1 of Section 3.2.8 of this document provides additional discussion of how the established controls apply to the specific Tank 241-SY-101 hazardous conditions represented by this accident.	
Natural Phenomena - High Wind				The controls for this accident that have been established in HNF-SD-WM-BIO-001 and HNF-SD-WM-TSR-006 apply to Tank 241-SY-101. See Section 5.3.2.23.1a and Table 6-1 of Section 3.2.8 of this document provides additional discussion of how the established controls apply to the specific Tank 241-SY-101 hazardous conditions represented by this accident.	
a. Waste Transport Vehicle Accident				The controls for this accident that have been established in HNF-SD-WM-BIO-001 and HNF-SD-WM-TSR-006 apply to Tank 241-SY-101. See Section 5.3.2.23.1a and Table 6-1 of Section 3.2.8 of this document provides additional discussion of how the established controls apply to the specific Tank 241-SY-101 hazardous conditions represented by this accident.	

Table 12. Technical Safety Requirement Cross-Reference for Tank 241-SY-101. (10 sheets)

Analyzed Accident	Safety Structures, Systems, and Components			Technical Safety Requirement	Derivation Basis
	Description	SC	SS		
Natural Phenomena - High Wind	The controls for this accident that have been established in HNF-SD-WM-BIO-001 and HNF-SD-WM-TSR-006 apply to Tank 241-SY-101. See Section 5.3.2.23.1b and Table 6-1 of HNF-SD-WM-BIO-001 for further details of the controls.				
b. Load Drop					
Natural Phenomena - High Wind	The controls for this accident that have been established in HNF-SD-WM-BIO-001 and HNF-SD-WM-TSR-006 apply to Tank 241-SY-101. See Section 5.3.2.23.1c and Table 6-1 of HNF-SD-WM-BIO-001 for further details of the controls.				
c. Aboveground Structure Failure					
Natural Phenomena - Lightning	The controls for this accident that have been established in HNF-SD-WM-BIO-001 and HNF-SD-WM-TSR-006 apply to Tank 241-SY-101. See Section 5.3.2.23.2 and Table 6-1 of HNF-SD-WM-BIO-001 for further details of the controls.				
Natural Phenomena - Seismic	The controls for this accident that have been established in HNF-SD-WM-BIO-001 and HNF-SD-WM-TSR-006 apply to Tank 241-SY-101. See Section 5.3.2.23.3 and Table 6-1 of HNF-SD-WM-BIO-001 for further details of the controls.				
General Control	The original analysis identified the need for a general control which prevents the transfer of waste into SSTs. This control is captured as a key element of AC 5.12, Transfer Controls. The transfer of waste out of Tank 241-SY-101 does not affect this control.				

HNF-SD-WM-BIO-001, 1999, Tank Waste Remediation System Basis for Interim Operation, Rev. 1-1, Fluor Daniel Hanford, Inc. Richland, Washington.

HNF-SD-WM-TSR-006, 1999, Tank Waste Remediation System Technical Safety Requirements, Rev. 0-U, Fluor Daniel Hanford, Inc., Richland, Washington.

Wagoner, J. D., 1998b, *Contract Number DE-AC06-96RL13200 - Supplemental Controls for Continued Operations in Tank 241-SY-101* (letter 98-SCD-140 to R. D. Hanson, Fluor Daniel Hanford, Inc.,

October 22), U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Notes: New controls appear in **bold italics**

*Indicates Existing Control

AC	=	Administrative Control.	RAPID	=	Respond and Pump In Days.
AWF	=	Aging Waste Facility.	SC	=	Safety-Class.
BIO	=	Basis for Interim Operation.	SL	=	Safety Limit.
CAM	=	continuous air monitor.	SR	=	surveillance requirement.
DST	=	double-shell tank.	SS	=	Safety Significant.
HEPA	=	high-efficiency particulate air (filter).	SSC	=	structure, system, and component.
LCO	=	Limiting Condition for Operation.	SST	=	single-shell tank.
LCS	=	Limiting Control Setting.	TSR	=	Technical Safety Requirement.
OGT	=	overground transfer (line).	TWRS	=	Tank Waste Remediation System.

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5.0 REFERENCES

- AIHA, 1998, *Emergency Response Planning Guidelines*, American Industrial Hygiene Association, Akron, Ohio.
- French, R. T., 1999, *Contract Number DE-AC06-96RL13200 – Submittal of Updated Unreviewed Safety Question (USQ) Evaluation and Supplemental Controls for Tank 241-SY-101*, (Letter 99-TSD-051 to R. D. Hanson, FDH, April 27), U.S. Department of Energy, Office of River Protection, Richland, Washington.
- HNF-3645, 1998, *Hazard Evaluation for Tank 241-SY-101 Waste Surface Level Growth*, HNF-3645, Rev. 0, Fluor Daniel Northwest, Inc., Richland, Washington.
- HNF-3824, 1999, *Tank 241-SY-101 Surface-Level-Rise Remediation Project Plan*, Rev. 0, Fluor Daniel Hanford, Inc., Richland, Washington.
- HNF-3966, 1999, *Hazard Evaluation for Transfer of Waste from Tank 241-SY-101 to Tank 241-SY-102*, Rev. 2, Fluor Daniel Northwest, Inc., Richland, Washington.
- HNF-4359, 1999, *Engineering Design Calculations for the SY-101 RAPID Mitigation Project*, Rev. 0-E, Lockheed Martin Hanford Corporation, Richland, Washington.
- HNF-4891, 1999, *Hazard Evaluation for Back-Dilution of Tank 241-SY-101 Waste*, Rev. 0, Fluor Daniel Northwest, Inc., Richland, Washington.
- HNF-IP-1266, 1999, *Tank Farms Operations Administrative Controls*, Lockheed Martin Hanford Corporation, Richland, Washington.
- HNF-SD-WM-BIO-001, 1999, *Tank Waste Remediation System Basis for Interim Operation*, HNF-SD-WM-BIO-001, Rev. 1-I, Fluor Daniel Hanford, Inc., Richland, Washington.^a
- HNF-SD-WM-SAR-067, 1999, *Tank Waste Remediation System Final Safety Analysis Report*, Fluor Daniel Hanford, Inc., Richland, Washington.
- HNF-SD-WM-TSR-006, 1999, *Tank Waste Remediation System Technical Safety Requirements*, Rev. 0-U, Fluor Daniel Hanford, Inc., Richland, Washington.
- Hu, T. A., 1999, Interoffice Memo to N. W. Kirch, "Hydrogen Generation Rate and Time to 25% LFL Calculation on Tank 241-SY-101 for Scenarios of the Waste Level Reaching 430 and 460 Inches" 74B40-99-043, dated March 12, 1999, Lockheed Martin Hanford Corporation, Richland Washington.

^aSee Section 1.1 for a discussion of the replacement of this reference with the FSAR.

- Kinzer, J. E., 1998, *Contract Number DE-AC06-96RL13200 – Declaration of an Unreviewed Safety Question (USQ) Related to Waste Surface Level Changes in Tank 241-SY-101*, (Letter 98-WSD-040 to H. J. Hatch, FDH, February 26), U.S. Department of Energy, Richland Operations Office, Richland, Washington.
- LA-UR-92-3196, 1996, *A Safety Assessment for Proposed Pump Mixing Operations to Mitigate Episodic Gas Releases in Tank 241-SY-101: Hanford Site, Richland, Washington*, LA-UR-92-3196, Rev. 14a, Los Alamos National Laboratory, Los Alamos, New Mexico.
- PNNL-13038, 1999, *Potential for Waste Stratification Resulting from Back Dilution in Tank SY-101*, Pacific Northwest National Laboratory, Richland, Washington.
- PNNL-13066, 1999, *Buoyant Response of the SY-101 Crust to Transfer and Back Dilution*, Pacific Northwest National Laboratory, Richland, Washington.
- TF-97-0975, 1999, *Tank Waste Remediation System (TWRS) Unreviewed Safety Question (USQ) Screening/Determination, Waste Surface Change in Tank 241-SY-101*, Rev. 3, Lockheed Martin Hanford Corporation, Richland, Washington.
- Wagoner, J. D., 1998a, *Contract Number DE-AC06-96RL13200 – Further Direction Regarding Tank 241-SY-101 Unreviewed Safety Question (USQ)* (Letter 98-WSD-043 to H. J. Hatch, FDH, March 5), U.S. Department of Energy, Richland Operations Office, Richland, Washington.
- Wagoner, J. D., 1998b, *Contract Number DE-AC06-96RL13200 – Supplemental Controls for Continued Operations in Tank 241-SY-101* (Letter 98-SCD-140 to R. D. Hanson, Fluor Daniel Hanford, Inc., October 22), U.S. Department of Energy, Richland Operations Office, Richland, Washington.

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APPENDIX A**

APPENDIX A

**TANK 241-SY-101 WASTE TRANSFER SYSTEM AND
MECHANICAL MITIGATION ARM
DESCRIPTION**

G.W. Ryan

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LIST OF TERMS

CVI 50071	Certified Vendor Information file #50071
EPDM	ethylene propylene diene monomer
MMA	mechanical mitigation arm
PPP	pre-fabricated pump pit
RAPID	Respond and Pump in Days
SY-101	Tank 241-SY-101
SY-102	Tank 241-SY-102

A1.0 INTRODUCTION

This appendix describes the Tank 241-SY-101 (SY-101) waste transfer system that will be used to transfer waste from SY-101 to Tank 241-SY-102 (SY-102). This system is installed as a temporary facility modification and has been designed to be easily removed after the transfer is complete. Also described in this appendix is the mechanical mitigation arm (MMA) which will be used for near term crust mitigation.

The figures provided in this appendix have been included to aid the reader in visualizing information that is presented in the text. These sketches should not be considered design drawings, and they must not be used to make engineering modifications to any systems, structures, or components depicted. Facility modifications are approved in accordance with detailed design information found in established procedures, configuration-controlled drawings, and vendor information.

A2.0 DESCRIPTION

A2.1 WASTE TRANSFER SYSTEM

A system to transfer waste from SY-101 to SY-102 has been installed in the 241-SY Tank Farm. This system consists of:

- a transfer pump installed in SY-101;
- an abovegrade pre-fabricated pump pit housing the mounting for the transfer pump, piping connections, and valves;
- a dedicated overground transfer line between SY-101 and SY-102; and
- a drop leg assembly (which includes a riser extension enclosure and a siphon break) in SY-102 to the permit controlled introduction of waste into SY-102.

A supporting feature to this transfer system is a portable water skid that will provide water for diluting the waste being transferred out of SY-101. Figure A-1 includes a sketch of the waste transfer system.

HNF-3885, *Functional Requirements and Technical Criteria for the 241-SY-101 RAPID Mitigation System*, should be referenced for specific functional details of the system.

Figure A-1. Waste Transfer System Sketch.

A2.1.1 Transfer Pump in Tank 241-SY-101

A New Generation Transfer Pump is installed in SY-101. This is a variable speed transfer pump, and it is planned to be used to transfer waste out of SY-101 at a flow rate of 230 L/min (60 gal/min). This flow rate is the estimated combination of waste and dilution water.

Design and operational details of the New Generation Transfer Pump can be found in Certified Vendor Information file #50071 (CVI 50071).

A2.1.2 Pre-fabricated Pump Pit

The installation of a transfer pump in SY-101 necessitated the design and installation of fully abovegrade pre-fabricated pump pit (PPP) assembly. This assembly fits onto a spare 42-inch riser on SY-101 (i.e., riser -007). The PPP is entirely abovegrade and is constructed of welded stainless steel plates. The floor has a nominal thickness of 25.4 mm (1 in.), and the sides and cover are designed to have a nominal thickness of 12.7 mm (0.5 in.). The approximate inside dimensions of the PPP are 2.9 m (9.5 ft) (length) by 2.4 m (8.0 ft) (width) by 0.8 m (2.6 ft) (depth).

Steel beams positioned on concrete piers support the PPP, allowing for level adjustments to ensure adequate waste drainage. Leak detection instrumentation is present in the sloped bottom of the PPP to detect transfer leakage. A depiction of the location and relative size of the PPP is included in Figure A-1.

The PPP contains the SY-101 transfer pump assembly, the service water jumper assembly, and the process line jumper assembly (Figure A-2). Additionally, the PPP contains leak detection and a seal liquid to allow liquid to drain into SY-101. These latter items are not depicted in Figure A-2.

Design drawings and HNF-4169, *Specification for SY101 RAPID Mitigation Prefabricated Pump Pit*, should be referenced for additional details of the PPP.

A2.1.3 Hose-in-Hose Design

The waste will be routed from SY-101 to SY-102 by way of an abovegrade double-encased piping system. The piping system consists of a 51 mm (2 in.) inside diameter primary pipe that is made from ethylene propylene diene monomer (EPDM) hose. The outer piping (or encasement) consists of a 10.1 cm (4 in.) inside diameter hose that is also made from EPDM. The outer hose is heat traced to maintain fluid temperatures and is also encased in insulation to minimize heat loss during the waste transfer.

A plan view sketch of the hose-in-hose assembly is provided in Figure A-2. Design drawings and HNF-4407, *Specification for SY-101 RAPID Mitigation System Hose and Hose Assembly*, should be referenced for additional details of the components that make up the hose-in-hose assembly.

Figure A-2. Contents of Pre-fabricated Pump Pit and Hose-In-Hose Assembly.

A2.1.4 Drop Leg, Siphon Break, and Riser Extension Enclosure

When the waste reaches SY-102, it is routed into the tank via a drop leg assembly that has been installed in an existing 42-inch riser (i.e., riser -007). The length of the drop leg has been designed to ensure that the incoming waste is deposited below the surface of the existing waste in SY-102.

A sketch of the drop leg assembly is provided in Figure A-3.

The drop leg includes a siphon break to ensure that waste flow stops when the transfer pump in SY-101 is turned off (Figure A-3). Additionally, a leak detection system is provided in the upper portion of the drop leg assembly to alert operators of waste leakage (see Figure A-3).

The riser that the drop leg has been installed in is fitted with an enclosure to ensure that confinement of the waste transfer system and waste tank is maintained. This feature is labeled as the "riser extension enclosure" in Figure A-3.

Also, provided as part of the drop leg assembly is a spray ring that will be used to help decontaminate the drop leg as it is being removed from SY-102. This feature is also displayed in Figure A-3.

Design drawings and HNF-4216, *Specification for SY-101 RAPID Mitigation System Anti-Syphoning Slurry Distributor Assembly*, should be referenced for additional details of the components that make up the drop leg assembly.

A2.1.5 Water Skid

Water is supplied to the water skid by an existing service water pit in Tank Farm 241-SY. The incoming water is heated to approximately 54 °C (130 °F) prior to use. Heated water provided via the skid will be used in the following ways:

- to heat the transfer line prior to use,
- to dilute the waste in SY-101 at the transfer pump inlet, and
- to flush the transfer line and pump after use to ensure that waste does not solidify and create blockages.

A detailed description of the water skid can be found in HNF-4043, *Specification for SY101 RAPID Mitigation Mobile Water Support Skid*.

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Figure A-3. Drop Leg Assembly (Including Siphon Break and Riser Extension Enclosure).

A2.2 MECHANICAL MITIGATION ARM

The mechanical mitigation arm (MMA) is constructed of a 9 m (30 ft) stainless steel vertical section with a cable actuated stainless steel arm 2 m (6 ft) in length for a total length of 11 m (36 ft). A sketch of this device is provided in Figure A-4.

The cable is attached approximately 0.6 m (2 ft) from the end of the arm and runs along the exterior to a point approximately 1.2 m (4 ft) above the elbow where it enters the interior of the MMA. The cable extends through an internal 2.5 cm (1 in.) pipe to a hydraulically positioned rod. The arm is actuated using a small hand pump and hydraulic piston mounted at the top of the MMA. Physical separation of components eliminates any possibility of the hydraulic fluid from leaking into the MMA or the tank.

Two water nozzles are installed on the MMA. One nozzle is located just above the point where the cable enters the vertical section of the MMA. This nozzle will soften the crust in the area of the cable to allow rotation and provide some decontamination flow. The second nozzle provides flow to the elbow to prevent binding due to solids build-up in the joint. The 2.5 cm (1 in.) pipe containing the cable inside the MMA shaft will also have purge flow through it to prevent waste introduction into the pipe.

A water source consisting of a storage tank, filter assembly, and throttling assembly will be used to provide the necessary pressure and flows for the MMA.

HNF-4089, *Engineering Task Plan for Near-Term Mechanical Mitigation of Tank 241-SY-101 Level Growth*, should be referenced for additional details of design, fabrication, and deployment of the MMA.

A3.0 REFERENCES

CVI 50071, 1999, Certified Vendor Information for the SY Project, Model 2A-513-A1 Lead Unit, Final Design Report Addendum, Engineering Memorandum 6673, Rev. 4, Westinghouse Electric Corporation, Cheswick, Pennsylvania.

HNF-3885, 1999, *Functional Requirements and Technical Criteria for the 241-SY-101 RAPID Mitigation System*, Rev. 0, Lockheed Martin Hanford Corporation, Richland, Washington.

HNF-4043, 1999, *Specification for SY101 RAPID Mitigation Mobile Water Support Skid*, Rev. 1-A, Numatec Hanford Corporation, Richland, Washington.

HNF-4089, 1999, *Engineering Task Plan for Near-Term Mechanical Mitigation of Tank 241-SY-101 Level Growth*, Rev. 0-A, Lockheed Martin Hanford Corporation, Richland, Washington.

Figure A-4. Mechanical Mitigation Arm.

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HNF-4169, 1999, *Specification for SY101 RAPID Mitigation Prefabricated Pump Pit*, Rev. 0, Cogema Engineering Corporation, Richland, Washington.

HNF-4216, 1999, *Specification for SY-101 RAPID Mitigation System Anti-Syphoning Slurry Distributor Assembly*, Rev. 0, Cogema Engineering Corporation, Richland, Washington.

HNF-4407, 1999, *Specification for SY-101 RAPID Mitigation System Hose and Hose Assembly*, Rev. 0, Lockheed Martin Hanford Corporation, Richland, Washington.

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APPENDIX B

**TANK 241-SY-101 WASTE TRANSFER EVALUATION
AND CONFIRMING CALCULATIONS**

J. C. VanKeuren

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LIST OF TERMS

AWF	Aging Waste Facility
BIO	Basis for Interim Operation
COB	cleanout box
DST	double-shell tank
EPDM	ethylene propylene diene monomer
HAZOP	Hazard and Operability study
JCO	Justification for Continued Operation
PPP	pre-fabricated pump pit
RR	release rate
SST	single-shell tank
SY-101	Tank 241-SY-101
SY-102	Tank 241-SY-102

B1.0 INTRODUCTION

Tank 241-SY-101 (SY-101) has recently exhibited a steady growth at the waste surface level. A path forward to mitigate the SY-101 surface level growth issue has been developed. The project has been directed to install the necessary equipment, including above ground transfer lines, to transfer waste from SY-101 to Tank 241-SY-102 (SY-102) as part of the crust growth remediation.

A focused hazard and operability (HAZOP) study was performed on January 21, 1999, and is documented in HNF-3966, *Hazard Evaluation for Transfer of Waste from Tank 241-SY-101 to Tank 241-SY-102*. Subsequent to this meeting a decision was made to change the design from an underground transfer line to an overground transfer line. The HAZOP was reconvened on March 8, 1999, to examine the impact of this change and a revision to the document issued (i.e., Rev. 1). A controls selection meeting was held on March 15 and 16, 1999. A third meeting was held on April 27, 1999, to consider the impact from changing from hose contained in pipe to a hose contained in a larger hose. The revised HAZOP was issued as Revision 2 of HNF-3966. The HAZOP did not identify any new or unique accidents in terms of transfers. The HAZOP did indicate that spray leaks and pool leaks are hazards for the SY-101 transfer.

The *Tank Waste Remediation System Basis for Interim Operation* (HNF-SD-WM-BIO-001) (BIO) Section 5.3.2.18, "Surface Leak Resulting in Pool," and Section 5.3.2.20, "Spray Leak in Structure or from Overground Waste Transfer Line," specifically refer to accidents involving overground waste transfers. The SY-101 transfer system has design features that differ from the transfer operation described in the BIO. This report discusses the accident analysis implications of the SY-101 transfer, excluding the flammable gas and ammonia release issues, which are being addressed separately.

The design requirements for the transfer systems are described in *RAPID Mitigation System Design Requirements Document* (HNF-3885). A submersible pump is inserted into SY-101 through a 42 in. riser. The riser is enclosed with a steel prefabricated pump pit (PPP), which contains the necessary piping, valves, flanges, hose, and other equipment to complete the transfer.

The transfer is made through a dedicated, encased overground line. Both the primary line and the encasement are ethylene propylene diene monomer (EPDM) hose. The waste is mixed with dilution water at the pump inlet, and the mixture is pumped through the line to SY-102. The waste enters SY-102 through a riser, and a downcomer releases the waste below the surface of the waste in SY-102. Parameters for the transfer are summarized and compared with BIO parameters for transfers in Table B-1.

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Table B-1. Summary of Parameters for the 241- SY-101 Transfer as Compared with BIO Parameters for Transfers.

Parameter	241-SY-101 Transfer	TWRS BIO
Pressure (psi)	330	1300
Flow L/min (gal/min)	265 L/min (70 gal/min)	1,149 L/min (300 gal/min)
Radionuclide mix	DST	AWF
Solids content	< 33%	33%
Pit design	Above ground, metal	Below ground concrete

HNF-SD-WM-BIO-001, 1999, *Tank Waste Remediation System Basis for Interim Operation*,
Rev. 1-C, Fluor Daniel Hanford, Inc., Richland, Washington.

The impact of these design differences for pool and spray leaks is discussed in Sections B3.0 and B4.0, respectively.

B2.0 CONCLUSIONS

The pool and spray leak scenarios for the SY-101 transfer have been compared with accident analysis given in the BIO. The conclusion of this comparison is that the frequency and consequences of pool leak and spray leaks that might occur during the SY-101 transfer are enveloped by the BIO analysis.

B2.1 SUMMARY OF CONTROLS CREDITED IN THE ANALYSIS

Table B-2 lists principal assumptions credited in the accident analysis evaluation.

Table B-2. Principal Assumptions Included in Mitigated Safety Analysis. (2 sheets)

Pool Leaks
Leak detectors are assumed to actuate when liquid depth reaches 5.08 cm (2 in.).
Flow is assumed to be stopped 30 min after the leak detector alarm.
The PPP is assumed to contain waste spills without significant leakage to the ground.
The PPP cover is assumed to contain splashing.
The maximum leak rate is 20 gal/min.
The encasement is assumed to contain leaks from primary hose.
Vehicle controls are assumed to prevent a collision that could lead to a simultaneous leak from both the primary pipe and the encasement.
Backflow of waste into flush/dilution water system is prevented.

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Table B-2. Principal Assumptions Included in Mitigated Safety Analysis. (2 sheets)

Spray Leak
The PPP is assumed to provide a tortuous path that prevents a direct spray release to the environment.
The hose encasement is assumed to prevent spray leak from the primary line from reaching the environment.
The pit drain is assumed to be closed to maximize the air expulsion because of liquid displacement.
Vehicle controls are assumed to prevent a collision that could lead to a simultaneous spray from both the primary hose and the encasement hose.
Backflow of waste into flush/dilution water system is prevented.
The maximum spray pressure is assumed to be less than the 1300 psi analyzed in Addendum 2 of the BIO.
Leak detectors are assumed to actuate when liquid depth reaches 5.08 cm (2 in.).
Flow is assumed to be stopped 30 min after the leak detector alarm.

PPP= pre-fabricated pump pit

BIO = HNF-SD-WM-BIO-001, 1999, *Tank Waste Remediation System Basis for Interim Operation*, Rev. 1-E, Fluor Daniel Hanford, Inc., Richland, Washington.

B3.0 POOL LEAK EVALUATION

B3.1 UNMITIGATED CONSEQUENCES

The BIO (HNF-SD-WM-BIO-001) Section 5.3.2.18 considers several hazardous conditions that could lead to pool leaks, including "Surface pools caused by leaks from [single-shell tank] SST temporary above grade (over the ground) transfers." A leak from the above ground transfer was not selected as the bounding accident. The bounding accident selected for analysis for the no controls case was a leak from a process pit caused by misrouting through an open nozzle. The unmitigated leak is assumed to occur at a flow of 1,136 L/min (300 gal/min), resulting in a 12 hour spill of 817,650 L (216,000 gal). The offsite receptor is assumed to be exposed to waste resuspended from the ground for an additional 12 hours. The pit volume is taken as 15,142 L (4,000 gal), so 802,507 L (212,000 gal) of waste are assumed to spill on the ground. The waste is assumed to be 67% liquids and 33% solids for the Aging Waste Facility (AWF) tanks.

This event bounds an unmitigated surface spill for SY-101 retrieval based on the following considerations:

Flow

The waste flow assumed in the BIO pool leak accidents is higher than the SY-101 transfer flow (1,136 L/min [300 gal/min] versus approximately 265 L/min [70 gal/min]).

Unit Liter Dose

The AWF 33% solids/67% liquids unit liter dose (ULD) is about 3 times higher than the equivalent ULD for double-shell tanks (DSTs). Because SY-101 is a DST, the DST source term, which is based on worst-case sample data from all DST tanks, envelopes SY-101.

Solids Content

The transfer analyses in the BIO assume that 33% solids is the maximum solid content that can be transferred. The SY-101 slurry solid content is enveloped by that value as shown by the following calculation.

The density of liquids in SY-101 is about 1.5 g/mL, and the absolute density of the solids is about 2.3 g/mL (Person 1999). A 33% solids/67% liquid mixture would therefore have a density of

$$\begin{aligned} D_{\text{mix}} &= 0.33D_s + 0.67D_l = (0.33)(2.3 \text{ g/mL}) + (0.67)(1.5 \text{ g/mL}) \\ &= 1.76 \text{ g/mL.} \end{aligned} \tag{3.1}$$

Actual SY-101 slurry measurements indicate a density of about 1.6 g/mL (Person 1999). This calculation shows that the solid content is less than 33%, even assuming no dilution. The ULD and the solid contents are enveloped by the BIO analysis.

The doses from a pool leak are smaller for the SY-101 retrieval accident than the doses calculated in the BIO because both the pool size and the ULDs are smaller for the SY-101 transfer. Controls are, however, required for the SY-101 transfer to limit the duration of any pool leak.

B3.2 MITIGATED CONSEQUENCES

Pool leaks in the PPP and the encasement will be considered separately.

B3.2.1 Pool Leaks in the Prefabricated Pump Pit

The mitigated analysis in BIO Section 5.3.2.18 considers a leak in a pit and concludes that the pit leak detector will respond rapidly enough to prevent overflow of the pits of volumes greater than 15 m³ (530 ft³). Pits with a volume of less than 15 m³ (530 ft³) require special evaluations. Controls are assumed to be effective in limiting the maximum credible leak rate to 76 L/min (20 gal/min). A leak in the primary hose outside the PPP will result in liquids leaking into the encasement and draining back into the PPP or to the SY-102 headspace because encasement

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integrity is assumed. The BIO does not discuss in detail the failure of overground lines outside the pit; however, four conditions are required for the overground transfer to be consistent with the BIO assumptions:

1. Controls must effectively prevent a simultaneous leak in both the primary line and the secondary encasement.
2. The maximum leak rate with controls is less than 76 L/min (20 gal/min).
3. Backflow of waste into the dilution/flush system is prevented.
4. Leaks plus drainback must not result in the pit overflowing.

The first condition is met by using vehicle controls to prevent a vehicle colliding with the hose. The second condition is met because the overground hose is a dedicated line, which prevents the possibility of a mistransfer to an open connector. Jumper connections will be tested before use. The third condition is met by the pressure switch that prevents backflow into the water system. The fourth condition requires an evaluation based on PPP volume and the design of the transfer hose. This evaluation is provided below.

The Justification for Continued Operation of Transfer Lines Having Structures with Less Volume Than 241-A-Valve Pit (HNF-2296) (JCO) requires that an evaluation be performed to determine if secondary covers are required for pits with interior volumes less than 15 m³ (530 ft³). The PPP dimensions are 2.4 m (8 ft) by 2.9 m (9.5 ft) by 0.8 m (2.6 ft). Most of the pit is empty. Piping, valves, and other components are expected to occupy only a few percent of the volume of the pit. Conservatively, 10% of the volume will be assumed to be filled with valves, piping, etc.

Secondary covers may be required for small volume structures such as cleanout boxes (COBs) that could overflow and pressurize. The criteria used to determine if secondary covers are required given in the JCO are:

Covers are required for structures that:

- Are physically connected to an active waste transfer pump not under administrative lock, and
- Are not under the control of A.C.5.22, Transfer Cover Removal Controls (HNF-SD-WM-TSR-006), and

- Have a volume, which is less than, or equal to 15 m^3 (530 ft^3), and
- Have an internal volume:

$$V \leq A + B + C \quad (3.2)$$

where V = volume of transfer associated structure

A = the volume of the transfer associated structure filled to the leak detector actuation point

B = 600 gal (maximum leak rate of 20 gal/min x maximum leak time of 30 min)

C = drainback volume in liters (gallons) (20% of line holdup).

The first three conditions are satisfied by the PPP. The volume comparison is calculated below. The volume of the pit is:

$$V = (8 \text{ ft})(9.5 \text{ ft})(2.6 \text{ ft}) = 198 \text{ ft}^3 = 5.6 \text{ m}^3. \quad (3.3)$$

Assuming 10% of the pit is filled with equipment, the void volume is:

$$V = (0.9)(5.6 \text{ m}^3) = 5.0 \text{ m}^3. \quad (3.4)$$

The leak detector is located about 5 cm (2 in.) above the floor of the pit. The pit floor is sloped to assure preferential collection of liquid at the leak detector. Conservatively neglecting the slope, the volume of the pit that would have to be filled to actuate the leak detector is:

$$A = (8 \text{ ft})(9.5 \text{ ft})(2 \text{ in.}/12 \text{ in./ft}) = 12.7 \text{ ft}^3 \text{ or } 0.36 \text{ m}^3 \quad (3.5)$$

$$B = 600 \text{ gal or } 2.27 \text{ m}^3. \quad (3.6)$$

The contribution from drainback (C) is zero because the encasement hose will drain to SY-102 rather than back to the PPP. C is conservatively assumed to be 20% of the volume of the primary hose. The total length of the hose between tanks SY-101 and SY-102 is about 45.7 m (150 ft). The inside diameter of 2-in. EPDM hose is 2 in.

$$C = 0.2 \pi D^2 L / 4 = 0.2 (3.14)(2.0 \text{ in.}/12 \text{ in./ft})^2 150 \text{ ft} / 4 = 0.65 \text{ ft}^3 = 0.019 \text{ m}^3 \quad (3.7)$$

$$A + B + C = 0.36 \text{ m}^3 + 2.27 \text{ m}^3 + 0.019 \text{ m}^3 = 2.65 \text{ m}^3. \quad (3.8)$$

Because $V = 5.0 \text{ m}^3$, V is greater than $A + B + C$, indicating that secondary covers are not required. It should also be noted that even if 100% of the hose volume is assumed to drain back into the PPP, the sum of $A + B + C$ would be 2.73 m^3 (96 ft^3), which is still significantly less than the pit volume of 5.0 m^3 (177 ft^3).

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The pool release calculations in a pit considers aerosol released from splashing. The dose calculation given in WHC-SD-WM-CN-049 assumes aerosol with a volume equal to 100% of the volume of the pit is released at 100 mg/m³ concentration. The larger pit volume assumed in the BIO will result in the release in the BIO bounding the PPP case.

The onsite receptors may be exposed to direct radiation from gamma radiation from a spill within the PPP because the PPP is located above ground. Therefore the dose calculation is a combination of doses from inhalation and external exposure. These combined doses shown in the following calculations are from *Tank Waste Compositions and Atmospheric Dispersion Coefficients for Use in Safety Analysis Consequence Assessments*, WHC-SD-WM-SARR-016; and *Calculation Note in Support of TWRs FSAR Spray Accident Analysis*, WHC-SD-WM-CN-048.

$$\text{Onsite Dose} = (Q)(X/Q')(BR)(ULD_{inh}) \quad (3.9)$$

$$\text{Offsite Dose} = (Q)(X/Q') [(BR)(ULD_{inh}) + ULD_{ing}] \quad (3.10)$$

$$X/Q' \text{ onsite} = 0.0341 \text{ s/m}^3 \text{ (WHC-SD-WM-SARR-016)} \quad (3.11)$$

$$X/Q' \text{ offsite} = 2.83 \times 10^{-5} \text{ s/m}^3 \text{ (WHC-SD-WM-SARR-016)} \quad (3.12)$$

$$\text{Inhalation dose } ULD_{inh} \text{ 33\% solids DST mix} = 1.8 \times 10^5 \text{ Sv/L} \text{ (WHC-SD-WM-CN-048, Section 6.1)} \quad (3.13)$$

$$\text{Ingestion dose } ULD_{ing} \text{ 33\% solids DST mix} = 0.20 \text{ Sv-m}^3/\text{s-L} \text{ (WHC-SD-WM-CN-048, Section 6.1)} \quad (3.14)$$

$$\text{Breathing rate (BR)} = 3.3 \times 10^{-4} \text{ m}^3/\text{s} \text{ (WHC-SD-WM-SARR-016).} \quad (3.15)$$

Q is the quantity of material released in liters. The air released from the PPP is assumed to contain aerosol at a concentration of 100 mg/m³ with a specific gravity of 1.4. The PPP has a volume of less than 5.6 m³ (198 ft³). An aerosol volume equal to the pit volume is assumed (no credit is taken for the volume of equipment in the pit).

$$Q = \frac{(5.6 \text{ m}^3)(100 \text{ mg/m}^3)}{(1.4 \text{ g/cm}^3)(1000 \text{ cm}^3/\text{L})(1000 \text{ mg/g})} \quad (3.16)$$

$$Q = 4.0 \times 10^{-4} \text{ L} \quad (3.17)$$

$$\begin{aligned} \text{Onsite Dose} &= (Q)(X/Q')(BR)(ULD_{inh}) \\ &= (4.0 \times 10^{-4} \text{ L})(0.0341 \text{ s/m}^3)(3.3 \times 10^{-4} \text{ m}^3/\text{s})(1.8 \times 10^5 \text{ Sv/L}) \\ &= 8.1 \times 10^{-4} \text{ Sv (0.081 rem)} \end{aligned} \quad (3.18)$$

$$\begin{aligned} \text{Offsite Dose} &= (Q)(X/Q') [(BR)(ULD_{inh}) + ULD_{ing}] \\ &= (4.0 \times 10^{-4} \text{ L})(2.83 \times 10^{-5} \text{ s/m}^3) [(3.3 \times 10^{-4} \text{ m}^3/\text{s}) \\ &\quad (1.8 \times 10^5 \text{ Sv/L}) + 0.20 \text{ Sv-m}^3/\text{s-L}] \\ &= 6.7 \times 10^{-7} \text{ Sv (6.7} \times 10^{-5} \text{ rem).} \end{aligned} \quad (3.19)$$

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The PPP is located above ground and, therefore, has the potential to provide direct exposure of gamma rays to the onsite receptor. A direct shine calculation was made assuming the pit is filled with 33% solid/67% liquid solution from a double-shell tank. The thickness of the metal walls is assumed to be 1.27 cm (0.5 in.). Gamma radiation producers in tank waste are the ^{137}Cs / $^{137\text{m}}\text{Ba}$, ^{60}Co , ^{154}Eu , and ^{155}Eu . Concentrations are based on WHC-SD-WM-SARR-016 concentrations for DST solids and liquids. The source term is shown in Table B-3.

Table B-3. Source Term for External Exposure Calculation.

Isotope	Activity Concentration DST Solids (Bq/L)	Activity Concentration DST Liquids (Bq/L)	Activity Concentration DST 33% Solids (Bq/L)	Total activity in PPP (5.55 m ³ volume) (Bq)
Cs-137	5.9 E+10	5.9 E+10	5.90 E+10	3.27 E+14
Ba-137m	5.58 E+10	5.58 E+10	5.58 E+10	3.10 E+14
Co-60	1.5 E+07	7.0 E+06	9.64 E+06	5.35 E+10
Eu-154	3.0 E+08	4.2 E+07	1.27 E+08	7.06 E+11
Eu-155	0.0 E+00	0.0 E+00	0.0 E+00	0.0 E+00

The external doses were calculated with the Microshield 4 (Grove 1992) computer code treating the PPP as a rectangular box with 1.27 cm (0.5 in.) iron walls. The Microshield output file is shown in Appendix B.1. The dose rate at 100 m is 6.21 mr/h (6.21×10^{-5} Sv/h). Assuming a 12-h exposure for the onsite receptor, the total exposure is 7.45×10^{-4} Sv (7.45×10^{-2} rem). The total exposure for the onsite receptor is therefore:

$$\text{Onsite Total Exposure} = 8.1 \times 10^{-4} \text{ Sv} + 7.45 \times 10^{-4} \text{ Sv} = 1.6 \times 10^{-3} \text{ Sv.} \quad (3.20)$$

Skyshine was not included for the PPP doses rate calculation. Skyshine is radiation reflected from the air and becomes a factor for sources with large unshielded surface areas and significant shielding in the direct path between the source and the receptor. The PPP shielding is the same on the top as the side (0.5 inches of steel). The roof area of the PPP is relatively small and there is a direct line of sight from the receptor to the PPP walls. The skyshine contribution will therefore be negligible. The contribution from bremsstrahlung radiation from $^{90}\text{Sr}/^{90}\text{Y}$ is also neglected. The bremsstrahlung contribution is only about 20% of the ^{137}Cs contribution for AWF solid (WHC-SD-WM-CN-049, Section 2.4.3.2), and the $^{90}\text{Sr}/^{90}\text{Y}$ solids activities are almost 2 orders of magnitude less for DST solids while the ^{137}Cs activities are comparable.

Dose from external exposure will be negligible offsite because the closest distance to the site boundary is more than 8.6 km. The offsite dose is the inhalation dose calculated above, or 6.7×10^{-7} Sv.

The risk guidelines are 0.005 Sv onsite and 0.001 Sv offsite. Risk guidelines are therefore met. The dose consequences also are below the doses calculated in the BIO (Table 5.3.2.18-2).

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The comparison with toxicological risk guidelines depends on the peak concentrations, which in turn depend on the release rate. WHC-SD-WM-CN-048 assumes that the exposure occurs within the first 15 min. The release rate (RR) during 15 min is therefore:

$$\begin{aligned} \text{RR} &= \frac{4.0 \times 10^{-4} \text{ L}}{(60 \text{ s/min}) (15 \text{ min})} \\ &= 4.4 \times 10^{-7} \text{ L/s.} \end{aligned} \quad (3.21)$$

The onsite and offsite sum of fractions for a continuous release of 33% solid/ 67% liquid from a DST during an accident in the anticipated frequency range is 1.3×10^4 s/L onsite and 68 s/L offsite (*Toxic Chemical Considerations for Tank Farm Releases*, WHC-SD-WM-SARR-011). The comparison with toxic risk guidelines is therefore:

$$\text{Onsite Toxic} = (4.4 \times 10^{-7} \text{ L/s})(1.3 \times 10^4 \text{ s/L}) = 0.0057 \quad (3.22)$$

$$\text{Offsite Toxic} = (4.4 \times 10^{-7} \text{ L/s})(68 \text{ s/L}) = 3.0 \times 10^{-5}. \quad (3.23)$$

Values less than 1 indicate that risk guidelines are met. The values calculated also are below those calculated for the mitigated accident of BIO Section 5.3.2.18.

B3.2.2 Mitigated Pool Leaks in the Hose

The transfer line is EPDM hosing encased in a second EPDM hose. Any leaks that occur in the primary EPDM hose will be contained in the encasement. The encasement hose runs along the ground to SY-102, and flow will tend to flow in that direction. The flow enters a (42 in.) riser in SY-102. If a leak occurs, flow will enter the SY-102 headspace rather than entering below the waste level. Headspace waste releases resulting in elevated ammonia concentrations are addressed in Appendix E.

The leak detectors in the PPP would not detect a leak in the hose that flows into SY-102. If flow in the encasement were blocked so that flow could not reach SY-102, the encasement would fill and eventually overflow back into the PPP. The leak detector placed in the PPP would detect the leak in time to prevent overflowing the PPP.

A simultaneous break of both the encasement and the primary hose could lead to unacceptable consequences. Controls need to be instituted to prevent vehicle collisions during pumping operations. BIO Table 5.3.2.18-4 item 6 indicates that use of concrete shielding system or vehicle restrictions is required around an overground transfer line.

B4.0 SPRAY LEAKS

B4.1 UNMITIGATED SPRAY LEAKS

The BIO Section 5.3.2.20 (HNF-SD-WM-BIO-001) includes evaluation of spray leaks caused by a breach in the pressure boundary of the piping, a jumper, or a valve. The accident scenario developed for the no controls case is a spray in a pit without cover blocks. A pressure of 300 psi was assumed in the analysis. The pipe thickness is based on 2 in. pipe and a 5 cm (2 in.) crack is assumed. The SY-101 transfer pump can reach a pressure of 330 psi. Addendum 2 to the BIO, which documents the analysis of the cross-site transfer system, considered pressures of up to 1300 psi. This analysis clearly bounds the SY-101 transfer. The argument given in BIO Section 3.1 for the pool leaks states that the ULD and solid contents for the SY-101 transfer are bounded by the BIO and apply to the spray leak.

The SY-101 spray leak differs from the BIO reference accident in that the spray would originate from the EPDM hose instead of a pipe. Because EPDM is a rubber type material, it is possible that a pin hole leak could produce a spray. The BIO analysis looks at 2 in. crack in the piping. A hose with a large crack would not be expected to sustain a spray leak because the flexibility of the hose would allow the crack to open, resulting in a pool leak rather than a spray. A spray from a pinhole leak would result in a significantly lower spray rate than a spray from a crack because the flow area is lower. The conclusion is that the spray leak for the SY-101 retrieval will be bounded by the BIO analysis, but controls are required to mitigate or prevent spray leaks.

B4.2 MITIGATED SPRAYS

B4.2.1 Sprays in a Pit

A mitigated spray in the PPP will have similar consequences to those for a pool leak. Details of the BIO spray analysis in a pit are given in WHC-SD-WM-CN-048, Rev 1. The BIO analysis assumes the peak air temperature in a pit caused by a waste leak is 120 °F. It is possible that the waste pumped from SY-101 may exceed this temperature. However, the spray in the PPP during the SY-101 transfer would be bounded by the BIO regardless of the temperature of the waste. The basis for that conclusion is outlined as follows:

The mitigated spray analysis in the BIO assumes that aerosol is expelled from the pit because of increases in temperature and relative humidity as well as liquid displacement. The release amount analysis is based on temperature, humidity, and specific volume data displayed on a psychrometric chart. The initial pit atmosphere conditions are assumed to be 30 °F and 15% relative humidity, which correspond to a specific volume of 12.35 ft³/lb. The final conditions are assumed to be 120 °F and 100% relative humidity, which correspond to a specific weight to 16.7 ft³/lb. The fraction released is therefore $[16.7/12.35-1] = 0.35$. See WHC-SD-WM-CN-048, Rev 1, Section 3.2.1.

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Higher air temperatures would lead to higher fractional releases. An air temperature of 130 °F and 100% relative humidity would produce a specific volume of about 17.3 ft³/lb. The fractional release would be 40% for these conditions. An air temperature of 155 °F and 100% relative humidity would produce a specific volume of about 18 ft³/lb. The fractional release would be 46% for these conditions.

The base calculation in WHC-SD-WM-CN-048, Rev 1 assumes a pit volume of 220 m³. The air displaced is therefore (0.35)(220 m³) = 77 m³. The air released is assumed to contain aerosol at a concentration of 100 mg/m³ with a specific gravity of 1.4. The quantity released is therefore:

$$Q(\text{BIO}) = \frac{(77 \text{ m}^3) (100 \text{ mg/m}^3)}{(1.4 \text{ g/cm}^3)(1000 \text{ cm}^3/\text{L})(1000 \text{ mg/g})}$$
$$Q(\text{BIO}) = 5.5 \times 10^{-3} \text{ L.} \quad (4.1)$$

The PPP has a volume of less than 5.6 m³. Substituting this volume in the above equation results in

$$Q(\text{PPP}) = \frac{(5.6 \text{ m}^3) (100 \text{ mg/m}^3)}{(1.4 \text{ g/cm}^3)(1000 \text{ cm}^3/\text{L})(1000 \text{ mg/g})}$$
$$Q(\text{PPP}) = 4.0 \times 10^{-4} \text{ L.} \quad (4.2)$$

The volume released from the PPP is, therefore, more than an order of magnitude less than the volume assumed released in the BIO analysis, even assuming a release of 100% of the PPP volume.

The quantity of aerosol released to the atmosphere from a spray release in the PPP cannot exceed 100% of the PPP volume because once the pit accumulates significant volume of material, the leak detector will indicate a leak has occurred and pumping will be terminated. The dose calculation for a spray in the PPP would be bounded by the analysis provided in this report. A spray release in the PPP is therefore bounded by the BIO analysis regardless of the waste temperature.

The spray leak calculation in the BIO assumed the source term was a mixture of solids and liquids from AWF tanks, which have a significantly higher ULD than solids and liquids from DSTs. The lower ULD for the SY-101 transfer increases the margin between the BIO and the spray in the PPP results. A tank specific source term is given in the Mixer Pump Safety Analysis (LA-UR-92-3196) based on crust sample data, which are significantly lower than the DST source term. However, the analysis in this section uses the DST values from WHC-SD-WM-SARR-016 to be consistent with the BIO transfer accident analyses.

The preceding analysis demonstrates that a leak will not result in filling and pressurization because the leak detector will cause flow to be terminated before filling of the PPP. However, even if the PPP were filled, a spray would not result. The PPP cover is a 12.7 mm (0.5 in.) steel plate. The density of steel is about 500 lb/ft³. The weight of 1 square inch of 0.5 in. steel plate is (0.5 in.)(1 in.²)(5.78 x 10⁻⁴ ft³/in.³)(500 lb/ft³) = 0.15 lb. The plate will therefore lift and relieve pressure at a pressure of 0.15 psi, before any significant pressurization of the PPP could occur.

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B4.2.2 Sprays From the Transfer Line

Above grade hose offers the potential for a spray from the hose if holes are present in both the inner and outer hose. This event would have unacceptable consequences and must be prevented. The outer hose is therefore safety class and controls are instituted to prevent common mode failures. Vehicle collisions with the hose are prevented by controls.

B5.0 REFERENCES

Grove, 1992, *MICROSHIELD Version 4*, Grove Engineering, Inc., 15125 Shady Grove Road, Rockville, Maryland.

HNF-2296, 1998, *Justification for Continued Operation of Transfer Lines Having Structures with Less Volume than 241-A-Valve Pit*, Rev. 0, Duke Engineering and Services Hanford Inc., Richland, Washington.

HNF-3885, 1999, *Functional Requirements and Technical Criteria for the RAPID Mitigation System*, Rev. 0, Lockheed Martin Hanford Corporation, Richland, Washington.

HNF-3966, 1999, *Hazard Evaluation for Transfer of Waste from Tank 241-SY-101 to Tank 241-SY-102*, Fluor Daniel Northwest, Inc., Rev. 2, Richland, Washington.

HNF-SD-WM-BIO-001, 1999, *Tank Waste Remediation System Basis for Interim Operation*, Rev. 1-E, Fluor Daniel Hanford, Inc., Richland, Washington.

LA-UR-92-3196, 1996, *A Safety Assessment for Proposed Pump Mixing Operations To Mitigate Episodic Gas Releases in Tank 241-SY-101: Hanford Site, Richland Washington*, Rev. 14a, Los Alamos National Laboratory, Los Alamos, New Mexico.

Person, J. C., 1999, *Memo to N. W. Kirch, Dilution Studies of Tank 241-SY-101 Waste-Preliminary Results*, 8100-99-015, Numatec Hanford Corporation, April 22, 1999.

WHC-SD-WM-CN-049, 1998, *Calculation Note for Surface Leaks Resulting in a Pool, TWRS FSAR Accident Analysis*, Rev. 0-B, Westinghouse Hanford Company, Richland, Washington.

WHC-SD-WM-SARR-011, 1996, *Toxic Chemical Considerations for Tank Farm Releases*, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

WHC-SD-WM-SARR-016, 1996, *Tank Waste Compositions and Atmospheric Dispersion Coefficients for Use in Safety Analysis Consequence Assessments*, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

WHC-SD-WM-SARR-048, 1996, *Calculation Note in Support of TWRS FSAR Spray Accident Analysis*, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

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ATTACHMENT B1

**MICROSHIELD OUTPUT FOR DOSE FROM PPP AT 100 METERS
WITH PPP FILLED WITH 33% DOUBLE-SHELL TANK SOLID /
67% DOUBLE-SHELL TANK LIQUIDS MIX**

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ATTACHMENT B1

**MICROSHIELD OUTPUT FOR DOSE FROM PPP AT 100 METERS
WITH PPP FILLED WITH 33% DOUBLE-SHELL TANK SOLID /
67% DOUBLE-SHELL TANK LIQUIDS MIX**

MicroShield 4.00 - Serial #4.00-00128

Westinghouse Hanford Company

Page : 1
DOS File: PPPMET1.MS4
Run Date: April 12, 1999
Run Time: 8:53 a.m. Monday
Duration: 0:00:03

File Ref: _____
Date: ____ / ____ / ____
By: _____
Checked: _____

Case Title: PPP 8 ft x 9.5 ft x 2.6 ft, 0.5 in steel, full of 33% DST solids

GEOMETRY 11 - Rectangular Volume			
	Centimeters	feet	inches
Dose point coordinate X:	10245.11	336.0	1.5
Dose point coordinate Y:	39.37	1.0	3.5
Dose point coordinate Z:	144.78	4.0	9.0
Rectangular volume width :	289.56	9.0	6.0
Rectangular volume length:	243.84	8.0	.0
Rectangular volume height:	78.74	2.0	7.0
Shield 1:	1.27	0.0	.5
Air Gap:	10000.0	328.0	1.0
Source Volume:	5.55954e+6 cm ³	196.333 cu ft.	339264. cu in.

MATERIAL DENSITIES (g/cm ³)			
Material	Source Shield	Shield 1 Slab	Air Gap
Air			0.00122
Iron		7.8	
Water	1.4		

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Page : 2
DOS File: PPPMET1.MS4
Run Date: April 12, 1999
Run Time: 8:53 a.m. Monday
Duration: 0:00:03

Case Title: PPP 8 ft x 9.5 ft x 2.6 ft, 0.5 in steel, full of 33% DST solids

BUILDUP

Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS	
	Quadrature Order
X Direction	10
Y Direction	10
Z Direction	10

SOURCE NUCLIDES					
Nuclide	curies	$\mu\text{Ci/cm}^3$	Nuclide	curies	$\mu\text{Ci/cm}^3$
Ba-137m	8.3784e+003	1.5070e+003	Co-60	1.4460e+000	2.6008e-001
Cs-137	8.8649e+003	1.5945e+003	Eu-154	1.9081e+001	3.4321e+000

===== RESULTS =====					
Energy (MeV) Buildup	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate in Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.1	2.857e+011	2.104e-003	4.686e-003	3.219e-006	7.169e-006
0.2	4.821e+010	9.372e-003	3.745e-002	1.654e-005	6.609e-005
0.4	5.037e+009	5.565e-003	2.550e-002	1.084e-005	4.969e-005
0.5	1.529e+009	2.800e-003	1.223e-002	5.497e-006	2.401e-005
0.6	2.790e+014	7.670e+002	3.155e+003	1.497e+000	6.159e+000
0.8	2.753e+011	1.425e+000	5.230e+000	2.710e-003	9.948e-003
1.0	2.707e+011	2.274e+000	7.562e+000	4.191e-003	1.394e-002
1.5	3.290e+011	6.551e+000	1.817e+001	1.102e-002	3.056e-002
TOTAL:	2.802e+014	7.773e+002	3.186e+003	1.515e+000	6.213e+000

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ATTACHMENT B2

PEER REVIEW CHECKLIST

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ATTACHMENT B2

PEER REVIEW CHECKLIST

Practice 134 290 1112
Publication Date 01Mar99
Attachment 02 - Sheet 1 of 1

FLUOR DANIEL NORTHWEST

TECHNICAL PEER REVIEWS

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: HNF-3737, APPENDIX B,

Title: TANK 241-54-101 WASTE TRANSFER EVALUATION AND CONFIRMING CALCULATIONS

Author: J. C. VAN KUREN

Date: 5/25/99

Scope of Review:

Yes No* NA

☐	☐	☒	Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
☒	☐	☐	Problem completely defined.
☒	☐	☐	Accident scenarios developed in a clear and logical manner.
☒	☐	☐	Necessary assumptions explicitly stated and supported.
☒	☐	☐	Computer codes and data files documented.
☒	☐	☐	Data used in calculations explicitly stated in document.
☒	☐	☐	Data checked for consistency with original source information as applicable.
☒	☐	☐	Mathematical derivations checked including dimensional consistency of results.
☒	☐	☐	Models appropriate and used within range of validity or use outside range of established validity justified.
☒	☐	☐	Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
☒	☐	☐	Software input correct and consistent with document reviewed.
☒	☐	☐	Software output consistent with input and with results reported in document reviewed.
☒	☐	☐	Limits/criteria/guidelines applied to analysis results are appropriate and referenced.
☒	☐	☐	Limits/criteria/guidelines checked against references.
☒	☐	☐	Safety margins consistent with good engineering practices.
☒	☐	☐	Conclusions consistent with analytical results and applicable limits.
☒	☐	☐	Results and conclusions address all points required in the problem statement.
☒	☐	☐	Format consistent with applicable guides or other standards.
☐	☐	☒	Review calculations, comments, and/or notes are attached.
☐	☐	☒	Traceability
☒	☐	☐	Document approved (for example, the reviewer affirms the technical accuracy of the document).

Reviewer (printed name and signature)

5/25/99
Date

* All "no" responses must be explained below or on an additional sheet.

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

NUCLEAR ENGINEERING

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APPENDIX C

**FLAMMABLE GAS CALCULATION NOTE FOR
TANK 241-SY-101 WASTE TRANSFERS**

K. O. Fein

DISCLAIMER

Some of the information in this appendix is from external sources (i.e., Pacific Northwest National Laboratory and Sandia National Laboratory) and originally was produced under separate cover. This information has been included for the reader's convenience and to clarify the discussion in the main text. To preserve its original intent, this information has not been edited. The format of the appendix, however, has been made as consistent as possible with the overall document.

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ACKNOWLEDGMENTS

This report contains material from a number of sources. The author would like to acknowledge the contributors. Charles W. Stewart and Perry A. Meyer and others at the Pacific Northwest National Laboratory developed the work included in Attachments A and B: "Potential Gas Release from Water Addition Under the Crust Layer in Tank 241-SY-101," and "Potential Gas Release by Bubble Slurry Flow Through a Hole in the Crust Layer in Tank 241-SY-101." Attachment C, "Scaling of Allowable Gas Releases;" and text Section 2.0 "Flammable-Gas Release and Consequences," was developed by Robert M. Marusich of Fluor Daniel Northwest, Inc. Attachment D, "Scaling Considerations for Burns In A Reduced Headspace Volume," and Attachment E, "Combustion Behaviors and Dose Consequences," were both contributed by Scott E. Slezak of Sandia National Laboratories. Attachment E, "Conversion of Flammable-Gas Dose Calculations from LANL Assumptions to the BIO," was prepared by John vanKeuren of Fluor Daniel Northwest, Inc. Lockheed Martin Services, Inc., provided editorial services and document formatting.

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LIST OF TERMS

BIO	Basis for Interim Operation
DST	double-shell tank
HEPA	high-efficiency particulate air (filter)
LANL	Los Alamos National Laboratory
LFL	Lower Flammability Limit
PPP	pre-fabricated pump pit
RSA	refined safety analysis
SY-101	Tank 241-SY-101
SY-102	Tank 241-SY-102
ULD	unit-liter dose

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C1.0 INTRODUCTION AND PURPOSE

This calculation note documents flammable-gas safety-analysis work performed in support of the plans to pump waste out of Tank 241-SY-101 (SY-101). The technical background and project activities related to this transfer are presented in HNF-3824 (Raymond 1999). The waste will be diluted as it is transferred to Tank 241-SY-102 (SY-102). Installation of the transfer pump requires that an opening be water lanced into the crust so that the pump can be lowered into the tank. Introducing dilution water inside the volute of the transfer pump was discussed in the hazard analysis (Shultz 1999) as a mechanism that could release water into SY-101. Installation of the transfer pump and use of water for dilution has the potential of initiating a gas release from the crust or the bubble slurry comprising the bottom layer of the crust. To analyze the possible gas-release mechanisms and investigate the consequences of those releases, a number of studies were initiated, several of which are summarized in this document and provided as attachments.

The following analyses are either summarized or included in this calculation note:

Water Dissolution

- *Potential Gas Release from Water Addition under the Crust Layer in SY-101*, by C.W. Stewart, TWS99.22, Pacific Northwest National Laboratory, Richland, Washington, May 1999. Included as Attachment A.

Bubble Slurry Flow

- *Potential Gas Release by Bubble Slurry Flow Through a Hole in the Crust Layer in SY-101*, by P. A. Meyer, C. W. Stewart, S. D. Rassat, R. T. Allemann, D. P. Mendoza, G. Terrones, and W. L. Kuhn, TWS99.27, Pacific Northwest National Laboratory, Richland, Washington, May 1999. Included as Attachment B.

Scaling Considerations

- "Scaling of Allowable Gas Releases to Maintain Equivalent Waste-Material Release Quantities to Those in LA-UR-92-3196 (LANL 1996)," R. Marusich, Fluor Daniel Northwest, Inc., Richland, Washington, April 1999. Included in Attachment C.
- "Scaling of Allowable Gas Releases to Meet the Structural Acceptance Criteria as Defined in LA-UR-92-3196 (LANL 1996)," R. Marusich, Fluor Daniel Northwest, Inc., Richland, Washington, April 1999. Included in Attachment C.
- Letter report, "Scaling Considerations for Burns in a Reduced Headspace Volume," S. Slezak, Sandia National Laboratories, Albuquerque, New Mexico, to G. W. Gault, DE&S Hanford, Inc., Richland, Washington, April 8, 1999. Included as Attachment D.

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Other Analyses

- “Conversion of Flammable Gas Dose Calculations from LANL Assumptions to BIO,” J. vanKeuren, Fluor Daniel Northwest, Inc., Richland, Washington, April 1999. Included in Attachment E.

Throughout the document, care has been taken to provide important numerical information in both metric and English units. This, however, was not done for pressures. The values for atmospheric pressure in the various units used in this report are as follows:

$$\begin{aligned} 1 \text{ atm} &= 14.7 \text{ psia (lbf/in}^2, \text{ absolute)} \\ &= 0.0 \text{ psig (lbf/in}^2, \text{ gauge – that is, psig = psia-14.7)} \\ &= 101325 \text{ Pa.} \end{aligned}$$

C2.0 FLAMMABLE-GAS RELEASE AND CONSEQUENCES

This section provides a discussion of the flammable-gas issues with regard to activities performed in the SY-101 waste. The potential for the release of flammable gas, including the conditions under which flammable gas is released, are discussed. Discussion of the quantities and rate of gas released are followed by a discussion of the effect of ignition on the structural integrity of the tanks and the release of radioactive material to the atmosphere. Consequences of the release also are discussed in this section.

C2.1 REPRESENTATIVE GAS-RELEASE SCENARIOS

Hazards Evaluation for Tank 241-SY-101 Waste Surface Level Growth (Shultz 1998) and *Hazards Evaluation for Transfer of Waste From Tank 241-SY-101 to Tank 241-SY-102* (Shultz 1999) were performed. Shultz (1998) evaluated the waste-surface-level growth problem and derived the hazardous conditions. Those related to flammable gas deflagrations are shown in Table C-1.

Table C-1. List of In-Tank Hazardous Conditions Identified during the Hazards Evaluation on Waste-Surface-Level Growth.

Potential to ignite and burn gas released from the waste. Gas can accumulate or be released because of:

- Buoyant displacement gas release subsequent to mixer pump failure or a disturbance of the lower layer of the waste (e.g., mixer-pump removal) or a spontaneous gas release
- Ventilation system plugging caused by waste level growth
- Crust growth with subsequent collapse
- Equipment removal
- Crust dissolution from above or below because of the use of water to support waste transfer or decontamination
- Crust penetration
- Seismic event.

Shultz (1999) evaluated the waste transfer from SY-101 to SY-102; the results of that portion of the hazards evaluation pertaining to flammable gas deflagrations in SY-101 are presented in Table C-2.

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Table C-2. List of In-Tank Hazardous Conditions Identified During the Hazards Evaluation on Waste Transfer.

1. Low waste level in SY-101 causes mixer pump inoperability with subsequent BD GRE.
2. Flammable gas in risers or in the pre-fabricated pump pit (PPP) enclosure or risers

This calculation note is only concerned with the hazardous conditions regarding gas release caused by crust disturbance. All of the other hazards are discussed in other documents.

As a result, the hazardous conditions to be covered by this calculation note are flammable gas releases from the crust because of:

- Crust disturbance (e.g., due to equipment removal and insertion)
- Crust dissolution.

C2.2 GAS-RELEASE QUANTITY AND RATE

Section C2.1 showed that the representative hazardous conditions covered by this report involve gas releases from the crust. Gas retention in the crust is discussed in detail in Attachment B. That information is summarized here.

A gas release can occur if a hole is made in the crust. The crust is composed of a hard top layer and a high void-fraction layer. Formerly, the crust was broken up and wetted by buoyant gas-release events before the mixer pump was installed and began operation. This crust is now essentially one continuous slab with slurry-filled openings (or fissures) through which generated gas can escape. The top layer has a dry surface and likely contains few flammable-gas-filled voids. Below the dry layer is a layer of bubble slurry, which is the term given to the three-phase mixture of gas bubble, liquid, and solid agglomerates. The void fraction for the bubble-slurry layer ranges from 0.3 to 0.7, with the greater fraction in the lower portion of the layer. Beneath the bubble-slurry layer is liquid (or slurry). The bubble slurry flows through the holes made in the hard top layer, because its density is much less than the hard top layer and bottom liquid layer. As the bubble slurry flows through the openings, the pressure change causes the gas to be released. Attachment B provides a more detailed discussion of crust layering, crust properties, and the bubble-slurry flow phenomena.

Water lancing will be used to soften the hard top layer, making it easier to insert equipment into the bubble-slurry layer. Water lancing and insertion of equipment will create openings in the crust through which bubble slurry will flow out. In either case, the opening diameter will probably be about 1 m. In addition, small chunks of the crust will likely break off the edge of the opening. As these chunks rotate, they will loose the gas that is attached to the bottom of the chunks. If these pieces sink, then a larger opening is created on the crust, allowing more of the bubble slurry to flow.

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The diameter of the opening is set to 2 m for the transfer pump to be conservative and to take care of any uncertainties. The diameter chosen for the mechanical mitigation arm should be chosen based on the dimensions of the arm plus additional damage outside the diameter. The calculations in this report were performed for a diameter of 2 m. Attachment B shows that the release is not sensitive to opening diameter. Attachment B, however, shows that neither the bubble-slurry flow rates or the total flow is very dependent on the diameter of the opening. Figures B-13 through B-15 of Attachment B provide the gas-flow rate and total gas flow as a function of the diameter of this opening, void fraction, and bubble-slurry layer thickness. Both gas-flow rate and total gas flow are quite sensitive to bubble-slurry layer thickness, somewhat sensitive to the void fraction, but essentially insensitive to the diameter of the opening.

Attachment B argues that a reasonable choice for void fraction is 0.6 and a reasonable choice for layer thickness is 0.5 m. Table C-3 provides the results, given these assumptions, and shows the sensitivities.

Table C-3. Gas Flow into the Tank Dome Caused by Bubble-Slurry Flow from the Crust.

Condition ¹		Flow and Flowrate		
Void fraction	Layer thickness (m)	Initial flowrate (m ³ /s)	Flowrate at 10 min (m ³ /s)	Total flow (m ³)
0.6	0.5	0.19	0.05	51
0.7	0.5	0.26	0.08	74
0.6	1.0	0.31	0.18	269

¹Base Case: Void Fraction = 0.6, layer thickness = 0.5 m.

Gas also can be released if water is injected beneath the crust during waste transfer, because transfer of the waste includes an in-line water addition. Water is added just upstream of the pump suction and, if the water is left on when the waste is not being pumped (pump off or blocked), water could flow out of the pump suction and rise to the crust. This extra water could dissolve the solids and dilute the liquid in the bubble-slurry layer, thereby releasing the gas held in the bubble-slurry layer gas. The gas-release mechanism will resemble the mudpot mechanism. The assumption was made that the released-gas flow rate through the crust into the dome is proportional to the water-flow rate. A detailed description of the phenomena of dilution and subsequent gas release is provided in Attachment A.

Figure A-5 of Attachment A provides the gas-release rate as a function of void fraction and dilution ratio. Attachment A argues that a reasonable value for void fraction is 0.6 and a reasonable value for dilution ratio is 1/5 or 0.2 m. The results of this argument are provided in Table C-4.

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Table C-4. Gas Flow into the Dome Caused by Water Addition Beneath the Crust.

Void fraction ¹	Dilution ratio ¹	Water flowrate (gal/min)	Gas release rate (m ³ /s)
0.6	0.2	30	0.019
0.6	0.2	70	0.042
0.6	0.2	100	0.066
0.7	0.2	30	0.030
0.7	0.2	70	0.066
0.7	0.2	100	0.094

¹Base Case: Void Fraction = 0.6, dilution ratio = 0.2 m

Table C-5 provides a summary of the gas-flow rates and total gas released from spontaneous and induced gas releases. The worst-case induced-flow rates are taken from the high side of the sensitivity study values.

Table C-5. Gas Release Rate and Total Gas Flow into the Tank Dome.

Gas release mechanism	Quantity released (m ³)	Flow rate (m ³ /s)	Comment
Bubble-slurry flow	51	0.19	Base case
Bubble-slurry flow	269	0.31	Worst case
Dilution	160	0.042	Base case
Dilution	160	0.094	Worst case

C2.3 FLAMMABILITY ASSESSMENT

Section C2.2 provided the gas-release rate and total release into the tank dome. The flammability of these releases is discussed in this section.

The flammability of the release is discussed in Attachment F. The gas releases from dilution and from bubble slurry flow taken from the base case conditions are shown on Figures F-7, F-8, and F-9 of Attachment F. These figures show the combustion mechanism as a function of gas-release rate and total-release volume. The gas-release rates and total-release volume for dilution flow is shown on Figure F-7 of Attachment F. The gas-release rates and total volume released from bubble slurry flow is shown in Figure F-8. The data points for bubble slurry flow on Figure F-8 were taken from an earlier version of the code presented in Attachment B. Using the data in the present version of Attachment B, the family of three curves would start 400, 500, and 600 ft³/min at 100 ft³, respectively, on Figure F-8. The three curves would trend slowly downward and to the right to 350 ft³/min, 150 ft³/min, and 60 ft³/min at 1,000 ft³. The new family of three curves would match the existing curves on Figure F-9 at 10 ft³/min. The combustion mechanism is the same for both sets of data.

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Figure F-8 shows that at a crust level of 11.7 m (460 in.) only plume burns are possible. At this same crust level, Figures F-7 and F-8 show that a gas release from the base-case dilution ($0.042 \text{ m}^3/\text{s}$) is flammable resulting in a well-mixed burn. Releases from the worst-case bubble slurry flow start out in the plume burn region and progress into the well-mixed burn region. The curve for the worst-case bubble slurry flow out of a 2 m diameter opening will look similar to the curves for the base-case bubble slurry flow except that it is shifted up and well to the right. The data points are $650 \text{ ft}^3/\text{min}$ and 650 ft^3 , $600 \text{ ft}^3/\text{min}$ and $1,000 \text{ ft}^3$, $450 \text{ ft}^3/\text{min}$ and $3,000 \text{ ft}^3$, $200 \text{ ft}^3/\text{min}$ and $6,000 \text{ ft}^3$, and $30 \text{ ft}^3/\text{min}$ and $9,000 \text{ ft}^3$. The worst-case gas release caused by dilution flow ($0.094 \text{ m}^3/\text{s}$ or 200 ft^3) could result in plume burns until about 71 m^3 ($2,500 \text{ ft}^3$) are released. Releases larger than this result in well-mixed burns. Table C-6 presents the results.

Table C-6. Combustion Mechanism for Gas Releases from Bubble Slurry Flow and Dilution Flow at a Waste Elevation of 11.7 m (460 in.).

Case	Combustion Mechanism
Bubble slurry flow, base case	Plume burn until $1,500 \text{ ft}^3$ of gas has been released. No burn after $1,500 \text{ ft}^3$ of gas has been released.
Bubble slurry flow, worst case	Plume burn until about $2,500 \text{ ft}^3$ of gas has been released. Well-mixed burns after $2,500 \text{ ft}^3$ of gas has been released.
Dilution flow, base case	No burn until $3,000 \text{ ft}^3$ has been released. Well-mixed burns for larger gas releases.
Dilution flow, worst case	No burn until $2,500 \text{ ft}^3$ has been released. Well-mixed burns for larger releases.

The April 30, 1999, waste level as read from the ENRAF in Riser 1A is 11.02 m (433.84 in.). The dome volume for this waste height comes from Attachment G. The graph on the last page of Attachment G is the easiest to use. The dome volume for this level is 0.68 of 1218 m^3 or 828 m^3 ($29,200 \text{ ft}^3$). At the elevation 11.7 m (460 in.) the dome volume is 0.45 of 1218 m^3 or 548 m^3 ($19,350 \text{ ft}^3$). Figures F-2 and F-4 of Attachment F show the influence of dome volume between a waste level of 10.9 m (430 in.) and 11.7 m (460 in.). The release rate below which there are no burns remains the same. The release volume for plume burns with potential for HEPA failure goes from 15.6 m^3 (550 ft^3) to 10 m^3 (350 ft^3) as the volume decreases. The borderline for well-mixed burns with HEPA failure goes from 113 m^3 ($4,000 \text{ ft}^3$) to 70 m^3 ($2,500 \text{ ft}^3$) as the dome volume decreases. Using these data, the combustion mechanism for the gas release from either bubble slurry flow case does not change significantly. The only change is the gas quantity released, at which the burn mechanism transitions from plume burns to well-mixed burns with HEPA failure occur.

C2.4 THE EFFECT OF COMBUSTION

The gas released into the dome contains the flammable gases of hydrogen, ammonia, methane, and nitrous oxide (an oxidizer). The gas also contains nitrogen (an inert gas in this situation). Ignition of the flammable gas can cause a burn or deflagration involving some or all of the flammable gas. The pressure in the tank increases as the temperature increases because of the burn or deflagration. The increased pressure and the rate of change of pressure with time result in forces, impulses, and energy being applied to the tank structure. Large burns or deflagrations can result in tank failure. The velocity with which the gas burns creates turbulence and accelerated airflow. This airflow, as well as the pressure pulse, can result in suspension of waste off the surface of the crust. The pressurization can create an unfiltered flow path out of the tank if the relief ports open on the multiport riser or if the HEPA filters fail. Impact of the ignition of the gas on the structure and on the release of suspended radioactive material from the crust are discussed below.

C2.4.1 Structural Effects

The discussion of the gas release and burn found in Attachment C, Section C2.0, provides information on the structural effects of flammable-gas burns and deflagrations. The discussion shows that the tank structure survives a 245 m^3 gas release into a 1218 m^3 dome space. The April 30, 1999, calculated dome volume is 815 m^3 . The extrapolated dome-space volume in September 1999 is 566 m^3 per Attachment A.

Attachment C, Section C2.0, argues that if the ratio of the present gas release to the present volume is the same as the ratio of the gas release to the dome volume discussed (245 m^3 to 1218 m^3), the tank does not fail. Table C-7 provides a comparison of the gas releases caused by bubble slurry flow (found in Table C-6) and dome volume to that in Attachment C, Section C2.0.

Table C-7. Ratios of Gas Release to Dome Volume.

Gas release condition	Gas release (m^3)/ Dome volume (m^3)
Refer to Attachment C ($245 \text{ m}^3/1218 \text{ m}^3$)	0.2
Base case bubble-slurry flow into September 1999 dome volume (566 m^3)	0.09
Worst case bubble-slurry flow into present dome volume (815 m^3)	0.33
Base case dilution release into September 1999 dome volume	0.28

Table C-7 shows that the gas releases caused by the worst-case bubble-slurry flow result in dome failure per the criteria used in discussion in Attachment C, Section C2.0. The base-case bubble-slurry flow does not. Note, however, that the total release in the worst-case bubble-slurry flow takes 1,000 min to occur. At 10 min, the total release from the worst-case bubble-slurry flow is

102 m³. Using the 10-min total for worst-case bubble-slurry flow, the ratio of gas release to the September 1999 dome volume is 0.18. The ratio using the present volume is 0.13. What this means is that, for dome failure to occur (because of ignition of the gas that resulted from bubble-slurry flow out of the crust), the ignition source would have to "wait" 10 min after the flow started. The 10-min duration is necessary for enough gas to accumulate such that ignition results in a deflagration large enough to fail the tank.

Figure B-15 of Attachment B does not consider the effects of ventilation. When the ratio of the volumetric flow rate into the dome to the total gas flow is equal to the ratio of the ventilation flow rate to the dome volume, the rate of gas added to the dome equals the rate of gas removed by the ventilation system. After some time, more gas is removed than is added because the flow rate from the bubble-slurry flow is steadily decreasing. This results in a decrease in the net quantity of gas in the dome. For flow from a 1 m thick bubble-slurry layer (Figure B-15 of Attachment B), this occurs at about 50 min after flow initiation. As a result, the spark must occur between 10 min and 50 min after flow initiation.

The ratio for the base case dissolution release also exceeds 0.20 and therefore is concluded to have the potential to fail the tank structure if ignition occurs.

C2.4.2 Waste Material Release

The other effect of ignition is the release of waste material from the dome caused by aerosol generation and tank pressurization as a result of a burn. The discussion in Attachment C, Section C1.0, shows that if the ratio of the gas release to the dome volume for the present conditions equals that in LANL (1996), the quantity of waste material released to the environment is the same.

The ratio of gas release to dome volume for the 113 m³ release, per Attachment C, Section C1.0, is 0.093 and the ratio for the 297 m³ release is 0.24. The quantity of radioactive material suspended and transported to the environment per LANL (1996) is 2.84 kg for the 113 m³ gas-release and burn case and 4 kg for the 297 m³ gas-release and burn case. Table C-7 shows that the ratio of gas release to dome volume for the base-case bubble slurry flow into the September 1999 dome volume is the same as that for the ratio of the 113 m³ gas release into a 1218 m³ dome space discussed in Attachment C, Section C1.0. Therefore, the release to the environment is 2.84 kg. Table C-8 presents this result and the other result obtained from Table C-7.

Table C-8. Quantity of Waste Material Release.

Condition	Waste material releases	Numerical value of release ¹
Bubble-slurry flow, base case into September 1999 dome volume	Essentially the same as the 113 m ³ gas release	2.84 kg
Bubble-slurry flow, worst case, into present dome volume	Somewhat worse than the 297 m ³ gas release, assuming no dome failure	Somewhat larger than 4 kg
Base case dissolution into September 1999 dome	Worse than the 297 m ³ gas release dome failure must be considered	>4 kg

¹Data from LANL (1996, Appendix D).

C2.5 CONSEQUENCES

The consequences of the waste material releases shown at the end of Section C2.4 are determined using a number of models. Table C-8 shows that the releases are about 4 kg if the dome does not fail. Section C2.4.1 showed that some cases result in dome failure; dome failure results in increased releases. Attachment E of this report provides a review of the consequences using the methodology of LANL (1996) and that of the tank farms *Tank Waste Remediation System Basis for Interim Operation* (HNF-SD-WM-BIO-001, FDH 1999a) (BIO) based on a 4 kg release of radioactive material. The dose consequences from Table C-15 in Attachment E for the 4 kg waste material release are presented in Table C-9.

Table C-9. Consequences of a 4 kg Release of Radioactive Material.

Dose consequence methodology	Methodology for waste unit-liter-dose values	Doses (rem)	
		100 m	Offsite
LANL (1996)	LANL (1996)	17	0.014
BIO (FDH 1999a)	BIO	1440	1.2
BIO (FDH 1999a)	LANL (1996)	17	0.02

BIO (FDH 1999a) doses are so much larger because the “Sv/L” term in the dose consequence calculation is determined using the greatest concentration of each radionuclide of interest that occurs in any double-shell tank (DST) (i.e., bounding source term). The term “Sv/L” that is used by Los Alamos National Laboratory (LANL) comes from essentially the same data source but is developed using concentrations from SY-101 only (i.e., tank-specific source term). This was judged to be acceptable because there were 2 full tank-waste-length core samples taken from SY-101 not long before the dose-consequence analysis was done. As a result, it was felt that the constituents were well known. Because there has been a prohibition on waste transfers into SY-101 for more than a decade, the term “Sv/L” used by LANL is still pertinent. Note, however, that if the tank dome does fail, the amount of waste material release may exceed 4 kg. The consequences could be more like those of the BIO (FDH 1999a) even with a tank-specific source term.

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Attachment F provides a discussion of consequences using the refined safety analysis (RSA) methodology (Slezak et al. 1998). The RSA was run using conditions similar to those in LANL (1996) with a 270 m³ gas release and burn. The 95 percentile onsite dose using the RSA was calculated to be 15.3 rem, where the dose in LANL (1996) for a 297 m³ burn was 12 rem. The RSA was also run for the gas release from bubble slurry, base case flows. Table C-8 showed that these results should be compared to the 113 m³ gas release and burn from LANL (1996). The 95 percentile onsite dose was calculated to be 6.25 rem. The onsite dose for the 113 m³ release in LANL (1996) is 8.8 rem.

There is a good agreement among LANL (1996), the RSA, and the BIO (FDH 1999a) using a tank-specific value for Sv/L for the case of no dome collapse.

For the case where ignition of the gas results in structural failure, the dome could collapse or be blown out. Depending on the concentration of the gas, ignition could result in a deflagration or detonation. The consequences of these conditions are found in FDH (1999b), Section 3.4.2.2. Table C-10 presents the onsite consequences taken from Table 3.4.2.2-5 of FDH (1999b) for ignition of gas quantities that can cause structural failure. The basis for the consequences in FDH (1999b) are the bounding source terms used in the BIO (FDH 1999a).

Table C-10. Onsite Consequences of Flammable-Gas Ignition
That Results in Structural Failure.

Condition	Onsite dose (rem)
Dome blowout	4.1
Dome collapse	6.8
Detonation and dome blowout	820

The difference in doses among FDH (1999b), the BIO (FDH 1999a), and LANL (1996) caused by differences in modeling and differences in the value of the flame speed upon which the aerosol resuspension from the crust is strongly based.

C2.6 THE IMPACTS OF POTENTIAL CONTROLS

The impacts of potential controls are discussed in Attachment A and Attachment F.

Figure A-6 of Attachment A provides the water-flow rate that results in flammable-gas concentrations just below the lower limit of flammability, given a continuous supply of water. The figure shows that for the expected void fraction of 0.6, 128 L/min (34 gal/min) the resulting flammable gas concentration will be just below the lower flammability limit, given a dome volume of 566 m³ (20,000 ft³). Equation 4.3 shows that this is true for any volume.

Figure 5 shows the gas-release rate as a function of water-flow rate. At a nominal 265 L/min (70 gal/min) water-flow rate, the Lower Flammability Limit (LFL) of 4% hydrogen in air is reached at 29 min for a dome volume of 566 m³ (20,000 ft³). The total quantity of water used is

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7500 L (2,000 gal). For the April 1999 dome volume (828 m^3 or $29,200 \text{ ft}^3$) the LFL is reached in 43 min. The total quantity of water used is 11,300 L (3,000 gal). Therefore, at the nominal flow rate and base-case void fraction, limitation of the total quantity of water added to 6800 L (1,800 gal) will prevent concentrations from exceeding the LFL. At 265 L/min (70 gal/min) it will take 26 min to transfer 6800 L (1,800 gal).

Attachment F provides a discussion of the effect on combustion of inerting the dome space or increasing the ventilation flow rate. Attachment F concludes that inerting will prevent well-mixed burns but will not prevent plume burns with the potential for HEPA failure. Plume burns can occur because the gas release is self-flammable; that is, contains both flammable gas and oxidizer in concentrations that are within the flammability limits. Attachment F concludes that increasing the ventilation rate does nothing to prevent or mitigate plume burns and has only a small effect on well-mixed burns. The effect is that for gas releases greater than 70 m^3 ($2,500 \text{ ft}^3$), somewhat more gas is needed to result in a well-mixed burn at the higher ventilation flow rate. Below 70 m^3 ($2,500 \text{ ft}^3$) there is no effect.

C3.0 ASSUMPTIONS

A number of assumptions were made in performing the analysis documented in this calculation note. These assumptions form the basis upon which future unreviewed-safety-question evaluators will begin to evaluate proposed changes, tests, or additions to the facility. These assumptions include the following.

C3.1 ASSUMPTIONS FROM POTENTIAL GAS RELEASE FROM WATER ADDITION UNDER THE CRUST LAYER

The parameters for crust gas-release calculations at initial transfer are included in Table C-11.

Table C-11. Parameters for Crust Gas-Release Calculations at Initial Transfer.

Parameter	Value	Comment
Hydrostatic pressure	1.3 atm	For 3 m crust thickness
Void fraction	0.5 - 0.7	Base case is 0.6
Hydrogen fraction, χ_{H_2}	0.4	Initial retained-gas sampler results
Ventilation flow rate, Q	11.3 m ³ /min (400 ft ³ /min)	Lower limit
Headspace volume, V _{HS}	566 m ³ (20,000 ft ³)	Estimated for 09/99 based on waste-level extrapolation

- The water plume does not mix with the waste, nor does it dissolve any solids, as it rises through the mixed slurry layer.
- Pure water is assumed to spread out and contact the base of the crust over a wide area where the void fraction is highest. Dissolution and gas release are assumed to occur only in the high-void bubble slurry layer.
- Gas bubbles are retained in the bubble slurry layer by the strength of the solid-liquid matrix surrounding them. When the matrix is dissolved sufficiently, gas is released.
- All (100% release fraction) of the gas in the dissolved material that is released is released instantaneously to the headspace. None of the gas is held up as it rises through the crust layer.
- All the released gas is assumed to be released from the base of the crust at the highest hydrostatic pressure to maximize the standard volume.
- The headspace ventilation rate is assumed to be at the lower limit of 11.3 m³/min (400 ft³/min).
- The solids are mainly sodium nitrate and nitrite, which are very soluble in water.

C3.2 ASSUMPTIONS FROM POTENTIAL GAS RELEASE BY BUBBLE SLURRY FLOW THROUGH A HOLE IN THE CRUST

The parameters for tank-scale bubble slurry flow calculations are included in Table C-12.

Table C-12. Parameters for Tank-Scale Bubble Slurry Flow Calculations.

Parameter	Value	Comment
Yield Stress	50 Pa	Inferred from double-shell tank non-convective-layer ball rheometer data. See Section B2.2 in Attachment B.
Viscosity	500 Pa-s	
Mid-crust void fraction	0.25	Void-fraction instrument and retained-gas sampler data extrapolated to 09/99 based on crust growth.
Bubble slurry void fraction	0.6	
Bubble slurry thickness	0.5 m	
Degassed density	1,750 kg/m ³	Preliminary core sample results.
Fluid density	1,580 kg/m ³	

- The bubble slurry layer is uniform across the tank. There are no irregularities on the crust bottom that would reduce the volume available for flow.
- The bubble slurry properties (i.e., yield stress, viscosity, density, void fraction) are uniform and constant.
- The hole is created instantaneously and is does not reseal. It is “clean,” free from debris that would reduce the driving pressure difference.
- The flow is dominated by viscous forces and spatial and temporal acceleration is neglected.
- The crust does not subside and restrict the flow as the bubble slurry is removed.
- The bubble slurry flows outward over the top surface immediately as it exits the hole. The driving pressure difference is not reduced because the bubble slurry mounds over the hole.
- All of the gas in the bubble slurry is released immediately at the surface (100% release fraction).

C3.3 ASSUMPTIONS FROM SCALING STUDIES

- Surface heat losses are negligible in large volumes such as the tank vapor space.
- The total amount of suspended aerosols is approximately constant for different volumes.

C3.4 ASSUMPTIONS FROM CONVERSION OF FLAMMABLE-GAS DOSE CALCULATIONS FROM LANL ASSUMPTIONS TO THE BIO

- The major differences between the LANL approach and the BIO approach were source term, computer codes (deposition, stack height), location of offsite receptors, and committed dose assumptions.

C3.5 ASSUMPTIONS FROM TRANSFER PUMP EJECTION

- The transfer pump is located on a shield plate and in a metal pump box on a 106.7 cm (42 in.) riser.
- The transfer pump weighs 1996 kg (4,400 lb).
- The enclosure and shield plate weigh 3402 kg (7,500 lb).

C3.6 ASSUMPTIONS FROM COMBUSTION BEHAVIORS AND DOSE CONSEQUENCES

- The stratified-layer combustion efficiency was set equal to unity; i.e., in the plume analyses where a stable stratified layer was computed to form, 100 percent of the released gas was assumed to react. (This is the limiting case that does not take credit for the real behavior that, during plume formation, some of the release gas at the boundaries is necessarily diluted below the LFL).
- When a mixing zone is computed to dilute the release gases below the LFL but the release gas is self-flammable, the combustion analysis is done for an undiluted volume of release gas equal to the smaller of the total release volume and the volume of the mixing zone. This assumption significantly overestimates the volume of flammable gases in the mixing zone.

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C4.0 REFERENCES

- EPRI, 1988, *Large Scale Hydrogen Combustion Experiments*, EPRI NP-3878, Volume 1, Electric Power Research Institute, Palo Alto, California.
- FDH, 1999a, *Tank Waste Remediation System Basis for Interim Operation*, HNF-SD-WM-BIO-001, Rev. 1-C, Fluor Daniel Hanford, Inc., Richland, Washington.
- FDH, 1999b, *Tank Waste Remediation System Final Safety Analysis Report*, HNF-SD-WM-SAR-067, Rev. 0, Fluor Daniel Hanford Company, Richland, Washington.
- Hu, T. A., 1999, "Tank Dome Space Volume Calculation as a Function of Waste Level for Tank 241-SY-101," Internal Letter 74B40-99-061, to J. M. Grigsby, March 30, 1999, Lockheed Martin Hanford Corporation, Richland, Washington.
- LANL, 1995, *Structural Sensitivity Study of Hydrogen Burns in Tank 101-SY for Various Waste Levels*, Calculation Note TSA 6-CN-WT-SA-ST-078, Los Alamos National Laboratory, Los Alamos, New Mexico.
- LANL, 1996, *A Safety Assessment for Proposed Pump Mixing Operations to Mitigate Episodic Gas Releases in Tank 241-SY-101: Hanford Site, Richland, Washington*, LA-UR-92-3196, Rev. 14a, Los Alamos National Laboratory, Los Alamos, New Mexico.
- Raymond, R. E., 1999, *Tank 241-SY-101 Surface-Level-Rise Remediation Project Plan*, HNF-3824, Rev. 0, prepared by Lockheed Martin Hanford Corporation for Fluor Daniel Hanford, Inc., Richland, Washington.
- Sherman, M. P., S. R. Tieszen, and W. B. Benedick, 1989, *FLAME Facility*, NUREG/CR-5275, U.S. Nuclear Regulatory Commission, Washington D.C.
- Shultz, M. V., Jr., 1998, *Hazard Evaluation for Tank 241-SY-101 Waste Surface Level Growth*, HNF-3645, Rev. 0, prepared by Fluor Daniel Northwest, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.
- Shultz, M. V., Jr., 1999, *Hazard Evaluation for Transfer of Waste from Tank 241-SY-101 to Tank 241-SY-102*, HNF-3966, Rev. 2, prepared by Fluor Daniel Northwest, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.
- Slezak, S. E., D. C. Williams, W. Cheng, F. Gelbard, and D. R. Bratzel, 1998, *Refined Safety Analysis Methodology for Flammable Gas Risk Assessment in the Hanford Site Tanks*, HNF-SD-WM-ES-410, Rev. 2, prepared by DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

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van Wingerden, C. J. M., and J. P. Zeeuwen, 1983, "Flame Propagation in the Presence of Repeated Obstacles: Influence of Gas Reactivity and Degree of Confinement," *Journal of Hazardous Materials*, Volume 8, p. 139-156, Elsevier Science Publishers, Amsterdam, the Netherlands.

WHC 1996a, *Tank Waste Compositions and Atmospheric Dispersion Coefficients for Use in Safety Analysis Consequence Assessments*, WHC-SD-WM-SAR-016, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

WHC 1996b, *Toxic Chemical Considerations for Tank Farm Releases*, WHC-SD-WM-SAR-011, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

ATTACHMENT A

**POTENTIAL GAS RELEASE FROM WATER ADDITION
UNDER THE CRUST LAYER IN TANK 241-SY-101**

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A1.0 INTRODUCTION

The 2 m thick floating crust layer in Tank 241-SY-101 (SY-101) at the Hanford Site continues to grow and already contains a large volume of flammable gas (Stewart et al., 1998).⁽¹⁾ To reverse crust growth and reduce its retained gas volume, the waste in SY-101 is planned to be diluted by transferring a large fraction of the waste out of the tank and replacing it with water.⁽²⁾ The submersible transfer pump is designed to introduce water at the inlet to provide in-line dilution. In-line dilution is necessary to make the waste pumpable and reduce the likelihood of transfer-line plugging.

It is possible that the in-line dilution stream could inadvertently continue to flow with the transfer pump off. This would introduce water directly into the waste near the tank bottom. It is also probable that the back-dilution system will introduce water through either the current mixer pump or another route beneath the waste surface.

Because it is much less dense than SY-101 waste, any water introduced beneath the waste surface will tend to form a buoyant plume and rise to the base of the floating crust layer. The gas-volume fraction in the bottom third of the crust is approaching 0.5 and will likely increase further.⁽³⁾ Therefore, the rising water plume will first contact the portion of the crust layer with the highest gas content, where solids dissolution could produce a significant gas release. The water addition scenario is illustrated in Figure A-1.

This letter report gives a conservative, if not bounding, estimate of the gas-release rates and volumes associated with water addition under the crust layer. Section A1.0 describes the gas release mechanism. Section A2.0 presents the model used to predict the amount of crust solids dissolved per unit volume of water and Section A3.0 covers the gas-release model. Section A4.0 estimates the actual gas-release rates and volumes for conditions expected to exist when the first transfer is made, and Section A5.0 summarizes the conclusions. References are listed in Section A6.0.

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- ¹ Stewart, C. W., January 18, 1999, "Technical Basis for the SY-101 Mitigation Plan," PNNL Letter Report, TWS99.18, Pacific Northwest National Laboratory, Richland, Washington.
 - ² Benegas, T. R., February 16-17, 1999, "Engineering Task Plan for Waste Transfer from Tank 241-SY-101 to Tank 241-SY-102," DRAFT report HNF-4044 prepared for the SY-101 Rapid Mitigation System Conceptual Design Review, prepared by Lockheed Martin Hanford Corporation for Fluor Daniel Hanford, Inc., Richland, Washington.
 - ³ Mahoney, L. A., December 28, 1998, "Preliminary Assessment of RGS Processing Results," Informal PNNL TWS memo, Pacific Northwest National Laboratory, Richland, Washington.

Figure A-1. Water Addition Scenario.

A2.0 GAS-RELEASE MECHANISM

The degassed material in the lower part of the floating crust layer that will be exposed to the dilution water is assumed to be essentially the same as the original nonconvective layer of settled solids on the bottom of the tank. The main crust-forming mechanism in the tank (Gauglitz et al. 1999), which has also been observed in chemical simulants and waste samples in the laboratory, is transport of solids upward attached to rising bubbles. Therefore, the solid-liquid matrix at the base of the crust should be very similar to that of the bulk waste under the crust. This is shown by core sample analysis (Reynolds 1993) and inferred from the core extrusion video in other flammable gas DSTs (Meyer et al. 1997). The degassed solid-liquid matrix at the base of the crust is estimated to contain 25% volume solids, which represents the original non-convective layer. The solids are mainly sodium nitrate and nitrite, which are very soluble in water.

Although the solid-liquid matrix may represent the original nonconvective layer, it is expected to contain much more gas; enough to approach a foam condition. The measured gas fractions approaching or exceeding 0.5 indicate that the bubbles are quite close together. Spheres of equal size are close-packed at a void fraction of 0.63. This implies that, at higher void fractions, a bubbly "quasi-foam" might exist in which the bubbles touch but still contain a significant volume of solid-liquid matrix (possibly containing smaller bubbles) in the interstitial space between them. A true foam, where polyhedral bubbles are separated only by a thin film of liquid with a few particles at the vertices, would begin to form as the void fraction exceeds about 0.85.⁽¹⁾

We believe that the formation of a true foam is unlikely. The bubble-particle agglomerates contacting the bottom of the crust are kept small by the action of the mixer pump so that surface tension and the supply of solid particles would, at least initially, prevent the formation of a true foam. Whether the small bubbles would eventually coalesce to form a foam is open to debate. However, the bubbly mixture observed oozing up around the pump column in the fall of 1997, and that seen bubbling up around the void-fraction-instrument mast in the summer of 1998, clearly contained more solids and liquid than a true foam. Because this material presumably originated from the high-void layer, the high-void material probably has a void fraction of less than 0.8.

The waste at the base of the crust may therefore range in structure from a continuous solid-liquid matrix containing discrete bubbles to a "quasi-foam" with individual round bubbles that are in contact but are separated and stabilized by the solid-liquid matrix between them. In either case, we assume that the surrounding or interstitial material holds the bubbles in place and prevents them from coalescing and migrating to the headspace. Conversely, dissolution of the solids in the matrix will allow the bubbles to coalesce into a larger gas volume that will penetrate through the crust into the tank headspace.⁽⁵⁾ The gas release mechanism is illustrated conceptually in Figure A-2.

1 Foam and 'quasi-foam' discussion by personal communication with Phil Gauglitz and Scott Rassat, PNNL, March 1999.

Figure A-2. Illustration of Gas Release Mechanism.

The exact mechanism by which this penetration occurs is not known. However, laboratory experiments with simulants (Gauglitz et al. 1999) show that a large “flat” bubble eventually finds or creates a high point at which the restraining layer fails, allowing the gas to escape suddenly. The first such penetration self-seals but produces a weak chimney through which subsequent bubbles continue to penetrate.

We assume that dissolution caused by the water plume contacting the base of the crust will occur over a wide area. Several chimneys are expected to form such that the gas release is essentially continuous at roughly the same rate that the solids are dissolved. Accumulation of gas freed by dissolution under the restraining layer to cause a later catastrophic release is not plausible. The vertical dimension of a bubble is limited to a few centimeters in material with the expected yield stress of <100 Pa (Stewart et al. 1996b) so that even a hypothetical tank-spanning bubble could contain only a few cubic meters of gas.

A3.0 DISSOLUTION MODEL

To estimate the gas-release rate resulting from dissolution, we must determine what dilution is required to initiate gas release. The free-solids volume fraction can be approximately related to the gas retention properties of the solid-liquid waste matrix that holds the gas bubbles in place by virtue of its strength. In this section, a relation is derived that describes how the solids volume fraction varies with dilution ratio. Experimental data then are applied in Section A4.0 to define the dilution ratio that will cause the gas retained by the solids to be released.

Given the densities of the liquid, ρ_L (includes water and dissolved solids), the free solid particles, ρ_{FS} , and the bulk solid-liquid matrix, ρ_M , the solids volume fraction is given by

$$\phi_{FS} = \frac{\rho_M - \rho_L}{\rho_{FS} - \rho_L} \quad (3.1a)$$

The free solids volume fraction is related to the liquid and free solids mass fractions, ψ_L and $\psi_{FS} = (1 - \psi_L)$, by

$$\phi_{FS} = \frac{1}{1 + \frac{\psi_L \rho_{FS}}{\psi_{FS} \rho_L}} \quad (3.1b)$$

Dilution data obtained from 1991 core sample material from the SY-101 nonconvective layer (Tingey et al. 1994) are used to estimate the effects of dilution on the densities until results of ongoing dilution tests on 1998 samples become available. The free solid and liquid densities interpreted from the Tingey et al. (1994) data are shown as functions of the amount of dilution factor in Figure A-3. The dilution factor F_D is defined as

$$F_D = \frac{V_{WD}}{V_{M0}} \quad (3.2)$$

where V_{WD} is the volume of water diluent added and V_{M0} is the initial undiluted volume of the degassed waste with which the water will be mixed. Note that the saturated liquid density remains approximately constant at 1500 kg/m^3 up to $F_D = 0.25$. This indicates that the most soluble free solids (sodium nitrate and nitrite) have been dissolved at this dilution ratio. Further water addition begins to dissolve sodium carbonate and sodium aluminate. We assume that a local water addition would be more likely to dissolve the most soluble components over a larger volume rather than most of the solids in a smaller volume.

The solids volume fraction can be related to the dilution ratio through the mass fractions and densities via Equation (3.1b). The free-solids density is given directly by the data in Figure A-3. The liquid density is related to the amount of water and dissolved solids by

$$\rho_L = \frac{M_{DS} + M_W}{V_{DS} + V_W} \quad (3.3)$$

where M_{DS} is the mass of solids dissolved in the liquid, M_w is the mass of water, and V_{DS} and V_w are the corresponding volumes.

Figure A-3. Free Solids Density as a Function of Dilution Ratio.

The volume of dissolved solids is less than the volume of the same mass of free solids by a factor, f_v . The volume factor is defined by

$$f_v = \frac{V_{FS}}{V_{DS}} \quad (3.4)$$

where V_{FS} is the volume that the free solids occupy before they are dissolved, and V_{DS} is the volume that those solids occupy after being dissolved. The SY-101 dilution test data (Tingey et al. 1994) suggest that f_v is approximately 2. That is, the volume of solids after they dissolve is about 1/2 of the volume they occupy before dissolution.

Applying Equation (3.4) for the volume factor, substituting the produce of density and volume for water mass and solving Equation (3.3) for M_{DS} yields:

$$M_{DS} = \frac{\rho_L - \rho_w}{\rho_{FS} f_v - \rho_L} \rho_{FS} f_v V_w \quad (3.5)$$

Dividing both sides of Equation (3.5) by $\rho_{FS} f_v$ and rearranging provides an expression for the volume fraction of dissolved solids in the liquid

$$\phi_{DSL} = \frac{V_{DS}}{V_{DS} + V_W} = \frac{\rho_L - \rho_W}{\rho_{FS} f_V - \rho_W} \quad (3.6a)$$

The volume fraction of water in the liquid, ϕ_{WL} is equal to $(1 - \phi_{DSL})$. Similarly, the liquid volume fraction, ϕ_L is $(1 - \phi_{FS})$. The mass fraction of dissolved solids in the liquid is related to the volume fractions and densities by

$$\psi_{DSL} = \frac{1}{1 + \frac{\phi_{WL} \rho_W}{\phi_{DSL} \rho_{FS} f_V}} \quad (3.6b)$$

The volume occupied by solids changes as the solids dissolve, but the total solids mass (dissolved and undissolved) is constant. Therefore the total solids mass fraction varies only with dilution.

$$\psi_S = \frac{M_S}{M_T} = \frac{M_S}{M_{T0} + F_D V_{M0} \rho_W} \quad (3.7)$$

where M_S is the solids mass and M_T and M_{T0} are the total mass and initial, undiluted mass, respectively. Dividing the numerator and denominator of Equation (3.7) by M_{T0} yields

$$\psi_S = \frac{\psi_{S0}}{1 + F_D \frac{\rho_W}{\rho_{M0}}} \quad (3.8)$$

where ρ_{M0} is the bulk density of the initial, undiluted waste. The initial solids mass fraction can be found from the initial water mass fraction by

$$\psi_{S0} = 1 - \psi_{W0} = 1 - \phi_{L0} \phi_{WL0} \frac{\rho_W}{\rho_{M0}} \quad (3.9)$$

where the initial liquid volume fraction, ϕ_{L0} , is known and the initial volume fraction of water in the liquid, ϕ_{WL0} , is derived from Equation (3.6). The liquid mass fraction is given by the identity:

$$\psi_L = \frac{\psi_W}{\psi_{WL}} \quad (3.10)$$

where the water mass fraction is $\psi_W = (1 - \psi_S)$ with ψ_S from Equation (3.8), and the water mass fraction in the liquid is $\psi_{WL} = (1 - \psi_{DSL})$ with ψ_{DSL} from Equation (3.6b). The free solids mass fraction, ψ_{FS} , is equal to $(1 - \psi_L)$, with ψ_L provided by Equation (3.10). Thus all the quantities needed to evaluate Equation (3.1b) for the free-solids volume fraction are now given in terms of

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phase densities, dilution ratio, and initial undiluted conditions. The resulting sequence of equations is summarized as follows:

$$\phi_{FS} = \frac{1}{1 + \left(\frac{1}{\psi_{FS}} - 1 \right) \frac{\rho_{FS}}{\rho_L}} \quad (3.11)$$

$$\psi_{FS} = \frac{\psi_S - \psi_{DSL}}{1 - \psi_{DSL}} \quad (3.12)$$

$$\psi_S = \frac{1 - \phi_{L0} \phi_{WL0} \frac{\rho_W}{\rho_{M0}}}{1 + F_D \frac{\rho_W}{\rho_{M0}}} \quad (3.13)$$

$$\psi_{DSL} = \frac{1 - \frac{\rho_W}{\rho_L}}{1 - \frac{\rho_W}{\rho_{FS} f_V}} \quad (3.14)$$

A4.0 GAS RELEASE MODEL

In this section, we first derive an estimate of the dilution ratio needed to release gas from the bubble slurry layer, based on the data of Tingey et al. (1994). The gas release model and assumptions are discussed and the model is evaluated for conditions expected to exist at the time of the initial transfer in September 1999.⁽¹⁾ Finally, the dilution results are also given for conditions representing the time planned for interim mitigation in April 1999. Spreadsheets for the dilution ratio and gas-release calculations are listed in Appendices A and B, respectively.

A4.1 DILUTION RATIO FOR GAS RELEASE

The free-solids volume fraction predicted from the Tingey et al. (1994) data using the model expressed by Equations (3.11) to (3.14) in Section A3.0 is plotted against the dilution factor in Figure A-4. The slight rise in the solids volume fraction as the dilution factor nears 1.0 is evidence of precipitation of aluminates as the pH decreases.⁽²⁾ However, aluminate precipitation is expected to occur much more slowly than the gas-release process. Therefore, we ignore it and compute the volume fraction, accounting only for water addition with no further dissolution, shown as the dash line, for dilution factors greater than 0.6.

There are no data to directly reveal what dilution is required to release gas. However, we do know that the undiluted waste, with a free-solids volume fraction of about 0.25, has sufficient yield stress to retain gas. Theoretically, a particulate slurry has no yield stress and therefore cannot retain gas if the solids volume fraction is below the gel point of about 0.2.⁽³⁾ This would clearly represent a lower bound, because the water would tend to dissolve more of the most soluble salts than required to make the solids volume fraction exactly 0.2. At the same time, measurements have shown that the mixed slurry resulting from the operation of the mixture pump has a solids volume fraction between 0.1 and 0.125 (Meyer et al. 1997). This material behaves as a fluid and retains a relatively small gas volume (Stewart et al. 1996a; Stewart et al. 1998).

It is reasonable to assume that if the free-solids volume fraction in gas-retaining solids was reduced to between the gel point and the mixed slurry value, most of the gas would be released. Figure A-3 shows that this requires a dilution ratio in the range of about 1/10 to 1/3. We choose a midrange dilution ratio of 1/5. This is consistent with an earlier assessment of dilution required to prevent gas retention and mitigate buoyant-displacement gas releases (Hudson et al. 1995).

¹ Future conditions are taken from C. W. Stewart, "Technical Basis for the SY-101 Mitigation Plan," PNNL letter report TWS99.18, January 1999, Pacific Northwest National Laboratory, Richland, Washington.

² LMHC Interoffice Memo, "Estimated Properties of Tank 241-SY-101 Waste Affecting Dilution and Transfer," 74B50-99-021, February 26, 1999, Lockheed Martin Hanford Corporation, Richland, Washington.

³ Personal communication with Bill Kubic, LANL, March 1999, Los Alamos National Laboratory, Los Alamos, New Mexico.

Figure A-4. Free Solids Volume Fraction versus Dilution Ratio.

A4.2 GAS RELEASE BY DILUTION FOR CONDITIONS OF SEPTEMBER 1999

As stated in the introduction, we assume that the gas freed by dilution of the underside of the crust layer is released immediately into the headspace. We also assume that all of the gas in the diluted waste is released and that the rate of gas release is directly proportional to the rate of water inflow. That is, gas-release begins as soon as the water contacts the crust. Given these assumptions, the gas-release rate is easily related to the water-flow rate. The standard volume of gas contained in waste is related to its degassed volume by

$$V_{\text{GAS}} = \frac{\alpha}{1 - \alpha} P V_{\text{NOGAS}} \quad (4.1)$$

where α is the void fraction and P is the average hydrostatic pressure ratio (P/P_{atm}) at which the gas is stored (we ignore the slight temperature correction for this application). The volume of water required to release the gas is expressed via the definition of dilution ratio, Equation (3.2), and the dilution ratio estimated to cause gas release, F_D . The gas release rate is then related directly to the water flow rate, $\dot{V}_{\text{WD}}$, by

$$\dot{V}_{\text{GAS}} = \frac{\alpha}{1 - \alpha} P \frac{\dot{V}_{\text{WD}}}{F_D} \quad (4.2)$$

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Figure A-5 plots the gas-release rate as a function of water-flow rate for void fractions of 0.5, 0.6, and 0.7, under the conditions which represent conditions expected in September 1999, the time of the initial waste transfer. The parameter values are listed in Table A-1.

Figure A-5. Gas-Release Rate versus Water-Flow Rate (Conditions at 09/99).

Table A-1. Parameter Values for Crust Gas-Release Calculations at Initial Transfer.

Parameter	Value	Comment
Hydrostatic pressure	1.3 atm	For 3 m crust thickness
Void fraction	0.5 - 0.7	Best estimate is 0.6
Hydrogen fraction, χ_{H_2}	0.4	Initial retained-gas sampler results
Ventilation flow rate, $\dot{Q}$	400 ft³/min	Lower limit
Headspace volume, V_{HS}	20,000 ft³	Estimated for 09/99 based on waste-level extrapolation

Assuming a constant release rate and neglecting the initial hydrogen concentration, the tank-headspace hydrogen concentration can be expressed as a function of time as (LANL 1995)

$$C_{H_2}(t) = \frac{\dot{V}_{GAS}\chi_{H_2}}{\dot{Q}} \left[1 - e^{-(\dot{Q}/V_{HS})t} \right] \quad (4.3)$$

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where χ_{H_2} is the hydrogen fraction of the released gas, $\dot{Q}$ is the ventilation rate, and V_{HS} is the tank-headspace volume. Given the parameters listed in Table A-1, which represent the conditions estimated to exist at the time of the initial transfer, continuous water-flow rates necessary to bring the headspace to the lower flammability limit (LFL) in the steady state with a ventilation flow rate of 400 ft³/min are plotted as a function of void fraction in Figure A-6. It is important to note that the headspace concentration given by Equation (3.3) is asymptotic to the steady-state value, so LFL will never actually be achieved.

It is apparent from Figure A-6 that some combinations of water-flow rate and void fraction could cause the headspace to exceed the LFL. In these cases it is useful to compute the time to reach LFL by solving Equation (4.3) for the time for C_{H_2} to reach 0.04, the LFL for hydrogen. These results, again for the parameter values in Table A-1, are shown in Figure A-7. Also shown on the figure is the maximum time available if water is being pumped from a 1,800-gal reservoir. It is clear that flammability is a potential only for void fractions exceeding about 60%. For the design flow rate of 70 gal/min, it takes 29 minutes to reach LFL at 60% void. However, this flow rate will drain a 1,800-gal reservoir in 26 minutes, so LFL cannot be reached.

Figure A-6. Continuous-Dilution Flow Rate for Lower Flammability Limit
(Conditions at 09/99).

Figure A-7. Time to Reach Lower Flammability Limit (Conditions at 09/99).

A4.3 GAS RELEASE BY DILUTION FOR CONDITIONS OF APRIL 1999

We are also interested in gas release by dilution during the time of interim mitigation scheduled for April 1999. The conditions estimated for this time period are shown in Table A-2. Plots of gas-release rate versus water flow and time to LFL for these conditions corresponding to Figures A-5 and A-7 are shown in Figures A-8 and A-9, respectively. The September 1999 results for 0.6 void fraction are also shown for comparison. It is clear that the flammability hazard increases greatly from April to September.

Table A-2. Parameter Values for Crust Gas-Release Calculations at Interim Mitigation.

Parameter	Value	Comment
Hydrostatic pressure	1.2 atm	For 2 m crust thickness
Void fraction	0.5	Retained-gas sampler measurement, 12/98
Hydrogen fraction, χ_{H_2}	0.4	Initial retained-gas sampler results
Ventilation flow rate, $\dot{Q}$	400 ft ³ /min	Lower limit
Headspace volume, V_{HS}	28,000 ft ³	Estimated for 04/99 based on waste-level extrapolations

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Figure A-8. Gas Release versus Water Flow (Conditions at 04/99).

Figure A-9. Time to Lower Flammability Limit versus Water Flow (Conditions at 04/99).

A5.0 CONCLUSIONS

While not a completely bounding analysis, the dissolution and gas-release models contain a number of very conservative assumptions that will cause the predicted gas-release rates to be conservative. These assumptions are as follows.

- The water plume does not mix with the waste, nor does it dissolve any solids, as it rises through the mixed slurry layer.
- Pure water is assumed to spread out and contact the base of the crust over a wide area where the void fraction is highest. Dissolution and gas release are assumed to occur only in the high-void bubble-slurry layer.
- Gas bubbles are retained in the bubble-slurry layer by the strength of solid-liquid matrix surrounding them. When this material is dissolved sufficiently, gas is released.
- All (100% release fraction) of the gas in the dissolved material is released instantaneously to the headspace. None of the gas is held up as it rises through the crust layer.
- All the released gas is assumed to be released from the base of the crust at the highest hydrostatic pressure to maximize the standard volume.
- The headspace ventilation rate is assumed to be at the lower limit of 400 ft³/min.

A5.1 RESULTS FOR THE TIME OF INITIAL TRANSFER, SEPTEMBER 1999

For the conditions expected to exist at the time of the initial transfer in September 1999, the dissolution and gas-release model described above shows that dilution with water at the full design flow of 70 gal/min will cause the tank headspace to reach LFL in 29 minutes with a 0.6 void fraction in the bubble slurry, 400 ft³/min ventilation flow, and a dilution factor of 0.2. A continuous water flow of 34 gal/min would not exceed LFL under the same conditions. If the maximum water volume that could be added at 70 gal/min were limited to 2,000 gal, LFL could not be exceeded. An instantaneous water addition of 1,500 gal or less would keep the tank headspace under LFL.

A5.2 RESULTS FOR THE TIME OF INTERIM MITIGATION, APRIL 1999

For the conditions expected to exist during interim mitigation in April 1999, the dissolution and gas-release model described above shows that dilution with water at the full design flow of 70 gal/min will cause the tank headspace to reach LFL in 89 minutes with a 0.5 void fraction in the bubble slurry, 400 ft³/min ventilation flow, and a dilution factor of 0.2. A continuous flow rate of less than 56 gal/min would not exceed LFL under the same conditions. If the maximum water volume that could be added at 70 gal/min were limited to 5,000 gal, LFL could not be

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exceeded. An instantaneous water addition of 3,500 gal or less would keep the tank headspace under LFL.

A6.0 REFERENCES

- Gauglitz, P. A., S. D. Rassat, S. M. Caley, L. A. Mahoney, and D. P. Mendoza, 1999, *A Discussion of SY-101 Crust Gas Retention and Release Mechanisms*, PNNL-12092, Pacific Northwest National Laboratory, Richland, Washington.
- Hudson, J. D., G. S. Barney, P. R. Breddt, A. R. Felmy, D. L. Herting, A. P. Larrick, D. A. Reynolds, C. W. Stewart, J. M. Tingey, and D. S. Trent, 1995, *An Assessment of the Dilution Required to Mitigate Hanford Tank 241-SY-101*, PNL-10417, Pacific Northwest Laboratory, Richland, Washington.
- LANL, 1995, *A Safety Assessment for Proposed Pump Mixing Operations to Mitigate Episodic Gas Releases in Tank 241-SY-101: Hanford Site, Richland, Washington*, LA-UR-92-3196 Rev. 14a, Los Alamos National Laboratory, Los Alamos, New Mexico.
- Meyer, P. A., M. E. Brewster, S. A. Bryan, G. Chen, L. R. Pederson, C. W. Stewart, and G. Terrones, 1997, *Gas Retention and Release Behavior in Hanford Double Shell Waste Tanks*, PNNL-11536 Rev. 1, Pacific Northwest National Laboratory, Richland, Washington.
- Reynolds, D. A., 1993, *Tank 101-SY Window E Core Sample: Interpretation of Results*, WHC-EP-0628, Westinghouse Hanford Company, Richland, Washington.
- Stewart, C. W., M. E. Brewster, P. A. Gauglitz, L. A. Mahoney, P. A. Meyer, K. P. Recknagle, and H. C. Reid, 1996a, *Gas Retention and Release Behavior in Hanford Single-Shell Waste Tanks*, PNNL-11391, Pacific Northwest National Laboratory, Richland, Washington.
- Stewart, C. W., J. M. Alzheimer, M. E. Brewster, G. Chen, R. E. Mendoza, H. C. Reid, C. L. Shepard, and G. Terrones, 1996b, *In Situ Rheology and Gas Volume in Hanford Double-Shell Waste Tanks*, PNNL-11296, Pacific Northwest National Laboratory, Richland, Washington.
- Stewart, C. W., J. M. Alzheimer, G. Chen, and P. A. Meyer, 1998, *In Situ Void Fraction and Gas Volume in Hanford Tank 241-SY-101 as Measured with the Void Fraction Instrument*, PNNL-12033, Pacific Northwest National Laboratory, Richland, Washington.
- Tingey, J. M., P. R. Breddt, and E. H. Shade, 1994, *The Effects of Heating and Dilution on the Rheological and Physical Properties of Tank 241-SY-101 Waste*, PNL-10198, Pacific Northwest National Laboratory, Richland, Washington.

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ENCLOSURE A

DILUTION-DATA SPREADSHEET

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	A	B	C	D	E	F	G	H
1	INPUT PARAMETERS							
2	rhoW	1000 kg/m ³						
3	fv	2						
4								
5	TINGEY ET AL. DATA							
6	fD	0	0.1	0.2	0.4	0.6	0.8	1.0
7	rhoS	2300	2300	2318	2365	2450	2570	2730
8	rhoL	1500	1500	1500	1492	1456	1385	1300
9								
10	MASS AND VOLUME FRACTION							
11	phiDSL	0.14	0.14	0.14	0.13	0.12	0.09	0.07
12	phiWL	0.86	0.86	0.86	0.87	0.88	0.91	0.93
13	phiFS	0.25	0.20	0.16	0.10	0.07	0.07	0.08
14	phiL	0.75	0.80	0.84	0.90	0.93	0.93	0.92
15	psiW	0.38	0.41	0.45	0.50	0.54	0.58	0.61
16	psiDSL	0.43	0.43	0.43	0.42	0.39	0.35	0.28
17	psiWL	0.57	0.57	0.57	0.58	0.61	0.65	0.72
18	psiFS	0.34	0.28	0.23	0.14	0.11	0.12	0.15
19	psiL	0.66	0.72	0.77	0.86	0.89	0.88	0.85
20	rhoM	1700	1661	1630	1576	1522	1464	1411

CELL	FUNCTION	FORMULA (or sample for range)
B11:H11	vf diss. sol. in liq.	(B8-\$B\$2)/(B7*\$B\$3-\$B\$2)
B12:H12	vf water in liq.	1-B11
B13:	vf free solids	0.25 - initial data point
C13:H13	vf free solids	1/(1+C19/C18*C7/C8)
B14:H14	vf liquid	1-B13
B15:H15	mf water	B12*B14*\$B\$2/B20
B16:H16	mf diss. sol. in liq.	1/(1+B12*\$B\$2/(B11*\$B\$3*B7))
B17:H17	mf water in liq.	1-B16
B18:H18	mf free solids	1-B15/B17
B19:H19	mf liquid	1-B18
B20:H20	mixture density	B13*B7+B14*B8

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ENCLOSURE B

GAS-RELEASE SPREADSHEET

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	A	B	C	D	E	F
1	DISSOLUTION GAS RELEASE SPREADSHEET					
2						
3	INPUT PARAMETERS			BS layer void	0.6	
4	Crust thick (m)	3		Avg. void	0.4	
5	Dilution ratio	0.2		hydrogen	0.4	
6	Pressure	1.30 atm		headspace	20000 ft ³	
7	Vent flow	400 ft ³ /min		Reservoir	1800 gal	
8	water vol. for lfl	1543 gal				
9	Rel rate for lfl	44 ft ³ /min		1.3 cmm		
10	constant	46.29				
11						
12	FLOW RATE FOR LFL					
13						
14	alpha	a/(1-a)	(m ³) = (gal)	gal/min for LFL		
15						
16	0.1	0.1	0.0027	463		
17	0.2	0.3	0.0061	206		
18	0.3	0.4	0.0105	120		
19	0.4	0.7	0.0163	77		
20	0.5	1.0	0.0245	51		
21	0.6	1.5	0.0367	34		
22	0.7	2.3	0.0571	22		
23	0.8	4.0	0.0979	13		
24						
25	RESPONSE TIME FROM ALARM TO LFL					
26	ALARM	0 p/m		1.000		
27	alpha	0.5	0.6	0.7		
28	a/1-a	1.0	1.5	2.3		
29	Flow rate (gal/min)				Max time	
30	13				140	
31	17				103	
32	22				82	
33	28				64	
34	34				52	
35	43				42	
36	51	115	46	24	35	
37	64	64	33	18	28	
38	77	46	26	15	23	
39	99	32	19	11	18	
40	120	24	15	9	15	
41	70	54	29	17	26	
42						

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	A	B	C	D	E
45					
46	GAS RELEASE RATES				
47					
48	alpha	0.5	0.6	0.7	
49	a/1-a	1.0	1.5	2.3	
50	Flow rate (gal/min)				
51	13	11	17	26	
52	17	15	23	35	
53	22	19	29	44	
54	28	24	37	57	
55	34	30	44	69	
56	43	37	56	86	
57	51	44	67	104	
58	64	56	83	130	
59	77	67	100	156	
60	99	85	128	199	
61	120	104	156	242	
62	163	141	211	328	
63	206	178	267	415	

DISSOLUTION GAS RELEASE SPREADSHEET FORMULAS

CELL	FUNCTION	FORMULA (or sample for range)
B6:	Pressure at crust base	$B4 \cdot (1-E4) \cdot 1700 \cdot 9.81 / 101320 + 1$
B8:	Water vol. For LFL	$E6 \cdot 0.04 / (E3 / (1-E3) \cdot E5 / B6 / B5) \cdot 7.5$
B9:	Rel. rate for LFL	$B7 \cdot 0.04 / (E5 - 0.04)$
D9:	Conv. ft ³ to m ³	$B9 / 35.314$
B10:	Evaluate constant	$0.04 \cdot \$B\$7 / (\$E\$5 \cdot \$B\$6 / \$B\$5 / 7.5)$

FLOW RATE FOR LFL

B16:B23	alpha/(1-alpha)	$A16 / (1-A16)$
C16:C23	Rel. per gallon of water	$B16 \cdot \$B\$6 / \$B\$5 / 7.5 / 35.314$
D16:D23	gal/min for LFL	$\$D\$9 / C16$

RESPONSE TIME FROM ALARM TO LFL

D26:	time fraction	$1 - B26 / 40000$
B28:D28	alpha/(1-alpha)	$B27 / (1-B27)$
B30:D41	Response time	$IF(\$B\$10 / (\$B\$28 \cdot \$A30) < 1, -\$D\$26 \cdot (\$E\$6 / \$B\$7) \cdot LN(1 - \$B\$10 / (\$B\$28 \cdot \$A30)), " ")$
E26:E37	Max. time of flow	$\$E\$7 / \$A30$

GAS RELEASE RATES

B49:D49	alpha/(1-alpha)	$B48 / (1-B48)$
B51:D63	Release rate	$\$A\$1 \cdot B\$49 \cdot \$B\$6 / \$B\$5 / 7.5$

ATTACHMENT B

**POTENTIAL GAS RELEASE BY BUBBLE SLURRY FLOW
THROUGH A HOLE IN THE CRUST LAYER IN SY-101**

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B1.0 INTRODUCTION

The 2 m thick floating crust layer in Tank 241-SY-101 (SY-101) at the Hanford Site continues to grow and already contains a large volume of flammable gas (Stewart et al. 1998).⁽¹⁾ To reverse crust growth and reduce its retained gas volume, the waste in SY-101 is planned to be diluted by transferring a large fraction of the waste out of the tank and replacing it with water.⁽²⁾

Installation of the transfer pump and the back-dilution process, among other scenarios, have the potential to disturb larger areas of the crust layer than the small-diameter penetrations performed previously.

A large disturbance could potentially create a path for the lower layers of crust to flow to the surface and release a large volume of gas. Measurements show that about the bottom half meter of the crust layer has a gas-volume fraction approaching 0.5 (Stewart et al. 1998). The gas fraction is predicted to increase further as the crust continues to grow.⁽³⁾ This material is expected to be relatively weak and should flow readily. Initial calculations and small-scale experiments show that the density difference between the upper portion of the crust and the high-void layer creates a pressure difference large enough to quickly drive a large fraction of the high-void layer up through a hole. Gas releases approaching historical large buoyant-displacement events in size and speed could occur. This scenario is shown in Figure B-1.

This report examines and quantifies the potential hazard represented by the "bubble slurry flow" scenario. Section B2.0 presents the current understanding of the configuration of the floating crust layer and describes the conditions required to create a bubble slurry flow. Section B3.0 presents models that predict the volume of waste that can flow, the gas-release rates, and the volumes resulting from a flow. Section B4.0 gives the results of scaled experiments with simulated crust and describes the use of the data to validate the release model. Gas release predictions are made for the full-scale tank in Section B5.0 and conclusions are summarized in Section B6.0. References are given in Section B7.0

¹ Stewart, C. W., "Technical Basis for the SY-101 Mitigation Plan," PNNL Letter Report, TWS99.18, January 1999, Pacific Northwest National Laboratory, Richland, Washington.

² Benegas, T. R., "Engineering Task Plan for Waste Transfer from Tank 241-SY-101 to Tank 241-SY-102," DRAFT report HNF-4044, prepared for the SY-101 Rapid Mitigation System Conceptual Design Review, February 16-17, 1999, prepared by Lockheed Martin Hanford Corporation for Fluor Daniel Hanford, Inc, Richland, Washington.

³ RGS data, Mahoney, L. A., "Preliminary Assessment of RGS Processing Results," Informal PNNL TWS memo, December 28, 1998, Pacific Northwest National Laboratory, Richland Washington; shows more gas than measured by the void-fraction instrument. Crust buoyancy model also predicts increasing void fraction.

Figure B-1. Bubble Slurry Flow Release Scenario.

B2.0 CURRENT UNDERSTANDING OF LOWER CRUST

The term "bubble slurry" is used in this report to describe the high gas-fraction waste in the lower half meter of the crust layer. This waste is not and probably will not become a true foam. As discussed below, the lower portion of the crust is believed to consist of individual round bubbles, possibly in contact with each other or nearly so, with a considerable volume of solids and liquid between them. In an analogy with a slurry of solid particles in a liquid, we coin the bubble slurry description. In contrast, a true foam consists mainly of gas with a little liquid and almost no solid content.

B2.1 BUBBLE CONFIGURATION

The non-gas portion of the bubble slurry layer that may be subject to flow is essentially the same material as the original nonconvective layer of settled solids on the bottom of the tank. The main crust-forming mechanism in the tank (Rassat et al. 1999), which has been observed in chemical simulants and waste samples in the laboratory, is transport of solids upward attached to rising bubbles. Therefore, the solid-liquid matrix at the base of the crust should be very similar to that of the bulk waste under the crust. This is also shown by core sample analysis (Reynolds 1993) and inferred from the core extrusion video in other flammable-gas double-shell tanks (DST) (Meyer et al. 1997). The degassed solid-liquid matrix at the base of the crust is estimated to contain 25 vol% solids, which represents the original nonconvective layer. The solids are mainly sodium nitrate and nitrite, which are very soluble in water.

Although the solid-liquid matrix may represent the original nonconvective layer, it is expected to contain much more gas; enough to approach a foam condition. The measured gas fractions approaching or exceeding 0.5 indicate that the bubbles are quite close together. Spheres are close-packed at a void fraction of about 0.63. This implies that, at higher void fractions, a quasi-foam or "bubble slurry" might exist in which the bubbles touch but still contain a significant volume of solid-liquid matrix (possibly containing smaller bubbles) in the interstitial space between them. A true foam, where polyhedral bubbles are separated only by a thin film of liquid with a few particles at the vertices, would begin to form as the void fraction exceeds about 0.85 (Prud'homme and Khan 1996).

We believe that the formation of a true foam is unlikely. The bubble-particle agglomerates contacting the bottom of the crust are kept small by the action of the mixer pump so that surface tension and the supply of solid particles would, at least initially, prevent the formation of a true foam. Whether the small bubbles would eventually coalesce to form a foam is open to debate. However, the bubbly mixture observed oozing up around the pump column in the fall of 1997 and that seen bubbling up around the void-fraction instrument mast in the summer of 1998, clearly contained more solids and liquid than a true foam. Because this material presumably originated from the high-void layer, the high-void material probably has a void fraction of less than 0.7.

The waste at the base of the crust may therefore range in structure from a continuous solid-liquid matrix containing discrete bubbles to a "bubble slurry" with individual round bubbles in

contact but are separated and stabilized by the solid-liquid matrix between them. In either case, we assume that the surrounding or interstitial material holds the bubbles in place and prevents them from coalescing and migrating to the headspace.

B2.2 YIELD STRESS AND VISCOSITY

Analysis of ball rheometer data in the nonconvective layers of five flammable-gas DSTs revealed a yield stress varying from essentially zero at the upper surface to a few hundred pascals near the bottom (Meyer et al. 1997) as shown in Figure B-2. At the same time, when the yield stress reached 200 to 300 Pa, the strength often increased abruptly to over 900 Pa (sufficient to support the ball). The ball rheometer data confirm the conclusion from the settling theory that yield stress increases in proportion to the net compaction force on the particles. The compaction force can be expressed as the lithostatic pressure gradient, which is determined by the net buoyancy of the solid particles, including the effects of bubbles, according to

$$dP_L/dz = g[\phi(\rho_P - \rho_L)(1 - \alpha) - \alpha\rho_L] \quad (2.1)$$

where ϕ is the solids volume fraction, ρ_P is the solid particle density, ρ_L is the liquid density, and α is the void fraction.

Figure B-2. Yield Stress Profile in Double-Shell Tanks.

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Assuming a particle density of 2200 kg/m^3 and a liquid density of 1500 kg/m^3 , Equation (2.1) reveals that the DST nonconvective layer with a void fraction of 0.04 has about one sixth the lithostatic pressure gradient as the lower portion of the crust layer at a void fraction of 0.60. Thus the yield stress in the bubble slurry layer should increase from the base about six times faster than in the typical DST nonconvective layer. Using SY-103 as the closest model for SY-101 waste, Figure B-2 would indicate a yield stress gradient of about 1.3 Pa/cm . If the bubble slurry layer is 50 cm deep, the maximum yield stress is $50 \times 1.3 \times 6 = 390 \text{ Pa}$ with an average of about 200 Pa. However, the presence of bubbles is expected to reduce the bulk yield stress in proportion to $(1-\alpha)$ to make the maximum and average bulk yield stress, in a slurry with 50% void, 200 Pa and 100 Pa, respectively.

Another observation from the DST ball rheometer data is that, upon reaching 200 to 300 Pa, the yield stress increased abruptly to more than 900 Pa (which is sufficient to support the ball). If this same phenomenon occurs in the crust, a yield stress of 300 Pa would occur at 38 cm. Then, assuming 50% void, the maximum and average bulk yield stress would be 150 Pa and 75 Pa, respectively. To be conservative, we assume that the bubble slurry layer will be 0.5 m in thickness at the time of the initial transfer and assign it an average bulk yield stress of 50 Pa.

The nonconvective layer material in DSTs was also found to be quite shear-thinning. Apparent viscosities at the lowest ball speed of 0.1 cm/sec ranged from near zero at the upper surface to on the order of 10^7 cP at the bottom. The apparent viscosity decreased in inverse proportion to the velocity down to the range of 10^5 cP at 10 cm/s ball speed (Stewart et al. 1996). The effect of a high void fraction on the viscosity is unclear. Small bubbles act like solid particles and increase the viscosity, but larger bubbles can support less shear than a very viscous fluid. For this analysis we assume that the high void fraction reduces the viscosity somewhat and use 500,000 cP (500 Pa-s) as the bubble slurry viscosity.

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B3.0 BUBBLE SLURRY FLOW MODEL

The bubble slurry model is a modified "squeeze" model where the nonflowing part of the crust is assumed to act as a piston that pushes the bubble slurry up through a hole. It is built around two important physical phenomena: (1) the yield stress of the material allows flow only from a conical volume that probably does not extend to the tank wall and (2) the crust subsides as a unit and liquid replaces the bubble slurry flowing to the surface. The model is illustrated in Figure B-3. Section B3.1 derives an expression for the angle under which bubble slurry can flow and Section B3.2 describes the flow model.

The hole is assumed to be "clean," free from debris that would reduce the driving pressure difference. We assume that the crust does not subside and restrict the flow as the bubble slurry is removed. We do not take credit for the reduction in pressure difference resulting from mounding of the bubble slurry over the hole as it flows outward. Finally, we assume that the gas in the bubble slurry is released immediately at the surface. Each of these assumptions is quite conservative and the overall scenario is quite hypothetical.

The bubble slurry layer, initially of thickness T_{BS} , flows through a hole of radius R_i in the non-flowing crust, which has a thickness H_C . The yield stress of the bubble slurry prescribes a conical region inside which flow can occur that makes an angle θ with the base of the non-flowing crust and has a radius R_{max} , which is less than the tank radius R_T . As the slurry flows, the crust is assumed to subside uniformly so that liquid rises in a concentric conical volume, narrowing the flow area to thickness $T(r, t)$. The thickness of the flow area at the inside of the hole is $T_i(t)$.

Figure B-3. Bubble Slurry Flow Model and Nomenclature.

B3.1 MINIMUM SLOPE FOR SLURRY FLOW VOLUME

The yield stress is the main limiting factor for the fraction of the total bubble slurry volume that can eventually flow. Assuming failure in pure shear, an estimate of the maximum slope of a wedge that will be supported before failure of the material is calculated. The force balance for the failing portion wedge along the assumed shear line of angle β is illustrated in Figure B-4.

Figure B-4. Force Balance on a Wedge.

The force balance is applied to the sliding (upper) wedge along the assumed shear line of angle β . At the instant when failure occurs, the sliding wedge is balanced by a shear force and the component of the wedge weight in the direction parallel to the shear line. The shear force per unit length, F is

$$F = \tau s, \quad (3.1)$$

where τ is the yield stress of the material in pure shear and s is the length of the sliding side of the wedge, which is given by

$$s = H \cot \theta \sec(\theta - \beta). \quad (3.2)$$

The weight of the wedge per unit length, W , is written in terms of the cross-sectional area of the wedge A_w , which is one half the sine of β times the product of the length of each side of the wedge that subtends the angle β . These length scales are the already calculated side, s , and the hypotenuse of the sliding wedge. The expressions for W and A_w are:

$$W = \frac{1}{2} \Delta \rho g A_w \quad (3.3)$$

$$A_w = \frac{1}{2} \sin \beta s H \csc \theta \quad (3.4)$$

where $\Delta \rho$ is the density difference between the suspending fluid and the bubble slurry. The force balance in the direction of the shear line is

$$F = W \sin(\theta - \beta). \quad (3.5)$$

Substituting Equations (3.1) to (3.4) into Equation (3.5) and simplifying leads to

$$2\tau = \Delta\rho g H \csc\theta \sin\beta \sin(\theta - \beta). \quad (3.6)$$

Upon the application of trigonometric identities, Equation (3.6) becomes

$$\cot\theta = \cot\beta - \frac{2\tau}{\Delta\rho g H} \csc^2\beta. \quad (3.7)$$

To obtain the extremum of the slope angle, θ , Equation (3.7) is implicitly differentiated with respect to the shear line angle β which yields:

$$\frac{d\theta}{d\beta} = \frac{\frac{\Delta\rho g H}{2\tau} \left(\frac{\Delta\rho g H}{2\tau} - 2\cot\beta \right)}{1 + \left(\frac{\Delta\rho g H}{2\tau} - 2\cot\beta \right)^2}. \quad (3.8)$$

Setting the derivative to zero we can solve for $\cot\beta$. Substituting the result back into Equation (3.7) to eliminate β , the following relationship for the critical angle θ_{cr} , is obtained:

$$\tan\theta_{cr} = \frac{8\tau\Delta\rho g H}{(\Delta\rho g H)^2 - 16\tau^2}. \quad (3.9)$$

The critical angle is the maximum slope that material of height H with a yield stress of τ and net density $\Delta\rho$ can assume. The estimate of the maximum height of a vertical layer is obtained from Equation (3.9) by solving for H and setting θ_{cr} to 90° . This operation yields

$$H_{90} = \frac{4\tau}{\Delta\rho g}. \quad (3.10)$$

For small angles, which result when $\Delta\rho g H \ll 4\tau$, Equation (3.9) reduces to

$$\theta_{cr} \cong \frac{8\tau}{\Delta\rho g H}. \quad (3.11)$$

A similar derivation for a conical wedge gives the same expression as Equation (3.11) except with a slightly smaller coefficient:

$$\theta_{cr} = \frac{6\tau}{\Delta\rho g H}. \quad (3.12)$$

The angle given by Equation (3.12), with the initial thickness of the bubble slurry layer and the inner radius of the hole, prescribes the maximum radius, $R_{\max}$, inside which flow can occur. Returning to the notation of Figure B-4, this is expressed as

$$R_{\max} = R_i + T_{BS} \frac{\Delta \rho g H_C}{8\tau}. \quad (3.13)$$

Note that Equation (3.13) can give a maximum radius greater than the tank radius. In this case, the volumes and flows are modified to the correct limits, as will be described in the next section.

B3.2 CONICAL ANNULUS FLOW MODEL

The model approximates the bubble slurry flow as viscous flow between two concentric conical frusta of the same inner and outer radii but different heights. The angle of the upper cone is prescribed by Equation (3.12) and is assumed to be sufficiently small that the flow can be treated as purely radial. The angle of the lower cone increases as the bubble slurry flows out of the space between the two cones. A no-slip boundary is applied to the upper surface and to the lower surface. In the slow-flow limit the radial momentum equation (inertial terms neglected) can be written as

$$u(\eta, r, t) = \frac{1}{2\mu} \frac{\partial P}{\partial r} [T(r, t) - \eta]^2 \quad (3.14)$$

where η is the vertical coordinate between the surfaces. The average radial velocity is obtained by integrating Equation (3.14) across the gap.

$$\bar{u}(r, t) = \frac{1}{T(r, t)} \int_0^{T(r, t)} u(\eta, r, t) d\eta = \frac{T^2(r, t)}{3\lambda\mu} \frac{\partial P(r, t)}{\partial r} \quad (3.15)$$

where λ is a coefficient to account for losses that are not modeled with purely radial flow. This included losses incurred as the flow turns upward upon entering the hole and drags in the hole itself. The best comparison with experimental data was obtained with $\lambda = 8$ (see Section B4.3). The radial volumetric flow at any radius $R_{\max} > r > R_i$ is simply the product of the average radial velocity and flow area at r :

$$Q(r, t) = -2\pi r \cdot \bar{u}(r, t) T(r, t). \quad (3.16)$$

Substituting Equation (3.15) for the velocity gives

$$Q(r, t) = -\frac{2\pi r}{3\lambda\mu} T^3(r, t) \frac{\partial P(r, t)}{\partial r}. \quad (3.17)$$

The radial flow rate can also be expressed as the time rate of change of the volume outside of r . To derive an expression for the volume, let the local layer thickness be defined in terms of the radii and the inside thickness $T_i(t) = T(R_i, t)$ by

$$T(r, t) = T_i(t) \left(\frac{R_{\max} - r}{R_{\max} - R_i} \right)^\beta. \quad (3.18)$$

Note that Equation (3.18) describes a cone with linear sides if $\beta = 1$. However, β is left as a variable at this point to avoid a singularity in a later step. The volume between the upper and lower surfaces between r and $R_{\max}$ can be computed as

$$V_F(r, t) = \int_r^{R_{\max}} 2\pi r T(r, t) dr = 2\pi T_i(t) \frac{(R_{\max} - r)^{\beta+1}}{(R_{\max} - R_i)^\beta} \left[\frac{R_{\max}}{\beta+1} - \frac{R_{\max} - r}{\beta+2} \right]. \quad (3.19)$$

Taking the time derivative of Equation (3.19) gives the volume flow rate as

$$Q(r, t) = \frac{dV_F(r, t)}{dt} = 2\pi \dot{T}_i(t) \frac{(R_{\max} - r)^{\beta+1}}{(R_{\max} - R_i)^\beta} \left[\frac{R_{\max}}{\beta+1} - \frac{R_{\max} - r}{\beta+2} \right]. \quad (3.20)$$

Equating the flow rates defined by Equations (3.17) and (3.20), substituting Equation (3.18) for $T(r, t)$, and solving for the radial pressure gradient gives

$$\frac{\partial P(r, t)}{\partial r} = 3\mu\lambda \frac{\dot{T}_i(t)}{T_i(t)^3} \frac{(R_{\max} - R_i)^{2\beta}}{r(R_{\max} - r)^{2\beta-1}} \left[\frac{R_{\max}}{\beta+1} - \frac{R_{\max} - r}{\beta+2} \right]. \quad (3.21)$$

Note that Equation (3.21) is singular at a radius of $R_{\max}$ unless $-1 < \beta \leq 1/2$. Setting $\beta = 0$ reduces Equation (3.21) to pure squeeze flow between two disks. We choose $\beta = 1/2$ to stay as close as possible to the conical shape prescribed by the yield stress. This yields

$$\frac{\partial P(r, t)}{\partial r} = \frac{6}{5}\mu\lambda \frac{\dot{T}_i(t)}{T_i(t)^3} (R_{\max} - R_i) \left[\frac{2}{3} \frac{R_{\max}}{r} + 1 \right]. \quad (3.22)$$

Integrating Equation (3.22) from $R_{\max}$ to R_i and rearranging gives an ordinary differential equation in time:

$$\frac{\dot{T}_i(t)}{T_i(t)^3} = -\Delta P \left\{ \frac{6}{5}\lambda\mu(R_{\max} - R_i) \left[\frac{2}{3} R_{\max} \ln \left(\frac{R_{\max}}{R_i} \right) + R_{\max} - R_i \right] \right\}^{-1}. \quad (3.23)$$

Solving Equation (3.23) for T_i gives the final result

$$\frac{T_i(t)}{T_{BS}} = \frac{1}{\left(1 + \frac{t}{\delta} \right)^{1/2}} \quad (3.24)$$

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where T_{BS} is the initial bubble slurry layer thickness and the time constant, δ , is defined by

$$\delta = \frac{3\mu\lambda(R_{\max} - R_i)}{5\Delta P T_{BS}^2} \left[\frac{2}{3} R_{\max} \ln \left(\frac{R_{\max}}{R_i} \right) + R_{\max} - R_i \right] \quad (3.25)$$

where ΔP is the initial pressure difference between the outer and inner radii at the bottom of the bubble slurry layer with the hole established. The pressure difference is given by:

$$\Delta P = g(\rho_C H_C + \rho_{BS} T_{BF}) - g\rho_{BS}(H_C + T_{BS}) = gH_C(\rho_C - \rho_{BS}) \quad (3.26)$$

where ρ_C is the density of the crust above the bubble slurry layer and ρ_{BS} is the density of the bubble slurry density. Expressed in terms of the void fraction, Equation (3.26) becomes

$$\Delta P = gH_C \rho_{DG} [1 - \alpha_C - (1 - \alpha_{BS})] = gH_C \rho_{DG} [\alpha_{BS} - \alpha_C] \quad (3.27)$$

where ρ_{DG} is the degassed density of the crust material.

The total volume of bubble slurry available for flow is given by Equation (3.19) evaluated at $t = 0$, $r = R_i$ with β set to $1/2$. The cylindrical volume representing the hole must also be added. When the outer radius is within the tank, $R_{\max} < R_T$, the flowable volume is given by:

$$V_{BS} = \frac{4}{15} \pi T_{BS} (R_{\max} - R_i) (2R_{\max} + 3R_i) + \pi R_i^2 T_{BS}. \quad (3.28)$$

When the outer radius is greater than the tank radius, $R_{\max} > R_T$, the portion of the volume outside the tank wall, which is computed with Equation (3.19) with $r = R_T$, must be subtracted out. This results in:

$$V_{BS} = \frac{4}{15} \pi T_{BS} (R_{\max} - R_i) (2R_{\max} + 3R_i) + \pi R_i^2 T_{BS} - \frac{4}{15} \pi T_{BS} \frac{(R_{\max} - R_T)^{3/2}}{(R_{\max} - R_i)^{1/2}} (2R_{\max} + 3R_T) \quad (3.29)$$

The volume of bubble slurry remaining at any time, $V(t)$, can be computed by substituting $T_i(t)$ for T_{BS} in Equation (3.28) or (3.29). Doing this and comparing to either of the original equations, we find that the fraction of the available bubble slurry volume remaining is equal to the ratio of thicknesses, which is given by Equation (3.24):

$$\frac{V_{BS}}{T_{BS}} = \frac{V(t)}{T_i(t)} \Rightarrow \frac{T_i(t)}{T_{BS}} = \frac{V(t)}{V_{BS}} = \frac{1}{\left(1 + \frac{t}{\delta}\right)^{1/2}}. \quad (3.30)$$

The fraction of bubble slurry released can be easily derived from Equation (3.30) as

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$$\frac{V_{\text{Rel}}(t)}{V_{\text{BS}}} = \frac{V_{\text{BS}} - V(t)}{V_{\text{BS}}} = 1 - \frac{1}{\left(1 + \frac{t}{\delta}\right)^{1/2}}. \quad (3.31)$$

The instantaneous bubble slurry flow rate is the time derivative of Equation (3.31):

$$Q_{\text{Rel}} = \frac{d}{dt} V_{\text{Rel}}(t) = \frac{V_{\text{BS}}}{2\delta \left(1 + \frac{t}{\delta}\right)^{3/2}}. \quad (3.32)$$

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B4.0 EXPERIMENTAL RESULTS

Experiments were conducted to investigate the potential release of relatively weak bubble slurries containing flammable gases from the bottom of the SY-101 floating layer (crust) resulting from creation of a large hole (diameter equal to thickness) in the floating layer. A scaled experimental system was devised whereby a clean hole could be established in the simulated crust nearly instantaneously. The volume of simulated bubbly slurry transferred from the bottom to the top of the floating layer was monitored as a function of time to quantify release-rate and volume. The experimental apparatus, simulated bubble slurries, procedure, and release-volume calculations are described in Section B4.1 and the results are provided in Section B4.2. The validation and calibration of the flow model against the experimental data are given in Section B4.3.

B4.1 APPARATUS

Figure B-5 depicts the experimental apparatus used in bubble slurry flow tests. The figure shows a section through the experimental floating layer at the start of an experiment and before the simulated bubble slurry is released. Excepting a few minor features, the simulated crust is cylindrically symmetric. The experimental crust diameter is 46 cm (18 in.) or about 1/50th tank scale. The initial crust thickness was set to ~4.6 cm (1.8 in.) or about 1/40th the thickness of the actual SY-101 crust (~72 in., Rassat et al. 1999). The experimental crust-release hole diameter is equal to the initial crust thickness (~4.6 cm) and is, therefore, equivalent to a hole in the SY-101 crust of 6 ft or more. Experiment volumes are a factor $\sim 10^{-5}$ smaller than the actual tank.

Figure B-5. Section of the Slurry Flow Apparatus at the Start of an Experiment.

At the start of the experiment, the crust consisted of two distinct vertical layers: a relatively low-density slurry or oil layer simulating a bubble slurry, contained beneath a higher density upper crust. The bottom of a 0.6 cm thick and 46 cm diameter rigid disk of acrylic is the boundary between the two layers. The upper crust consists of the acrylic disk, a central release chimney⁽¹⁾

¹ The chimney models a hole through the firm upper part of the floating layer in Tank SY-101.

(~4.6 cm inside-diameter acrylic tube), and a series of acrylic rings to contain released slurry or oil. To increase the density of the upper crust, extra mass was added uniformly around the periphery of the upper crust disk. The bulk of the upper crust volume is initially air filled.

The total crust thickness is measured from the top of the release chimney (and the graduated retention rings) to the bottom of the slurry or oil layer. Depending on the initial slurry or oil layer thickness, the heights of the chimney and retention rings were adjusted to maintain a constant total crust thickness of 4.6 cm. The initial water freeboard, defined as the difference in elevation from the crust top to the water level, was controlled by the extra mass added to the upper crust. In the oil-glass slurry experiments the water freeboard was 25% of the crust thickness (1.2 cm) below the top of the crust. This is proportional to recent SY-101 tank conditions where the liquid level was reportedly ~18 in. below the top of the ~72 in. crust (Rassat et al. 1999). The proportional experiment freeboard reflects proper scaling for buoyancy including relative density of the bulk average crust to the convective liquid.

Generally, two video cameras were operated in each experiment. One camera was focused on the graduated retention rings to obtain release volume (level) information, and the other was used to obtain a wider view of the crust and release events. Each video image was recorded on an S-VHS video cassette recorder. Time and date stamps were recorded simultaneously, and the times on the two devices were synchronized to within one second. An audio recording of researcher observations was also typically obtained.

B4.1.1 Simulated Bubble Slurries

Two types of simulated bubble slurry were used. Low-density viscous oils, including a light mineral oil and an automotive transmission oil, were used in a few tests. The results of these tests are not reported here. The majority of experiments were conducted with mixtures of the light mineral oil and hollow glass microspheres. The glass reduced the bulk density of the simulated bubble slurry and increased its viscosity. This simulant is a better representation of the bubble slurry in the tank.

The density of both the light mineral oil (Fisher)¹ and the automatic transmission oil were measured at 0.84-0.86 g/mL. The 3M Scotchlite² glass bubbles (series K20) used in oil-glass slurries are nominally ~110 μm diameter and have a true density of 0.20 g/mL. A mixture of 32.5 volume percent glass in 67.5 volume percent mineral oil of 0.85 g/mL results in a calculated slurry density of 0.61 g/mL. After standing ~15 min. in air, this slurry simulant partially separates to give a thin lower oil layer under a predominant upper slurry. The amount of separation is assumed to be negligible in the time scale of the typical experiment. However, inhomogeneities (thicker chunks) in the slurry were noted in several release experiments, and this reflects the non-ideal properties of the mixed slurry simulant.

The viscosities of representative samples of the oils and oil-glass slurry were measured using a Haake³ CV 20 rheometer and Couette cup- and bob-type viscometers. (Note: the Couette viscometer spins the cup rather than the bob during measurements). Viscosities were measured

¹ Fisher is a trademark of Fisher Scientific Company.

² 3M Scotchlite is a trademark of the 3M Company.

³ Haake is a trademark of Gebruder Haake G.m.b.H.

in the range of 30 to 1000 cP. Viscosities greater than 200 cP were tested with a Haake model ME30 viscometer, and viscosities less than 200 cP were tested with the Haake model ME45 viscometer. The strain rate was adjusted from 0 to 250 to 300 s^{-1} and then back to zero at a rate of 150 s^{-1}/min during each rheogram. Oil-glass slurry samples were prepared a couple of hours before the analysis, and they were remixed just before the samples were loaded in the viscometer cup. All viscosity tests were run under ambient conditions ($\sim 22^\circ\text{C}$). Measurements on a given sample were repeated and checked for consistency. An electronic data acquisition system was used to record the measured stress as a function of strain rate for evaluation at a later time.

Measured viscosities for the mineral oil and transmission oil were 45 and 70 mPa-s (cP), respectively. Rheograms indicate that these pure oils were Newtonian (viscosity does not change with the rate of flow). The oil-glass slurry had a low but measurable yield stress, demonstrating Bingham plastic behavior (non-Newtonian: yield stress must be exceeded before flow starts; thereafter the rate-of-shear versus shear stress curve is linear). This is apparent in the rheogram shown in Figure B-6. A linear regression of the data gives an estimated slurry yield stress of ~ 2 Pa and a viscosity of the yielded material of 290 cP.

Figure B-6. Viscosity of 32.5 Volume-Percent Glass in 67.5 Volume-Percent Mineral Oil.

B4.1.2 Procedure

A water bath temperature of $\sim 20^\circ\text{C}$ was established. The plastic upper crust was floated in the water with the removable "crust" plug and a temporary rubber stopper in place in the release chimney. Trapped air was removed from under the plastic-crust layer by venting through a small (~ 0.64 cm outside diameter) standpipe located near the edge of the crust, and then the standpipe was sealed. The appropriate amount of extra mass was placed symmetrically on the upper crust plate to achieve a balanced, flat surface. Simulated bubble slurry, either oil or an oil-glass mixture, was pumped under the upper crust plate using a peristaltic pump and plastic tubing.

The end of the feed tube was held just under the crust plate, while the floating plate was rotated slowly. The location of the feed tube was moved radially, as well, to establish a uniform layer of simulant beneath the plate.

Three to five min were typically required to pump the slurry. After video camera operation was verified, and generally within two min of simulant addition, the flow was initiated. First, the air-tight rubber stopper was removed from the release chimney. The small amount of water, if any, that had seeped past the removable plug was dabbed with a paper towel. The removable plug was hooked to a simple counter-leverage device so that no net vertical force was exerted on the crust as the plug was removed. The release of simulant through the chimney to the upper crust was monitored as a function of time with video cameras.

B4.1.3 Release Volume Calculations

After the experiment, the level (height) of released oil or oil-glass slurry in the retention rings as a function of time was retrieved from the video tapes. The level data were converted to volumes using measured dimensions of the retention rings. Because of imperfections in the measurement scheme (e.g., slight variations in level, meniscus effects, and parallax corrections), the reported experiment release volumes are estimated to be accurate to about $\pm 10\%$.

In the experiments, the relative densities of the convective liquid (water) and floating layer (upper crust and simulated slurry) are scaled to the respective tank properties. This is represented as

$$\rho_{ec} = \rho_{tc} \left(\frac{\rho_{cl}}{\rho_{tl}} \right) \quad (4.1)$$

where ρ_{ec} is the bulk density of the "gas-free" experimental crust, ρ_{tc} is the bulk density of the gas-free tank crust, ρ_{cl} is the density of the experimental convective liquid, and ρ_{tl} is the density of the convective tank waste. Using tank-waste densities of 1750 kg/m^3 for ρ_{tc} and 1500 kg/m^3 for ρ_{tl} , the estimated density of the experimental gas-free crust is 1170 kg/m^3 .

The gas fractions of the experimental simulated slurry and upper crust layers are related to the layer densities by

$$\alpha_{sl} = 1 - \frac{\rho_{sl}}{\rho_{ec}} \quad (4.2)$$

and

$$\alpha_{uc} = 1 - \frac{\rho_{uc}}{\rho_{ec}}, \quad (4.3)$$

respectively. Here, ρ_{sl} is the density of the experimental slurry (or oil) and ρ_{uc} is the density of the experimental upper crust. Through control of the floating-layer freeboard in the oil-glass slurry experiments, the bulk average equivalent gas fraction of the experimental floating layer was set to ~ 0.35 . This is equal to the average gas fraction estimated in the SY-101 floating layer

(Rassat et al. 1999). As determined from Equation (4.2), the equivalent gas fraction of the oil-glass slurry was 0.48.

B4.2 EXPERIMENTAL RESULTS

A series of experiments was conducted with oil-glass slurry simulants of varying initial depth. The initial slurry-layer thickness was 1/2 (2.3 cm), 1/3 (1.5 cm), or 1/4 (1.1 cm) of the total crust thickness. Figures B-7 and B-8 show the fraction of the total slurry volume released as a function of time for the two thickest slurry layers. The figures include results for several replicate experiments at each thickness. Expectedly, larger volumes of slurry were released as the thickness of the initial slurry layer increased. The low values of the second replicate in the 1/3 thickness test can be attributed to higher than normal yield stress.

Less expectedly, a compounding effect was observed in which the fraction of the initial slurry volume released also increased as layer thickness (volume) increased. For example, Figure B-7 indicates maximum release fractions of 0.15 to 0.18 for a slurry layer initially 1.5 cm thick (~2500 mL) corresponding to slurry-release volumes of ~410 to 460 mL. In the case of a 2.3 cm thick (~3750 mL) slurry layer, shown in Figure B-8, the maximum release fractions (0.28 to 0.32) and released slurry volumes (1100 to 1200 mL) were considerably higher. The slurry-release data for the thinnest slurry layer (1.1 cm, ~1900 mL initial) are consistent with trends for the thicker layers. However, only ~100 mL or less of slurry was released in each of two thin layer tests, equivalent to a maximum release fraction of <0.06. The results are not plotted, because the small release volumes yielded very few data points.

The slurry-release volumes do not scale with the ratio of the initial layer thickness, but are more closely scaled to the square (or cube) of the relative heights, as predicted by the releasable volume model described in Section B3.1, because of the yield strength of the material and the resulting geometry of the unreleased slurry layer. The unreleased oil-glass slurry layer was observed to have a sloped surface as depicted schematically in Figure B-9, again as assumed in the model. In the thin slurry tests, the sloped surface was confined to an area within approximately one hole diameter of the edge of the release chimney. With the thickest initial slurry layers, a sloped surface was observed from the edge of the release chimney to the outer edge of the experimental crust (a plastic wall). The slurry volume released is approximated as the volume of a frustum of a cone. As such, the volume released is highly dependent on the initial slurry-layer thickness.

B4.3 MODEL VALIDATION WITH EXPERIMENTAL DATA

The experiments using 1.1 cm, 1.5 cm, and 2.3 cm bubble slurry thickness were simulated with the model derived in Section B3.2. The densities and equivalent void fractions were input as discussed in Section B4.1. The bubble slurry void fraction was assigned a constant 0.39, consistent with the measurement. The density of the simulated upper crust layer was adjusted by means of the simulated void fraction, holding the density constant at 1000 kg/m³, to be consistent with the freeboard of 1/4 of the total crust thickness set in the experiment.

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Figure B-7. Slurry Release Fraction - $T_{BS} = 1.5$ cm.

Figure B-8. Slurry Release Fraction - $T_{BS} = 2.3$ cm.

Figure B-9. Sloped Surface of Unreleased Oil-Glass Slurry Layer (not to scale).

To make a meaningful comparison, the computed releasable volume must be close to the maximum release fraction recorded in each experiment. To obtain this correspondence, the yield stress was adjusted while the other properties were held constant. This adjustment is appropriate because of the uncertainty in the yield-stress measurement and because the rheology of the material was observed to change with time. In any event, the values of yield stress used remain close to the measured value of about 2 Pa. The important parameters for the model comparisons are listed in Table B-1. Setting the parameter at $\lambda = 8$ was found to give the best overall comparison.

Table B-1. Experimental Data Parameters.

Experiment	1/4 Height	1/3 Height			1/2 Height	
Run No.	1	1	2	3	1	2
Bubble slurry layer thickness (cm)	1.14	1.52	1.52	1.52	2.28	2.28
Upper crust thickness (cm)	3.43	3.05	3.05	3.05	2.29	2.29
Yield stress (Pa)	1.8	1.45	2.1	1.33	2.3	2.1
Viscosity (cP)	300	300	300	300	300	300
Upper void fraction	0.20	0.18	0.18	0.18	0.11	0.11
Max. data release fraction	0.055	0.165	0.094	0.182	0.285	0.322
Calculated max. release fraction	0.057	0.171	0.099	0.191	0.301	0.351
Time constant (s)	0.8	2.5	1.1	2.9	2.3	2.9
Calculated cone angle (degree)	14.2	8.6	12.4	8.0	9.1	8.3

The comparisons of the 1/3 thickness tests are plotted in Figure B-10 and the 1/2 and 1/4 thickness tests in Figure B-11. The entire set of experimental results was compared with the model in Figure B-12 by normalizing the time by the time constant computed for the model, and the release fraction by the releasable volume fraction.

In most tests the model compares quite well at longer times but over-predicts the release in the first two min. This is especially true of the 1/2 thickness tests (Fig. B-11). However, because the model is conservative and short times are essentially instantaneous compared to tank ventilation rates, we consider the model valid for predicting tank-scale releases caused by bubble slurry flow.

Figure B-10. Bubble Slurry Model Validation - 1/3 Thickness Test Data.

Figure B-11. Bubble Slurry Model Validation - 1/2 and 1/4 Thickness Test Data.

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Figure B-12. Bubble Slurry Model Validation - Normalized Data.

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B5.0 TANK-SCALE PREDICTIONS

The model was exercised for a range of hole diameters, bubble slurry void fractions, and bubble slurry-layer thickness around a base case representing a best estimate of what tank conditions might be at the time of initial waste transfer in September 1999. The base-case parameter values are listed in Table B-2. Model predictions are shown by plotting total gas release and average release rate versus time in Figures B-13, B-14, and B-15. Note that the middle curve represents the base case on all three figures. The spreadsheet performing the calculations is given in Appendix A.

Table B-2. Parameters for Tank-Scale Bubble Slurry Flow Calculations.

Parameter	Value	Comment
Yield stress	50 Pa	Inferred from double-shell tank nonconvective layer ball rheometer data. See Section B2.2.
Viscosity	500 Pa-s	
Mid-crust void fraction	0.25	Void-fraction instrument and retained-gas sampler data extrapolated to 09/99 based on crust growth.
Bubble slurry void fraction	0.6	
Bubble slurry thickness	0.5 m	
Degassed density	1750 kg/m ³	Preliminary core sample results.
Fluid density	1580 kg/m ³

Figure B-13. Tank-Scale Predictions - Sensitivity to Hole Diameter.

Figure B-14. Tank-Scale Predictions - Sensitivity to Bubble Slurry Void Fraction.

Figure B-15. Tank-Scale Predictions - Sensitivity to Bubble Slurry-Layer Thickness.

In all cases except the thick bubble slurry layer (Fig. B-15), the release is over half complete in 10 min and the average release rate falls below the 40 cfm, which is the minimum required to maintain flammability, ⁽¹⁾ in about half an hour. The average gas-release rate is plotted against the cumulative release volume for the base case (0.6 void fraction, 0.5 m bubble slurry layer thickness, and 2 m diameter hole) in Figure B-16. The total release is under 2,000 ft³.

The sensitivity studies show little effect of hole diameter, a moderate variation with void fraction, and a very strong sensitivity to the thickness of the bubble slurry layer as observed in the experiments. If the bubble slurry thickness were to reach 1 m, the model predicts a total release approaching 10,000 ft³, comparable to the largest historic buoyant-displacement releases. Half of the total is released in the first 30 min, which is slower than a buoyant displacement. Furthermore, because of the high compaction forces, it is very unlikely that flow could occur over more than a 30 to 50 cm layer. A more likely and less conservative scenario, with estimated current conditions of a 2 m crust with 30 cm of bubble slurry at a 50% void fraction, gives a gas release through a 2 m diameter hole on the order of 125 ft³ at release rates less than 50 ft³/min.

Figure B-16. Base-Case Release Rate Versus Total Gas Release.

1 The calculation assumes 40% hydrogen in the released gas and a 400 cfm vent-flow rate.

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B6.0 CONCLUSIONS

While the model described in this report represents a very conservative hypothetical event, it compares well with experiments simulating the assumed geometry. We believe that it adequately bounds the gas releases induced by large disturbances to the crust layer in SY-101.

The assumptions built into the model are as follows.

- The bubble slurry layer is uniform across the tank. There are no irregularities on the crust bottom that would reduce the volume available for flow.
- The bubble slurry properties (i.e., yield stress, viscosity, density, void fraction) are uniform and constant.
- The hole is created instantaneously and does not re-seal. It is "clean," free from debris that would reduce the driving pressure difference.
- The flow is dominated by viscous forces, and spatial and temporal acceleration is neglected.
- The crust does not subside and restrict the flow as the bubble slurry is removed.
- The bubble slurry flows outward over the top surface immediately as it exits the hole. The driving pressure difference is not reduced because the bubble slurry mounds over the hole.
- All of the gas in the bubble slurry is released immediately at the surface (100% release fraction).

The potential gas release through a 2 m diameter hole for conservatively estimated conditions at the time of the initial transfer is predicted to be about 1800 ft³. The first 1000 ft³ is released in seven min at a rate of 100 to 300 ft³/min. The rate then slows considerably with the next 500 ft³, requiring 93 min. At current conditions, the potential release with the same hole diameter would be only 125 ft³, with the first 100 ft³ exiting in about 10 min. The model is not very sensitive to hole diameter, nominally sensitive to void fraction, and very sensitive to bubble slurry layer thickness.

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B7.0 REFERENCES

- Meyer P. A., M. E. Brewster, S. A. Bryan, G. Chen, L. R. Pederson, C. W. Stewart, and G. Terrones, 1997, *Gas Retention and Release Behavior in Hanford Double Shell Waste Tanks*, PNNL-11536, Rev. 1, Pacific Northwest National Laboratory, Richland, Washington.
- Prud'homme R. K., and S. A. Khan (eds.), 1996, *Foams: Theory, Measurements, and Applications*, Marcel Dekker, Inc., New York, New York.
- Rassat S. D., P. A. Gauglitz, S. M. Caley, L. A. Mahoney, and D. P. Mendoza, 1999, *A Discussion of SY-101 Crust Gas Retention and Release Mechanisms*, PNNL-12092, Pacific Northwest National Laboratory, Richland, Washington.
- Reynolds D. A, 1993, *Tank 101-SY Window E Core Sample: Interpretation of Results*, WHC-EP-0628, Westinghouse Hanford Company, Richland, Washington.
- Stewart C. W., J. M. Alzheimer, M. E. Brewster, G. Chen, R. E. Mendoza, H. C. Reid, C. L. Shepard, and G. Terrones, 1996, *In Situ Rheology and Gas Volume in Hanford Double-Shell Waste Tanks*, PNNL-11296, Pacific Northwest National Laboratory, Richland, Washington.
- Stewart C. W., J. M. Alzheimer, G. Chen, and P. A. Meyer, 1998, *In Situ Void Fraction and Gas Volume in Hanford Tank 241-SY-101 as Measured with the Void Fraction Instrument*, PNNL-12033, Pacific Northwest National Laboratory, Richland, Washington.

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ENCLOSURE A

BUBBLE SLURRY FLOW SPREADSHEET

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	A	B	C	D
1	BUBBLE SLURRY MODEL			
2				
3	INPUTS			
4	Tank Radius Ro (m)	11.4		
5	Hole Radius Ri (m)	1		
6	Crust Thickness Hc (m)	2.5		
7	Foam Layer Thickness To (m)	0.5		
8	Yield Strength (Pa)	50		
9	Foam Viscosity (Pa-s)	500		
10	Above Crust Void (alpha_c)	0.25		
11	Foam Void (alpha_f)	0.6		
12	Degassed Density rsl (kg/m3)	1750		
13	Supernate Density rl (kg.m3)	1580		
14	Time Constant Factor	8		
15	CALCULATED VALUES			
16	Foam Angle (Deg)	3.98		
17	Rm/Ri	8.19		
18	Max Radius (m)	8.19		
19	Gas Pressure Ratio	1.35		
20	Pressure Difference (Pa)	15021.6		
21	TIME CONSTANT tau (s)	85.90		
22	RELEASABLE VOLUMES			
23	Bubble Slurry Volume (m ³)	60.0		
24	Gas Volume (m ³)	48.7		
25	Gas Volume (ft ³)	1718.1		
26	Volume Fraction	0.294		
27	MODEL PREDICTIONS			
28	Time (s)	Vrel/Vtot	Gas Rel. (ft ³)	Rel. Rate (ft ³ /min)
29	10	0.054	92	552
30	17	0.086	148	524
31	32	0.146	252	472
32	60	0.233	400	400
33	100	0.320	550	330
34	170	0.421	723	255
35	320	0.540	928	174
36	600	0.646	1110	111
37	1000	0.719	1235	74
38	1700	0.781	1341	47
39	3200	0.838	1440	27
40	6000	0.881	1514	15

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CELL	FUNCTION	FORMULA (or sample for range)
B16	Foam angle	$6*B8/(9.81*B7*(B13-(1-B11)*B12))*180/3.14159$
B17	Radius ratio	$1+B7/(B5*B16*PI()/180)$
B18	Max. radius	$B17*B5$
B19	Pressure ratio	$1+((1-B10)*B6 + (1-B11)*B7)*B12*9.81/101320$
B20	Pressure difference	$((1-B10) - (1-B11))*B12*9.81*B6$
B21	Time constant (s)	$3/2*B14*B9*(B18*LN(B18/B5)*4/15+2/5*(B18-B5))*(B18-B5)/(B20*B7^2)$
B23	BS volume (m ³)	$4*PI()*B7*(B18-B5)*(2*B18+3*B5)/15+PI()*B5^2*B7-IF(B18>B4,4*PI()*B7*(B18-B4)^1.5/SQRT(B18-B5)*(2*B18+3*B4)/15,0)$
B24	Gas volume (m ³)	$B19*B23*B11$
B25	Gas volume (ft ³)	$B24*35.314$
B26	Vol. Fraction	$B23/(3.14159*B4^2)/B7$
B29:B40	Vrel/Vtot	$1-1/SQRT(1+A29/B$21)$
C29:C40	Gas Rel. (ft ³)	$B29*B$25$
D29:D40	Rel. Rate (ft ³ /min)	$C29/A29*60$

ATTACHMENT C

SCALING OF ALLOWABLE GAS RELEASES

Fluor Daniel Northwest, Inc.

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**C1.0 SCALING OF ALLOWABLE GAS RELEASES TO MAINTAIN
EQUIVALENT WASTE-MATERIAL RELEASE QUANTITIES
TO THOSE IN LA-UR-92-3196 (LANL 1996)**

Because of crust layer growth, the dome space volume in SY-101 is much smaller than it was when the mixer pump was installed. Consequently, the results of the gas release and burn analyses from the baseline mixer-pump safety assessment (LANL 1996) are no longer correct. This report provides the equation by which the gas releases analyzed in LANL (1996) need to be modified, so that a burn of these gases results in the same resuspension and release of radioactive material as that in LANL (1996).

Appendix D of the mixer-pump safety assessment (LANL 1996) provided dose calculations for a 113 m³ (4,000 ft³), gas release and burn, a 245 m³ (8,650 ft³) gas release and burn, and a 297 m³ (10,480 ft³) gas release and burn. Each of these calculations assumed a dome space volume of 1,218 m³ (43,043 ft³). The 113 m³ release is shown in LANL (1996) to bound pump insertion and removal. This release also bounds other activity-induced releases described in LANL (1996). The 297 m³ release bounds the mixer-pump operation in a tank having a significant layer of gas-retaining sludge. The main parameters to be scaled are those related to flow out of the tank dome. The conclusions are provided at the end of this section. The parameters relating to structural response are discussed in Section C2.0.

The gas is assumed to be released into the tank dome space and ignited, pressurizing the dome space. The pressure is relieved by flow of the hot dome gases out of the multiport riser. In the gas release calculations performed for LANL (1996), the flow area of the multiport riser is reduced to 66 percent of the full area. In addition, the vent areas (relief panels) open at a pressure of 6 psig. The codes used in LANL (1996) contained models for the ventilation system and noted that greater than 90 percent of the release was through the multiport riser. The focus will therefore be on the multiport riser.

The aerosol release (curies of radioactive material to the environment) is determined by multiplying the dome atmosphere release (i.e., the "gas" release) by the Ci/m³ in the dome. The equation is:

$$\text{Curies, out} = (\text{dome volume})(\text{fraction release})(\text{Ci/m}^3).$$

The concentration of radioactive material in the dome is found by determining the quantity of radioactive material suspended from the surface of the waste as a result of the burn. This quantity is mixed in the dome and is available for release. In addition, the radioactive material normally suspended in the dome atmosphere also is released. LANL (1996) used a resuspension model that requires the velocity of the dome gases over the crust as input. The velocity of dome gases is taken to be the same as the burning velocity. The burning velocity was calculated in LANL (1996) and found to be 50 m/s. LANL doubled this value for conservatism.

The burning velocity was that calculated for the 297 m³ gas release and burn. The hydrogen concentration in the dome at ignition is 7.7 percent, based on a gas composition of 31.4% hydrogen and a dome volume of 1218 m³. The quantity of aerosol resuspended for the

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113 m³ case was not determined by the burning velocity but instead was chosen to be the same as that for the 297 m³ gas release and burn case. In reality, the amount of aerosol suspended will be less, because the hydrogen concentration is 3 percent, not 7 percent. The lower concentration results in a lower burning velocity.

The burning velocity is proportional to the flammable-gas concentration, the turbulence of the release and burn, and the additional turbulence caused by the unevenness of the crust. A precise determination of the change in burning velocity in the lessened dome volume is difficult because the hydrogen concentration in the gas that is burning is not well known. However, an indication of the change can be obtained from Sherman et al. (1989). Sherman performed tests in a 30 m long, 1.83 m wide, and 2.44 m tall rectangular channel. The channel was designed to be a half-scale replica of the upper plenum of a pressurized water-reactor containment having an ice condenser. For the case having 13% top venting and no obstacles, the flame speed for a 15% hydrogen, 85% air mixture 25 m from the ignition point is 30 m/s (Sherman et al. [1989, p. 107]). For the case having no venting or obstacles, the flame speed is about 20 m/s (Sherman et al. [1989, p. 59]). For the case of no venting but with obstacles, the flame speed is 600 m/s, because a transition to a detonation occurred under these conditions. In this case, the obstacles took up 33 percent of the volume. In SY-101, the hydrogen concentration in the burning gas is less than 15 percent. The crust is certainly uneven although not to the point that 33 percent of the volume is taken up. This test indicates that the flame speed in the SY-101 condition being studied should be about 30 m/s.

In a different experiment (van Wingerden and Zeeuwen 1983), the flame velocity was measured in a 1 m³ vessel having obstacles. The obstacles varied from a single plate 0.6 m by 0.6 m to two 0.6 m by 0.6 m plates separated by a 0.1 m gap. The ignition source was in the middle of the tank near the plates. A number of sticks were placed perpendicularly between the plates in the two-plate case. The flame velocity with no plates for the hydrocarbon gases studied was about 2 to 5 m/s, depending on the gas. With a single plate and sticks (no top plate) the flame speeds increased from 5 to 20 m/s, depending on the gas. The gas concentration was at or near stoichiometric concentrations. With the parallel plates and perpendicular sticks arrangement, the flame speed increased to 25 to 40 m/s. Because the crust surface is rough, the burn in SY-101 is similar to the single plate with sticks case; the flame speed should be 5 to 20 m/s, based on this analysis.

The crust surface in SY-101 at the time of the mixer-pump safety assessment (LANL 1996) was relatively flat, because the episodic gas releases propelled the liquid tank waste over the crust, wetting and smoothing it. Gas release events like these have not occurred since the mixer pump went fully operational in late 1993 to early 1994. The crust surface at present is much more uneven. There are saltcake mounds and shelves. There are circular depressions where water has contacted the crust. There are places where the crust resembles a small coral reef and other places where it resembles a small flat plain. As a result, the burning velocity could be greater than it was for the mixer-pump safety assessment (LANL 1996).

However, the large gas release and crust motion considered in LANL (1996) caused more turbulence than would the prolonged bubble slurry flow in the present case. In addition, LANL (1996, Appendix D) indicated that the gas speed over the crust was conservatively doubled (to 100 m/s) over that calculated by the code for the burn considered.

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Burning velocity is also a function of the hydrogen concentration. The hydrogen concentrations in the volume being burned for the mixer-pump safety assessment (LANL 1996), as compared to burns considered here, are roughly similar. The 297 m³ (10,500 ft³) release in LANL (1996) resulted in a hydrogen concentration of 7.7 percent. The hydrogen concentration in the burning volume in the 113.3 m³ (4,000 ft³) case was likely less (fully mixed concentration is 3% which either is not flammable or is just inside the LFL, depending on the nitrous oxide concentration). The hydrogen concentration in the gas flow out of the waste in the present condition is the same as that in the mixer-pump safety assessment (LANL 1996). The velocity into the dome is greater and the quantity released is less. The concentration distribution (or profile) likely has a lower average concentration, which would result in lower burning velocity.

For the reasons above, the burning velocity is judged to be similar between the two cases. Because the burning velocity is the same, the total curies of radioactive material transported from the crust surface to the vapor space is the same.

The gas release is dependent on the dome-space pressure and dome-space air temperature after the burn. The burn will increase the dome-space temperature, which will increase the dome pressure. The positive pressure difference between the dome and the environment results in a flow to the environment via the multiport riser. The quantity of dome atmosphere that will flow out is equal to the number of moles of gas in the dome at the end of burning minus the number of moles after the dome has depressurized to atmospheric pressure.

The 113.3 m³ (4,000 ft³) gas release and burn in LANL (1996) resulted in a peak dome pressure of 2.58 bar (2.45 atm) with a peak temperature of 798 K (LANL 1996, Table D-2). The conditions come from 100% of the gas burning even though the fully mixed hydrogen concentration was only 3%. The present hydrogen, ammonia, and nitrous oxide concentrations are quite similar to those of LANL (1996). It will be assumed that all of the flammable gas burns. Therefore the burn energy per mole of gas is also quite similar. As a result, if the allowable gas release is made directly proportional to the dome volume (i.e., constant flammable-gas concentration), the energy release (assuming all of the gas burns) will result in the same peak pressure in the smaller volume.

A set of tests relevant to this discussion in EPRI (1988) provides peak pressures as a function of hydrogen concentration for vessels up to 2,100 m³. Table C-1 provides the results of these tests.

With the exception of very small vessels at low concentrations, the peak pressure is essentially the same for the same flammable-gas concentrations. This is also the case for the 7.7% hydrogen concentration that resulted from the 297 m³ gas release. Table C-1 demonstrates that the curies released to the environment will be the same if the ratio of gas release to available dome volume remains the same.

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Table C-1. Peak Pressure for Various Volumes, Various Hydrogen Concentrations (EPRI 1988).

Conditions	Vessel Size (m ³)	Vessel	Peak Pressure (atm)		EPRI Figure No.
			6% H ₂	10% H ₂	
Quiescent	2,100	sphere	1.8	3.7	Fig. 4-14
Quiescent	25	sphere	1.2	3.7	Fig. 4-14
Quiescent	5	Vertical cylinder, aspect ratio of 4	1.7	3.7	Fig. 4-15
Quiescent	5	Vertical cylinder, aspect ratio of 2	1.2 to 1.6	3.7	Fig. 4-15
Quiescent	0.3	Horizontal cylinder, aspect ratio of 3	1.0	3.7	Fig. 4-17

The last item to consider is the difference in gas-release mechanism and quantity. The gas from the crust-mitigation activities is released through one opening in the crust. The initial flow rate is about 5.7 to 8.5 m³/min (200 to 300 ft³/min) out of a 1 to 2 m diameter opening (Attachment B). The gas release occurs over a larger area, because the bubble slurry spreads out over the crust as it flows out of the opening. The total release is 42.5 to 56.6 m³ (1,500 to 2,000 ft³) over about 10 min. The velocity is 0.045 to 0.117 m/s (9 to 23 ft/min). The gas release in the pre-mixer pump conditions described in LANL (1996, Appendix D) shows that 70% of the 113.3 m³ (4,000 ft³) release occurs over 200 s. This equates to a flow rate of 0.4 m³/s (840 ft³/min). The model used in LANL (1996) assumed that the release occurred over 60% of the waste surface or over an opening 17.7 m (58 ft) in diameter. The velocity is 1.5 mm/s (0.3 ft/min). The initial flow velocity in the bubble slurry flow case is much more rapid than is the flow rate in LANL (1996). The flow bubble slurry rate at 10 minutes is still larger (33%) than the rate of gas flow into the dome in LANL (1996).

The flow rate and flow area in LANL (1996) result in a burn near the crust, where the flammable gas will be above the flammability limit. The upward velocity is so low that there is not much momentum to move the gas away from the surface. The gas density is not significantly different from that of air. Buoyancy therefore will not be a large contributor to mixing high up in the dome. As a result, the 113.3 m³ (4,000 ft³) release forms a well-mixed volume in the lower half of the dome or lower two thirds of the dome where it is ignited (a "pancake burn"). The 297 m³ gas release forms a well-mixed volume throughout the dome.

While the bubble slurry flow comes out of a 1 to 2 m opening, the gas release may not be instantaneous as it leaves the crust. If the gas comes out slowly as the bubble slurry flows over the crust (as froths are prone to do), the release area will be greater. This calculation will assume a release from the equivalent of a 5 m diameter opening (rather than 1 to 2 m diameter actual opening) to account for the spreading. This assumption makes the flow area 19.6 m² (211 ft²). The velocity, assuming the same gas volumetric flow rate, is 5.08 mm/s (1 ft/min). This velocity is much closer to the one used in LANL (1996). If, instead, the gas release is instantaneous, the flammable volume could be at the top of the dome or within the rising plume itself. At 81.3 mm/s (16 ft/min) it takes 30 to 45 s to reach the top of the dome. Ignition in this volume

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(above the crust) would suspend less of the surface of the crust than would be the case for ignition of a volume near the crust.

What has been shown is that if total gas release is maintained at the same ratio with respect to the dome volume as that in LANL (1996) (i.e., the concentration of flammable gases remains the same), the release of radioactive material from the tank to the atmosphere is the same as it was in LANL (1996).

Conclusion

The scaling factor is the following:

Equivalent gas release volume, $m^3 = (113 m^3)(\text{present dome space volume, } m^3)/1218 m^3$

where $113 m^3$ is the gas release volume from LANL (1996)

$1218 m^3$ is the dome volume in LANL (1996).

Table C-2 presents the results.

Table C-2. Equivalent Gas Release to Match the $113 m^3$ Release into a $1218 m^3$ Dome Volume Given in LANL (1996).

Waste Level		Dome Volume		Equivalent Gas Release (m^3)	Equivalent H_2 Release (m^2) ¹
m	in.	M^3	ft^3		
10.7	420	950	33,500	88.1	27.7
10.8	425	900	31,800	83.5	26.2
10.9	430	850	30,000	78.8	24.8
11.0	435	800	28,240	74.2	23.3
11.2	440	750	26,500	69.6	21.8
11.3	445	700	24,700	64.9	20.4

¹ H_2 release = 0.314 times the gas release.

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C2.0 SCALING OF ALLOWABLE GAS RELEASES TO MEET THE STRUCTURAL ACCEPTANCE CRITERIA AS DEFINED IN LA-UR-92-3196 (LANL 1996)

In this section the gas release and burn within the dome as a function of volume are determined. The gas release will be based on a gas release and burn that does not result in structural damage greater than that of the mixer-pump safety assessment (LANL 1996). The conclusion is provided at the end of this section.

LANL (1996, Appendix K) provides the structural consequences of gas burns in Tank SY-101 before mixer pump operation. The appendix shows that none of the important structure limits are violated if a 245 m³ (8,650 ft³) gas release and burn occurs in a 1218 m³ dome volume. Some of the structural limits are violated for the 261.4 m³ (9,230 ft³) release and burn in the 1218 m³ dome volume.

Appendix K presented the structural limits and then the results. The major result was that the 261.4 m³ gas release and burn results in a dome apex velocity that exceeds the limit chosen to preclude dome failure because of soil separation from the dome and subsequent reimpaction. The 245 m³ gas release and burn also resulted in a large dome-apex velocity, but not enough to result in soil separation and reimpaction. Appendix K showed that for both the 245 m³ and the 261.4 m³ gas release and burn there was extensive concrete cracking and rebar yielding.

Appendix K presented plots of burn pressure, dome displacement, and dome velocity versus time. Table C-3 shows some of the data.

In both the 245 m³ release and the 261.4 m³ release, the headspace is well mixed and the hydrogen concentration at the time of ignition is about 6.5%.

Table C-3. Burn Pressure, Dome Displacement, and Dome Velocity Data.

Time after ignition (s)	Pressure (psia)		Dome apex displacement				Dome apex velocity			
	245 m ³	261.4 m ³	245 m ³		261.4 m ³		245 m ³		261.4 m ³	
			(mm)	(in.)	(mm)	(in.)	mm/s	in./s	mm/s	in./s
0.0	15	15	0	0	0	0	0	0	0	0
0.1	25	26	50.8	2	50.8	2	203.2	8	254	10
0.2	53	55	88.9	3.5	101.6	4	508	20	762	30
0.3	58	60	165.1	6.5	127	5	-254	-10	-254	-10
0.4	57	60	203.2	8	203.2	8	1397	55	1574.8	62
0.5	56	58	254	10	279.4	11	762	30	762	30
0.6	-	-	292.1	11.5	330.2	13	-381	-15	-254	-10
Peak	58	60	304.8	12	368.3	14.5	1397	55	1574.8	62

Other modeling assumptions were as follows. The waste was modeled as having no ability to compress. Ignition was assumed to occur at the dome apex, because that assumption resulted in the fastest pressurization. The soil was assumed to have a depth of at least 2.13 m (7 ft) and to

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have a density of 1920 kg/m^3 (120 lb/ft^3). Also included in the soil loading were the mixer pump and concrete structures (e.g., pump pit, cover block, and multiport riser pad). The total loading was calculated to be $3.6 \times 10^6 \text{ kg}$.

The parameter of greatest importance to dome failure is the rate of change of pressure. Structural analysis shows that dome failure is caused by soil separation and reimpaction. Soil separation and reimpaction is a function of the dome-apex velocity, which is a function of the rate of change of pressure.

The problem is similar to a propulsion problem. The hydrogen burn in the dome is the propellant. The burn creates a force that pushes up the soil and the dome. The energy equation for the dome is as follows:

$$dU/dt = (dQ/dt) - (dW/dt) \quad (1)$$

where U = system internal energy = $m C_v T$
 W = work done on the system
 Q = heat added by the hydrogen burn.

The term " dU/dt " is found from the following:

$$dU/dt = m C_v dT/dt \quad (2)$$

where m = mass of air in the dome
 C_v = specific heat of the dome air at constant volume
 T = dome air temperature.

The term " dW/dt " is found from the following:

$$dW/dt = P dV/dt + V dP/dt \quad (3)$$

where P = dome pressure
 V = dome volume.

The term " dQ/dt " is found from the following:

$$dQ/dt = V_G F_H \rho_H Q_{CH} / (L/BV) \quad (4)$$

where V_G = volume of gas released into the dome, m^3
 F_H = fraction of the gas that is hydrogen = 0.314 per Appendix B of LANL (1996)
 ρ_H = density of hydrogen, $\text{g/m}^3 = 90 \text{ g/m}^3$
 Q_{CH} = heat of reaction of hydrogen in air = 29000 cal/g
 BV = burning velocity, m/s
 L = characteristic length of the system. Taken to be tank diameter for this case.

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Assume that the ideal gas law can obtain "dP/dt". This assumption yields the following:

$$(V/nR) dP/dt = dT/dt. \quad (5)$$

Substituting equations 2, 3, and 5 into equation 1 and gathering terms results in the following:

$$[(VMC_v/nR)+V] dP/dt - dQ/dt = PdV/dt. \quad (6)$$

Substituting m/Mw for n, where Mw = molecular weight, yields

$$[(VMwC_v/R) + V] dP/dt - dQ/dt = P(dV/dt). \quad (7)$$

The momentum equation for the soil is as follows:

$$m_s(dv_s/dt) = PA - W_s \quad (8)$$

where m_s = soil mass
 v_s = soil velocity
 P = dome pressure
 A = dome area
 W_s = soil weight.

These equations have to be coupled with the conservation of energy equations of the steel liner (energy of motion as well as strain energy) to obtain the response. Solving the coupled set of equations is too difficult to do in this paper. Soil motion is related to the duration of the dome pressure and the dome volume change if the energy absorbed by the liner is neglected. As a result, a solution of the energy equation for the dome space will be presented to obtain the dome pressure and volume change. The parameters to be solved are P and dV/dt.

The structural analysis is reviewed here to determine if the results confirm equation 7. Unfortunately, there are no sensitivity studies for the effect of the pressure and rate of change of pressure on smaller dome volumes. There are studies on the effect of this on larger volumes. The peak pressure, rate of change of pressure, and dome-apex velocity caused by a flammable-gas burn within Tank SY-101 having waste levels of 7620 mm (300 in.) and 6350 mm (250 in.), were evaluated in LANL (1995). For each analysis it was assumed that the gas release was 263.3 m³ (9,300 ft³). The burning velocity was allowed to change because of the lower concentrations of hydrogen at these lower levels. In the results that follow, the burning velocity is assumed to be directly proportional to hydrogen concentration. Table C-4 provides the results.

Table C-4. Results of Structural Analysis in LANL (1995; 1996).

Gas Release		Dome Volume (m ³)	Waste Level		Rate of Change of Pressure psia/s	Maximum Dome Apex Velocity	
m ³	ft ³		m	in.		mm/s	in./s
261.4	9230	1218	10.11	398	325	1651.0	65
245.0	8650	1218	10.11	398	312	1270.0	50
263.3	9300	2220	7.62	300	87.5	406.4	16
263.3	9300	2763	6.35	250	50	254.0	10
Not specified		2763	6.35		250	1524.0	60

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Data from Table C-4 were substituted into portions of equation 7. The results are shown in Table C-5.

Table C-5. Parameters Calculated from the Structural Analysis in LANL (1995; 1996).

dP/dt (psia/s)	dQ/dt (10 ⁹ J/s)	[(VMw C _v /R) + V]	Dome Apex Velocity/(0.1 dP/dt)	(dQ/dt)/(0.01 dP/dt)
325	3.92	4250	2	1.26
312	3.65	4250	1.6	1.17
87.5	2.17	7748	1.8	2.48
50	1.74	9643	2.0	3.48
300	3.36	9643	2.0	1.12

While there are trends in Tables C-3 through C-5, most relationships appear nonlinear. This is especially apparent in Table C-3, where the peak rate of change of pressure occurs at about 0.15 s but the peak dome-apex velocity occurs at 0.4 s, and the peak dome displacement occurs after 0.6 s. The most straightforward relationship is that between dome-apex velocity and rate of change of pressure (i.e., (dP/dt)/apex velocity is approximately equal to 5). This relationship (between the apex velocity and dP/dt) appears to hold for volumes in the 250 m³ range, but may not hold for the much smaller volumes that could be experienced in the future; data are just not available. However, it is known that the term "dP/dt" has the greatest value when "dV/dt" is zero. It will be assumed that this relationship does hold for decreasing volume.

Re-deriving the equation for "dP/dt" with dV/dt equal to zero yields the following:

$$dP/dt = (dQ/dt)/[V(C_v M_w/R) + V]. \quad (9)$$

To relate this equation to soil motion, integrating "dP/dt" yields:

$$P = Q/[V(C_v M_w/R) + V]. \quad (10)$$

Let $K = [(C_v M_w/R) + 1]$. Substituting into the soil momentum equation (equation 8) yields:

$$m_s dv_s/dt = QA/KV - W_s. \quad (11)$$

Integrating over the duration of the pressure pulse yields:

$$v_s = [(QA/KV) - W_s](t_{pp}/m_s) \quad (12)$$

where t_{pp} is the time of the pressure pulse.

The distance the soil travels is found by integrating again:

$$S_s = [(QA/BV) - W_s](t_{pp}^2/2m_s) \quad (13)$$

for the 245 m³ (8,650 ft³) gas release and burn conditions studied in LANL (1996)

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where $Q = 8.4 \times 10^8 \text{ J}$
 $A = 550 \text{ m}^2$ (estimate based on 411 m^2 waste area)
 $K = 3.5$
 $V = 1218 \text{ m}^3$
 $W_s = 4.1 \times 10^7 \text{ N}$
 $m_s = 4.2 \times 10^6 \text{ kg}$ based on LANL (1996) and $6.7 \times 10^5 \text{ kg}$ for concrete walls and dome
 $t_{pp} = 0.23 \text{ s}$.

Solving for v_s and S_s yields:

$$v_s = 3.68 \text{ m/s} = 145 \text{ in/s}$$
$$S_s = 0.42 \text{ m} = 17 \text{ in.}$$

These values are larger than those found in LANL (1996), because the energy absorbed by the dome liner and the effect of soil friction were not factored in. Also, no credit was taken for the increase in volume as the pressure increased. This would tend to reduce the pressure and the rate of change of pressure.

This conclusion is based on the following assumptions.

- The burning velocity is a function of concentration alone. Smaller volumes having the same hydrogen concentration do not experience a significant increase in burning velocity. The burning time is assumed to be the same as the time found from the burning velocity.
- The composition of the gas released into the dome is the same as that in LANL (1996).
- No credit was taken for waste compression. This is conservative. If a 1 m thick layer of the crust contains 50% gas-filled voids and is compressed from 1.3 atm to 4.2 atm (62 psia), the volume change is 284 m^3 ($10,000 \text{ ft}^3$). The effect of waste compression is not easily quantified, because the response time of the crust to compression cannot be easily compared to the duration of the pressure pulse (which is very fast).
- The energy absorption of the liner and soil friction is not considered. This is conservative, because addition of these factors would absorb energy and reduce dome velocities.
- Intuition indicates that the dome response should be proportional to total energy of the burn. The equations show that the dome response is proportional to energy divided by volume. The reason for the difference could be a term not considered in the derivations or that the conclusion based on intuition is only valid at much smaller volumes where other factors come into play.
- Credit is not taken for the change in dome volume as the pressure is increasing. This is conservative.

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Conclusion

It is seen that if the hydrogen concentration in the reduced volume remains the same as that in LANL (1996) for the 245 m³ (8,650 ft³) gas release into a 1218 m³ volume, the soil velocity and soil displacement are the same. The dome will not fail.

The scaling factor to maintain equal structural consequences is found from:

$$\text{Gas release (m}^3\text{)} = 245 \text{ m}^3 \text{ (present dome volume)}/1218 \text{ m}^3.$$

Because 0.314 of this gas is hydrogen per LANL (1996), the allowable hydrogen release for the 245 m³ gas-release case is found from:

$$\text{H}_2 \text{ release (m}^3\text{)} = 76.9 \text{ m}^3 \text{ (present dome volume)}/1218 \text{ m}^3.$$

Table C-6 presents a comparison of the allowable releases (assuming that 100 percent of the hydrogen burns). The waste level is from Hu (1999).

Table C-6. Equivalent Total Gas and Hydrogen Releases to Match
Structural Acceptance Criteria.

Waste Level		Dome Space Volume		Equivalent Release (m ³)	
M	in.	m ³	ft ³	Total Gas	Hydrogen
10.7	420	950	33,500	191	60.0
10.8	425	900	31,800	181	56.8
10.9	430	850	30,000	171	53.7
11.0	435	800	28,240	161	50.5
11.2	440	750	26,500	151	47.3
11.3	445	700	24,700	141	44.2

C3.0 REFERENCES

EPRI, 1988, *Large Scale Hydrogen Combustion Experiments*, EPRI NP-3878, Volume 1, Electric Power Research Institute, Palo Alto, California.

LANL, 1995, *Structural Sensitivity Study of Hydrogen Burns in Tank 101-SY for Various Waste Levels*, Calculation Note TSA 6-CN-WT-SA-ST-078, Los Alamos National Laboratory, Los Alamos, New Mexico.

LANL, 1996, *A Safety Assessment for Proposed Pump Mixing Operations to Mitigate Episodic Gas Releases in Tank 241-SY-101: Hanford Site, Richland, Washington*, LA-UR-92-3196, Rev. 14a, Los Alamos National Laboratory, Los Alamos, New Mexico.

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ATTACHMENT D

**LETTER, "SCALING CONSIDERATIONS FOR BURNS IN A
REDUCED HEADSPACE VOLUME"**

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April 8, 1999

G. W. Gault

R1-44

Duke Engineering & Services

P.O. Box 350

Richland, Washington 99352-0350

Dear Mr. Gault

Attached are my thoughts on scaling considerations for analyses of burns in reduced headspace volumes. This material was prepared in response to a request from Mr. Mike Grigsby. It is for your consideration in the preparation of the safety assessment for transfer of waste from Tank 241-SY-101 to Tank 241-SY-102. If you have any questions please feel free to contact me at (505) 844-2050.

Cc: J. M. Grigsby
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SCALING CONSIDERATIONS FOR BURNS IN A REDUCED HEADSPACE VOLUME.

The recommended scaling approach to conservatively ensure that radiological consequences and tank structural damage from a burn are less than or equal to that previously calculated is as follows. Reduce the "allowable" gas release, by the same proportion as the reduced headspace volume, to the headspace volume assumed in the previous calculations. This recommendation is based on the following evaluation of deflagration accident phenomena.

For flammable mixtures in large volumes, where surface heat losses are negligible during a burn, the burn pressure is a function of mixture composition and pressure and is independent of the volume. Heat-loss effects are negligible at dimensions above ~2.54 cm (1 in.) (diameter or height of the vapor space), so they may be neglected for all headspace combustion scenarios. For a given mixture composition, the burn pressure is not increased by a reduced headspace volume. However, for a given release amount, a smaller headspace volume will increase the concentration of H_2 , N_2O , NH_3 , etc., in the final mixture in a well-mixed headspace. This may affect whether a given release volume creates a flammable mixture or whether a flammable mixture is near the LFL or near stoichiometric (optimal) conditions.

For H_2 -air mixtures, burns very near the LFL for upward flame propagation (4% H_2) produce virtually no pressure rise whatsoever because the flame speed is very slow and the flame temperature is very low. Burns near the LFL for downward flame propagation (8% H_2) produce ~3 atm of overpressure (~45 psi gage), which is very close to the thermodynamically ideal case for complete combustion with zero heat loss in a constant volume. Burns near the stoichiometric concentration (29.5% H_2) produce ~7 atm of overpressure (~100 psi gage), which is closely predicted by the thermodynamically ideal case. In terms of structural consequences from a headspace burn, there would be little difference between a burn with ~10% H_2 and one with ~30% H_2 because severe structural damage would occur for both cases.

For a fast release rate, the amount of source gas required to produce a given concentration in the headspace will decrease linearly with headspace volume. If the release rate is high compared to the normal ventilation rate, then the peak concentration of the release gas is equal to

$1 - e^{-V_{GRE}/V_{head}}$. In this case, halving both the GRE volume, V_{GRE} , and the headspace volume, V_{head} , results in the same concentration. If the release rate is slow compared to the ventilation rate, then the peak concentration of the release gas cannot exceed the ratio of the release rate to the ventilation rate, independent of the headspace volume. (That is, if the ventilation rate is ten times faster than the release rate, the fraction of released gases can never exceed 10% in the headspace.) If the release rate is slow enough, the ventilation system at 11.3 m³/min (400 ft³/min) will prevent flammable mixtures no matter how large the volume of gases released from the waste.

The influence of headspace volume on the amount of material that may be released by a combustion event is not well known. For a given headspace pressure generated by a combustion event, the amount of gas that must vent from the tank to reduce the pressure back to atmospheric is directly proportional to the headspace volume for an ideal isentropic venting process. (An isentropic expansion analysis is conservative, because heat transfer during the process will reduce the amount of gas that will vent.) Therefore, for equal pressure burns, the release from a

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smaller headspace will be proportionately reduced if the volumetric loading of suspended waste particles is the same.

There is some uncertainty about how a reduced headspace volume may affect how much waste may be suspended by a combustion event. In a smaller headspace with a larger surface to volume ratio, the increased influence of the rough waste surface may promote a somewhat faster burning velocity. This would generate higher gas velocities for aerosolizing loose particles from the waste surface. But the waste surface appears to be mostly moist and dried solids that are not readily aerosolized by simple gas flow. Very fine loose particles on the surface will be suspended by slow gas flows, so the *additional* amount of aerosols suspended by an increased burn velocity should be small. But the total amount of aerosols generated within a given tank may be nearly constant as the headspace volume is reduced, because the amount of readily suspended fine waste particles on the surface of the waste is not affected by the change in headspace volume.

The post-burn pressure remains constant if the headspace gas concentrations are constant. However, for the same post-burn pressure, the total energy available to cause structural damage, fail the HEPA, heat the waste and tank surfaces, cause waste motion, sweep up particles, etc., scales directly with the headspace volume. Consequently, as the headspace volume is reduced, the energy available to generate aerosols by wave motion, splashing, flash heating of the waste surface, etc., will be reduced so long as there is no gross structural failure of the tank. Gross structural failures can result in items falling into the waste, and the potential energy of the falling objects is then added to the combustion energy available to create aerosols.

A burn in a reduced headspace volume may result in reduced, but not increased, accident consequences. There is some uncertainty about how much the consequences may be reduced because it is not known how much the available combustion energy to generate tank damage and aerosols must be reduced before the mass of aerosols suspended will be significantly reduced. A smaller headspace will necessarily vent a smaller volume of gas that carries the aerosols out of the tank. If the total amount of aerosols suspended is nearly constant, the increased loading of aerosols per unit volume of gas compensates for the reduced volume of gas vented to yield the same release amount for the same pressure, independent of headspace volume. If the reduced combustion energy has a more dominant effect and the amount of aerosols suspended is reduced with headspace volume, then the release amount for the same burn pressure will decrease with decreasing headspace volume. Within the technical uncertainties, the conservative estimate is that the release amount is independent of headspace volume for the GREs considered in the current authorization basis. The best estimate is that the release amount will decrease with decreasing headspace volume. These estimates assume that the allowable gas release is scaled in direct proportion to the headspace volume. There is no clear technical basis for a reduced headspace volume to result in a release amount larger than that determined by the current authorization-basis analysis.

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ATTACHMENT E

RESULTS FROM SCALING STUDIES

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E1.0 RESULTS FROM SCALING STUDIES

Two independent efforts, one by Sandia National Laboratories and another by Fluor Daniel Northwest, Inc., were initiated to look at the allowed flammable gases in the vapor space as the volume of the vapor space is reduced. Both concluded that by maintaining the same flammable concentration, the consequences of any burn would be bounded by previously performed analyses (as in the BIO [FDH 1999a]). Because the vapor space is being reduced by the crust growth, this means that the total quantity of flammable gas that can be released without exceeding the results of previous analyses will be smaller in the future than has been allowed in the past. Accident scenarios that are developed will therefore be scaled to this linear relationship for determination of acceptable total releases. The work from Sandia National Laboratories is included in Attachment D. The two reports from Fluor Daniel Northwest, Inc., looked at two aspects – the first scaled the 113 m³ release from the LANL mixer-pump safety assessment (LANL 1996) to investigate the required scaling for consequence analysis (onsite and offsite doses); the second scaled the 245 m³ release for structural consequences to the tank. Both are included as Attachment C.

The allowable hydrogen releases that keep the consequences for activities involving insertion and removal below those given in LANL (1996) are summarized in Table E-1.

Table E-1. Allowable Hydrogen Releases.

Level		Volume		Allowable Hydrogen Release (m ³)	
m	in.	M ³	ft ³	Dose Consequence Scaling	Structural Response Scaling
10.7	420	950	33,500	27.5	60.0
10.8	425	900	31,800	26.2	56.8
10.9	430	850	30,000	24.8	53.7
11.0	435	800	28,240	23.3	50.5
11.2	440	750	26,500	21.9	47.3
11.3	445	700	24,700	20.4	44.2

E1.1 CONVERSION OF FLAMMABLE-GAS DOSE CALCULATIONS FROM LANL ASSUMPTIONS TO THE BIO

To facilitate comparison of dose consequences among the BIO (FDH 1999a), the LANL (1996) mixer-pump safety assessment, and new analyses performed for the small waste transfer out of SY-101, it is necessary to establish a conversion process between the LANL (1996) document and the BIO (FDH 1999a). This work is documented below.

E1.1.1 Introduction to the Dose Conversion Process

Doses are computed for a 4 kg release as well as for several releases evaluated in the mixer-pump safety assessment. Doses are calculated using the BIO DST solids source term as well as the LANL source term.

E1.1.2 Doses for a 4 kg Release from Tank 241-SY-101

The release from the tank is assumed to be 4.0 kg of waste. The density of the waste is 1.65 kg/L.

The amount of liters released is $4.0 \text{ kg} / 1.65 \text{ kg/L} = 2.42 \text{ L}$.

E1.1.3 Dose with Double-Shell Tank Solids Unit-Liter-Dose

The unit-liter dose (ULD) for DST solids is used because SY-101 is a DST and the entrained waste would be from the solid crust. Data for the dose calculation are taken from WHC (1996a).

$$X/Q \text{ onsite} = 0.0341 \text{ s/m}^3.$$

$$X/Q \text{ offsite} = 2.83 \times 10^{-5} \text{ s/m}^3.$$

$$\text{Inhalation dose } ULD_{\text{inh}} \text{ DST solids} = 5.3 \times 10^5 \text{ Sv/L}.$$

$$\text{Ingestion dose } ULD_{\text{ing}} \text{ DST solids} = 0.48 \text{ Sv-m}^3/\text{s-L}.$$

$$\text{Breathing rate} = 3.3 \times 10^{-4} \text{ m}^3/\text{s}.$$

$$\text{Onsite Dose} = (Q)(X/Q)(BR)(ULD_{\text{inh}})$$

$$= (2.42 \text{ L})(0.0341 \text{ s/m}^3)(3.3 \times 10^{-4} \text{ m}^3/\text{s})(5.3 \times 10^5 \text{ Sv/L})$$

$$= 14.4 \text{ Sv (1440 rem)}.$$

$$\text{Offsite Dose} = (Q)(X/Q)[(BR)(ULD_{\text{inh}}) + ULD_{\text{ing}}]$$

$$= (2.42 \text{ L})(2.83 \times 10^{-5} \text{ s/m}^3) [(3.3 \times 10^{-4} \text{ m}^3/\text{s})(5.3 \times 10^5 \text{ Sv/L}) + 0.48 \text{ Sv-s/L-m}^3]$$

$$= 0.012 \text{ Sv (1.2 rem)}.$$

E1.1.4 Dose with BIO Methods, LANL Source Term for a 4 kg Release

LANL (1996, Table G-1) provides an SY-101-specific source term. The ULD based on the mixer-pump source term is $6.1 \times 10^3 \text{ Sv/L}$ as computed below. The ingestion dose contribution for the offsite receptor will be ignored because the 24-hour ingestion dose contribution is less than 1% of the inhalation dose for DST solids in WHC (1996a).

$$\text{Onsite Dose} = (Q)(X/Q)(BR)(ULD_{\text{inh}})$$

$$= (2.42 \text{ L})(0.0341 \text{ s/m}^3)(3.3 \times 10^{-4} \text{ m}^3/\text{s})(6.1 \times 10^3 \text{ Sv/L})$$

$$= 0.166 \text{ Sv (16.6 rem)}.$$

$$\begin{aligned}\text{Offsite Dose} &= (Q)(X/Q)[(BR)(ULD_{inh}) + ULD_{ing}] \\ &= (2.42 \text{ L})(2.83 \times 10^{-5} \text{ s/m}^3)(3.3 \times 10^{-4} \text{ m}^3/\text{s})(6.1 \times 10^3 \text{ Sv/L}) \\ &= 1.4 \times 10^{-4} \text{ Sv (0.014 rem)}.\end{aligned}$$

E1.1.5 Toxic Releases – 4 kg Release

Toxic release consequences are compared to risk guidelines assuming a 200-second release time.

$$\text{Release rate} = 2.42 \text{ L}/200 \text{ s} = 0.012 \text{ L/s}.$$

Toxic releases are evaluated for both anticipated and unlikely risk categories. The sum of fractions for DST solids is given in WHC (1996b). The values are given in Table E-2.

Table E-2. Sum of Fractions for Double-Shell Tank Solids (s/L).

Receptor	Anticipated	Unlikely	Extremely Unlikely
Onsite	1.8 E+04	3.3 E+03	6.3 E+02
Offsite	1.9 E+02	1.5 E+01	2.8 E+00

The comparisons to anticipated and unlikely risk guidelines are as follow.

Anticipated

$$\text{Onsite} = 0.012 \text{ L/s} \times 1.8 \times 10^4 \text{ s/L} = 216.$$

$$\text{Offsite} = 0.012 \text{ L/s} \times 190 \text{ s/L} = 2.28.$$

Unlikely

$$\text{Onsite} = 0.012 \text{ L/s} \times 3300 \text{ s/L} = 39.6.$$

$$\text{Offsite} = 0.012 \text{ L/s} \times 15 \text{ s/L} = 0.18.$$

E1.1.6 Doses for Releases Described in the Mixer-Pump Safety Assessment

Radiological Doses

LANL (1996) reports doses from three flammable-gas burn volumes. The doses are reported in Table E-3.

Table E-3. Doses for Flammable-Gas Releases from LANL (1996).

Burn size m ³ (ft ³)	Release amount (kg) ¹	Onsite LANL- calculated dose (rem) ²	Onsite dose calculated with BIO ³ methods (rem) ⁴	Onsite doses, BIO methods, LANL source term (rem) ⁴	Offsite doses, BIO methods (rem) ⁴	Offsite doses, BIO methods, LANL source term (rem) ⁴
113 (4000)	2.84	8.8	1020	11.8	0.85	0.0099
245 (8660)	3.73	11.25	1340	15.5	1.12	0.013
297(10480)	3.97	11.9	1430	16.5	1.19	0.014

¹ from LANL (1996, Table D-5)

² from LANL (1996, Table D-6)

³ FDH (1999a)

⁴ Ratioed from calculation above for the 4 kg release.

Comparison to Toxic Risk Guidelines

The comparison of the results to the risk guidelines shows that the value is directly proportional to the release amount. The calculation therefore can be ratioed from the calculations above. The results are presented in Table E-4.

Table E-4. Comparison of Results to Risk Guidelines for Toxic Releases.

Burn size (m ³)	Release amount (L)	Risk Guidelines ¹			
		Anticipated		Unlikely	
		Onsite	Offsite	Onsite	Offsite
113	2.84	153	1.62	28.0	0.128
245	3.73	201	2.13	37.3	0.1687
297	3.97	214	2.26	39.7	0.179

¹Values greater than 1 indicate that risk guidelines are exceeded.

No tank-specific toxic source term was created for the mixer-pump safety assessment. The mixer-pump safety assessment looks only at ammonia releases. The calculation in Table E-4 is bounding because a tank-specific toxic source term for SY-101 would have a lower sum of fractions, because the DST source term consists of worst-case sample data from all DSTs.

E1.1.7 Discussion of Source Term

The doses using the BIO (FDH 1999a) methodology differ from doses reported in the mixer-pump safety assessment. There are several reasons for this. A tank-specific source term is used, a different computer code is used, the LANL model includes depositions, the offsite receptor location is different, and some of the release is modeled as being released from a 5 m stack. The major difference in the doses is caused by the different source terms. In addition, the receptors were at different locations.

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The inventories used by LANL in the calculation are given in LANL (1996, Table G-1). The BIO data are based on sample data reported in WHC (1996a). A ULD is generated using the LANL-assumed inventories for SY-101 in Table E-5.

Table E-5. Unit-Liter Dose for Mixer-Pump Inventories.

Isotope	Inventory (Ci/kg) ¹	Inventory (Bq/L) ²	Dose Conversion Factor (Sv/Bq)	ULD (Sv/L)
Sr-90	3.4E-02	2.08 E+09	6.47 E-08	1.34 E+02
Y-90	3.4E-02	2.08 E+09	2.28 E-09	4.73 E+00
Tc-99	3.0E-04	1.83 E+07	2.25 E-09	4.12 E-02
I-129	2.9E-04	1.77 E+07	4.69 E-08	8.30 E-01
Cs-137	4.5E-01	2.75 E+10	8.63 E-09	2.37 E+02
Np-237	5.1E-04	3.11 E+07	1.46 E-04	4.55 E+03
Pu-239	1.6 E-05	9.77 E+05	1.16 E-04	1.13 E+02
Pu-240	1.0 E-09	6.11 E+01	1.16 E-04	7.08 E-03
Am-241	1.5 E-04	9.16 E+06	1.20 E-04	1.10 E+03
Total				6.13 E+03

¹From Table G-1 of the LANL SY-101 mixer-pump safety assessment (LANL 1996).

²Assumes a density of 1.65 kg/L.

The ULD used for DST solids is 5.3×10^5 Sv/L, which is significantly higher than the ULD based on LANL data. Part of the difference is that the BIO source term is based on the worst-case inventories for all DST solids, while the mixer-pump safety assessment uses a tank-specific source term derived in 1992 based on crust samples. The LANL mixer-pump safety assessment source term has the pedigree of being in an approved safety assessment but may not include the latest sample data.

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ATTACHMENT F

COMBUSTION BEHAVIORS AND DOSE CONSEQUENCES

Sandia National Laboratories

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TERMS

%LFL	percentage of lower flammability limit
%MinOx	percentage of the minimum required amount of oxidizer
AB	authorization basis
AICC	adiabatic, isochoric complete combustion
BD	buoyant displacement
GRE	gas-release event
HEPA	high-efficiency particulate air (filter)
LFL	lower flammability limit
REG	risk evaluation guideline
RSA	refined safety analysis
SY-101	Tank 241-SY-101
ULD	unit liter dose
V&V	verification and validation

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F1.0 SUMMARY OF FINDINGS

The RSA methodology (Slezak et al. 1998) was used to determine the potential combustion behaviors, radiological and toxicological dose consequences, and annual risk for gas releases in Tank 241-SY-101 (SY-101) with a reduced headspace volume. These results were compared to those computed with the same methodology for BD gas-release events (GRE) in a larger headspace, as considered in the current authorization basis (AB). Key findings of this work are as follows.

1. None of the crust dissolution and bubble slurry release scenarios developed by Pacific Northwest National Laboratory produce dose and risk consequences that are outside the current AB.
2. Practical increases in headspace ventilation have insignificant impact on risk and dose consequences.
3. Inerting the headspace may reduce dose consequences and risk by one to two orders of magnitude, but it cannot eliminate localized burns with the potential to fail the high-efficiency particulate absorber (HEPA) filter.
4. Restricting the rate of water addition to 265 L/min (70 gal/min) may reduce risk compared to a 757 L/min (200 gal/min) water addition, but the benefit is only a factor of ~2 to ~4.
5. Restricting the amount of water addition to 6814 L (1800 gal) in addition to limiting the water addition rate to 265 L/min (70 gal/min) would be more effective in preventing crust dissolution-induced flammable conditions.
6. Bubble slurry releases may produce localized burns with the potential to fail the HEPA filter.
7. There is very high statistical confidence (>95%) that risk from spontaneous events is within onsite risk evaluation guidelines (REG), and even higher confidence (>99%) that the risk is within offsite REGs.
8. The statistical confidence is that risk within REGs is lower for waste-intrusive operations, but still ~80% or higher. Some kinds of administrative controls, such as controls to limit the amount of waste disturbed by an intrusive operation, can increase this confidence.
9. Toxicological consequences for most cases, including those in the current AB, are higher than guidelines.

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F2.0 ANALYSIS MODELS

The models used in the refined safety-analysis (RSA) methodology (Slezak et al. 1998) were used to determine the potential combustion behaviors and risk consequences for gas releases from the crust in SY-101 with a reduced headspace volume. The details of the models are described in Slezak et al. (1998), and the models are only briefly described here.

Gas releases are assumed to occur at a constant release rate over the duration of the release event. The volume of gas retained in a tank is determined from the estimated void fraction of gas in the waste and the total volume and density of waste. The volume of gas in a release is determined from the efficiency of the release, which is defined as the amount of gas released divided by the total amount of gas retained. For the crust-release analyses, a constant value was used for the void fraction of gas retained in the waste, and values for the efficiency and duration of a release were varied to match the crust-release results computed by Pacific Northwest National Laboratory (Attachments A and B).

The composition of the released gas can be specified in the RSA methodology as a mixture of hydrogen, nitrogen, nitrous oxide, ammonia, and methane. Initial calculations used an assumed crust-release gas composition of 40% H₂, 35% N₂, 20% N₂O, 5% NH₃, and 0% CH₄. Later calculations used an assumed composition of 36.7% H₂, 29% N₂, 21% N₂O, 12% NH₃, and 1.3% CH₄. This composition is slightly modified from the Pacific Northwest National Laboratory "best estimate" composition of 36% H₂, 29% N₂, 21% N₂O, 12% NH₃, 0.6% CH₄, and 0.7% other hydrocarbons. The 0.7% "other hydrocarbons" were added to the 0.6% CH₄ value to produce the 1.3% CH₄ value used in the combustion analyses. The hydrogen concentration was increased to 36.7% H₂ so that the composition values would sum to 100.0 percent.

The RSA methodology can compute the combustion consequences for gas releases into a partially or fully inerted headspace atmosphere. For the crust release calculations, the inerting gas was assumed to be N₂. Normal air is approximately 79% N₂ and 21% O₂. Nitrogen diluent will not make hydrogen-air mixtures nonflammable until enough N₂ is added to reduce the O₂ concentration below 5 percent in the initial N₂-air mixture. For the crust-release analyses with an inert headspace, it was assumed that enough N₂ diluent was added to reduce the oxygen concentration to 4 percent.

Two forms of headspace combustion are evaluated in the RSA methodology—burns in a well-mixed headspace and burns in "plumes." Plumes are actually modeled as a complex combination of mixing zone, plume, and stratified layer models, as described in Slezak et al. (1998). For the waste and headspace temperatures in SY-101 and the gas release composition used in the crust-release analyses, the released gases are buoyant. A mixing-zone model is used to compute the initial mixing of released gases with the headspace gases as it forms into a plume. A separate plume model is used to compute the mixing of gases up to the dome. The gases are then assumed to spread out across the dome, without further mixing, into a buoyant stratified layer. A stability analysis is performed to determine if the stratified layer is stable against break-up by natural-convection currents within the headspace. If the layer is stable, the entire volume of released gases is assumed to collect in the stratified layer. The headspace is assumed to

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maintain a constant pressure, and only headspace gases are exhausted during the release. If the mixture is flammable, the consequences for a burn in this layer are computed. A diffusion model is used to determine the time for the gases to dilute below the lower flammability limit (LFL). If the mixture at the base of the plume is flammable but the mixture in the stratified layer is not, then the consequences for a burn in the mixing zone are computed using the flammable composition at the base of the plume. If the release gases are self-flammable (the compositions used in the crust-release analysis are self-flammable) but the mixture at the base of the plume is not, then the RSA conservatively computes the consequences for a burn in the mixing zone, using the undiluted release-gas composition.

The plume analysis used in the RSA is limited to waste levels in SY-101 lower than about 11.68 m (460 in.). For higher waste levels, the headspace height becomes less than the mixing-zone height for the plume release area used in the computer-code implementation of the models. The calculations default to a well-mixed analysis when there is insufficient headspace height for buoyant plumes to form. Consequently, no plume-combustion results are presented for crust-release analyses with waste heights above 11.68 m (460 in.).

The well-mixed headspace model in the RSA is identical to the model used in the safety assessment for rotary-mode core sampling (Hamilton 1996). The headspace is assumed to maintain a constant pressure. The exhaust-flow rate during the release, for both passive and active ventilation systems, is equal to the larger of the gas-release rates from the waste and the normal ventilation rate. The instantaneous gas composition being exhausted during the release is assumed to be the well-mixed composition for the total amount of gas released up to that instant, less the release gases already exhausted. If the mixture is flammable at the end of the release, which is the time of maximum release-gas concentration when a constant release rate is assumed, then the combustion consequences are computed for the peak concentration mixture.

The computed combustion pressure is based on adiabatic, isochoric complete combustion (AICC) of the fuel and oxidizer gases. For stratified-layer burns, a combustion-efficiency factor may be used to reduce the number of moles of fuel that react, to account for dilution below the LFL at the boundaries of the plume during the time the plume is forming. For the results presented in this report, the plume-combustion efficiency was set to 100 percent. For well-mixed burns, an empirical sine curve is used to transition the peak pressure from atmospheric (i.e., zero pressure rise) at the upward-propagation, lean flammability limit (4% for H₂ in air) to the computed AICC pressure at the downward-propagation, lean flammability limit (8% for H₂ in air). This empirical curve closely approximates the observed well-mixed combustion behavior for hydrogen-air mixtures. At 8% H₂ in air, the computed AICC pressure is approximately 45 psig, which is approximately the dome-failure pressure used in analyses of double-shell tanks. Further discussion of the empirical sine curve is included in Slezak et al. (1998). The empirical sine curve model for the well-mixed combustion efficiency was used in the results presented in this report. The ignition-energy requirements for mixtures are not incorporated into the combustion analysis. All mixtures computed to be flammable are conservatively assumed to be ignitable by potential ignition sources within a tank. In reality, many of the mixtures, particularly the self-flammable mixtures, have minimum ignition energies that are much higher than those available from friction-generated sparks or static electrical sparks.

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The amount of material suspended by a combustion event that gets released from a tank is computed to be proportional to the amount of headspace gas that must vent from the headspace in an isentropic (i.e., ideal) process to reduce the headspace pressure back to atmospheric. The amount of material suspended by a combustion event in the first place is determined from uncertainty distributions provided by experts (Slezak and Bratzel 1998). The amount of material suspended is principally controlled by combustion-generated gas flows in the headspace, not the gas-release mechanisms, so the estimate for the amount of material suspended are applicable to the crust-release scenarios. Material releases are modeled as volume releases with a diameter equal to that of the tank and a height determined from the computed expansion volume of the vented headspace gases. A virtual source model is used to simulate the effects of a source having the dimensions of the computed release volume. Onsite radiological and toxicological dose consequences of the material release are computed for a receptor located 100 m from the point of release. Offsite consequences are computed for a receptor located at the nearest site boundary. The Hanford Site-developed unit liter dose (ULD) methodology is used to compute the dose consequences. The radiation doses are computed based on a distribution of wind speeds and stability classes developed from meteorological data for the 200 Areas and the ULD for DST liquids.

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F3.0 QUALITY ASSURANCE/VERIFICATION AND VALIDATION

Since April 1998, the RSA analytical models and FORTRAN code have undergone extensive verification and validation (V&V), performed by a multidisciplinary team of 12 people working at Sandia National Laboratories and at the Hanford Site.

Validation tests have been run covering a broad spectrum of parameters for each model implemented by the code. The combustion models were tested with respect to deflagration limits and pressures, detonation limits, frequency of burns, and well-mixed and plume-headspace mixing behaviors. The results were compared to data (monitoring and experimental) and alternate calculations. Other models in the RSA, which include many types of GREs (buoyant displacement [BD], mixer pump induced, etc.), saltwell pumping, steady-state gas release, and accident consequences (radiological dose and toxicological) were validated similarly. Each model was also tested for adherence to expected trends as specified by the Sandia and Hanford Site developers of the RSA.

The conceptual, design, and implementation products of the Refined Safety Analysis have been verified. For the conceptual-phase products, all of the model equations have been independently reviewed and re-derived. The design was evaluated through regular design-review meetings and traceability analyses. The traceability analyses checked that all equations and statements about analysis logic in Slezak et al. (1998) and other project documents were incorporated in the FORTRAN code. Four design reviews have been held since June 1998 with extensive Hanford Site participation. The design was inspected for support of requirements. Implementation-related products have been evaluated through inspection and operational use. The source code has been reviewed for adherence to basic science principles and support of the RSA descriptions in Slezak et al. (1998). The database used by the FORTRAN code has been inspected for adherence to specifications. The units on parameter values used by the FORTRAN code have been checked for consistent use throughout the calculations. Tests were run to exercise all of the main control paths through the models, as well as data flow. A software user's guide was prepared and reviewed, code installation test cases were constructed and run, and the graphical user interface was evaluated for adherence to requirements and usability.

Errors and unexpected results encountered during any V&V activity are tracked in the form of discrepancy reports in the Action Request System, a commercial action-item tracking tool. One of the benefits of using this tool is the ability to generate action reports on changes that have been made by the developer to address discrepancies. The action reports identify when the originator of a discrepancy report needs to verify the changes for correctness. These action reports become the basis for regression tests. Metrics can be collected on problem areas, which assists the development team with process-improvement activities.

All testing documentation has become a part of the project's quality assurance records. In May 1999, a report will be published that describes in detail all of the V&V activities performed for the FORTRAN code.

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As part of the V&V effort, an Excel¹-based implementation of the gas-release, combustion, and material-release models described in Slezak et al. (1998) was independently created as a code verification tool. The Excel analysis was specifically designed to verify that the release and combustion models were executing properly in the RSA code. Both the verification tool and the FORTRAN code were used to compute the crust-release combustion-behavior maps. The independent programming and comparison testing between the results ensures that the results have been properly computed. The Excel tool does not include a ULD analysis. The verification tool was able to check the FORTRAN calculations only to the point of the computed amount of material released from a tank by a combustion event. Separately, however, the validation activities have compared the dose consequences computed to result from given mass-release amounts against other reported analyses using the ULD methodology. These activities have confirmed that the dose consequences are being properly computed in the RSA code.

¹ Excel is a trademark of Microsoft Corporation.

F4.0 FLAMMABILITY MAPS

The combustion behaviors for crust releases in reduced SY-101 headspace volumes are presented in 10 flammability maps of gas-release rate, in standard cubic feet per minute, versus total release volume. The maps are parameterized by the assumed-source gas composition, waste height, ventilation rate, and initial headspace atmosphere. By comparing the various maps, the changes in combustion behavior caused by changes in these parameters can be illustrated.

F4.1 GENERALIZED BEHAVIORS

All of the maps contain a family of rounded "L"-shaped curves. These are lines of constant percentage of the LFL on a well-mixed basis. The lines are shown for 25 percent, 50 percent, 75 percent, and 100 percent of the LFL. These curves become steeply vertical for small release volumes, because a minimum release volume is required to mix with the headspace gas to reach a given percentage of lower flammability limit (%LFL) in the headspace. The curves become horizontal at small release rates, because a minimum release rate is required to overcome the effect of ventilation and reach a given %LFL in the headspace. Viewed alternately, for a fixed very high release rate, the maximum %LFL increases nearly linearly with increasing release volume for the conditions of interest here. For a fixed very large release volume ($\sim 283\text{m}^3$ or 10,000 scf), the maximum %LFL increases nearly linearly with increasing release rate for the conditions of interest. These near-linear behaviors may not be self-evident from the figures, because log-log scales are used. In the curved portions of the lines, the phenomenon that controls the peak concentration transitions from a limited-release volume to a limited-release rate.

The figures show an additional curve for the well-mixed concentration that, if ignited, would result in just enough pressure in the tank to fail the HEPA filters. The failure pressure for the type of HEPA filters in the SY-101 ventilation system is listed in the RSA database (Barton et al. 1999) as 5 psig. Because hydrogen-dominated flames near the upward-propagation LFL cause insignificant pressure rises, the well-mixed concentration required to generate 5 psig is somewhat higher than the 4% LFL value often cited. As noted earlier, the RSA uses an empirical fit to experimental data to model the pressure increase for mixtures between the upward-propagation LFL and the downward-propagation LFL (8% H_2 in pure H_2 -air mixtures).

Note that the 5 psig value for HEPA filter failure is the sum of the estimated pressure at which the paper filter medium is physically damaged, 3 lbf/in², and 2 lbf/in² for pressure losses through the ductwork necessary to generate a 3 lbf/in² differential across the filter. This is much higher than the often-cited maximum pressure differential of approximately 25 cm (10 in.) of water column (0.36 lbf/in² [gage] differential [psid]) across the filter to meet the performance requirement of 99.9+% filter effectiveness for airborne particles larger than 0.1 micron. The RSA computes the amount of material that may blow past the HEPA filter when the pressure differential is between 25 cm (10 in.) of water column and 5 psi. If the peak differential does not exceed 5 psi, it is assumed that filter effectiveness is restored once the post-combustion headspace pressure has returned to normal levels.

The figures show regions where plume burns may occur and where the pressure increase from plume burns is potentially sufficient to fail the HEPA filter. There is a minimum release rate of $0.05 \text{ m}^3/\text{s}$ ($106 \text{ ft}^3/\text{min}$), below which mixing zones are computed to not form. For slower release rates molecular diffusion is sufficient to prevent the formation of flammable mixtures in the mixing zone. For higher release rates, the model predicts that burns in mixing zones formed by sufficiently large releases could potentially fail the HEPA filter. When the release rate becomes very high, on the order of $\sim 0.5 \text{ m}^3/\text{s}$ ($1,000 \text{ ft}^3/\text{min}$), the model predicts that flammable buoyant stratified layers may form. The distinction between mixing zone burns and stratified layer burns is not important to whether or not a localized burn may fail the HEPA filter. Therefore, the figures combine the results under the single label of plume burns.

A waste height of 11.68 m (460 in.) is used as the baseline value for the comparisons discussed below. This value is used because it is the approximate waste height conservatively predicted to exist at the time of a waste transfer to SY-102 late in 1999.

F4.2 EFFECT OF INCREASING WASTE HEIGHT

Figures F-1 through F-6 show the computed combustion behaviors for waste heights of 10.54, 10.92, 11.30, 11.68, 12.07, and 12.45 m (415, 430, 445, 460, 475, and 490 in.). All of the results are for an $11.33 \text{ m}^3/\text{min}$ ($400 \text{ ft}^3/\text{min}$) ventilation rate, normal air in the headspace, and a release gas composition of 40% H_2 , 35% N_2 , 20% N_2O , 5% NH_3 , and 0% CH_4 . The figures show that, as the waste height increases, the curves uniformly shift horizontally toward the left. That is, smaller release volumes will produce a given concentration as the headspace volume is reduced, so the curves shift toward the left.

The figures show no plume combustion results for 12.07 m (475 in.) and 12.45 m (490 in.) waste heights. At these waste heights, the computed distance from the waste to the dome is less than the thickness of the mixing zone required for plume formation. This condition is outside the range of applicability for the plume model, so only well-mixed combustion behaviors are analyzed by the code and shown in the figures.

F4.3 EFFECT OF DIFFERENT GAS COMPOSITION

Figure F-7 shows the computed combustion behaviors for a waste height of 11.68 m (460 in.) and a release-gas composition of 36.7% H_2 , 29% N_2 , 21% N_2O , 12% NH_3 , and 1.3% CH_4 . The ventilation rate was $11.33 \text{ m}^3/\text{min}$ ($400 \text{ ft}^3/\text{min}$) and the headspace atmosphere was normal air for these calculations. Figures F-7 and F-4 illustrate the effect of the release-gas composition on the combustion behaviors. The figures are virtually identical for well-mixed combustion, showing that the well-mixed combustion behavior for lean mixtures is not sensitive to the specific release-gas composition.

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For plume burns, a slightly reduced release volume of the Pacific Northwest National Laboratory best-estimate composition gas in Figure F-7 is required to fail the HEPA filter, compared to the results for Figure F-4 (8.5 m^3 [300 ft^3] versus 10.5 m^3 [370 ft^3]). The difference is because of the increased amount of ammonia and methane in the best-estimate composition. Ammonia and methane have higher heats of reaction than hydrogen, and the best-estimate mixture is richer in fuel gases, so the energy released by combustion per mole of release gas is higher for this mixture. Consequently, somewhat smaller volumes of near-stoichiometric or rich-plume mixtures may release enough combustion energy to fail the HEPA filter. This effect is not evident for the well-mixed case, because of the strong influence of the hydrogen on the computed LFL and the reduced pressures generated by near-LFL mixtures.

Figure F-1. Computed Combustion Behaviors for a Waste Height of 10.54 m (415 in.).

Figure F-2. Computed Combustion Behaviors for a Waste Height of 10.92 m (430 in.).

Figure F-3. Computed Combustion Behaviors for a Waste Height of 11.30 m (445 in.).

Figure F-4. Computed Combustion Behaviors for a Waste Height of 11.68 m (460 in.).

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Figure F-5. Computed Combustion Behaviors for a Waste Height of 12.07 m (475 in.).

Figure F-6. Computed Combustion Behaviors for a Waste Height of 12.45 m (490 in.).

Figure F-7. Computed Combustion Behaviors for Crust-Dissolution Cases at a Waste Height of 11.68 m (460 in.) with Alternate Release-Gas Composition at 11.33 m³/min (400 ft³/min).

F4.4 EFFECT OF INCREASED VENTILATION RATE

Figures F-7 and F-9 illustrate the effect on the computed combustion behaviors of increasing the ventilation rate from 11.33 m³/min (400 ft³/min) to 17.0 m³/min (600 ft³/min). The constant-%LFL curves for the well-mixed combustion case shift uniformly upward with increasing ventilation rate, while the plume combustion regions are unaffected. The 50% increase in ventilation rate from Figure F-7 to Figure F-9 causes an equal percentage increase in the release rate required to form a given well-mixed concentration in the headspace, but only for very large release volumes. For small releases with slow release rates, the influence of the ventilation rate is reduced. For small releases with high release rates, the influence of the ventilation rate is negligible. This is because the duration of these releases becomes very short, and the ventilation system cannot exhaust a significant fraction of the headspace gases during short releases.

For plume burns, the combustion behavior is computed to be virtually unaffected by the ventilation rate. For practical rates, the ventilation is unable to influence whether flammable mixing zones or flammable buoyant stratified layers can form. Because some plume burns can fail the HEPA filter and are prevented only with an order of magnitude or larger increase in ventilation rate, increased ventilation does not significantly reduce potential dose consequences. However, what is not evident from the figures is that the ventilation rate does have an influence on the length of time that a buoyant stratified layer may remain flammable. The influence that practical increases in ventilation rate have on the computed risk from plume burns is because of the decreased time at risk.

F4.5 EFFECT OF HEADSPACE INERTING

Figures F-7 and F-10 illustrate the effect on the computed combustion behaviors of adding enough N₂ to reduce the pre-release headspace O₂ concentration to 4 percent. Within the range of the scales in the figures, inerting is able to prevent all releases from being flammable when well mixed. Inerting is not, however, able to prevent the formation of flammable mixing zones that, if ignited, have the potential to cause HEPA filter failure.

The constant-%LFL lines for a well-mixed headspace are unchanged between Figures F-8 and F-10. (Although Figure F-10 does not show 75% and 100% LFL lines, they are the same as shown in Figure F-8.) The reason is that adding increasing amounts of N₂ to a release gas and air mixture or to release gas alone (for self-flammable mixtures) does not change the computed %LFL values. The %LFL value is based on the fuel-to-oxidizer ratio, which is not influenced by adding diluent, and the flammability limits for the amount of diluent present. For hydrogen in air, the amount of H₂ in the net mixture at the upward-propagation lean-flammability limit (4 percent) is unaffected by the addition of diluent until the O₂ concentration is reduced below 5 percent. Below 5% O₂, H₂-air mixtures are not flammable, because there is insufficient oxidizer present. Because the computed LFL values are dominantly influenced by the hydrogen in the release gas, and the H₂ LFL values are not affected by additional N₂, adding N₂ to the headspace has negligible influence on the computed %LFL values.

Figure F-8. Computed Combustion Behaviors for Bubble Slurry Release Scenarios at a Waste Height of 11.68 m (460 in.) with Alternate Release-Gas Composition.

Figure F-9. Computed Combustion Behaviors for Crust-Dissolution Cases at a Waste Height of 11.68 m (460 in.) with Alternate Release-Gas Composition at 17.0 m³/min (600 ft³/min).

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Figure F-10. Computed Combustion Behaviors for Bubble Slurry Releases at a Waste Height of 11.68 m (460 in.) with Alternate Release-Gas Composition and Inert Headspace at 11.33 m³/min (400 ft³/min).

A mixture is not necessarily flammable when the computed %LFL value is above 100 percent because the %LFL value only indicates whether sufficient fuel is present. The mixture also must have sufficient oxidizer present. The percentage of the minimum required amount of oxidizer (%MinOx) also must be computed. A mixture is flammable only when both %LFL $\geq$ 100 percent and %MinOx $\geq$ 100 percent. Comparing Figures F-8 and F-10 for the assumed gas-release composition, all large releases are not flammable on a well-mixed basis when the headspace is initially ~96% N₂, because the %MinOx values are everywhere less than 100 percent in Figure F-10. Below and to the left of the line labeled "52% LFL = 52% Min. Oxidizer," the %LFL values are smaller than the %MinOx values; above and to the right of the line the reverse is true. In the lower left area, well-mixed releases are not flammable, mostly because there is insufficient fuel present; in the upper right area well-mixed releases are not flammable, mostly because there is insufficient oxidizer present.

Figure F-10, the analysis reveals that inerting the headspace does not eliminate the potential for plume burns that can fail the HEPA filter. Comparing Figures F-8 and 10, headspace inerting has no impact on the minimum amount of gas that must be released to form a plume that, if ignited, could potentially fail the HEPA filter. This is because of the conservative assumption, discussed in the next section, that self-flammable release gases may form undiluted mixing zones. For somewhat larger plume releases of a self-flammable gas like the mixture used in Figures F-10 and F-11, flammable mixing zones or stratified layers can be computed to form, because the dilution during plume formation is insufficient to render the mixture nonflammable.

Figure F-11 illustrates the effect of simultaneously inerting the headspace to 4% O₂ and increasing the ventilation rate to 17.0 m³/min (600 ft³/min). The influence of the increased ventilation rate moves the %LFL and %MinOx lines upward from Figure F-10 to Figure F-11, the same as illustrated in Figures F-7 and F-9 for increasing the ventilation rate with a normal air atmosphere. This has no effect on the region of potentially flammable mixtures, which is caused by plume releases.

Figures F-10 and F-11 have a demarcation line labeled "Plume Model Boundary" at a release volume of ~76.5 m³ (2,700 ft³). This line indicates the largest release volume, at a waste height of 11.68 m (460 in.), analyzed as a plume release. For larger releases, the computed thickness of the stratified layer is greater than the headspace height, so the analysis reverts to the well-mixed model. Because the well-mixed model indicates that flammable mixtures are not formed if the headspace is inerted, the plume-model boundary line indicates a pseudo-maximum flammable-release volume. All releases larger than ~8.5 m³ (300 ft³) with release rates above ~2.8 m³/min (100 ft³/min) are listed as "plume burns with potential for HEPA failure", even those above ~76.5 m³ (2,700 ft³). This is because flammable conditions will exist during the initial stages of releases that ultimately exceed ~76.5 m³ (2,700 ft³).

F4.6 CONSERVATISMS IN THE PLUME-COMBUSTION RESULTS

Two conservatisms in the plume burn calculations strongly influence the boundaries shown in the figures for plume burns that may fail the HEPA filter. These conservatisms ensure that real plume-burn behavior is bounded by the reported values.

Figure F-11. Computed Combustion Behaviors for Crust-Dissolution Cases at a Waste Height of 11.68 m (460 in.) with Alternate Release-Gas Composition and Inert Headspace at 17.0 m³ (600 ft³/min).

The first important conservatism is that for the figures presented here, the stratified-layer combustion efficiency was set equal to unity. This means that in the plume analyses where a stable stratified layer was computed to form, 100 percent of the released gas was assumed to react. This is the limiting case that does not take credit for the real behavior that during plume formation some of the release gas at the boundaries is necessarily diluted below the LFL. The minimum release volume for HEPA failure increases with decreasing combustion efficiency. In the RSA, an uncertainty distribution is used for the stratified-layer combustion efficiency. The results in the figures included here show the smallest possible volume for which an individual RSA run may indicate HEPA failure. The mean volumes for HEPA failure from a stratified-layer burn that is computed with the combustion-efficiency uncertainty distribution are approximately twice the values reported here. Setting the combustion efficiency to 100 percent also allowed direct comparisons between results from the FORTRAN code and the Excel verification tool when checking the accuracy of the results reported here.

The second important conservatism occurs when a mixing zone is computed to dilute release gases below the LFL but the release gas is self-flammable. For this case the combustion analysis is performed for an undiluted volume of release gas equal to the smaller of the total release volume and the volume of the mixing zone. This assumption significantly overestimates the volume of flammable gases in the mixing zone. The minimum release volume that is needed for a mixing-zone burn to fail the HEPA computed with this assumption is identical to the minimum volume computed for a buoyant stratified-layer burn with 100 percent combustion efficiency. Consequently, the two plume-burn conservatisms produce consistent results. The mixing-zone assumption, however, results in the minimum release rate for a plume burn that can fail the HEPA filter to be about an order of magnitude less than would be computed without the assumption. This ensures that, within the technical uncertainty associated with plume burns, the reported results bound the true release rate required to form mixtures that, if ignited, can fail the HEPA filter.

For the figures included in this report, the conservatisms ensure that all of the individual plume burn conditions that may be computed to lead to HEPA failure are contained within the region labeled "plume burns with potential for HEPA failure." Many analyzed plume releases with conditions within this region do not lead to HEPA failure, however, when the computed combustion efficiency is much less than the 100% value assumed for the figures.

F4.7 COMBUSTION BEHAVIORS FOR BUBBLE SLURRY RELEASES

Figure F-8 illustrates the potential combustion behaviors for the bubble slurry releases modeled by Pacific Northwest National Laboratory (Attachment B) with a normal air atmosphere, a bubble slurry thickness of 0.5 m, and a slurry void fraction of 0.6. In this model the release rate is not constant, as assumed in the RSA. To make a valid comparison between the RSA results and the Pacific Northwest National Laboratory results, Pacific Northwest National Laboratory reported the cumulative release volume as a function of time. This allowed the instantaneous average release rate to be computed as a function of volume released. The results are plotted in Figure F-8. As a release progresses in the RSA model, the instantaneous conditions move horizontally across the flammability maps from left to right at a constant release rate. In the Attachment B bubble slurry release analysis, the rate of release decreases with time. Therefore,

as the bubble slurry release progresses, the instantaneous conditions slide down the bubble slurry release curves from upper left to lower right.

Figure F-8 shows that for the bubble slurry releases described in Attachment B, the headspace concentrations computed with the well-mixed headspace model are never flammable. For the 6 m diameter release area, however, the peak %LFL in a well-mixed headspace is very close to 100 percent. The model predicts that this case exceeds the LFL for a short time if the waste height is a little above 11.68 m (460 in.). At that height, however, the HEPA filter would not fail if an ignition source occurred during this short time. Above about 12.06 m (475 in.), the model predicts that the HEPA filter could fail because of a well-mixed headspace burn from a 6 m diameter release if an ignition event occurred at the right time. For all of the bubble slurry release cases, there is some time when the models predict that flammable plumes may form that, if ignited, could fail the HEPA filter. As noted earlier, however, the plume model is not applicable to waste heights above 11.68 m (460 in.). For these cases, only the well-mixed analysis is representative of potential headspace combustion behavior.

Figure F-10 shows that if the initial headspace oxygen concentration is 4% because of the addition of nitrogen diluent, for all release areas there is some time when flammable plumes may form that, if ignited, could fail the HEPA filter. Headspace inerting is not effective at reducing risk from the bubble slurry releases hypothesized in Attachment B.

The results from the analysis in Attachment B may be conservative and overestimate release rates and volumes from bubble slurry releases. The RSA conservatively underestimates the release rates and volumes necessary to form mixtures that could potentially threaten HEPA filter integrity. Taken together, the true potential for a bubble slurry release to form plumes that, if ignited, could potentially fail the HEPA filter, is probably much less than implied by Figure F-10, but the potential cannot be dismissed.

F4.8 COMBUSTION BEHAVIORS FOR CRUST-DISSOLUTION RELEASES

Figures F-7 and F-9 show the potential combustion behaviors with a normal air atmosphere and a waste height of 11.68 m (460 in.) for the crust dissolution cases analyzed in Attachment A. Figure F-11 shows the potential combustion behaviors if the headspace is inerted with nitrogen. In the crust dissolution scenarios, the gas release is computed to be linearly proportional to the amount of water injected below the crust. The model in Attachment A assumes that there is negligible time delay between the addition of water and the release of gas. Therefore, the rate of gas release from the crust is modeled as directly proportional to the rate of water injection. Because the rate of water injection is assumed constant, the crust-dissolution release scenarios match the constant gas-release rate assumption used in the RSA combustion models.

The crust dissolution scenario results shown in Figures F-7, F-9, and F-11 are for a dissolution ratio of 0.2. That is, 3.8 L (1 gal) of water is assumed to release the gas retained in 19.0 L (5 gal) of crust. For the "no reservoir" cases, it is assumed that there is no limit to the water injected below the crust, so all of the gas retained in the crust is eventually released. The total amount of gas in the crust depends on the assumed void fraction in the crust. For the cases with a limit to the amount of water that could be inadvertently injected below the crust, the amount of crust that can be dissolved is limited, so the total release volumes are proportionately reduced. For all of

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the crust dissolution scenarios, the assumed void fractions are so high and the dissolution ratio so low that the crust volume reduction from gas release is always computed to be greater than the volume of water added. The results reported here are for a constant waste height, which is conservative compared to the conditions actually described in Attachment A.

For very large releases ($\sim 283 \text{ m}^3$ [$10,000 \text{ ft}^3$]) the peak well-mixed concentration is almost linearly proportional to the release rate. This may not be readily evident from Figures F-1 through F-9 because of the log-log scales. Because the release rate is proportional to the water-injection rate, reducing the injection rate proportionately reduces the peak well-mixed %LFL value for very large releases.

For a waste height of 11.68 m (460 in.), air in the headspace, and the release-gas composition shown in Figure F-7, all of the cases with no limit to the water addition are computed to form flammable well-mixed headspace mixtures. Burns in these mixtures would fail the HEPA filter. Most of the cases would potentially also cause more severe structural damage.

If there is no limit to the water addition, an extrapolation of the results in Figure F-7 indicates that the water-injection rate must be limited to less than $\sim 76 \text{ L/min}$ (20 gal/min) for a $11.33 \text{ m}^3/\text{min}$ ($400 \text{ ft}^3/\text{min}$) ventilation system to effectively prevent any of the scenarios from forming a flammable well-mixed headspace. If the injection rate is limited to 265 L/min (70 gal/min), an $11.33 \text{ m}^3/\text{min}$ ($400 \text{ ft}^3/\text{min}$) ventilation system does not prevent the potential for burns resulting in HEPA failure for any of the assumed crust void-fraction values. Figure F-9 shows that if the ventilation rate is increased to $17.0 \text{ m}^3/\text{min}$ ($600 \text{ ft}^3/\text{min}$) in addition to the 265 L/min (70 gal/min) water-injection-rate limit, HEPA failure may not occur if the crust void fraction is less than 60 percent. Benign burns that do not fail the HEPA filter may potentially occur under these conditions, however.

If the total amount of water addition is limited to 6814 L (1,800 gal) and the water injection rate is limited to 265 L/min (70 gal/min), then the scenarios with crust void fractions of 0.5 and 0.6 do not create flammable conditions. For the case with a 0.7 crust void fraction, these water-addition limits are not sufficient to eliminate the potential for a flammable well-mixed headspace that, if ignited, could fail the HEPA filter. Figure F-9 shows that this is true even if, in addition to limiting water addition, the ventilation rate is increased to $17.0 \text{ m}^3/\text{min}$ ($600 \text{ ft}^3/\text{min}$).

Comparing Figure F-7 with Figures F-4, F-5, and F-6 illustrates that if the waste level reaches 12.07 m (475 in.), the water-addition amount and rate limits will not prevent the 0.6 void-fraction case from potentially failing the HEPA filter. At 12.45 m (490 in.), the HEPA filter could potentially be failed by a burn in a well-mixed headspace if the average crust void fraction was ~ 0.53 .

Figure F-11 shows the crust dissolution cases if the headspace is initially inerted with sufficient nitrogen to reduce the oxygen concentration to 4 percent. All of the release endpoints (that is, the conditions at the end of the release duration) are outside of the region for plume burns with a potential to fail the HEPA filter. However, horizontal arrows indicating the path taken to reach the endpoints are shown in Figure F-11 to emphasize that for a time during some releases there is a potential for plume burns that may fail the HEPA filter. Inerting is not computed to eliminate the potential for burns leading to HEPA failure when the water addition rate is limited to 265 L/min (70 gal/min) if the average crust void fraction is greater than ~ 0.63 .

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F5.0 CONSEQUENCES

The RSA code was used to compute the dose consequences that would result from each of the Pacific Northwest National Laboratory crust-release scenarios, as well as for the 113 m³ and 269.8 m³ releases analyzed in the existing AB. Comparing the consequences computed by the RSA code for the 113 m³ and 269.8 m³ releases against those listed in the AB documents provides a "calibration" for how the computed consequences are affected by the different accident-analysis methodologies.

The RSA code produces several metrics for evaluating the consequences and risk associated with an accident. The metrics of note here are the mean dose-consequence value, the 95% dose consequence value, the comparison to REGs, and the expected risk. The mean dose-consequence value is the average or most likely dose consequence for tank conditions that are computed to result in a combustion accident with a non-zero frequency. Because several input parameters have very large uncertainty about their true values, the range of potential values for the dose consequences is large, often several orders of magnitude. Therefore, the 95% dose-consequence value is important for estimating how much the dose-consequence values for individual runs in the code may vary from the most likely value. The 95% value is a standard metric for a value with very high confidence that it would not be exceeded in an actual event. The 95% value is approximately equal to the "2-sigma" confidence level in normal statistical analyses. Zero-consequence values for runs that are computed to remain nonflammable are not included in the determination of the mean and 95% consequence values.

The value reported by the RSA code as "REG comparison" is the percentage of the results that fall below the REGs. The mean and 95% dose-consequence values do not account for the computed frequency that the doses may occur. High-consequence events may not exceed REGs if they are sufficiently unlikely. The REG-comparison value incorporates the frequency (probability) information and represents a confidence level that the event consequences would not exceed the REGs. The REG-comparison value includes those cases computed to have no dose consequences.

If a particular type of accident occurs once every 10 years, and the radiological-dose consequence of such an accident is 1 rem, then the average annual risk from this type of accident is $(1 \text{ rem/accident}) \times (1 \text{ accident}/10 \text{ years}) = 0.1 \text{ rem/year}$. This is also called the "expected risk" for this type of accident. The total expected risk is the sum of the expected risk from all types of accidents. The RSA computes a statistical estimate of the total annual risk from flammable-gas accidents, based on the frequency and consequence information for all of the individual runs in an analysis. Expected risk values may show different trends than the dose-consequence values, because they incorporate the results of runs computed to have no dose consequences. The expected risk numbers are most useful for comparing values between different cases to see how much the different tank conditions affect the annual risk.

F5.1 COMPARISON TO AUTHORIZATION BASIS CASES

Version 2.1 of the RSA code was used to compute the radiological and toxicological consequences of burns resulting from the bubble slurry and crust-dissolution scenarios described in Attachment B. The code also was used to evaluate two deterministic accidents included in the current AB. The consequences computed with the RSA methodology were compared to the consequences computed with the AB methodology to determine how similar or different the results are for the two methodologies.

Table F-1 summarizes the results of the comparisons between the AB and the RSA methodology. For the first case, a release of 269.8 m³ of gas is released in 300 s with the height of the waste equal to 10.54 m (415 in.). In the second case, the volume of gas released was 113 m³, with all other conditions equal to the first case. For these two cases, the composition of the released gas was set equal to the “conservatively estimated” composition in the mixer-pump safety assessment (LANL 1996). For the third case, the pre-mixer-pump conditions in SY-101 were evaluated using the gas composition and waste property data in the pedigreed database of the RSA (Barton et al. 1999). In the third case, the gas-release amount was not fixed at a single value. Instead, a distribution of release amounts and frequencies were determined from the BD GRE model in the RSA.

Several observations can be made from Table F-1. First, the mean and 95th percentile dose-consequence values computed with the BD GRE model of the RSA are larger than those computed for the 113 m³ and 269.8 m³ releases. This is because the BD model has a lognormal distribution of release amounts, and some releases “out on the tail” of the distribution are larger than 270 m³. Neither of the AB releases is computed to be potentially detonable, but about 10% of the releases analyzed with the BD GRE model are potentially detonable. The consequences of a detonation are computed to be larger than the consequences of a burn, so the mean and 95th percentile dose consequences are higher for the BD GRE model than for the other two cases. The 95th percentile value of ~15 rem for onsite radiological dose consequence computed for the RSA base case is very close to the value of 17 rem computed in the AB analysis.

A second observation from Table F-1 is that the expected-risk value for spontaneous events computed with the BD GRE model is 2 to 4 orders of magnitude larger than when computed with the AB releases. One reason for this result is the larger dose-consequence values for the BD GRE model. Another reason is that conservation of generated gas requires that the release frequencies be small for large and constant release amounts used in the AB cases. The distribution of release amounts in the BD GRE model results in many runs being analyzed with smaller but more frequent releases. Frequent releases that can potentially fail the HEPA filter contribute substantially to the expected risk values.

A third observation from Table F-1 is that for spontaneous events, less than 5% of the computed results for all three cases exceed the REGs. This indicates with high confidence that the risk from pre-mixer-pump conditions in SY-101 met the REGs, even if the risk was determined to be

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Table F-1. Comparison of the Consequences of Burns in the Refined Safety-Analysis Code Base Case and the Authorization-Basis Case.

BASE CASE COMPARISONS	AB case: 269.8 m ³ , 300 s	AB case: 113 m ³ , 300 s	RSA base case (pre-mixer pump)
gas composition	LANL mixer pump SA	LANL mixer pump SA	Pedigreed Database
on-site rad dose, mean, rem	1.49	1.28	7.53
on-site rad dose, 95%ile, rem	4.42	4.9	15.3
on-site expected risk, spontaneous events, rem/year	1.05 E-04	7.64 E-03	1.52 E+00
on-site expected risk, induced events, rem/year	9.82 E-02	1.87 E-01	3.75 E-02
on-site REG comparison, spontaneous event (% below REG)	98.2	98.3	96.2
on-site REG comparison, induced event (% below REG)	91.9	91.2	98.5
off-site rad dose, mean, rem	3.16 E-03	2.42 E-03	4.08 E-02
off-site rad dose, 95%ile, rem	5.11 E-03	6.10 E-03	4.21 E-02
off-site expected risk, spontaneous events, rem/year	1.65 E-07	1.77 E-05	4.82 E-03
off-site expected risk, induced events, rem/year	2.06 E-04	3.49 E-04	9.69 E-05
off-site REG comparison, spontaneous event (% below REG)	100	99.9	99.6
off-site REG comparison, induced event (% below REG)	99.8	99.8	99.9
on-site tox, mean, spontaneous events, fraction of guidelines	34.3	50.4	715
on-site tox, 95%ile, spontaneous events, fraction of guidelines	110	137	3410
off-site tox, mean, spontaneous events, fraction of guidelines	0.31	0.647	33.1
off-site tox, 95%tile, spontaneous events, fraction of guidelines	0.746	1.03	115
on-site tox, mean, induced events, fraction of guidelines	268	326	963
on-site tox, 95%ile, induced events, fraction of guidelines	832	1070	3350
off-site tox, mean, induced events, fraction of guidelines	4.88	8.26	34.7
off-site tox, 95%tile, induced events, fraction of guidelines	7.51	11.8	157
For all cases:			
waste height = 10.54 m (415 in.)			
ventilation rate = 485 ft ³ /min			
normal air in headspace			

unacceptably high. For all three cases, less than 10 percent of the events induced by waste-intrusive operations were computed to exceed the REGs. Note that the BD model of the RSA predicts higher confidence that the risk from induced releases does not exceed REGs. This is because the BD GRE model is comparatively sophisticated in predicting that the risk from induced GREs is less shortly after a spontaneous event than shortly before a spontaneous event. This type of analysis is not possible for cases with a fixed GRE release amount. The simplified analysis for the AB cases is thus more conservative and predicts a higher potential for waste-disturbing operations to induce releases. For all three cases, the confidence is greater than 99.5 percent that the REGs for offsite risk are met for both spontaneous and induced events.

Figures F-12 and F-13, respectively, show the onsite and offsite results of the dose-consequence calculations for the RSA base case. The red stair-stepped line across the top of the figure is the REG. Two clusters of points can be seen in the figures. The larger cluster (with black points), mostly in the range of 10^{-3} to 10^{-6} events per year, are those events computed to be induced by seismic events. No black points appear at a frequency higher than 10^{-2} /year because the analysis assumes a zero probability that earthquakes more frequent, and thus less energetic, than the "100-year earthquake" can induce GREs. The smaller cluster of blue points are those events computed to occur spontaneously because of BD GREs. These occur mostly in the range of 5 events/year to 1 event/10 years, but spontaneous events are computed to occur with frequencies as low as 10^{-6} /year and less. Scattered throughout the figures are red points of operations-induced events.

Finally, Table F-1 indicates with high confidence that the toxicological dose consequences of the analyzed cases are greater than the guidelines. The toxicological consequences computed for the risk safety-analysis base case are higher than for the AB cases for the same reason as discussed above for why the radiological consequences also are greater.

F5.2 CONSEQUENCES FOR CRUST-DISSOLUTION SCENARIOS

Tables F-2 through F-5 present the consequence results computed for the crust-dissolution scenarios described in Attachment A. The results in Table F-2 were computed with the assumptions of normal air in the headspace and $11.33 \text{ m}^3/\text{min}$ ($400 \text{ ft}^3/\text{min}$) of ventilation. For Table F-3 the ventilation rate was increased to $17.0 \text{ m}^3/\text{min}$ ($600 \text{ ft}^3/\text{min}$). Tables F-4 and F-5 assume $11.33 \text{ m}^3/\text{min}$ ($400 \text{ ft}^3/\text{min}$) and $17.0 \text{ m}^3/\text{min}$ ($600 \text{ ft}^3/\text{min}$), respectively, of ventilation in a headspace with sufficient N_2 added to reduce the ambient O_2 concentration to 4 percent. All of the results reported in Tables F-2 through F-5 are for a waste height of 11.68 m (460 in.).

Table F-2 shows that for the "uncontrolled" cases of 757 L/min (200 gal/min) water addition and no limit to the amount of water that can be added, the mean onsite radiological-dose consequence is ~4 rem. The 95th percentile values for radiological-dose consequences are ~16 rem for the best-estimate void-fraction value of 0.6 and the optimistic value of 0.5, and ~13 rem for the pessimistic value of 0.7. These 95th percentile values compare favorably with the value of 17 rem in the AB analysis. Table F-2 indicates that the dose consequences will be reduced by

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Figure F-12. Onsite Radiological Consequences.

AF Base Case for SY-101
Tank: SY-101 Output Date: 04/23/1999 11:34:08 AM

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Figure F-13. Offsite Radiological Consequences.

Table F-2. Consequence Results for the Crust-Dissolution Cases with Air and 11.33 m³/min (400 ft³/min).

CRUST DISSOLUTION CASES: air + 400 ft³/min												
water addition rate, gal/min	200	no limit	200	no limit	200	no limit	70	no limit	70	no limit	70	70
reservoir size, gal	no limit	0.7	3.55	12.7	7.31 E-04	6.32 E-04	9.86 E-04	8.47 E-04	8.47 E-05	2.24 E-04	2.07 E-04	0
crust void fraction	no limit	0.7	3.55	12.7	7.31 E-04	6.32 E-04	9.86 E-04	8.47 E-04	8.47 E-05	2.24 E-04	2.07 E-04	0
on-site rad dose, mean, rem	no limit	0.7	3.55	12.7	7.31 E-04	6.32 E-04	9.86 E-04	8.47 E-04	8.47 E-05	2.24 E-04	2.07 E-04	0
on-site rad dose, 95%ile, rem	no limit	0.7	3.55	12.7	7.31 E-04	6.32 E-04	9.86 E-04	8.47 E-04	8.47 E-05	2.24 E-04	2.07 E-04	0
on-site expected risk, spontaneous events, rem /year	no limit	0.7	3.55	12.7	7.31 E-04	6.32 E-04	9.86 E-04	8.47 E-04	8.47 E-05	2.24 E-04	2.07 E-04	0
on-site expected risk, induced events, rem /year	no limit	0.7	3.55	12.7	7.31 E-04	6.32 E-04	9.86 E-04	8.47 E-04	8.47 E-05	2.24 E-04	2.07 E-04	0
on-site REG comparison, spontaneous event (% below REG)	no limit	0.7	3.55	12.7	7.31 E-04	6.32 E-04	9.86 E-04	8.47 E-04	8.47 E-05	2.24 E-04	2.07 E-04	0
on-site REG comparison, induced event (% below REG)	no limit	0.7	3.55	12.7	7.31 E-04	6.32 E-04	9.86 E-04	8.47 E-04	8.47 E-05	2.24 E-04	2.07 E-04	0
off-site rad dose, mean, rem	no limit	0.7	3.55	12.7	7.31 E-04	6.32 E-04	9.86 E-04	8.47 E-04	8.47 E-05	2.24 E-04	2.07 E-04	0
off-site rad dose, 95%ile, rem	no limit	0.7	3.55	12.7	7.31 E-04	6.32 E-04	9.86 E-04	8.47 E-04	8.47 E-05	2.24 E-04	2.07 E-04	0
off-site expected risk, spontaneous events, rem /year	no limit	0.7	3.55	12.7	7.31 E-04	6.32 E-04	9.86 E-04	8.47 E-04	8.47 E-05	2.24 E-04	2.07 E-04	0
off-site expected risk, induced events, rem /year	no limit	0.7	3.55	12.7	7.31 E-04	6.32 E-04	9.86 E-04	8.47 E-04	8.47 E-05	2.24 E-04	2.07 E-04	0
off-site REG comparison, spontaneous event (% below REG)	no limit	0.7	3.55	12.7	7.31 E-04	6.32 E-04	9.86 E-04	8.47 E-04	8.47 E-05	2.24 E-04	2.07 E-04	0
off-site REG comparison, induced event (% below REG)	no limit	0.7	3.55	12.7	7.31 E-04	6.32 E-04	9.86 E-04	8.47 E-04	8.47 E-05	2.24 E-04	2.07 E-04	0
on-site tox, mean, spontaneous events, fraction of guidelines	no limit	0.7	3.55	12.7	7.31 E-04	6.32 E-04	9.86 E-04	8.47 E-04	8.47 E-05	2.24 E-04	2.07 E-04	0
on-site tox, 95%ile, spontaneous events, fraction of guidelines	no limit	0.7	3.55	12.7	7.31 E-04	6.32 E-04	9.86 E-04	8.47 E-04	8.47 E-05	2.24 E-04	2.07 E-04	0
off-site tox, mean, spontaneous events, fraction of guidelines	no limit	0.7	3.55	12.7	7.31 E-04	6.32 E-04	9.86 E-04	8.47 E-04	8.47 E-05	2.24 E-04	2.07 E-04	0
off-site tox, 95%ile, spontaneous events, fraction of guidelines	no limit	0.7	3.55	12.7	7.31 E-04	6.32 E-04	9.86 E-04	8.47 E-04	8.47 E-05	2.24 E-04	2.07 E-04	0
on-site tox, mean, induced events, fraction of guidelines	no limit	0.7	3.55	12.7	7.31 E-04	6.32 E-04	9.86 E-04	8.47 E-04	8.47 E-05	2.24 E-04	2.07 E-04	0
on-site tox, 95%ile, induced events, fraction of guidelines	no limit	0.7	3.55	12.7	7.31 E-04	6.32 E-04	9.86 E-04	8.47 E-04	8.47 E-05	2.24 E-04	2.07 E-04	0
off-site tox, mean, induced events, fraction of guidelines	no limit	0.7	3.55	12.7	7.31 E-04	6.32 E-04	9.86 E-04	8.47 E-04	8.47 E-05	2.24 E-04	2.07 E-04	0
off-site tox, 95%ile, induced events, fraction of guidelines	no limit	0.7	3.55	12.7	7.31 E-04	6.32 E-04	9.86 E-04	8.47 E-04	8.47 E-05	2.24 E-04	2.07 E-04	0
For all cases:												
normal air in headspace	no limit	0.7	3.55	12.7	7.31 E-04	6.32 E-04	9.86 E-04	8.47 E-04	8.47 E-05	2.24 E-04	2.07 E-04	0
ventilation rate = 600 ft ³ /min	no limit	0.7	3.55	12.7	7.31 E-04	6.32 E-04	9.86 E-04	8.47 E-04	8.47 E-05	2.24 E-04	2.07 E-04	0
waste height = 11.68 m (460 in.)	no limit	0.7	3.55	12.7	7.31 E-04	6.32 E-04	9.86 E-04	8.47 E-04	8.47 E-05	2.24 E-04	2.07 E-04	0

Table F-3. Consequence Results for the Crust-Dissolution Cases with Air and 17.0 m³/min (600 ft³/min).

CRUST DISSOLUTION CASES: air + 600 ft ³ /min													
water addition rate, gal/min	200	200	200	200	200	200	200	200	200	200	200	200	200
reservoir size, gal	no limit	no limit	no limit	no limit	no limit	no limit	no limit	no limit	no limit	no limit	no limit	no limit	no limit
crust void fraction	0.7	0.6	0.5	0.7	0.6	0.5	0.7	0.6	0.5	0.7	0.6	0.5	0.5
on-site rad dose, mean, rem	3.71	4.03	2.67	4.54	0.892	0	1.07	0	0	1.07	0	0	0
on-site rad dose, 95%ile, rem	13.2	17.1	9.19	16.2	3.77	0	4.11	0	0	4.11	0	0	0
on-site expected risk, spontaneous events, rem/year	7.62 E-04	6.68 E-04	3.27 E-04	9.29 E-04	7.40 E-05	0	1.86 E-04	0	0	1.86 E-04	0	0	0
on-site expected risk, induced events, rem/year	5.77 E-01	6.05 E-01	3.50 E-01	7.05 E-01	1.27 E-01	0	1.66 E-01	0	0	1.66 E-01	0	0	0
on-site REG comparison, spontaneous event (% below REG)	97.8	97.4	98.5	97.4	99.4	100	99.2	100	100	99.2	100	100	100
on-site REG comparison, induced event (% below REG)	79.6	78.4	84	78.2	89.9	100	90.3	100	100	90.3	100	100	100
off-site rad dose, mean, rem	6.62 E-03	6.17 E-03	4.16 E-03	6.62 E-03	8.14 E-04	0	1.07 E-03	0	0	1.07 E-03	0	0	0
off-site rad dose, 95%ile, rem	1.64 E-02	1.68 E-02	8.33 E-03	1.64 E-02	2.41 E-03	0	2.71 E-03	0	0	2.71 E-03	0	0	0
off-site expected risk, spontaneous events, rem/year	1.78 E-06	7.95 E-07	3.91 E-07	1.78 E-06	5.39 E-08	0	1.16 E-07	0	0	1.16 E-07	0	0	0
off-site expected risk, induced events, rem/year	8.20 E-04	8.04 E-04	5.30 E-04	8.23 E-04	1.20 E-04	0	1.54 E-04	0	0	1.54 E-04	0	0	0
off-site REG comparison, spontaneous event (% below REG)	100	100	100	100	100	100	100	100	100	100	100	100	100
off-site REG comparison, induced event (% below REG)	99.3	99.4	99.8	99.3	100	100	100	100	100	100	100	100	100
on-site tox, mean, spontaneous events, fraction of guidelines	103	105	60.1	126	17.8	0	18.8	0	0	18.8	0	0	0
on-site tox, 95%ile, spontaneous events, fraction of guidelines	319	364	203	386	87	0	88.6	0	0	88.6	0	0	0
off-site tox, mean, spontaneous events, fraction of guidelines	0.976	0.844	0.395	0.976	0.0865	0	0.0912	0	0	0.0912	0	0	0
off-site tox, 95%ile, spontaneous events, fraction of guidelines	2.48	2.56	1.17	2.48	0.312	0	0.345	0	0	0.345	0	0	0
on-site tox, mean, induced events, fraction of guidelines	1170	1410	864	1430	218	0	216	0	0	216	0	0	0
on-site tox, 95%ile, induced events, fraction of guidelines	3920	4910	2710	4850	1190	0	1210	0	0	1210	0	0	0
off-site tox, mean, induced events, fraction of guidelines	23.7	23.4	12.1	23.7	2.23	0	2.33	0	0	2.33	0	0	0
off-site tox, 95%ile, induced events, fraction of guidelines	62.4	57.6	25.8	62.9	8.28	0	7.69	0	0	7.69	0	0	0
For all cases:													
normal air in headspace													
ventilation rate = 600 ft ³ /min													
waste height = 11.68 m (460 in.)													

Table F-4. Consequence Results for the Crust-Dissolution Cases with Inerting and 11.33 m³/min (400 ft³/min).

CRUST DISSOLUTION CASES: inerting + 400 ft ³ /min													
water addition rate, gal/min	200	200	200	70	70	70	70	70	70	70	70	70	70
reservoir size, gal	no limit	no limit	no limit	no limit	no limit	no limit	no limit	no limit	no limit	no limit	no limit	1800 gal	1800 gal
crust void fraction	0.7	0.6	0.5	0.7	0.6	0.5	0.7	0.6	0.5	0.7	0.6	0.6	0.5
on-site rad dose, mean, rem	0.295	0.295	0.295	0.295	0	0	0.295	0	0	0.295	0	0	0
on-site rad dose, 95%ile, rem	0.606	0.606	0.606	0.606	0	0	0.606	0	0	0.606	0	0	0
on-site expected risk, spontaneous events, rem/year	6.87 E-05	6.84 E-05	6.84 E-05	6.82 E-05	0	0	6.82 E-05	0	0	6.82 E-05	0	0	0
on-site expected risk, induced events, rem/year	1.77 E-02	1.77 E-02	1.77 E-02	3.64 E-03	0	0	3.64 E-03	0	0	3.64 E-03	0	0	0
on-site REG comparison, spontaneous event (% below REG)	99.4	99.4	99.4	99.4	100	100	99.4	100	100	99.4	100	100	100
on-site REG comparison, induced event (% below REG)	97.8	97.8	97.8	98.6	100	100	98.6	100	100	98.6	100	100	100
off-site rad dose, mean, rem	2.51 E-04	2.51 E-04	2.51 E-04	2.51 E-04	0	0	2.51 E-04	0	0	2.51 E-04	0	0	0
off-site rad dose, 95%ile, rem	3.28 E-04	3.28 E-04	3.28 E-04	3.28 E-04	0	0	3.28 E-04	0	0	3.28 E-04	0	0	0
off-site expected risk, spontaneous events, rem/year	4.89 E-08	4.87 E-08	4.87 E-08	4.85 E-08	0	0	4.85 E-08	0	0	4.85 E-08	0	0	0
off-site expected risk, induced events, rem/year	1.94 E-05	1.94 E-05	1.94 E-05	3.39 E-06	0	0	3.39 E-06	0	0	3.39 E-06	0	0	0
off-site REG comparison, spontaneous event (% below REG)	100	100	100	100	100	100	100	100	100	100	100	100	100
off-site REG comparison, induced event (% below REG)	100	100	100	100	100	100	100	100	100	100	100	100	100
on-site tox, mean, spontaneous events, fraction of guidelines	7.74	7.63	7.63	7.63	0	0	7.63	0	0	7.63	0	0	0
on-site tox, 95%ile, spontaneous events, fraction of guidelines	19.7	19.3	19.3	19.3	0	0	19.3	0	0	19.3	0	0	0
off-site tox, mean, spontaneous events, fraction of guidelines	0.0366	0.0363	0.0363	0.0363	0	0	0.0363	0	0	0.0363	0	0	0
off-site tox, 95%ile, spontaneous events, fraction of guidelines	0.0594	0.0587	0.0587	0.0587	0	0	0.0587	0	0	0.0587	0	0	0
on-site tox, mean, induced events, fraction of guidelines	41.4	41.4	41.4	22.8	0	0	22.8	0	0	22.8	0	0	0
on-site tox, 95%ile, induced events, fraction of guidelines	84.4	84.4	84.4	55.4	0	0	55.4	0	0	55.4	0	0	0
off-site tox, mean, induced events, fraction of guidelines	0.437	0.437	0.437	0.176	0	0	0.176	0	0	0.176	0	0	0
off-site tox, 95%ile, induced events, fraction of guidelines	1.112	1.112	1.112	0.445	0	0	0.445	0	0	0.445	0	0	0
For all cases:													
waste height = 11.68 m (460 in.)													
ventilation rate = 400 ft ³ /min													
inerting with N ₂ to 4% O ₂ in headspace													

Table F-5. Consequence Results for the Crust-Dissolution Cases with Inerting and 17.0 m³/min (600 ft³/min).

CRUST DISSOLUTION CASES: Inerting + 600 ft ³ /min									
water addition rate, gal/min	200	no limit	200	no limit	200	no limit	70	no limit	70
reservoir size, gal									
crust void fraction	0.7	0.295	0.6	0.295	0.5	0.7	0.6	0.5	0.7
on-site rad dose, mean, rem	0.295	0.295	0.295	0.295	0.295	0.295	0	0	0.295
on-site rad dose, 95%ile, rem	0.606	0.606	0.606	0.606	0.606	0.606	0	0	0.606
on-site expected risk, spontaneous events, rem/year	6.87 E-05	6.84 E-05	6.84 E-05	6.82 E-05	6.84 E-05	6.82 E-05	0	0	6.82 E-05
on-site expected risk, induced events, rem/year	1.77 E-02	1.77 E-02	1.77 E-02	3.64 E-03	1.77 E-02	3.64 E-03	0	0	3.64 E-03
on-site REG comparison, spontaneous event (% below REG)	99.4	99.4	99.4	99.4	99.4	99.4	100	100	99.4
on-site REG comparison, induced event (% below REG)	97.8	97.8	97.8	97.8	97.8	98.6	100	100	98.6
off-site rad dose, mean, rem	2.51 E-04	2.51 E-04	2.51 E-04	2.51 E-04	2.51 E-04	2.51 E-04	0	0	2.51 E-04
off-site rad dose, 95%ile, rem	3.28 E-04	3.28 E-04	3.28 E-04	3.28 E-04	3.28 E-04	3.28 E-04	0	0	3.28 E-04
off-site expected risk, spontaneous events, rem/year	4.89 E-08	4.87 E-08	4.87 E-08	4.85 E-08	4.87 E-08	4.85 E-08	0	0	4.85 E-08
off-site expected risk, induced events, rem/year	1.94 E-05	1.94 E-05	1.94 E-05	3.39 E-06	1.94 E-05	3.39 E-06	0	0	3.39 E-06
off-site REG comparison, spontaneous event (% below REG)	100	100	100	100	100	100	100	100	100
off-site REG comparison, induced event (% below REG)	100	100	100	100	100	100	100	100	100
on-site tox, mean, spontaneous events, fraction of guidelines	7.74	7.63	7.63	7.63	7.63	7.63	0	0	7.63
on-site tox, 95%ile, spontaneous events, fraction of guidelines	19.7	19.3	19.3	19.3	19.3	19.3	0	0	19.3
off-site tox, mean, spontaneous events, fraction of guidelines	0.0366	0.0363	0.0363	0.0363	0.0363	0.0363	0	0	0.0363
off-site tox, 95%ile, spontaneous events, fraction of guidelines	0.0594	0.0587	0.0587	0.0587	0.0587	0.0587	0	0	0.0587
on-site tox, mean, induced events, fraction of guidelines	41.4	41.4	41.4	22.8	41.4	22.8	0	0	22.8
on-site tox, 95%ile, induced events, fraction of guidelines	84.4	84.4	84.4	55.4	84.4	55.4	0	0	55.4
off-site tox, mean, induced events, fraction of guidelines	0.437	0.437	0.437	0.176	0.437	0.176	0	0	0.176
off-site tox, 95%ile, induced events, fraction of guidelines	1.112	1.112	1.112	0.445	1.112	0.445	0	0	0.445
For all cases:									
waste height = 11.68 m (460 in.)									
ventilation rate = 600 ft ³ /min									
inerting with N ₂ to 4% O ₂ in headspace									

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about a factor of 3 to 4 if the water-injection rate is controlled to 265 L/min (70 gal/min). If the amount of water that can be added is controlled by a surge tank to be no more than 6814 L (1,800 gal), there are no dose consequences computed for the 0.5 and 0.6 void-fraction cases. Figure F-7 shows that these two cases do not form flammable mixtures. Limiting the water addition to 6814 L (1,800 gal) reduces the consequences for the 0.7 void-fraction case by about a factor of 3 to 4 compared to the unlimited 265 L/min (70 gal/min) case.

For all of the cases in Table F-2 that lead to flammable conditions, the expected risk for spontaneous events is in the range of $\sim 10^{-4}$ to $\sim 10^{-3}$ rem/year. This is comparable to the expected risk computed for spontaneous events in the AB cases of Table F-1. The expected risk from the crust-dissolution scenarios is thus not significantly different from cases within the existing AB. (Note: The crust dissolution values were computed using the same fixed-release-amount model as used for the AB cases in Table F-1. The expected risk value of $\sim 10^0$, computed for the RSA base case, is not a valid comparison because it was computed using the variable-release-amount BD GRE model.) The computed offsite radiological-dose consequences are generally $\sim 1,000$ times less than the computed onsite consequences. For this reason, the offsite expected risk values are $\sim 1,000$ times less than the onsite values.

For spontaneous events, 100 percent of the results for all of the cases had consequences within the offsite REGs. For every case, less than 5 percent of the results were computed to exceed the onsite REGs. These results are virtually the same as the results for the AB and RSA cases in Table F-1.

For induced events, values for expected risk and percentage of points less than REGs cannot be computed without information on the probabilities of intrusive operations inducing plume and well-mixed GREs. The RSA project developed uncertainty distributions for these probabilities, but it is questionable whether these distributions apply to SY-101 crust-release scenarios because of the unique gas-retention and release properties of the SY-101 crust. Therefore, for the analyses reported here, the following log-uniform distributions were used. A log-uniform distribution is uniform across the logarithms of the range of values. The probability distribution for a globally waste-disturbing activity inducing a large well-mixed release ranged between 1/10 and 1/1,000. The probability distribution of a locally waste-disturbing activity inducing a plume release also ranged from 1/10 to 1/1,000. The probability distribution for a globally waste-disturbing activity inducing a plume release varied from 1 to 1/100. The probability distribution for a locally waste-disturbing activity inducing a well-mixed release ranged between 1/100 and 1/10,000.

In other terms, the probability that a globally waste-disturbing activity induces a plume release is anticipated. The probability that a locally waste-disturbing activity induces a well-mixed release is unlikely. The probabilities for a globally waste-disturbing activity inducing a well-mixed release and a locally waste-disturbing activity inducing a plume release straddled the division between anticipated and unlikely. These distributions were assigned arbitrarily, but were considered reasonably conservative for this scoping risk assessment. If one wishes to consider the effect of different distributions, a uniform shift of the distributions up or down an order of magnitude should cause a corresponding shift in the computed expected-risk values for induced events. Changing the frequency of waste-disturbing operations should also cause a

corresponding shift in the computed values. However, administrative controls limiting the frequency of waste-disturbing operations per year will not change the risk *per operation*. With these probability distributions for operations-induced GREs, both the onsite and offsite expected risk values in Table F-2 for induced events are generally $\sim 1,000$ times larger than the corresponding expected-risk value for spontaneous events. The onsite expected risk for induced events in the uncontrolled cases with unlimited water addition at 757 L/min (200 gal/min) is $\sim 6 \times 10^{-1}$ rem/year, and the offsite expected risk is $\sim 8 \times 10^{-4}$. If the water addition rate is limited to 265 L/min (70 gal/min), the expected risk values may be reduced to $\sim 1.5 \times 10^{-1}$ and 2×10^{-4} rem/year, respectively. The control thus reduces expected risk by about a factor of 4. The expected risk values for induced releases with the water-addition rate control are virtually the same as the results for the AB cases in Table F-1. Therefore, the flammable gas risk from operations-induced events is not significantly different from the level already evaluated in the AB.

Comparing Tables F-2 and F-3 reveals that increasing the ventilation rate from 11.33 m³/min (400 ft³/min) to 17.0 m³/min (600 ft³/min) has very little effect on dose consequences, expected risk, and percentage of results below REGs. The only exception to this generalization is that of unlimited water addition at 265 L/min (70 gal/min) if the average void fraction in the crust is 0.5. The increased ventilation is computed to prevent this case from producing flammable conditions. This is shown in Figures F-7 and F-9. The change in ventilation moves the conditions from very marginally able to fail the HEPA filter to very marginally short of the LFL.

Although the effect is small, for the uncontrolled releases the dose values and expected-risk values can be slightly *increased* by an increase in the ventilation rate. This is an artifact of the RSA, where the well-mixed headspace combustion is evaluated for the headspace mixture at end of release, when the release-gas concentration is highest. For tanks at or below capacity, and for release amounts and durations experienced in SY-101, headspace concentrations are always lean. The maximum release-gas concentration is computed to occur at the end of release, when the equivalence ratio is closest to the optimal value of 1. Evaluating the combustion consequences for the mixture at the end of the release is thus conservative for the normal application of the analysis. However, for the large release amounts in the crust-dissolution and bubble slurry release scenarios, when evaluated in the reduced headspace volume of SY-101, the headspace concentration at the end of the release is rich. The code computes that increasing the ventilation rate results in a slight increase in consequences, because a higher ventilation rate results in diluting the mixture closer to the ideal ratio.

The actual consequences of a combustion event are highly dependent on the timing of the ignition event. The RSA calculations do not search for the time of ignition that would produce the maximum consequences, because that point is normally at the end of the release, where the code evaluates combustion consequences. It is important to note that all releases that can form a fuel-rich concentration in the headspace on a well-mixed basis must at some time during the release pass through the ideal concentration. Thus, all cases resulting in rich well-mixed concentrations can potentially have consequences equal to those computed for a stoichiometric headspace composition if the ignition source occurs at the same time as the optimal concentration.

For the crust-dissolution cases with unlimited water addition at 757 L/min (200 gal/min), the code only evaluates the consequences of a well-mixed headspace burn. This is because a well-

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mixed analysis for a flammable headspace results in the largest computed consequences. The releases in the crust-dissolution scenarios are so large that by the end of the releases the computed thicknesses of the stratified layers, based on the model described in Slezak et al. (1998), are greater than the headspace height. When this condition is computed to occur, the range of applicability of the plume model has been exceeded, because recirculation within the headspace must occur but is not included in the plume model. Therefore, the analyses for all 757 L/min (200 gal/min) crust-dissolution cases revert to the well-mixed model.

For the crust-dissolution cases with 265 L/min (70 gal/min) of water addition and no limit to the amount of water that may be inadvertently added, the only difference from the 757 L/min (200 gal/min) scenarios is the rate of release of the gas. The code only evaluated the consequences of a well-mixed headspace burn for these cases. All of the scenarios have combustion consequences that fail the HEPA filter except for the case of 17.0 m³/min (600 ft³/min) ventilation and an average crust-void fraction of 0.5. For this case, the increased ventilation rate, coupled with the smallest release volume and slowest release rate among these scenarios, is able to prevent the well-mixed headspace from reaching flammable conditions.

If the water-addition rate is limited to 265 L/min (70 gal/min) and the total amount of inadvertent water addition is limited to 6814 L (1,800 gal), then flammable conditions are computed to occur only if the average crust-void fraction is 0.7. For the lower void fractions, the rate of release is so slow that a mixing zone does not form, and the release volume is too small to create a flammable well-mixed headspace. If the average crust-void fraction is 0.7, the limited amount of water addition limits the release amount enough to keep the equivalence ratio less than 1 for the flammable well-mixed headspace. For these lean mixtures, the increased ventilation rate decreases the combustion consequences.

Tables F-4 and F-5 show the results for the crust-dissolution scenarios when evaluated with enough nitrogen added to the headspace to reduce the steady-state oxygen concentration to 4 percent. In all cases, the inerting was computed to prevent the headspace from becoming flammable on a well-mixed basis, as shown in Figure F-11. However, as emphasized in Figure F-11, at some time during the releases, five of the cases can form flammable plumes because the release gas is flammable before mixing with the headspace gases. In Tables F-4 and F-5 the consequences reported for these five cases are for the time when 56.6 m³ (2,000 ft³) of gas has been released. Careful study of Tables F-4 and F-5 reveal that, within the range of conditions examined, differences in headspace-ventilation rate and rate of gas release have no impact on the computed results.

Comparing Tables F-4 and F-5 against Tables F-2 and F-3 shows that inerting the headspace can reduce the dose consequence and expected-risk values by one to two orders of magnitude. Inerting affects the computed combustion consequences for plume burns, because the combustion efficiency is reduced. Inerting the tank headspace does not eliminate the potential for local burns, so no further reductions in consequence and risk are practical.

F5.3 BUBBLE SLURRY RELEASE CONSEQUENCES

Table F-6 shows the computed consequences for the bubble slurry releases for several different combinations of conditions. Figures F-8 and F-10 show that the bubble slurry releases can form flammable plumes, but not a flammable well-mixed headspace. The plume-combustion consequences reported in Table F-6 show that inerting the headspace may reduce onsite radiological dose consequences by about a factor of 10, but the expected risk values are reduced by a lesser amount. The radiological dose-consequence and expected-risk values without an inerted headspace are not significantly different from the values already considered by the AB cases shown in Table F-1.

Table F-6. Computed Consequences for the Bubble Slurry Releases.

BUBBLE SLURRY RELEASES													
release hole diameter, m	2	2	4	6	2	2	4	6	2	2	4	6	2
net release amount, ft ³	400	1023	1229	1417	400	1023	1229	1417	400	1023	1229	1417	1023
net release rate, ft ³ /min	1300	444	749	1084	1300	444	749	1084	1300	444	749	1084	444
inerted headspace? (O ₂ = 4%)	no	no	no	no	yes	yes	yes	yes	yes	yes	yes	yes	no
on-site rad dose, mean, rem	1.5	1.49	1.49	1.59	0.255	0.237	0.234	0.418	0.255	0.237	0.234	0.418	1.49
on-site rad dose, 95%ile, rem	6.3	6.25	6.22	5.71	0.764	0.704	0.695	0.599	0.764	0.704	0.695	0.599	6.25
on-site expected risk, spontaneous events, rem/year	4.04 E-04	4.09 E-04	4.12 E-04	1.10 E-03	2.23 E-04	2.11 E-04	2.08 E-04	1.43 E-04	2.23 E-04	2.11 E-04	2.08 E-04	1.43 E-04	4.08 E-04
on-site expected risk, induced events, rem/year	6.75 E-02	7.95 E-02	8.01 E-02	8.79 E-02	1.46 E-02	1.71 E-02	1.71 E-02	2.78 E-02	1.46 E-02	1.71 E-02	1.71 E-02	2.78 E-02	7.69 E-02
on-site REG comparison, spontaneous event (% below REG)	97.6	97.6	97.6	97.6	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	97.6
on-site REG comparison, induced event (% below REG)	90.3	90.1	90.1	90.8	97.6	97.7	97.7	97.8	97.6	97.7	97.7	97.8	90.1
off-site rad dose, mean, rem	2.46 E-03	2.40 E-03	2.39 E-03	2.03 E-03	2.24 E-04	2.11 E-04	2.08 E-04	4.26 E-04	2.24 E-04	2.11 E-04	2.08 E-04	4.26 E-04	2.40 E-03
off-site rad dose, 95%ile, rem	6.68 E-03	6.44 E-03	6.44 E-03	6.02 E-03	4.05 E-04	3.77 E-04	3.74 E-04	1.26 E-03	4.05 E-04	3.77 E-04	3.74 E-04	1.26 E-03	6.48 E-03
off-site expected risk, spontaneous events, rem/year	4.67 E-07	4.63 E-07	4.64 E-07	3.86 E-06	1.02 E-07	9.60 E-08	9.49 E-08	1.39 E-07	1.02 E-07	9.60 E-08	9.49 E-08	1.39 E-07	4.62 E-07
off-site expected risk, induced events, rem/year	8.76 E-05	1.02 E-04	1.03 E-04	1.20 E-04	1.28 E-05	1.46 E-05	1.46 E-05	3.71 E-05	1.28 E-05	1.46 E-05	1.46 E-05	3.71 E-05	9.81 E-05
off-site REG comparison, spontaneous event (% below REG)	100	100	100	100	100	100	100	100	100	100	100	100	100
off-site REG comparison, induced event (% below REG)	99.9	99.9	99.9	99.9	100	100	100	99.9	100	100	100	99.9	99.9
on-site tox, mean, spontaneous events, fraction of guidelines	56	52.3	52.5	52.4	7.44	6.59	6.5	5.96	7.44	6.59	6.5	5.96	52.2
on-site tox, 95%ile, spontaneous events, fraction of guidelines	177	179	182	166	23	20.9	20.7	19.1	23	20.9	20.7	19.1	178
off-site tox, mean, spontaneous events, fraction of guidelines	0.473	0.447	0.447	0.541	0.0338	0.0305	0.0301	0.0264	0.0338	0.0305	0.0301	0.0264	0.446
off-site tox, 95%ile, spontaneous events, fraction of guidelines	1.22	1.21	1.21	1.01	0.0602	0.0561	0.0553	0.0487	0.0602	0.0561	0.0553	0.0487	1.21
on-site tox, mean, induced events, fraction of guidelines	301	309	311	291	43.8	42.3	41.8	39.9	43.8	42.3	41.8	39.9	307
on-site tox, 95%ile, induced events, fraction of guidelines	1080	1120	1120	1080	108	95.4	94.4	83.7	108	95.4	94.4	83.7	1100
off-site tox, mean, induced events, fraction of guidelines	4.8	4.89	4.89	4.8	0.428	0.419	0.414	0.414	0.428	0.419	0.414	0.414	4.86
off-site tox, 95%ile, induced events, fraction of guidelines	9.38	9.94	9.94	9.14	0.87	0.77	0.76	0.76	0.87	0.77	0.76	0.76	9.88
For all cases:													
crust thickness = 2.5 m													
bubble slurry layer thickness = 0.5 m													
bubble slurry yield strength = 50 Pa													
bubble slurry viscosity = 500 Pa-s													
above crust void = 0.25													
bubble slurry void = 0.6													
degassed density = 1700 kg/m ³													
supernatant density = 1500 kg/m ³													
waste height = 11.68 m (460 in.)													
ventilation rate = 400 ft ³ /min													

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F6.0 CONCLUSION

All of the crust dissolution and bubble slurry release scenarios produce dose and risk consequences that are comparable to, or slightly less than, the values computed for large releases evaluated in the current AB. Within the numerical scatter inherent to statistical analyses such as this one, there is high statistical confidence that all of the scenarios considered here have consequences within the current AB.

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F7.0 REFERENCES

- Barton, W. B., J. D. Bingham, and M. A. Kufahl, 1999, *Gas Release Event Safety Analysis Tool Pedigree Database for Hanford Tanks*, HNF-SD-WM-TI-806, Lockheed Martin Hanford Corporation., Richland, Washington.
- Hamilton, D. W., 1996, *A Safety Assessment for Rotary Mode Core Sampling in Flammable Gas Single Shell Tanks, Hanford Site, Richland, Washington*, WHC-SD-WM-SAD-035, Westinghouse Hanford Company, Richland, Washington.
- LANL, 1996, *A Safety Assessment for Proposed Pump Mixing Operations to Mitigate Episodic Gas Releases in Tank 241-SY-101: Hanford Site, Richland, Washington*, LA-UR-92-3196, Rev. 14a, Los Alamos National Laboratory, Los Alamos, New Mexico.
- Slezak, S. E., and D. R. Bratzel, 1998, *Flammable Gas Project Expert Elicitation Results for Hanford Site Double-Shell Tanks*, HNF-2577, prepared by Lockheed Martin Hanford Corporation for Fluor Daniel Hanford, Inc, Richland, Washington.
- Slezak, S. E., D. C. Williams, W. Cheng, F. Gelbard, and D. R. Bratzel, 1998, *Refined Safety Analysis Methodology for Flammable Gas Risk Assessment in the Hanford Site Tanks*, HNF-SD-WM-ES-410, Rev. 2, prepared by DE&S Hanford, Inc., for Fluor Daniel Hanford, Inc., Richland, Washington.

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ATTACHMENT G

**TANK DOME SPACE VOLUME CALCULATION AS A FUNCTION OF WASTE
LEVEL FOR TANK 241-SY-101**

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INTEROFFICE MEMO

LOCKHEED MARTIN

74B40-99-061

From: Models and Inventory
Phone: 373-4098 R2-11
Date: March 30, 1999
Subject: TANK DOME SPACE VOLUME CALCULATION AS FUNCTION OF
WASTE LEVEL FOR TANK 241-SY-101

To: J. M. Grigsby R1-49

cc: LMHC Correspondence Control H7-09
S. A. Barker R2-11
C. DeFigh-Price R2-12
G. D. Johnson S7-73
K. M. Hodgson R2-11 *KMH*
N. W. Kirch R2-11
D. C. Larson L1-01
R. M. Marusich B4-47
R. E. Raymond R2-38
D. A. Reynold R2-11
TAH File/LB

Reference: Tank 241-SY-101 Tank Cross Section Drawing of H-2-37772, Rev. 0.

This letter provides dome space volume calculations as a function of waste levels for tank 241-SY-101 as requested by the tank 241-SY-101 pumping project (Attachment 1). The calculations are based on the tank 241-SY-101 tank cross section drawing (Reference) and were performed in MathCad Version 7 (Copyright © 1997 by MathSoft, Inc.)

Details of the calculations and the chart of dome space volume and volume percent verses waste level is given in Attachment 2.

T. A. Hu

T. A. Hu
Scientist II

tah/mjg

Attachments (2)

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74840-99-061
Attachment 1
Page 1 of 1

Hu, Tachung A (Albert)

From: Grigsby, J M (Mike)
Sent: Monday, March 29, 1999 9:25 AM
To: Hu, Tachung A (Albert); Kirch, Nicholas W (Nick)
Subject: SY-101 headspace volume vs. waste height - chart please

Importance: High

Albert and Nick,

A number of briefings will need to be made to upper management and RL regarding the situation in SY-101 very soon. It is clear talking to mid management that a very helpful prop for our discussions would be a chart that shows available headspace volume vs. waste height in SY-101 and even better would be to include the percent of headspace available compare to the LANL SA assumption of 1216m³ (43043 ft³). That is 100% at 1216m³ and 50% at 608m³.

Could you use your algorithms contained in 74840-99-043 attachment 2 and produce a chart with the above information? It would be really great if I could have it by COB tomorrow, Tuesday March 30th.

Thank you,

Mike Grigsby

74B40-99-061

ATTACHMENT 2

**Consisting of 5 pages
including this cover sheet**

Author ALST Date 3/30/99 Checked by [Signature] Date 3/30/99

Tank SY-101 Dome Space Volume Calculation as Function of Waste Elevation

March 30, 1999 by T A Hu

Reference: Tank 241-SY Tank Cross Section Drawing of H-2-3772

Part I : Tank volume below 422.313 inch

$$H01 := 422.313 \cdot \text{in}$$

$$R1 := 37.5 \text{ ft}$$

$$V1(h) := \left[\pi \cdot R1^2 \cdot (h \cdot \text{in}) \right]$$

$$V1(1) = 368.155 \cdot \text{ft}^3 \quad \text{waste volume per inch}$$

$$V1(422.313) = 1.555 \cdot 10^5 \cdot \text{ft}^3$$

Part II : Tank volume between 422.313 and 460.375 inch

The primary liner has an arc with a radius of 4 feet between the elevation of 422.313 and 460.375 inches.

$$H02 := 460.375 \cdot \text{in}$$

$$r0 := 48 \text{ in}$$

$$R2(h2) := 37.5 \text{ ft} - \left[4 \text{ ft} - \frac{\sqrt{r0^2 - h2^2} \text{ in}}{12 \frac{\text{in}}{\text{ft}}} \right]$$

$$R2(10) = 37.412 \cdot \text{ft}$$

$$V2(h2) := \left(\int_0^{h2} \pi \cdot \frac{R2(h2)^2}{12} dh2 \right) \text{ ft}$$

$$V2(38.0625) = 1.366 \cdot 10^4 \cdot \text{ft}^3$$

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Author ALH Date 7/30/99 Checked by SAF Date 3/30/99

Part III : Tank volume above 460.375 inch to 561.5 inch

The concrete dome, above the tank elevation of 460 inches is a body of revolution formed by an ellipse with a major and minor diameter of 80 and 30 feet respectively.

$$a := 40 \cdot \text{ft} \quad b := 15 \cdot \text{ft} \quad R3(h3) := a \cdot \sqrt{1 - \frac{h3^2}{b^2}}$$

When $h3 = 6.5746 \text{ ft}$ or 78.8952 inch , the diameter is 431.4375 inch at the elevation of 460.375 inch

$$R3(6.5746 \text{ ft}) = 35.953 \cdot \text{ft}$$

$$V3(h3) := \int_{6.5746 \cdot \text{ft}}^{h3 \cdot \text{in}} \pi \cdot R3(h3)^2 \cdot dh3 \quad V3(180) = 1.933 \cdot 10^4 \cdot \text{ft}^3$$

Calculation of Total Tank Volume

$$Vt := V1(422.313) + V2(38.0625) + V3(180) \quad Vt = 1.885 \cdot 10^5 \cdot \text{ft}^3$$

Equations of Domespace Volume

Waste level below 422.313 inch

$$Dsp1(H) := Vt - V1(H)$$

Waste level between 422.313 and 480.325 inch

$$Dsp2(H) := Vt - (V1(422.313) + V2(H - 422.313))$$

Waste level above 480.325 inch

$$Dsp3(H) := Vt - (V1(422.313) + V2(38.0625) + V3(H - 381.41))$$

$$Dsp1(395.3) = 1.216 \cdot 10^3 \cdot \text{m}^3$$

$$Dsp2(430) = 854.352 \cdot \text{m}^3$$

$$Dsp3(470) = 457.409 \cdot \text{m}^3$$

$$Dsp1(410) = 1.063 \cdot 10^3 \cdot \text{m}^3$$

$$Dsp2(440) = 750.936 \cdot \text{m}^3$$

$$Dsp3(490) = 291.594 \cdot \text{m}^3$$

$$Dsp1(420) = 958.529 \cdot \text{m}^3$$

$$Dsp2(450) = 649.367 \cdot \text{m}^3$$

$$Dsp3(500) = 220.247 \cdot \text{m}^3$$

$$Dsp2(460) = 551.083 \cdot \text{m}^3$$

$$Dsp3(520) = 104.333 \cdot \text{m}^3$$

$$Dsp3(540) = 29.008 \cdot \text{m}^3$$

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Author ALV/LS Date 3/7/99 Checked by Radepa Date 3/30/99

Tank SY-101 domespace volume as function of waste level is given as follows.

$$\text{Dsp}(H) := \begin{cases} \text{Dsp1}(H) & \text{if } (H < 422.313) \\ \text{Dsp2}(H) & \text{if } 422.313 < H < 460.375 \\ \text{Dsp3}(H) & \text{otherwise} \end{cases}$$

H := 395.3 - 560

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APPENDIX C

Author acw/15u Date 3/1/98 Checked by Dafayn Date 3/30/97

As function of waste level, domespace volumes in terms of percent of LANL safety analysis volume of 1216 m³.

$V_{dsp} := 1216 \cdot m^3$ (See attachment 1)

$$Dsp\%(H) := \begin{cases} Dsp1(H) \cdot \frac{100}{V_{dsp}} & \text{if } H < 422.313 \\ Dsp2(H) \cdot \frac{100}{V_{dsp}} & \text{if } 422.313 < H < 460.375 \\ Dsp3(H) \cdot \frac{100}{V_{dsp}} & \text{if } H > 460.375 \end{cases}$$

$H := 395.3 - 561.5$

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ATTACHMENT H

PEER REVIEW CHECKLISTS

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Practice 134 290 1112
Publication Date 01Mar99
Attachment 02 - Sheet 1 of 1

FLUOR DANIEL NORTHWEST

TECHNICAL PEER REVIEWS

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: ~~HNF-3737~~ Appendix C
Title: Flammable Gas Calc Note Sec. 1-6⁴, Exec Summary, Attachment D

Author: Numerous

Date:

Scope of Review: Section 1-6⁴ and Exec Summary - full review
Attachment D review based on conclusions of Attachment C and F and judgement.

Yes	No*	NA	
☒	☐	☒	** Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
☒	☐	☐	Problem completely defined.
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☒	☐	☐	Traceability
☒	☐	☐	Document approved (for example, the reviewer affirms the technical accuracy of the document).

Robert M Marusich / Robert Marusich
Reviewer (printed name and signature)

5/11/99
Date

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FLUOR DANIEL NORTHWEST

TECHNICAL PEER REVIEWS

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed:

Title: *Flam Gas Calc Note*

Author: *R. M. Marusich*

Date: *5/10/99*

Scope of Review: *Accident Scenario Section (Section 2)*

Yes No* NA

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Kenneth D. Fein (Kenneth Fein)
Reviewer (printed name and signature)

5/10/99
Date

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FLUOR DANIEL NORTHWEST

TECHNICAL PEER REVIEWS

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed:

Title: *Minimum Elevation of Base of Crust layer*

Author: *PA Meyer*

Date: *5/6/99*

Scope of Review: *General review of method, agreement with results based on past experience and numerical value of results (ie results obviously correct given nature of problem)*

Yes No* NA

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Robert M Marusich / Robert Marusich

Reviewer (printed name and signature)

5/6/99

Date

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See Scope of Review Statement

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TECHNICAL PEER REVIEWS

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: *Attached C*
Title: *Scaling The 113m³ & 245m³ Gas Release into The*
Author: *Dave A. Tank 241-57-101 - FDNW*
Date: *Rm Marcusick*
Scope of Review: *4/29/99*
Attached to HNF-4323² Appendix C

Yes	No	NA	
☒	☐	☐	** Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
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Kenneth O. Fin

Reviewer (printed name and signature)

4/29/99

Date

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Publication Date 01Mar99
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FLUOR DANIEL NORTHWEST

TECHNICAL PEER REVIEWS

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: "Summary of Findings" Scott Slezak's input
Title: to the Calculation Note (Attachment F Combustion
Author: S. Slezak, Sandia Behaviors & Base Cause(s))
Date:
Scope of Review: See Attached

Yes No* NA

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Robert M Marusich / Robert Marusich

Reviewer (printed name and signature)

4/29/99

Date

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FLUOR DANIEL NORTHWEST, INC.

DESIGN ANALYSIS

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Client	WO/Job No.	
Subject	101-87 Combustion	Date
Calculations		By
Location		Checked
		By
		Revised
		By

Peer Review Calculations on the "Use of the Refined Safety Analysis method to determine combustion behavior and dose consequences for tank 101-87" by S. Slezacek Sandia Nat'l Laboratory.

1. pg 2 plume burns, mixing layer burns, stratified layer burns are covered in Slezacek 1998 a reviewed and approved report.
2. Assertion that gas flow into the dome at $100 \text{ ft}^3/\text{min}$ will not result in a flammable concentration until about 5000 ft^3 total is released. The hydrogen concentration in the tank dome V_H/V is found from the following (when V_H at $t=0$ is 0)

$$\frac{V_H}{V} = \frac{\dot{V}_{in,H}}{\dot{V}_{in} + \dot{V}_v} \left[1 - \exp\left(-\frac{\dot{V}_{in} + \dot{V}_v}{V} t\right) \right]$$

$\dot{V}_{in,H}$ = volumetric flow rate of hydrogen into the tank, m^3/s

$\dot{V}_{in}$ = volumetric flow rate of gas into the tank, m^3/s
= $100 \text{ ft}^3/\text{min}$ or $0.047 \text{ m}^3/\text{s}$

BD-8002-142 (12/98)

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Subject	Date	By
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$$\dot{V}_v = \text{ventilation flow rate, m}^3/\text{s}$$

$$= 400 \text{ cfm} = 0.19 \text{ m}^3/\text{s}$$

$$V = \text{dome volume, m}^3 = 793 \text{ m}^3 \text{ at present}$$

$$\dot{V}_H = 0.4 \dot{V}_{in} \text{ per document.}$$

$$t = 2332 \text{ s for } V_H/V = 0.04$$

$$= 39 \text{ min}$$

$$\text{at } 100 \text{ ft}^3/\text{min} = 3900 \text{ ft}^3$$

If $\dot{V}_{in}$ is not accounted for $t = 2161 \text{ s}$
 $= 36 \text{ min}$
 $= 3600 \text{ ft}^3 \text{ released.}$

Level at 793 m^3 is 434 in

Figure 2 at 430 in. shows 490 reached at
 $3600 \text{ ft}^3 \text{ released}$

Results confirmed.

3. pg 7 Effect of volume change.

a) use the calculation above for 490 in. waste

$$490 \text{ in} = 292 \text{ m}^3$$

$$t = 921 \text{ s} = 15 \text{ min}$$

$$= 1500 \text{ ft}^3 \text{ gas flow in}$$

$$t = 796 \text{ s} = 13 \text{ min if } \dot{V}_{in} \text{ not considered}$$

$$\text{code gets } = 1300 \text{ ft}^3 \text{ gas flow in}$$

$$1000 \text{ ft}^3 \text{ close enough.}$$

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FLUOR DANIEL NORTHWEST, INC.

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	Checked	By
Location	Revised	By

- b) 113 and 297m³ scaling calculation shows that the pressure is the same in a smaller volume if the concentration is the same.

Volume at 430m = 793m³

Volume at 490m = 292m³

edge of well mixed burns with HEPN failure is

4000 ft³ at 430m.
1000 ft³ at 490

$$\frac{292}{793} = 2.7$$

so by the scaling model, well mixed burns with HEP A failure ~~edge~~ would be 1500 ft³. Code get 1000 ft³ - conservative

Code confirmed to be reasonable and conservative.

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Location	Revised	By

pg 7 effect of gas composition

Case 1

40% H_2
35% N_2
20% N_2O
5% NH_3

Case 2

36.7% H_2
29% N_2
21% N_2O
12% NH_3
1.3% CH_4

Use the Mixer Pump SA (LANL 1996) equation
B-3 and B-4 to find the equivalent fuel.

$$\eta = \frac{F(N_2O)}{F(H_2) + 1.5F(NH_3) + 4F(CH_4)}$$

$$\text{Fuel} = F(H_2)[1.35\eta + (1-\eta)] + \\ F(NH_3)[1.84\eta + 1.32(1-\eta)] + \\ F(CH_4)[4.71\eta + 3.32(1-\eta)]$$

where $F(x)$ = fraction of x in the gas

Case 1 $\eta = 0.42$

Case 2 $\eta = 0.35$

Case 1 Fuel = $0.46 + 0.077 = 0.537$

Case 2 Fuel = $0.412 + 0.18 + 0.049 = 0.641$

The fuel content of Case 2 is 1.14 times that of Case 1.
gas growth at edge of well mixed burner

Case 1 2500 ft³
Case 2 2300 ft³

difference is 1.09

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edge of plume burns with HEPA failure

Case 1 350 ft³

Case 2 290 ft³ difference is 1.2

code values confirmed.

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TECHNICAL PEER REVIEWS

CHECKLIST FOR TECHNICAL PEER REVIEW

Attachment B

Document Reviewed:

Title: Potential Gas Release by Bubble Slurry Flow

Author: PA Meyer, C. Stewart, R T Altemann

Date: 5/6/98

Scope of Review: Detailed check + Independent calculation (See below)

Yes No* NA

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Robert M Marusich / Robert M Marusich

Reviewer (printed name and signature)

5/6/99

Date

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This document was checked thoroughly with the exception of the spreadsheet. The spreadsheet was run to verify the results, but the equations within the spreadsheet were not checked (next page)

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checklist for Technical Peer Review
(continued)

The derivations were checked. The results were checked using a simplified model (See attached) and were found to be reasonable.

END

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Subject	Date	By
	Checked	By
Location	Revised	By

Peer Review Check of Bubble Slurry Flow results

The proposed model in Attachment B is modelled by the equation below (from Bird, Stewart and Lightfoot, "Transport Phenomena")

For flow out of a circular disk containing a hole in the center due to squeezing pressure the flow is given by:

$$Q = \frac{4\pi b^3 p}{3\mu \ln \frac{r_2}{r_1}}$$

where Q = volumetric flow rate, m^3/s

b = half width of gap, m

p = squeezing pressure, Pa

μ = viscosity of fluid

= 1500 Pa-s per PNL-10682, "In situ Determination of Rheological Properties and Void Fraction in Hanford Waste Tank 241-SY-101", CW Stewart et al.

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DESIGN ANALYSIS

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Condition of Crust

bubble slurry layer can be 0.5m to 1m thick

assume average void fraction of 0.45

(based on 0.3 at top of bubble slurry
and 0.6 at bottom from PNNL-12033

"In Situ Void Fraction and Gas Volume
in Tank 101-57 as measured by the UFI")

Solids Fraction = 0.15 per Attachment A
of Calc Note to which this
is attached.

Liquid Fraction = 0.4

Density of liquid 1500 kg/m³
PNNL-11536 Rev 1 "Gas Retention and
Release Behavior in Hanford DSTs"
has 1600 for post-mixed conditions in
Tank 101-57. Less solids in the
premixed case so use 1500

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Density of ~~kg~~ Solids 2300 kg/m^3 based
on density of sodium salts.

Crust height $= 2 \text{ m}$

$$\rho_{\text{bubble slurry}} = 0.4(1500) + 0.15(2300) + 0.45(0) \\ = 945 \text{ kg/m}^3$$

$$\rho_{\text{degassed slurry}} = \frac{0.4(1500) + 0.15(2300)}{0.55} = 1718 \frac{\text{kg}}{\text{m}^3}$$

Tank radius (r_2) $= 11.4 \text{ m}$

radius of opening $= 0.64 \text{ m}$ based on
water lance diameter. Model
not very sensitive to hole diameter.

ΔP across opening

$$[(\rho_{\text{lig}} g h_{\text{crust}})] - [\rho_{\text{degass}} g h_{\text{degass}} + \rho_{\text{slurry}} g h_{\text{slurry}}]$$

$$\left. \begin{array}{l} h_{\text{crust}} = 2 \text{ m} \\ \rho_{\text{lig}} = 1500 \text{ kg/m}^3 \end{array} \right\} \text{hydrostatic pressure of liquid from below}$$

$h_{\text{degass}} = 0.5 \text{ m}$ assume that the bubble
slurry comes up opening and loses its

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gas in the upper 0.5m The rest of
the opening contains bubble slurry
at a density of ρ_{slurry}

let b = half thickness of bubble
slurry layer

$1m$ = crust thickness above bubble
slurry

then

$$\Delta P = (1+2b)(\rho_{\text{lig}} g) - [0.5g\rho_{\text{degass}} + 0.5g\rho_{\text{slurry}} + 2bg\rho_{\text{slurry}}]$$

as bubble slurry flows out " b " is
reduced. The Gas out = $Q(0.45)$

The equations were put into a spreadsheet

Results

<u>t, min</u>	<u>total Gas out, m^3</u> <u>1m bubble slurry layer</u> <u>this Spreadsheet</u>		<u>0.5m layer</u> <u>Spreadsheet</u>	
		<u>Att. B</u>		<u>Att. B</u>
0	0	0	0	0
1	19	19.3	4.5	11
5	57	71	18	27
10	78	113	28	31

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Attachment B used a viscosity of 500 Pa-s
Not 1500 Pa-s

changing that in the spread sheet yields
(for the 1.0 m layer)

t min		Att. B
0	0	0
1	44	19
5	91	71
10	110	113

The results are reasonably close given the
differences in the modelling.

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APPENDIX C

Practice 134 290 1112
Publication Date 01Mar99
Attachment 02 - Sheet 1 of 1

FLUOR DANIEL NORTHWEST

TECHNICAL PEER REVIEWS

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed:

Title:

Author:

Date:

Potential Gas Release From Water Addition Attachment A
C W Stewart
5/6/99

Scope of Review:

Detailed review of chapter 4-6, Simplified
Calculation to verify results of chapt 3, 4 (See Attached)

Yes No* NA

☐ ☐ ☒ **

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

☒ ☐ ☐

Problem completely defined.

☒ ☐ ☐

Accident scenarios developed in a clear and logical manner.

☒ ☐ ☐

Necessary assumptions explicitly stated and supported.

☐ ☐ ☒

Computer codes and data files documented.

☒ ☐ ☐

Data used in calculations explicitly stated in document.

☒ ☐ ☐

Data checked for consistency with original source information as applicable.

☒ ☐ ☒ (see)

Mathematical derivations checked including dimensional consistency of results.

☒ ☐ ☐ Scope

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

☐ ☐ ☒ (See)

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

☒ ☐ ☐

Software input correct and consistent with document reviewed.

☒ ☐ ☐

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

☐ ☐ ☒

Limits/criteria/guidelines applied to analysis results are appropriate and referenced.

☐ ☐ ☒

Limits/criteria/guidelines checked against references.

☒ ☐ ☐

Safety margins consistent with good engineering practices.

☒ ☐ ☐

Conclusions consistent with analytical results and applicable limits.

☒ ☐ ☐

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

☐ ☐ ☒

Format consistent with applicable guides or other standards.

☒ ☐ ☐ **

Review calculations, comments, and/or notes are attached.

☐ ☐ ☒

Traceability

☒ ☐ ☐

Document approved (for example, the reviewer affirms the technical accuracy of the document).

Robert M Marusich / Robert M Marusich

Reviewer (printed name and signature)

5/6/99

Date

* All "no" responses must be explained below or on an additional sheet.

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

NUCLEAR ENGINEERING

Attachment A.1-1

FLUOR DANIEL NORTHWEST, INC.

DESIGN ANALYSIS

Calc. No. _____
Revision _____
Page No. 2 of 3

Client	WO/Job No.	
Subject	Date	By
	Checked	By
Location	Revised	By

Gas Release Due to Dilution

Assume water can be loaded with chemicals to the point that it has the same concentration as the present liquid. The concentration of the present liquid is given in Table 2-1 of the Mixer Pump Safety Assessment.

<u>Component</u>	<u>amount in Tank</u>	<u>g/L</u>
NaOH	3.22M	129
NaAlO ₂	1.9M	156
NaNO ₂	3.28M	226
NaNO ₃	4.23M	340
Na ₂ CO ₃	0.6M	64
Na ₂ SO ₄	0.12M	17
Na ₃ PO ₄	0.19M	31
		<u>963g</u>

There are 3.78L in a gallon. So 1 gallon of tank waste can hold 3640g of chemical constituents.

Assume a solids volume fraction beneath the crust of 0.2. Assume a void fraction of 0.5. The liquid fraction is 0.3.

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DESIGN ANALYSIS

Calc. No. _____
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Client	WO/Job No.	
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	Checked	By
Location	Revised	By

Take 1 gallon of beneath-the-crust waste.

In this 1 gallon is 0.3 gallons of liquid
0.5 gallons of gas
0.2 gallons of solid

The density of sodium salts is about 2.1 g/cm^3
or 7938 g/gallon .

Assume 1 gallon of water mixes with 1 gallon of waste. Within the 1 gallon of waste is 0.2 gallons of solids or 1588 g of solids.

The liquid can dissolve 3640 g of solids as chemicals. So 1 gallon of water can dissolve the solids in 2.29 gallons of waste.

Doing this liberates 1.14 gallons of gas or 0.15 ft^3 of gas; 70 gallons/min will liberate $10 \text{ ft}^3/\text{min}$ of gas per this model. Stewart's model gives $90 \text{ ft}^3/\text{min}$.

Using the expansion factor of 1.3 (pressure beneath the crust is 1.3 atm). Then we get 13 scfm of gas per 70 gpm water assuming that the water loads to its max. concentration before liberating gas. If the water absorbs

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DESIGN ANALYSIS

Calc. No. _____
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$\frac{1}{7}$ of the solids before releasing gas then
the release rate is 91scfm / 70gpm
which is what Stewart gets.

The value $\frac{1}{7}$ or 7 is a dilution factor.
It represents the fact that the solid will
go into solution but the final solution
will not be as concentrated. If there
were a solution to the problem of
"what is the minimum amount of water
needed to release gas", this would be a
better way to approach the problem. Since
I do not know of any, use of dilution factors
seems reasonable.

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APPENDIX D

RESERVED FOR FUTURE USE

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APPENDIX E

**CALCULATION OF POSTULATED AMMONIA CONCENTRATIONS DURING
TANK 241-SY-101 REMEDIATION ACTIVITIES AND OPERATIONS**

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LIST OF TERMS

ISC	Industrial Source Complex
LANL	Los Alamos National Laboratory
MMA	mechanical mitigation arm
PEL-TWA	permissible exposure limit–time-weighted average
RDF	reduction factor

APPENDIX E

E1.0 INTRODUCTION

Gases trapped in the 241-SY-101 waste include ammonia, which is a toxic gas. The potential exists for ammonia releases during transfers or other 241-SY-101 mitigation activities. Ammonia release calculations are made for three accident scenarios: 1) release due to mechanical mitigation arm release operation, 2) bubble slurry release due to water lancing and 3) release of ammonia from a transfer that releases gas to the headspace of 241-SY-102.

E2.0 METHODOLOGY

E2.1 DERIVATION OF RELATIVE CONCENTRATIONS

The concentration at the receptor is given by:

$$C = (Q') (X/Q') \quad (E-1)$$

Where

C = concentration at the receptor (mg/m^3)
 Q' = release rate of the material (mg/s)
 (X/Q') = atmospheric dispersion coefficient (s/m^3)

For the flow out the stack

$$Q' = V' C_s \quad (E-2)$$

Where

V' = volumetric flow rate out of the stack
 C_s = concentration at the stack

Substituting Equation 2 into Equation 1

$$C = V' C_s (X/Q') \text{ or} \quad (E-3)$$

$$C/C_s = V'(X/Q') \quad (E-4)$$

The reduction factor (RDF) is the stack concentration divided by the receptor concentration or:

$$\text{RDF} = C_s / C = 1/[V'(X/Q')] \quad (E-5)$$

E2.2 ATMOSPHERIC DISPERSION COEFFICIENTS (X/Q')

The GXQ computer code (WHC-SD-GN-SWD-30002) was used for the calculation. A stack release was modeled using the following assumptions:

- Stack height 3.38 m (11 ft 1 in.)
- Stack diameter 0.206 m (8.125 in.)
- ISC-2 plume rise model
- Volumetric flow 0.401 m³/s (850 cfm)
- Receptor height is 2 m (6.569 ft)
- No buildings are located near the stack
- No rain protector on top of the stack

The 101-SY primary ventilation stack has a height of 13 ft 2 in. and an inside diameter of 8 in. and the backup stack has a height of 11 ft 1 in. and an inside diameter of 8-1/8 in.. The dimensions for the backup stack will be assumed in this analysis, as the shorter, slightly wider stack will produce less dispersion. The ventilation flows are 866 cfm for the primary stack and 935 cfm for the backup stack. The assumed flow of 850 cfm is less than the flow in either stack. The assumed conditions therefore bound both stacks.

Calculations for X/Q's for a ground level release are given in WHC-SD-WM-SARR-016. The peak X/Q' at 100 m is 0.0341 s/m³.

The Industrial Source Complex (ISC) plume rise model (EPA, 1992) was implemented in GXQ to include buoyancy and momentum rise models for the stack release. The gas temperature is assumed to be the same temperature as the air, so no credit for rise due to buoyancy is included. The ventilation flow in the stack will result in the plume continuing to rise after leaving the stack due to momentum, which decreases the concentration at the onsite receptor. The GXQ output for this run is shown in Appendix E.1. Calculations were made for all 16 sectors for several distances. The X/Q' are shown in Table E-1. The peak X/Q' was 1.49×10^{-3} s/m³. For a flow of 850 cfm (0.401 m³/s), the reduction factor is 1670.

NRC Regulatory Guide 1.145 indicates that for a stack release, fumigation conditions should be evaluated for a release in which short term concentrations are a factor. Fumigation is a short duration condition that occurs shortly after sunrise. The warming of the ground results in a temperature profile that moves slowly up and traps releases. Much of the plume rise effects are negated. The condition only last for up to 30 minutes but since we are concerned about peak ammonia concentration, it appears non-conservative to neglect this effect. GXQ does not explicitly model fumigation effects. However, an examination of the models used in GXQ

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indicates GXQ will use NRC Regulatory Guide 1.145 fumigation equations if the outputs are adjusted correctly. These adjustments include activating the toggle for the building wake model, and setting the mixing layer height equal to the effective stack height. The effective stack height was calculated by running GXQ in a mode that gives detailed information including effective stack height with the meteorology set equal to the conditions that produce the highest X/Q (2.65 m/s, Class E stability) at 100 m. This calculation showed an effective stack height of 6.18 m. The fumigation calculation was made with the plume rise model turned off, and the mixing height and initial plume height set equal to 6.18 m. The X/Q's with fumigation effects are also shown in Table E-1 and the computer outputs are shown in Attachment E-1. The peak X/Q' with fumigation is $1.50 \times 10^{-2} \text{ s/m}^3$ and RDF for this condition is about 166.

Table E-1. X/Qs at 100 m Receptor for Stack Releases.

Sector	X/Q without fumigation s/m^3	X/Q with fumigation s/m^3
S	1.41 E-03	1.11 E-02
SSW	1.29 E-03	9.29 E-03
SW	1.25 E-03	9.62 E-03
WSW	1.25 E-03	9.62 E-03
W	1.41 E-03	1.28 E-02
WNW	1.41 E-03	1.12 E-02
NW	1.42 E-03	1.18 E-02
NNW	1.44 E-03	1.16 E-02
N	1.43 E-03	1.33 E-02
NNE	1.24 E-03	9.60 E-03
NE	1.39 E-03	1.00 E-02
ENE	1.44 E-03	1.08 E-02
E	1.49 E-03	1.50 E-02*
ESE	1.49 E-03*	1.33 E-02
SE	1.49 E-03	1.30 E-02
SSE	1.42 E-03	1.10 E-02
Reduction Factor**	1670	166

* Peak X/Q'

** Reduction factor = $1 / (\text{Peak X/Q}' \times 0.401 \text{ m}^3/\text{s flow})$

E2.3 COMPARISON TO LOS ALAMOS NATIONAL LABORATORY MIXER PUMP CALCULATION

The LANL mixer pump Safety Assessment (LA-UR-92-3196) calculated a peak X/Q' of 0.0018 s/m^3 for the stack releases. The GXQ value without fumigation is about 17% lower than the LANL value, but 17% is well within the uncertainties in the calculation especially since slightly different dimensions were assumed. LANL does not appear to have included fumigation effects.

E2.4 RISK GUIDELINES

Risk Guidelines for the ammonia gas are (AIHA 1998):

ERPG-1	=	25 ppm for anticipated events
ERPG-2	=	200 ppm for unlikely events
ERPG-3	=	1000 ppm for extremely unlikely events

E3.0 AMMONIA CONCENTRATION COMPARISON TO RISK GUIDELINES

E3.1 SOURCE TERM

E3.1.1 Release Due to Operation of the Mechanical Mitigation Arm

The peak ammonia concentration at the stack was assumed to be 850 ppm (see Hedengren 1999a).

E3.1.2 Release Due to Bubble Slurry Flow from a Hole in the Crust

The peak ammonia concentration at the stack was calculated to be 3400 ppm (see Mahoney et al. 1999).

E3.1.3 Transfer of 241-SY-101 Waste to 241-SY-102

The worst case peak ammonia concentration of the stack from releases during the transfer of waste from 241-SY-101 to 241-SY-102 is 14902 ppm for the transfer (see Hedengren 1999b and Hedengren 1999c). This is a conservative case which includes contributions from 241-SY-101, 241-SY-102 and 241-SY-103.

E3.1.4 Transfer of 241-SY-101 Waste to 241-SY-102 – No Drop Leg

The peak ammonia concentration in the dome space with no drop leg is 62,300 ppm (Hedengren 1999c). Stack concentrations are calculated in Section E3.2.4.

E3.2 ACCIDENT EVALUATIONS

E3.2.1 MMA Operation

E3.2.1.1 Unmitigated. The worst case conditions for the mechanical mitigation arm (MMA) assume a ground level release. The reduction factor a ground level release is 73. The peak concentration is $850/73.1 = 11.6$ ppm. This below the ERPG-1 of 25 ppm and is also below the permissible exposure limit–time-weighted average (PEL-TWA) of 25 ppm which is based on a weekly exposure.

E3.2.1.2 MMA – Mitigated. Since the MMA mitigated is below the risk guideline, no mitigation is required. The effect of the stack, even with fumigation conditions would reduce the 100-m concentration to $850/166 = 5.1$ ppm.

E3.2.2 Release due to Bubble Slurry Flow

E3.2.2.1 Unmitigated. The peak ammonia concentration in the stack was calculated to be 3400 ppm (see Mahoney et al. 1999). The concentration assuming a ground level release is $3400/73.1$ is 46.5 ppm. This level is above the 25 ppm anticipated event limit.

E3.2.2.2 Bubble Slurry Flow Mitigated. The presence of the stack is a mitigating factor. Taking credit for the stack, the reduction factor is 166 assuming fumigation conditions. The onsite concentration is therefore reduced to $3400/166 = 20.5$ ppm. The mitigated case is under the 25 ppm limit.

E3.2.3 Ammonia Release Caused by Transfer of 241-SY-101 Waste to 241-SY-102

E3.2.3.1 Unmitigated. The ammonia concentration related to transfer for a ground level release is $14902/73.1 = 204$ ppm. This is above the anticipated guideline of 25 ppm as well as the unlikely guideline of 200 ppm.

E3.2.3.2 Transfer- Mitigated. The transfer concentration for a release from the stack is $14902/166 = 89.8$ which is still above the guideline for anticipated events (25 ppm). An ammonia monitor will however respond if levels start to reach significant levels. A dedicated operator monitors this transfer which will reduce operator response time. Monitoring and shutdown will prevent high concentrations of ammonia to the 100 m receptor.

The mitigated accident includes the stack and the ammonia monitor as mitigating features.

E3.2.4 Ammonia Release Assuming Transfer of 241-SY-101 Waste to 241-SY-102 With No Drop Leg

E3.2.4.1 Unmitigated. The ammonia concentration for a transfer without the drop leg or other controls is shown in Table E-2. The concentration with crust dissolution in 241-SY-101 was taken from Hedengren (1999b, page C-7). The ammonia concentration in the tank headspace in 24-SY-102 due to evaporation from transferred waste is taken from Hedengren (1999c). A gas release event (GRE) in 241-SY-103 is also assumed. The concentration from the GRE in 101-SY-103 was taken from Hedengren (1999b, Table C-7). The stack concentrations were calculated assuming a 450 cfm ventilation flow from 241-SY-101 and a 200-cfm flow from both 241-SY-102 and 241-SY-103. The total stack flow from the three tanks is directed through the stack (850 cfm). Concentrations were calculated assuming a ground level release. The total ammonia concentration is 355 ppm at the 100-m receptor, which is above the anticipated guideline of 25 ppm.

Table E-2. Unmitigated Ammonia Concentrations During Waste Transfer.

Source tank	Release Mechanism	Peak Dome Concentration (ppm)	Peak Stack Concentration (ppm)	Peak Concentration at 100 m-Ground Level Release (ppm)
241-SY-101	Crust Dissolution	20,700	11,000	150
241-SY-102	Evaporation from transferred waste	62,300	14,700	201
241-SY-103	GRE	850	200	2.7
Total	--	--	25,900	354

E3.2.4.2 Mitigated. The release from the stack with controls is shown in Table E-3. The dome and stack concentrations for 241-SY-101 from crust dissolution is the same as with no controls but the onsite concentration is less since credit is taken for the stack. The ammonia concentrations in 241-SY-101 and 241-SY-102 is given as a function of time in Hedengren (1999d, Table 1). The ammonia concentration at the time of the peak 241-SY-101 concentration is assumed for 241-SY-102. Ammonia concentrations at the receptor with and without fumigation were calculated assuming reduction factors of 166 and 1670, respectively. Peak concentrations are below guidelines with no fumigation but exceed guidelines under fumigation conditions (for an anticipated event frequency).

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Table E-3. Mitigated Ammonia Concentrations During Waste Transfer.

Source tank	Release Mechanism	Peak Dome Concentration (ppm)	Peak Stack Concentration ppm	Peak Concentration at 100 m- no fumigation (ppm)	Peak Concentration at 100 m - with Fumigation (ppm)
241-SY-101	Crust Dissolution	20,700	11,000	6.6	66
241-SY-102	Evaporation from transferred waste	11,100	2,612	1.6	16
241-SY-103	GRE	850	200	0.12	1.2
Total	--	--	13,812	8.3	83

E3.3 EFFECT OF INCREASED DISTANCE

Calculations were made assuming fumigation for distances out to 500 m. The X/Qs and reduction factors are shown in Table E-4. Also shown are the peak concentrations for the transfer related releases.

Table E-4. X/Qs and Reduction Factors as a Function of Distance with Fumigation.

Distance (m)	X/Q(s/m ³)	Reduction factor for flow 0.401 m ³ /s	Concentration Transfer (ppm)
100	1.50 E-02	166	89.8
200	8.14 E-03	306	48.6
300	5.65 E-03	441	33.8
400	4.36 E-03	572	26.1
500	3.57 E-03	699	21.3

E4.0 WORKER SAFETY ISSUES

E4.1 MMA OPERATION

Calculation of concentrations close to a stack (inside 100 m) is a difficult problem since the equations normally used for plume modeling are not valid close to the source. The LANL mixer pump analysis (LA-UR-92-3196) was examined to see if the calculation could be applied to this case. LANL used a computer code called GASFLOW (Travis and Wilson, 1989) and calculated an exclusion radius of 9-m around the stack to assure that levels were below 500 ppm for the

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largest release. The concentration is proportional to the release rate. The largest mass release rate given in the LANL report is 11.2 g/s (Table D-3, Case 1a). The equivalent release rate to produce a 25 ppm concentration at the 9 m boundary would be $(11.2 \text{ g/s}) (25/500) = 0.56 \text{ g/s}$.

The MMA case assumes a release 850 ppm at a flow of 850 cfm. Converting ppm to mg/m^3 assuming STP conditions

$$\text{mg/m}^3 = \frac{\text{ppm} \times (\text{MW g/mole})}{(22.4 \text{ L/mole})}$$

The conversion between ppm and mg/m^3 depends on temperatures and pressures. Standard temperature and pressure are assumed in this analysis.

The molecular weight for ammonia is 17, so this conversion factor is $0.759 \text{ mg/m}^3/\text{ppm}$.

$$Q' = (850 \text{ ppm}) (0.759 \text{ mg/m}^3/\text{ppm}) (850 \text{ cfm}) (4.72 \times 10^{-4} \text{ m}^3/\text{s/cfm})$$

$$Q' = 260 \text{ mg/s} = 0.26 \text{ g/s}$$

Since the release rate for this case is less than 0.56 g/s, a 9-m exclusion zone would be conservative relative to the 25-ppm limit. This limit is conservative since the LANL calculation assumes a rain deflector, which would tend to deflect the gas flow downward.

E4.2 BUBBLE SLURRY CALCULATIONS

The calculations in section 3.2 indicate that the bubble slurry flow induced ammonia concentration at 100 m is below 25 ppm with controls. Concentrations inside 100 m are potentially higher than 25 ppm. A stack-monitoring limit of 1000 ppm has been instituted for the 241-SY tank farm operation. Based on the calculations described in Section E4.1, a 9-m exclusion diameter appears acceptable if the ammonia concentrations in the stack are less than 1000 ppm. If stack levels exceed 1000 ppm, evacuation of workers at greater distances than currently specified by procedures may be required. Ammonia has a strong, irritating odor and it is highly likely that significant releases of ammonia would be detected by the workers prior to concentrations reaching dangerous levels. Thus, ammonia releases would be detected by the stack monitors and workers themselves prior to reaching dangerous levels.

E4.3 TRANSFER OPERATIONS

The same considerations apply to the transfer operations as apply to bubble slurry releases, that is as long as concentrations at the stack are below 1000 ppm, the exclusion distance recommended for the MMA is appropriate. If concentrations exceed 1000 ppm, larger exclusion distances than currently required by procedures may be needed.

E5.0 REFERENCES

- AIHA, 1998, *Emergency Response Planning Guidelines*, American Industrial Hygiene Association, Akron, Ohio.
- EPA, 1992, *User's Guide for the Industrial Source Complex Dispersion Model, Volume 1 Users Instruction*, United States Environmental Protection Agency, Research Triangle Park, North Carolina.
- Hedengren, D. C., 1999a, Letter Number 9952980, Memo to P. L. Bartley, *Ammonia Releases from a 12 foot Diameter Surface Hole in the Crust of Double Shell Tank 241-SY-101*, Lockheed Martin Hanford Corporation, Richland, Washington.
- Hedengren, D. C., 1999b, Letter Number 74B40-99-079, Memo to N. W. Kirch, *Ammonia Concentrations at SY Tank Farm Stack and Downwind of the Stack for Transfers of Waste From Tank 241-SY-101 to Tank 241-SY-102*, Lockheed Martin Hanford Corporation, Richland, Washington.
- Hedengren, D. C., 1999c, Letter Number 74B40-99-081, Memo to N. W. Kirch, *Predicted Ammonia Concentrations for Transfer of Waste from Tank 241-SY-101 to Tank 241-SY-102 for No Dilution in Tank SY-101 and No Drop Leg in Tank SY-102*, Lockheed Martin Hanford Corporation, Richland, Washington.
- Hedengren, D. C., 1999d, Letter Number 74B40-99-092, Memo to N. W. Kirch, *Ammonia Concentrations at SY Tank Farm Stack From Transfer of Waste from Tank 241-SY-101 to Tank 241-SY-102*, Lockheed Martin Hanford Corporation, Richland, Washington.
- Mahoney, L. A., P. A. Meyers and C. W. Stewart, 1999, *Ammonia Releases from a Bubble Slurry Flow Through a Hole in the Crust Layer in SY-101*, Pacific Northwest National Laboratory, TWS99.35, Richland Washington.
- LA-UR-92-3196, 1996, *A Safety Assessment for Proposed Pump Mixing Operations To Mitigate Episodic Gas Releases in Tank 241-SY-101: Hanford Site, Richland Washington*, Rev. 14a, Los Alamos National Laboratory, Los Alamos, New Mexico.
- NRC Regulatory Guide 1.145, 1976, *Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants*, U.S. Nuclear Regulatory Commission, Washington D.C.
- Travis, J. R., and T. L. Wilson, 1993, *GASFLOW: The Theoretical Model to Analyze Accidents in Nuclear Containments, Confinements, and Facility Buildings*, Fourth International Conference on Simulation Methods in Nuclear Engineering, Montreal, Canada.
- WHC-SD-GN-SWD-30002, 1999, *GXQ Program Users' Guide*, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

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WHC-SD-WM-SARR-011, 1996, *Toxic Chemical Considerations for Tank Farm Releases*, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

WHC-SD-WM-SARR-016, 1996, *Tank Waste Compositions and Atmospheric Dispersion Coefficients for Use in Safety Analysis Consequence Assessments*, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

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ATTACHMENT E1

GXQ OUTPUT FILES

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ATTACHMENT E1

GXQ OUTPUT FILES

Current Input File Name: twrstck2mr1.IN

"

"

GXQ Version 4.0
December 19, 1994

General Purpose Atmospheric Dispersion Code
Produced by Westinghouse Hanford Company

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.

Code Custodian is: Brit E. Hey
Westinghouse Hanford Company
P.O. Box 1970
Richland, WA 99352
(509) 376-2921

Run Date = 06/08/99
Run Time = 16:15:45.30

INPUT ECHO:

TWRS 101SY 99.5% river bd M 3.38m stack 8.125 inch diameter ISC model, 2 m receptor

c GXQ Version 4.0 Input File

c mode

1

c

c MODE CHOICE:

c mode = 1 then X/Q based on Hanford site specific meteorology

c mode = 2 then X/Q based on atmospheric stability class and wind speed

c mode = 3 then X/Q plot file is created

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop

T F F F F F

c ifox = t then joint frequency used to compute frequency to exceed X/Q

c = f then joint frequency used to compute annual average X/Q

c inorm = t then joint frequency data is normalized (as in GENII)

c = f then joint frequency data is un-normalized

c icdf = t then cumulative distribution file created (CDF.OUT)

c = f then no cumulative distribution file created

c ichk = t then X/Q parameter print option turned on

c = f then no parameter print

c isite = t then X/Q based on joint frequency data for all 16 sectors

c = f then X/Q based on joint frequency data of individual sectors

c ipop = t then X/Q is population weighted

c = f then no population weighting

c

HNF-3737 REV 1 APPENDIX E

```

c X/Q AND WIND SPEED ADJUSTMENT MODELS:
c  ipuff idep isrc iwind
c    0    0    0    0
c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:
c  iwake ipm  iflow ientr
c    0    0    1    0
c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:
c  (irise igrnd)iwash igrav
c    2    0    0    0
c ipuff = 1 then X/Q calculated using puff model
c      = 0 then X/Q calculated using default continuous plume model
c idep  = 1 then plume depletion model turned on (Chamberlain model)
c isrc  = 1 then X/Q multiplied by scalar
c      = 2 then X/Q adjusted by wind speed function
c iwind = 1 then wind speed corrected for plume height
c iwake = 1 then NRC RG 1.145 building wake model turned on
c      = 2 then MACCS virtual distance building wake model turned on
c ipm   = 1 then NRC RG 1.145 plume meander model turned on
c      = 2 then 5th Power Law plume meander model turned on
c      = 3 then sector average model turned on
c iflow = 1 then sigmas adjusted for volume flow rate
c ientr = 1 then method of Pasquill used to account for entrainment
c irise = 1 then MACCS buoyant plume rise model turned on
c      = 2 then ISC2 momentum/buoyancy plume rise model turned on
c igrnd = 1 then Mills buoyant plume rise modification for ground effects
c iwash = 1 then stack downwash model turned on
c igrav = 1 then gravitational settling model turned on
c      = 0 unless specified otherwise, 0 turns model off
c
c PARAMETER INPUT:
c
c      release      reference      frequency
c      height      anemometer      to
c      hs(m)       height          exceed
c                   ha(m)          hm(m)          Cx(%)
c
c      3.38000E+00  1.00000E+01      1.00000E+03      5.00000E-01
c
c      initial      initial      release      deposition      gravitational
c      plume        plume        duration    velocity        settling
c      width        height      trd(hr)     velocity        velocity
c      Wb(m)        Hb(m)          vd(m/s)     vg(m/s)
c
c      0.00000E+00  0.00000E+00      0.00000E+00      1.00000E-03      1.00000E-03
c
c      ambient      initial      initial      release      convective
c      temperature  plume        plume        diameter    heat release
c      Tamb(C)      temperature  flow rate    d(m)         rate(1)
c                   T0(C)         V0(m3/s)     qh(w)
c
c      2.00000E+01  2.00000E+01      4.01000E-01      2.06000E-01      0.00000E+00
c
c (1) If zero then buoyant flux based on plume/ambient temperature difference.
c
c      X/Q          Wind
c      scaling      Speed
c      factor       Exponent
c      c(?)         a(?)

```

HNF-3737 REV 1 APPENDIX E

```

c      1.00000E+00      7.80000E-01
c
c RECEPTOR DEPENDENT DATA (no line limit)
c FOR MODE      make      RECEPTOR DEPENDENT DATA
c 1 (site specific)      sector distance receptor-height
c 2 (by class & wind speed) class windspeed distance offset receptor-height
c 3 (create plot file)      class windspeed xmax imax ymax jmax xqmin power
c
c RECEPTOR PARAMETER DESCRIPTION
c sector = 0, 1, 2... (all, S, SSW, etc.)
c distance = receptor distance (m)
c receptor height = height of receptor (m)
c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
c windspeed = anemometer wind speed (m/s)
c offset = offset from plume centerline (m)
c xmax = maximum distance to plot or calculate to (m)
c imax = distance intervals
c ymax = maximum offset to plot (m)
c jmax = offset intervals
c xqmin = minimum scaled X/Q to calculate
c power = exponent in power function step size

```

MODE:

Site specific X/Q calculated.

LOGICAL CHOICES:

Joint frequency used to calculate X/Q based on frequency of exceedance.
No normalization of joint frequency.
X/Q calculated for single sector.

MODELS SELECTED:

Flow adjustment model.
ISC2 momentum/buoyancy plume model based on temperature difference.
Default Gaussian plume model selected.

WARNING/ERROR MESSAGES:

WARNING #10 - X/Q may be underestimated for plume rise scenario without
accounting for entrainment.

JOINT FREQUENCY DATA:

200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)
Created 8/26/92 KR

TWRS 101SY 99.5% river bd M 3.38m stack 8.125 inch diameter ISC model, 2 m receptor

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q (s/m3)	AVERAGE INDIVIDUAL SCALED X/Q (s/m3)	ATM. STAB. CLASS	WIND SPEED (m/s)
S	100	2	6.30	1	1.41E-03	1.41E-03	E	0.89
SSW	100	2	4.53	1	1.29E-03	1.29E-03	C	0.89
SW	100	2	2.93	1	1.25E-03	1.25E-03	C	0.89

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APPENDIX E

WSW	100	2	2.72	1	1.25E-03	1.25E-03 C	0.89
W	100	2	4.80	1	1.41E-03	1.41E-03 E	0.89
WNW	100	2	3.98	1	1.41E-03	1.41E-03 E	0.89
NW	100	2	4.72	1	1.42E-03	1.42E-03 F	4.70
NNW	100	2	4.58	1	1.44E-03	1.44E-03 F	4.70
N	100	2	4.36	1	1.43E-03	1.43E-03 F	4.70
NNE	100	2	2.49	1	1.24E-03	1.24E-03 C	0.89
NE	100	2	3.90	1	1.39E-03	1.39E-03 E	0.89
ENE	100	2	6.17	1	1.44E-03	1.44E-03 F	4.70

WARNING #1 - Selected frequency is below minimum available.

Selected frequency is 0.500000

Minimum cumulative frequency is 0.790000

X/Q below set equal to value corresponding
to minimum cumulative frequency.

E	100	2	14.05	1	1.49E-03	1.49E-03 E	2.65
---	-----	---	-------	---	----------	------------	------

WARNING #1 - Selected frequency is below minimum available.

Selected frequency is 0.500000

Minimum cumulative frequency is 0.840000

X/Q below set equal to value corresponding
to minimum cumulative frequency.

ESE	100	2	18.80	1	1.49E-03	1.49E-03 E	2.65
-----	-----	---	-------	---	----------	------------	------

WARNING #1 - Selected frequency is below minimum available.

Selected frequency is 0.500000

Minimum cumulative frequency is 0.555000

X/Q below set equal to value corresponding
to minimum cumulative frequency.

SE	100	2	10.83	1	1.49E-03	1.49E-03 E	2.65
SSE	100	2	4.78	1	1.42E-03	1.42E-03 F	4.70
S	15360	0	6.30	1	6.45E-06	6.45E-06 E	0.89
SSW	15640	0	4.53	1	4.00E-06	4.00E-06 F	2.65
SW	13875	0	2.93	1	5.95E-06	5.95E-06 F	2.65
WSW	11100	0	2.72	1	7.91E-06	7.91E-06 F	2.65
W	11100	0	4.80	1	1.83E-05	1.83E-05 G	2.65
WNW	11100	0	3.98	1	1.04E-05	1.04E-05 G	4.70
NW	11440	0	4.72	1	1.83E-05	1.83E-05 G	2.65
NNW	8690	0	4.58	1	2.59E-05	2.59E-05 G	2.65
N	8760	0	4.36	1	2.75E-05	2.75E-05 G	2.65
NNE	10610	0	2.49	1	1.00E-05	1.00E-05 E	0.89
NE	10680	0	3.90	1	1.05E-05	1.05E-05 E	0.89
ENE	10530	0	6.17	1	1.77E-05	1.77E-05 G	2.65
E	12630	0	14.05	1	1.90E-05	1.90E-05 F	0.89
ESE	18730	0	18.80	1	1.11E-05	1.11E-05 F	0.89
SE	22440	0	10.83	1	8.46E-06	8.46E-06 G	2.65
SSE	19960	0	4.78	1	4.75E-06	4.75E-06 G	4.70

HNF-3737 REV 1
APPENDIX E

Current Input File Name: twrstckr1.IN

"

"

"

GXQ Version 4.0
December 19, 1994

General Purpose Atmospheric Dispersion Code
Produced by Westinghouse Hanford Company

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.

Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.

Code Custodian is: Brit E. Hey

Westinghouse Hanford Company

P.O. Box 1970

Richland, WA 99352

(509) 376-2921

Run Date = 06/09/99

Run Time = 08:10:30.01

INPUT ECHO:

TWRS 101SY 99.5% 3.38 m stack 8.125 inch diameter ISC model, 2 m receptor, detail

c GXQ Version 4.0 Input File

c mode

2

c

c MODE CHOICE:

c mode = 1 then X/Q based on Hanford site specific meteorology

c mode = 2 then X/Q based on atmospheric stability class and wind speed

c mode = 3 then X/Q plot file is created

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop

T F F T F F

c ifox = t then joint frequency used to compute frequency to exceed X/Q

c = f then joint frequency used to compute annual average X/Q

c inorm = t then joint frequency data is normalized (as in GENII)

c = f then joint frequency data is un-normalized

c icdf = t then cumulative distribution file created (CDF.OUT)

c = f then no cumulative distribution file created

c ichk = t then X/Q parameter print option turned on

c = f then no parameter print

c isite = t then X/Q based on joint frequency data for all 16 sectors

c = f then X/Q based on joint frequency data of individual sectors

c ipop = t then X/Q is population weighted

c = f then no population weighting

c

c X/Q AND WIND SPEED ADJUSTMENT MODELS:

c ipuff idep isrc iwind

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```

0      0      0      0
c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:
c  iwake ipm  iflow ientr
0      0      1      0
c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:
c  (irise igrnd)iwash igrav
2      0      0      0
c ipuff = 1 then X/Q calculated using puff model
c       = 0 then X/Q calculated using default continuous plume model
c idep  = 1 then plume depletion model turned on (Chamberlain model)
c isrc  = 1 then X/Q multiplied by scalar
c       = 2 then X/Q adjusted by wind speed function
c iwind = 1 then wind speed corrected for plume height
c iwake = 1 then NRC RG 1.145 building wake model turned on
c       = 2 then MACCS virtual distance building wake model turned on
c ipm   = 1 then NRC RG 1.145 plume meander model turned on
c       = 2 then 5th Power Law plume meander model turned on
c       = 3 then sector average model turned on
c iflow = 1 then sigmas adjusted for volume flow rate
c ientr = 1 then method of Pasquill used to account for entrainment
c irise = 1 then MACCS buoyant plume rise model turned on
c       = 2 then ISC2 momentum/buoyancy plume rise model turned on
c igrnd = 1 then Mills buoyant plume rise modification for ground effects
c iwash = 1 then stack downwash model turned on
c igrav = 1 then gravitational settling model turned on
c       = 0 unless specified otherwise, 0 turns model off
c
c PARAMETER INPUT:
c
c      release      reference      mixing      frequency
c      height      anemometer      height      to
c      hs (m)      ha (m)      hm (m)      exceed
c                                     Cx(%)
c
c      3.38000E+00      1.00000E+01      1.00000E+03      5.00000E-01
c
c      initial      initial      release      deposition      gravitational
c      plume      plume      duration      velocity      settling
c      width      height      trd(hr)      velocity      velocity
c      Wb(m)      Hb(m)      vd(m/s)      vg(m/s)
c
c      0.00000E+00      0.00000E+00      0.00000E+00      1.00000E-03      1.00000E-03
c
c      ambient      initial      initial      release      convective
c      temperature      plume      plume      diameter      heat release
c      Tamb(C)      temperature      flow rate      d(m)      rate(1)
c                                     V0 (m3/s)      qh(w)
c
c      2.00000E+01      2.00000E+01      4.01000E-01      2.06000E-01      0.00000E+00
c
c (1) If zero then buoyant flux based on plume/ambient temperature difference.
c
c      X/Q      Wind
c      scaling      Speed
c      factor      Exponent
c      c(?)      a(?)
c
c      1.00000E+00      7.80000E-01

```

HNF-3737 REV 1 APPENDIX E

```

c
c RECEPTOR DEPENDENT DATA (no line limit)
c FOR MODE      make      RECEPTOR DEPENDENT DATA
c 1 (site specific)      sector distance receptor-height
c 2 (by class & wind speed) class windspeed distance offset receptor-height
c 3 (create plot file)    class windspeed xmax imax ymax jmax xqmin power
c
c RECEPTOR PARAMETER DESCRIPTION
c sector = 0, 1, 2... (all, S, SSW, etc.)
c distance = receptor distance (m)
c receptor height = height of receptor (m)
c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
c windspeed = anemometer wind speed (m/s)
c offset = offset from plume centerline (m)
c xmax = maximum distance to plot or calculate to (m)
c imax = distance intervals
c ymax = maximum offset to plot (m)
c jmax = offset intervals
c xqmin = minimum scaled X/Q to calculate
c power = exponent in power function step size

```

MODE:

X/Q calculated by stability class and wind speed.

LOGICAL CHOICES:

X/Q parameter print option selected.

MODELS SELECTED:

Flow adjustment model.

ISC2 momentum/buoyancy plume model based on temperature difference.

Default Gaussian plume model selected.

WARNING/ERROR MESSAGES:

WARNING #10 - X/Q may be underestimated for plume rise scenario without accounting for entrainment.

TWRS 101SY 99.5% 3.38 m stack 2 ft diameter ISC model, 2 m receptor, 100m detai

ATM.	WIND			RECEPTOR	SCALED
STAB.	SPEED	DISTANCE	OFFSET	HEIGHT	X/Q
CLASS	(m/s)	(m)	(m)	(m)	(s/m3)

atmospheric stability class	=E				
receptor distance	=	100.000			m
trans. dist. from plume to puff	=	0.000000			m
receptor horizontal offset	=	0.000000			m
receptor height	=	2.00000			m
momentum flux	=	1.53573			m4/s2
buoyancy flux	=	0.000000			m4/s3
distance dependent momentum rise	=	2.80584			m
distance dependent buoyancy rise	=	0.000000			m
plume rise limit	=	2.80584			m
stack downwash	=	0.000000			m

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APPENDIX E

gravitational settling	=	0.000000	m
effective release height (he)	=	6.18584	m
anemometer wind speed	=	2.65000	m/s
wind speed at release height	=	2.65000	m/s
wind speed at he	=	2.65000	m/s
effective wind speed	=	2.65000	m/s
crit. wind spd. prevent. liftoff	=	0.000000	m/s
initial vertical plume speed	=	12.0315	m/s
Pasquill sigma y (unadjusted)	=	6.69471	m
Pasquill sigma z (unadjusted)	=	3.48941	m
Pasquill sigma x (flow adj.)	=	6.69471	m
Pasquill sigma y (flow adj.)	=	6.74098	m
Pasquill sigma z (flow adj.)	=	3.74911	m
Pasquill sigma y (wake adj.)	=	0.000000	m
Pasquill sigma z (wake adj.)	=	0.000000	m
Pasquill sigma y (meander adj.)	=	0.000000	m
Pasquill sigma y (rise adj.)	=	0.000000	m
Pasquill sigma z (rise adj.)	=	0.000000	m
off-axis horizontal factor	=	1.00000	
plume trapping reflection factor	=	1.17198	
off-axis vertical factor	=	0.628402	
plume depletion factor	=	1.00000	
source term factor	=	1.00000	
atmospheric disper. coeff. (X/Q)	=	0.149334E-02	
E		2.65 100 0 2 1.49E-03	

HNF-3737 REV 1
APPENDIX E

Current Input File Name: twrstck8r1.IN

"
"
"
"
"
"

GXQ Version 4.0

December 19, 1994

General Purpose Atmospheric Dispersion Code
Produced by Westinghouse Hanford Company

Users Guide documented in WHC-SD-GN-SWD-30002 Rev. 1.
Validation documented in WHC-SD-GN-SWD-30003 Rev. 1.
Code Custodian is: Brit E. Hey

Westinghouse Hanford Company
P.O. Box 1970
Richland, WA 99352
(509) 376-2921

Run Date = 06/09/99
Run Time = 09:07:06.60

INPUT ECHO:

TWRS FSAR 99.5% 3.38 m stack 8.125inch diameter ISC off, fumigation Hb=6.18

c GXQ Version 4.0 Input File

c mode

1

c

c MODE CHOICE:

c mode = 1 then X/Q based on Hanford site specific meteorology

c mode = 2 then X/Q based on atmospheric stability class and wind speed

c mode = 3 then X/Q plot file is created

c

c LOGICAL CHOICES:

c ifox inorm icdf ichk isite ipop

T F F F F F

c ifox = t then joint frequency used to compute frequency to exceed X/Q

c = f then joint frequency used to compute annual average X/Q

c inorm = t then joint frequency data is normalized (as in GENII)

c = f then joint frequency data is un-normalized

c icdf = t then cumulative distribution file created (CDF.OUT)

c = f then no cumulative distribution file created

c ichk = t then X/Q parameter print option turned on

c = f then no parameter print

c isite = t then X/Q based on joint frequency data for all 16 sectors

c = f then X/Q based on joint frequency data of individual sectors

c ipop = t then X/Q is population weighted

c = f then no population weighting

HNF-3737 REV 1 APPENDIX E

```

c
c X/Q AND WIND SPEED ADJUSTMENT MODELS:
c  ipuff idep isrc iwind
c    0      0      0      0
c DIFFUSION COEFFICIENT ADJUSTMENT MODELS:
c  iwake ipm  iflow ientr
c    2      0      1      0
c EFFECTIVE RELEASE HEIGHT ADJUSTMENT MODELS:
c  (irise igrnd)iwash igrav
c    0      0      0      0
c ipuff = 1 then X/Q calculated using puff model
c      = 0 then X/Q calculated using default continuous plume model
c idep  = 1 then plume depletion model turned on (Chamberlain model)
c isrc  = 1 then X/Q multiplied by scalar
c      = 2 then X/Q adjusted by wind speed function
c iwind = 1 then wind speed corrected for plume height
c iwake = 1 then NRC RG 1.145 building wake model turned on
c      = 2 then MACCS virtual distance building wake model turned on
c ipm   = 1 then NRC RG 1.145 plume meander model turned on
c      = 2 then 5th Power Law plume meander model turned on
c      = 3 then sector average model turned on
c iflow = 1 then sigmas adjusted for volume flow rate
c ientr = 1 then method of Pasquill used to account for entrainment
c irise = 1 then MACCS buoyant plume rise model turned on
c      = 2 then ISC2 momentum/buoyancy plume rise model turned on
c igrnd = 1 then Mills buoyant plume rise modification for ground effects
c iwash = 1 then stack downwash model turned on
c igrav = 1 then gravitational settling model turned on
c      = 0 unless specified otherwise, 0 turns model off
c
c PARAMETER INPUT:
c
c      release          reference          mixing          frequency
c      height          anemometer          height          to
c      hs (m)          height          height          exceed
c                   ha (m)          hm (m)          Cx (%)
c
c      3.38000E+00      1.00000E+01      6.18000E+00      5.00000E-01
c
c      initial          initial          release          deposition          gravitational
c      plume            plume            duration          velocity          settling
c      width            height          trd(hr)          velocity          velocity
c      Wb (m)           Hb (m)                   vd(m/s)          vg(m/s)
c
c      2.06000E-01      6.18000E+00      0.00000E+00      1.00000E-03      1.00000E-03
c
c      ambient          initial          initial          release          convective
c      temperature      plume            plume            diameter          heat release
c      Tamb(C)           temperature      flow rate        d(m)              rate(1)
c                   T0 (C)          V0 (m3/s)                   qh(w)
c
c      2.00000E+01      2.00000E+01      4.01000E-01      2.06000E-01      0.00000E+00
c
c (1) If zero then buoyant flux based on plume/ambient temperature difference.
c
c      X/Q              Wind
c      scaling          Speed
c      factor           Exponent

```

HNF-3737 REV 1 APPENDIX E

```

c   c(?)          a(?)
c   -----
c   1.00000E+00    7.80000E-01
c
c RECEPTOR DEPENDENT DATA (no line limit)
c FOR MODE      make      RECEPTOR DEPENDENT DATA
c 1 (site specific)      sector distance receptor-height
c 2 (by class & wind speed) class windspeed distance offset receptor-height
c 3 (create plot file)    class windspeed xmax imax ymax jmax xqmin power
c
c RECEPTOR PARAMETER DESCRIPTION
c sector = 0, 1, 2... (all, S, SSW, etc.)
c distance = receptor distance (m)
c receptor height = height of receptor (m)
c class = 1, 2, 3, 4, 5, 6, 7 (P-G stability class A, B, C, D, E, F, G)
c windspeed = anemometer wind speed (m/s)
c offset = offset from plume centerline (m)
c xmax = maximum distance to plot or calculate to (m)
c imax = distance intervals
c ymax = maximum offset to plot (m)
c jmax = offset intervals
c xqmin = minimum scaled X/Q to calculate
c power = exponent in power function step size

```

MODE:

Site specific X/Q calculated.

LOGICAL CHOICES:

Joint frequency used to calculate X/Q based on frequency of exceedance.

No normalization of joint frequency.

X/Q calculated for single sector.

MODELS SELECTED:

Flow adjustment model.

MACCS Virtual source building wake model selected.

Default Gaussian plume model selected.

WARNING/ERROR MESSAGES:

JOINT FREQUENCY DATA:

200 AREA (HMS) - 10 M - Pasquill A - G (1983 - 1991 Average)

Created 8/26/92 KR

TWRS FSAR 99.5% 3.38 m stack 8.125inch diameter ISC off, fumigation Hb=6.18

SECTOR	DISTANCE (m)	RECEPT HEIGHT (m)	SECT. FREQ. (%)	POPULATION	TOTAL POPULATION SCALED X/Q (s/m3)	AVERAGE INDIVIDUAL SCALED X/Q (s/m3)	ATM. STAB. CLASS	WIND SPEED (m/s)
S	100	2	6.30	1	1.11E-02	1.11E-02	E	0.89
SSW	100	2	4.53	1	9.29E-03	9.29E-03	E	0.89
SW	100	2	2.93	1	9.62E-03	9.62E-03	E	0.89
WSW	100	2	2.72	1	9.62E-03	9.62E-03	E	0.89

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APPENDIX E

W	100	2	4.80	1	1.28E-02	1.28E-02 E	0.89
WNW	100	2	3.98	1	1.12E-02	1.12E-02 E	0.89
NW	100	2	4.72	1	1.18E-02	1.18E-02 E	0.89
NNW	100	2	4.58	1	1.16E-02	1.16E-02 E	0.89
N	100	2	4.36	1	1.33E-02	1.33E-02 F	0.89
NNE	100	2	2.49	1	9.60E-03	9.60E-03 E	0.89
NE	100	2	3.90	1	1.00E-02	1.00E-02 E	0.89
ENE	100	2	6.17	1	1.08E-02	1.08E-02 E	0.89
E	100	2	14.05	1	1.50E-02	1.50E-02 F	0.89
ESE	100	2	18.80	1	1.33E-02	1.33E-02 F	0.89
SE	100	2	10.83	1	1.30E-02	1.30E-02 E	0.89
SSE	100	2	4.78	1	1.10E-02	1.10E-02 E	0.89
S	200	2	6.30	1	5.98E-03	5.98E-03 E	0.89
SSW	200	2	4.53	1	4.14E-03	4.14E-03 G	2.65
SW	200	2	2.93	1	4.15E-03	4.15E-03 G	2.65
WSW	200	2	2.72	1	4.15E-03	4.15E-03 G	2.65
W	200	2	4.80	1	6.91E-03	6.91E-03 E	0.89
WNW	200	2	3.98	1	6.04E-03	6.04E-03 E	0.89
NW	200	2	4.72	1	6.34E-03	6.34E-03 E	0.89
NNW	200	2	4.58	1	6.23E-03	6.23E-03 E	0.89
N	200	2	4.36	1	7.19E-03	7.19E-03 F	0.89
NNE	200	2	2.49	1	4.94E-03	4.94E-03 G	2.65
NE	200	2	3.90	1	5.26E-03	5.26E-03 E	0.89
ENE	200	2	6.17	1	5.82E-03	5.82E-03 E	0.89
E	200	2	14.05	1	8.14E-03	8.14E-03 F	0.89
ESE	200	2	18.80	1	7.19E-03	7.19E-03 F	0.89
SE	200	2	10.83	1	7.01E-03	7.01E-03 E	0.89
SSE	200	2	4.78	1	5.90E-03	5.90E-03 E	0.89
S	300	2	6.30	1	4.15E-03	4.15E-03 E	0.89
SSW	300	2	4.53	1	2.90E-03	2.90E-03 G	2.65
SW	300	2	2.93	1	2.92E-03	2.92E-03 G	2.65
WSW	300	2	2.72	1	2.91E-03	2.91E-03 G	2.65
W	300	2	4.80	1	4.80E-03	4.80E-03 E	0.89
WNW	300	2	3.98	1	4.20E-03	4.20E-03 E	0.89
NW	300	2	4.72	1	4.40E-03	4.40E-03 E	0.89
NNW	300	2	4.58	1	4.33E-03	4.33E-03 E	0.89
N	300	2	4.36	1	4.99E-03	4.99E-03 F	0.89
NNE	300	2	2.49	1	3.44E-03	3.44E-03 G	2.65
NE	300	2	3.90	1	3.67E-03	3.67E-03 E	0.89
ENE	300	2	6.17	1	4.04E-03	4.04E-03 E	0.89
E	300	2	14.05	1	5.65E-03	5.65E-03 F	0.89
ESE	300	2	18.80	1	4.99E-03	4.99E-03 F	0.89
SE	300	2	10.83	1	4.87E-03	4.87E-03 E	0.89
SSE	300	2	4.78	1	4.09E-03	4.09E-03 E	0.89
S	400	2	6.30	1	3.20E-03	3.20E-03 E	0.89
SSW	400	2	4.53	1	2.24E-03	2.24E-03 G	2.65
SW	400	2	2.93	1	2.25E-03	2.25E-03 G	2.65
WSW	400	2	2.72	1	2.25E-03	2.25E-03 G	2.65
W	400	2	4.80	1	3.70E-03	3.70E-03 E	0.89
WNW	400	2	3.98	1	3.24E-03	3.24E-03 E	0.89
NW	400	2	4.72	1	3.40E-03	3.40E-03 E	0.89
NNW	400	2	4.58	1	3.34E-03	3.34E-03 E	0.89
N	400	2	4.36	1	3.85E-03	3.85E-03 F	0.89
NNE	400	2	2.49	1	2.66E-03	2.66E-03 G	2.65
NE	400	2	3.90	1	2.83E-03	2.83E-03 E	0.89
ENE	400	2	6.17	1	3.12E-03	3.12E-03 E	0.89
E	400	2	14.05	1	4.36E-03	4.36E-03 F	0.89

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ESE	400	2	18.80	1	3.85E-03	3.85E-03 F	0.89
SE	400	2	10.83	1	3.76E-03	3.76E-03 E	0.89
SSE	400	2	4.78	1	3.16E-03	3.16E-03 E	0.89
S	500	2	6.30	1	2.62E-03	2.62E-03 E	0.89
SSW	500	2	4.53	1	1.83E-03	1.83E-03 G	2.65
SW	500	2	2.93	1	1.84E-03	1.84E-03 G	2.65
WSW	500	2	2.72	1	1.84E-03	1.84E-03 G	2.65
W	500	2	4.80	1	3.03E-03	3.03E-03 E	0.89
WNW	500	2	3.98	1	2.65E-03	2.65E-03 E	0.89
NW	500	2	4.72	1	2.78E-03	2.78E-03 E	0.89
NNW	500	2	4.58	1	2.73E-03	2.73E-03 E	0.89
N	500	2	4.36	1	3.15E-03	3.15E-03 F	0.89
NNE	500	2	2.49	1	2.17E-03	2.17E-03 G	2.65
NE	500	2	3.90	1	2.31E-03	2.31E-03 E	0.89
ENE	500	2	6.17	1	2.55E-03	2.55E-03 E	0.89
E	500	2	14.05	1	3.57E-03	3.57E-03 F	0.89
ESE	500	2	18.80	1	3.15E-03	3.15E-03 F	0.89
SE	500	2	10.83	1	3.07E-03	3.07E-03 E	0.89
SSE	500	2	4.78	1	2.58E-03	2.58E-03 E	0.89

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ATTACHMENT E2

PEER REVIEW CHECKLISTS

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ATTACHMENT E2

PEER REVIEW CHECKLISTS

Practice 134 290 1112
Publication Date 01Mar99
Attachment 01 - Sheet 1 of 1

FLUOR DANIEL NORTHWEST

TECHNICAL PEER REVIEWS

HEDOP REVIEW CHECKLIST

Document Reviewed:

Title:

Author:

Date:

Scope of Review:

Yes No* NA

☒ ☐ ☐

1. A detailed technical review and approval of the environmental transport and dose calculation portion of the analysis has been performed and documented.

☐ ☐ ☒

2. Detailed technical review(s) and approval(s) of scenario and release determinations have been performed and documented.

☐ ☐ ☒

3. HEDOP-approved code(s) were used.

☐ ☐ ☒

4. Receptor locations were selected according to HEDOP recommendations.

☒ ☐ ☐

5. All applicable environmental pathways and code options were included and are appropriate for the calculations.

☒ ☐ ☐

6. Hanford site data were used.

☐ ☐ ☒

7. Model adjustments external to the computer program were justified and performed correctly.

☒ ☐ ☐

8. The analysis is consistent with HEDOP recommendations.

☐ ☐ ☒

9. Supporting notes, calculations, comments, comment resolutions, or other information is attached. (Use the "Page 1 of X" page numbering format and sign and date each added page.)

☒ ☐ ☐

10. Approval is granted on behalf of the Hanford Environmental Dose Overview Panel.

* All "no" responses must be explained below or on an additional sheet.

D.A. Himes
HEDOP-Approved Reviewer (printed name and signature)

6/29/99
Date

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

NUCLEAR ENGINEERING

HNF-3737 REV 1
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Practice 134 290 1112
Publication Date 01Mar99
Attachment 02 - Sheet 1 of 1

FLUOR DANIEL NORTHWEST

TECHNICAL PEER REVIEWS

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed:

Title: HNF-3737, Appendix E.- Calculation of Postulated Ammonia...

Author: J.C. Van Keuren

Date: 6/29/99

Scope of Review: entire document

Yes	No	NA	
☐	☐	☒	** Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
☒	☐	☐	Problem completely defined.
☐	☐	☒	Accident scenarios developed in a clear and logical manner.
☒	☐	☐	Necessary assumptions explicitly stated and supported.
☒	☐	☐	Computer codes and data files documented.
☒	☐	☐	Data used in calculations explicitly stated in document.
☒	☐	☐	Data checked for consistency with original source information as applicable.
☒	☐	☐	Mathematical derivations checked including dimensional consistency of results.
☒	☐	☐	Models appropriate and used within range of validity or use outside range of established validity justified.
☒	☐	☐	Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
☒	☐	☐	Software input correct and consistent with document reviewed.
☒	☐	☐	Software output consistent with input and with results reported in document reviewed.
☒	☐	☐	Limits/criteria/guidelines applied to analysis results are appropriate and referenced.
☒	☐	☐	Limits/criteria/guidelines checked against references.
☒	☐	☐	Safety margins consistent with good engineering practices.
☒	☐	☐	Conclusions consistent with analytical results and applicable limits.
☒	☐	☐	Results and conclusions address all points required in the problem statement.
☒	☐	☐	Format consistent with applicable guides or other standards.
☐	☐	☒	** Review calculations, comments, and/or notes are attached.
☒	☐	☐	Traceability
☒	☐	☐	Document approved (for example, the reviewer affirms the technical accuracy of the document).

D.A. Himes
Reviewer (printed name and signature)

6/29/99
Date

* All "no" responses must be explained below or on an additional sheet.

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

NUCLEAR ENGINEERING

APPENDIX F
CONTROL DECISION RECORD
TANK 241-SY-101 WASTE TRANSFERS AND BACK DILUTION

L. J. Kripps

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CONTROL DECISION RECORD
TANK 241-SY-101 WASTE TRANSFERS AND BACK DILUTION

F1.0 INTRODUCTION

Control decision meetings for the transfer of waste from Tank 241-SY-101 to Tank 241-SY-102 were held on March 15 and 16, 1999. The agenda for the control decision meetings is included in Enclosure 1, and a list of meeting attendees is included in Enclosure 2.

The purpose of the control decision meetings was to identify existing controls and/or select new controls to protect the public, onsite workers, facility workers, and the environment from potential hazardous conditions and postulated accidents for a Tank 241-SY-101 waste transfer. Controls include Safety-Class and Safety-Significant structures, systems, and components (SSCs); technical safety requirements (TSRs)^a; and other controls that provide defense-in-depth or environmental protection.

The scope of the control decision meetings covered waste transfers from Tank 241-SY-101 to Tank 241-SY-102 that are planned to remediate the Tank 241-SY-101 surface-level-rise condition (see HNF-3824, *Tank 241-SY-101 Surface-Level-Rise Remediation Project Plan*). The first waste transfer will move approximately 380,000 to 570,000 liters (100,000 to 150,000 gal) of waste and is scheduled for September 1999. The possible back dilution of Tank 241-SY-101 waste with water following the waste transfer was not within the scope of the control decision meetings.

The control decision meetings were conducted in accordance with the established and approved process and criteria described in the Tank Waste Remediation System (TWRS) Basis for Interim Operation (HNF-SD-WM-BIO-001). A summary of the control decision process and criteria was presented at the start of the control decision meetings and is included in Enclosure 3. Control decisions were based on the best available information from the waste transfer hazard and accident analyses and on the technical expertise and experience of the meeting participants. Decisions were made by consensus.

Subsequent to the March 15 and 16, 1999 control decision meetings, several revisions to controls occurred. Control revisions were based on the results of actions assigned at the meetings (i.e., a subsequent design decision to provide a passive siphon break and a subsequent decision on the specific instrument systems that will be used to measure the quantity of waste transferred from Tank 241-SY-101). A revision also resulted from the resolution of a subsequent SSC classification issue raised by the TWRS Design Authority (i.e., Safety-Class versus Safety-Significant SSC instrument systems to measure the quantity of waste transferred from

^a As a result of direction received from the U.S. Department of Energy, Office of River Protection (French 1999), new TSR-level controls for Tank 241-SY-101 remediation activities will be imposed as prudent contractor controls necessary for safe operation.

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Tank 241-SY-101). These control revisions and their bases are specifically identified in the summary of the control decision discussions in Section F3.0.

In addition, control decisions were reviewed against the final waste transfer design and the final documented hazard and accident analyses since these were not completed until after the March 15 and 16, 1999 meetings. This review identified that the final analysis of ammonia releases during Tank 241-SY-101 waste transfers without controls could result in exposures to onsite workers above risk evaluation guidelines. To select controls for the protection of onsite workers from postulated ammonia releases, another control decision meeting was held on May 18, 1999. A control revision because of a new ethylene propylene diene monomer (EPDM) hose-in-hose design for the overground transfer line and a control revision based on the completed riser 241-SY-102 drop leg enclosure leak detection system design were also considered at the May 18, 1999 meeting. The agenda and list of attendees for the May 18, 1999 control decision meeting are included in Enclosure 14. The control decisions and control revisions and their bases from the May 18, 1999 meeting are included in the Section F3.0 summary of control decision discussions.

On September 9, 1999, a control decision meeting was held to consider the need for new or revised controls for the back dilution of Tank 241-SY-101 waste with water following the first waste transfer. Several waste transfer controls were also reviewed at this control decision meeting. Controls previously established to protect the Tank 241-SY-101 mixer pump safety function were reviewed based on the results of a workshop on the effects of crust ingestion on pump performance. In response to a request, the requirement for continuous flammable gas monitoring when water sources are connected to Tank 241-SY-101, especially when the water source is small, was also reviewed. The agenda, list of attendees, and the purpose, scope, and process for the September 9, 1999 control decision meeting are included in Enclosure 15. The control decisions and control revisions and their bases from the September 9, 1999 meeting are included in the Section F3.0 summary of control decision discussions.

Based on new and revised information on the expected buoyant response of the Tank 241-SY-101 crust to waste transfers and back dilution, a control decision meeting was held on October 13, 1999 to reconsider whether waste volume transfer and back dilution controls were needed to protect the Tank 241-SY-101 mixer pump safety function. This control decision meeting also considered controls required for the addition of back dilution water on top of the crust (i.e., the control decision meeting on September 9, 1999 only considered the addition of water low in Tank 241-SY-101). The agenda, list of attendees, and the purpose, scope, and process for the October 13, 1999 control decision meeting are included in Enclosure 16. The control decisions and control revisions and their bases from the October 13, 1999 meeting are included in the Section F3.0 summary of control decision discussions.

Section F2.0 is an overview of the control decision meeting presentations on March 15 and 16, 1999; on May 18, 1999; on September 9, 1999; and on October 13, 1999. The presentations described the Tank 241-SY-101 waste transfer system design and operation, the plan for back dilution following the first waste transfer, and the results of waste transfer and back dilution hazard and accident analyses. The presentations provided the background and the basis for the subsequent control decision discussions. Copies of the presentations are included in the enclosures to this Control Decision Record.

Section F3.0 is a summary of the control decision discussions on the representative accidents and the associated represented hazardous conditions that were considered at the March 15 and 16, 1999 meetings and at the subsequent May 18, 1999, September 9, 1999; and October 13, 1999 meetings. The discussion summary identifies the controls that were considered, and the reasons why specific controls were selected or not selected.

Attachment 1 is a summary of new controls for Tank 241-SY-101 waste transfers and back dilution. Attachments 2 through 8 contain the individual control decision records of the selected safety SSCs, TSRs (or prudent contractor controls necessary for safe operation), and defense-in-depth controls for each representative accident, and the associated represented hazardous conditions, considered at the control decision meeting for Tank 241-SY-101 waste transfers. Attachment 9 is the control decision record of selected safety SSC, TSRs (or contractor prudent controls necessary for safe operation), and defense-in-depth control for back dilution.

F2.0 OVERVIEW OF CONTROL DECISION MEETING PRESENTATIONS

F2.1 PRESENTATIONS AT THE MARCH 15 AND 16, 1999 CONTROL DECISION MEETINGS

The first technical presentation described the current design and planned operation of the Tank 241-SY-101 waste transfer system (see Enclosure 4). This design and operation information was used as the basis for the control decisions at the March 15 and 16, 1999 meetings. Subsequent to the control decision meetings, the waste transfer system design was finalized (i.e., the waste transfer system final design review was held on April 29 and 30, 1999). The final design of the waste transfer system was reviewed to determine whether any design revisions occurred subsequent to March 15 and 16, 1999 that could affect the control decisions. The results of this review are included in the Section F3.0 control decision discussion summary (see also Section F2.2).

The next presentations provided an overview (Enclosure 5) and the results (Enclosure 6) of the hazard analysis performed on the Tank 241-SY-101 waste transfer. The hazardous conditions resulting from the hazard analysis included the following.

1. Hazardous conditions having potential onsite or offsite consequences addressed by the Authorization Basis, but presenting control allocation concerns (i.e., hazardous conditions that after the allocation of existing controls were either a) judged to potentially require additional controls or b) determined to pose issues with respect to the application of existing controls). (See Enclosure 6, Part 1)
2. Hazardous conditions having potential onsite or offsite consequences addressed by the Authorization Basis (i.e., hazardous conditions that, after the allocation of existing controls, were judged to be acceptably prevented or mitigated). (See Enclosure 6, Part 2)

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3. Hazardous conditions having no consequences, or consequences impacting only the facility worker. (See Enclosure 6, Part 3)

Analyses demonstrating that existing controls acceptably prevent or mitigate hazardous conditions for the Tank 241-SY-101 waste transfer (i.e., hazardous conditions in the second group above) were presented (see Enclosures 7 and 8). These analyses were finalized subsequent to the control decision meetings and are documented in Appendixes B and E. The final analyses in Appendixes B and E were reviewed to determine whether any revisions occurred subsequent to the control decision meetings that could affect the control decisions. The results of this review are included in the Section F3.0 control decision discussion summary. (See also Section F2.2).

Note: Prior to the March 15 and 16, 1999 control decision meetings, a group of individuals with knowledge of the existing TWRS Authorization Basis and the Tank 241-SY-101 waste transfer hazard analysis met to review all of the hazardous conditions with potential onsite or offsite consequences (S2 and S3, respectively). At this meeting, existing controls were allocated to these hazardous conditions and the hazardous conditions were placed in either the first or second group above. This enabled the control decision meetings to focus on hazardous conditions that required control determinations. Subsequent to the control decision meetings, another group of knowledgeable individuals reviewed all of the hazardous conditions with facility worker consequences that are anticipated (S1, F3), and all of the hazardous conditions with potentially significant environmental consequences (E2 and E3). The purpose of this review was to identify the need for additional controls to protect facility workers or the environment for the Tank 241-SY-101 waste transfer. No new facility worker or environmental controls were identified from this review (i.e., existing controls in the TWRS Authorization Basis and new Tank 241-SY-101 controls acceptably provide for protection of facility workers and environment).

Presentations were then made providing the results of accident analyses of representative flammable gas accidents for the Tank 241-SY-101 waste transfer. These included presentations on the following.

- The estimated risk (i.e., frequency and consequences) of representative flammable gas accidents from the existing TWRS Authorization Basis (Enclosure 9)
- Postulated gas release mechanisms from the Tank 241-SY-101 crust, and gas release models developed for estimating potential crust gas releases from waste transfer operations and activities (Enclosure 10)
- Tank 241-SY-101 waste transfer flammable gas accident results from the Refined Safety Analysis Tool (Enclosure 11)

The above accident analyses were finalized subsequent to the control decision meetings and are documented in Appendix C. The final analyses in Appendix C were reviewed to determine whether any revisions occurred subsequent to the control decision meetings that could affect the control decisions. No control revisions resulted from this review.

F2.2 PRESENTATIONS AT THE MAY 18, 1999 CONTROL DECISION MEETING

The first presentation at the May 18, 1999 meeting was a review of the control decision process and criteria. This review used the Enclosure 3 presentation from the March 15 and 16, 1999 meetings.

Technical presentations were then provided on potential ammonia release mechanisms, the methods used to calculate ammonia exposures, and the results of possible ammonia exposures to onsite and facility workers from Tank 241-SY-101 crust disturbing activities and from Tank 241-SY-101 waste transfers (Enclosure 14, Parts 3 and 4). The analyses presented on ammonia releases and exposures were all new since the March 15 and 16, 1999 control decision meetings. Based on the information presented, controls were selected to protect onsite and facility workers from postulated ammonia releases (see Section F3.7).

Information was also presented to support the re-consideration of control decisions on:

1. The SSC classification of the leak detection system in the riser 241-SY-102-007 drop leg enclosure (Enclosure 14, Part 5), and
2. The requirement that the safety function of the overground transfer encasement and connections be maintained following the impact of missiles generated by high wind (Enclosure 14, Part 6).

Control revisions resulting from the May 18, 1999 control decision discussions are included in Section F3.0.

F2.3 PRESENTATIONS AT THE SEPTEMBER 9, 1999 CONTROL DECISION MEETING

The first technical presentations at the September 9, 1999 control decision meeting supported the review of previous control decisions to protect the Tank 241-SY-101 mixer pump safety function (i.e., control of gas retention at depth and prevention of buoyant displacement gas release events). Presentations included a review of present controls (Enclosure 15 – Part 4), a summary of a workshop held in August 1999 on the effects of crust ingestion on Tank 241-SY-101 mixer pump performance (Enclosure 15 – Part 5), and an initial listing and evaluation of control options for protection of the mixer pump safety function (i.e., ensuring mixer pump operability) (Enclosure 15 – Part 6).

To support the review of the safety function of the siphon break in the Tank 241-SY-102 drop leg, a presentation summarized the results of an analysis of potential siphon flow in the transfer line between Tanks 241-SY-101 and 241-SY-102 (Enclosure 15 – Part 7). Possible siphon break control options were also presented (Enclosure 15 – Part 8).

The initial presentation supporting back dilution control decisions was a description of the planned operation. The major points were that the first back dilution would be via the Tank 241-SY-101 mixer pump burrowing ring or the transfer pump, and that back dilution water would be supplied by the same water skid used to supply the waste transfer dilution water. The

results of the back dilution hazard analysis were then summarized (Enclosure 15 – Part 9). The results of the following analyses performed to support control decisions for back dilution were also presented.

- Analysis of the effects of back dilution on crust floatation (Enclosure 15 - Part 10, see also PNNL-13066).

Note: Subsequent to the September 9, 1999 control decision meeting, new and revised analysis of the effects of back dilution on crust floatation became available. This new and revised analysis was presented at the October 13, 1999 control decision meeting (see Section F2.4) and was used as the basis for reconsideration of several September 9, 1999 control decisions.

- Analysis of mixing of the back dilution water with the slurry. (Note: This presentation stated that the mixing analysis of a 100,000 gallon back dilution with water addition rates up to 500 gpm via the mixer pump burrowing ring showed the water will be well mixed with the slurry. Results for larger back dilutions (e.g., 150,000 gallons of water) via the mixer pump burrowing ring and back dilution via the transfer pump were not complete, but it was stated that similar results were expected. This was confirmed by the mixing analyses completed subsequent to the control decision meeting that are documented in PNNL-13038, *Potential for Waste Stratification Resulting from Back Dilution in Tank 241-SY-101*
- Analysis of the potential for adverse structural effects from crust movement caused by back dilution (Enclosure 15 – Part 11). The conclusion of this calculation of crust velocity and energy was that even at back dilution water addition rates of several hundreds of gpm, crust movement was too slow to cause adverse structural effects.
- Analysis of flammable gas releases from slurry resulting from back dilution (Enclosure 15 – Part 12). (Note: In addition to the results presented at the control decision meeting, Enclosure 15 - Part 12 includes results of parametric analyses performed subsequent to the meeting.)

An initial list and evaluation of possible back dilution controls was presented as a starting basis for the control decision discussions (Enclosure 15 – Part 13).

The final presentations supported a request to review the control requiring continuous flammable gas monitoring when water sources are connected to Tank 241-SY-101, especially for small water sources (Enclosure 15 – Part 14). A list and evaluation of possible control options was presented (Enclosure 15 – Part 15). Also presented was the basis for the 500-gallon threshold for water additions that differentiates global and local waste disturbing operations. It was noted in the presentation that this threshold is changing to 2000 gallons based on the flammable gas analyses documented in Appendix C.

F2.4 PRESENTATIONS AT THE OCTOBER 13, 1999 CONTROL DECISION MEETING

The primary presentation at the October 13, 1999 control decision meetings was a summary of the analysis of the expected buoyant response of the Tank 241-SY-101 crust to waste transfers and back dilution (Enclosure 16 – Part 4). This analysis, contrary to the preliminary results that were available for the September 9, 1999 control decision meeting, showed a potential for the crust to sink. The potential for the crust to sink and adversely affect Tank 241-SY-101 mixer pump operation and/or performance is dependent on the quantity of waste transferred out during the first waste transfer and the quantity of dilution water added back to the Tank 241-SY-101 waste.

Presentations on possible waste transfer and back dilution control decisions (Enclosure 16 – Part 5) formed the basis for the control decision discussions. Enclosure 16 – Part 6 contains a summary of Tank 241-SY-101 waste transfer siphon calculations that were reviewed with respect to the waste volume transfer control.

F3.0 CONTROL DECISION DISCUSSION SUMMARY

Based on the Tank 241-SY-101 waste transfer hazard and accident analyses, control decisions were required for the following three new representative flammable gas accident scenarios, and the potential hazardous conditions that these accident scenarios represented.

- Flammable gas deflagration - induced gas release from crust disturbance
- Flammable gas deflagration - induced gas release from crust dissolution
- Flammable gas deflagration - buoyant displacement gas release event plus additional gas release from the crust

In addition, control decisions were required for potential hazardous conditions that were represented by the following existing representative accidents, but where issues were identified concerning whether existing controls acceptably prevented and/or mitigated the hazardous conditions.

- Flammable gas deflagration – general
- Spray leak in structure or from overground transfer line
- Surface leak resulting in pool
- Mixing of incompatible material - toxic vapor generation

A summary of the control decision discussions for Tank 241-SY-101 waste transfers for these representative accidents, and the potential hazardous conditions that they represent, is presented

in Sections F3.1 to F3.7. These sections provide the basis for the selected waste transfer controls and encompass the discussions at the March 15 and 16, May 18, September 9, and October 13, 1999 control decision meetings and other reviews that resulted in control revisions.

A summary of the control decision discussions for back dilution of Tank 241-SY-101 waste is presented in Section F3.8. This section is based primarily on the control decision discussions at the September 9, and October 13, 1999 control decision meetings.

F3.1 FLAMMABLE GAS DEFLAGRATION – INDUCED GAS RELEASE FROM CRUST DISTURBANCE

The representative accident is a flammable gas deflagration due to an induced gas release caused by operations and activities that disturb the Tank 241-SY-101 crust (e.g., waste transfer pump installation, crust disturbance as the waste level falls during the transfer) with subsequent ignition. A list of existing controls that may prevent or mitigate this representative accident was made, and then possible new controls were identified and evaluated. Following the selection of controls for the representative accident, the potential hazardous conditions represented by this accident (see Enclosure 6, Part 1) were reviewed and additional controls were selected, if necessary. The control decision discussions are summarized below, and the selected controls are presented in Attachment 2.

Existing Controls

Safety SSCs - Safety-Class (SC): DST/AWF Ventilation

SC: Tank 241-SY-101 Hydrogen Monitor (7500 ppm*)

SC: Tank 241-SY-101 Ammonia Monitor (3000 ppm*)

* Maximum gas concentrations in the LA-UR-92-3196 Level I controls for mixer pump operation

TSRs - Limiting Condition for Operation (LCO) 3.2.1: DST and AWF Ventilation System

Administrative Control (AC) 5.9: Flammability Controls (LA-UR-92-3196 Level I mixer pump controls)

Supplemental Controls (Wagoner 1998)

Note: For this representative accident, the mixer pump controls were assumed to effectively control gas retention at depth and, therefore, the only postulated gas releases are from the crust.

Possible New Controls

Waste level – This control was proposed to protect accident analysis assumptions. This control was not selected based on a consensus that the accident analysis should include sensitively studies for expected waste levels, and if the waste levels assumed in the accident analysis were exceeded, an Unreviewed Safety Question (USQ) evaluation would be triggered.

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Minimum Ventilation System Flowrate (400 cfm or higher) – The LA-UR-92-3196 Level II controls include a 400 cfm minimum ventilation system flowrate requirement. The Refined Safety Analysis Tool analysis showed that the risk from a flammable gas deflagration was not very sensitive to ventilation flowrate (analyses performed for 400 and 600 cfm – see Enclosure 11 and Appendix C). The consensus was that this control should remain as a Level II control.

Flammable gas monitoring (during tank operations and activities that could disturb the crust) – The existing TSR AC 5.11 flammable gas monitoring controls are not applicable to Tank 241-SY-101, and the LA-UR-92-3196 Level I controls on hydrogen and ammonia monitoring are associated with mixer pump operation. The consensus was that flammable gas monitoring be selected as a TSR-level control (i.e., to expand the applicability of AC 5.11 to include Tank 241-SY-101 and/or elevate and augment the LA-UR-92-3196 Level II flammable gas monitoring controls). There was some discussion on whether there should be an LCO on the hydrogen and ammonia monitoring systems, but the consensus was for a flammable gas monitoring program (i.e., an AC) consistent with other TWRS facilities.

Ignition Controls – The existing TSR AC 5.10 ignition controls are not applicable to Tank 241-SY-101. Ignition controls were selected by consensus as a TSR-level control (i.e., to expand the applicability of AC 5.10 to include Tank 241-SY-101 and/or elevate and augment the LA-UR-92-3196 Level II ignition controls).

Water Addition Controls (location, rate, volume, temperature) – The consensus was that water addition controls should remain as LA-UR-92-3196 Level II controls. Flammable gas monitoring was the preferred control because it provides a direct measure of the gas release hazard and addresses all gas release mechanisms from the crust. There was some discussion of an interlock to automatically stop water addition on high hydrogen concentration, but the discussion was deferred to the representative flammable gas deflagration crust dissolution accident (see Section 3.2).

Mixer Pump Not Operating (during operations and activities that could disturb the crust) - This control was proposed to protect accident analysis assumptions. This is a LA-UR-92-3196 Level II control, and the consensus was that it should remain as a Level II control because flammable gas monitoring, which was selected as a control, addresses cumulative gas release mechanisms.

Waste Disturbance Size Limits – The difficulty in limiting the size of a waste disturbance, and the impracticality of monitoring for compliance, led to a consensus not to select this control.

Inerting – Although the information on the feasibility of inerting Tank 241-SY-101 included in Enclosure 12 was not formally presented at the meeting, the cost and time to implement an inerting system for Tank 241-SY-101 were recognized as significant factors to consider with respect to this possible control. The cost estimate for an inerting system is close to \$2 million dollars, and implementation of an inerting system would add significant complexity and risk to the efforts to remediate the Tank 241-SY-101 surface-

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level-rise condition. In addition, the Refined Safety Analysis Tool analysis showed that an inerted tank does not significantly reduce the risk of a flammable gas deflagration (see Enclosure 11 and the Appendix C). Based on these considerations, the consensus was that inerting Tank 241-SY-101 not be selected as a control.

Video Camera Monitoring – The consensus was that video camera monitoring should be implemented as a defense-in-depth control recognizing the value of observing crust behavior, but the difficulty of defining criteria that would prompt ceasing operations and activities.

Time Delay from Mixer Pump Operation - The LA-UR-92-3196 Level II controls include an intrusive control that requires that there be at least a 4 hour waiting period following the last activity that can induce a gas release. The consensus was that this control should remain as a Level II control, because flammable gas monitoring, which was selected as a control, addresses the potential for overlapping gas release events.

Dome Pressure Monitoring – This is a LA-UR-92-3196 Level II control to detect large, rapid gas release events [i.e., a buoyant displacement gas release event (BD GRE)]. While dome pressure monitoring provides a faster indication of a BD GRE than flammable gas monitoring, the consensus was that it would likely not detect gas releases due to crust disturbances since these would not be expected to significantly increase the tank dome pressure.

Attachment 2 is the control decision record of the safety SSCs, TSRs (or prudent contractor controls necessary for safe operation), and defense-in-depth controls selected to prevent potential flammable gas deflagration hazardous conditions and postulated accidents caused by induced gas releases from crust disturbance.

F3.2 FLAMMABLE GAS DEFLAGRATION – INDUCED GAS RELEASE FROM CRUST DISSOLUTION

The representative accident is a flammable gas deflagration due to an induced gas release caused by dissolution of the Tank 241-SY-101 crust from planned or inadvertent water addition with subsequent ignition. A list of existing controls that may prevent or mitigate this representative accident was made (including the controls selected above for the flammable gas deflagration crust disturbance accident), and then possible new controls were identified and evaluated. Following the selection of controls for the representative accident, the potential hazardous conditions represented by this accident (see Enclosure 6, Part 1) were reviewed and additional controls were selected, if necessary. The control decision discussions are summarized below, and the selected controls are presented in Attachment 3.

Existing Controls

Safety SSCs - SC: DST/AWF Ventilation

SC: Tank 241-SY-101 Hydrogen Monitor (7500 ppm*)

SC: Tank 241-SY-101 Ammonia Monitor (3000 ppm*)

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*Maximum gas concentrations in the LA-UR-92-3196 Level I controls for mixer pump operation

TSRs - LCO 3.2.1: DST and AWF Ventilation System

AC 5.9: Flammability Controls (LA-UR-92-3196 Level I mixer pump controls)

Supplemental Controls (Wagoner 1998)

Tank 241-SY-101 Ignition Controls

Tank 241-SY-101 Flammable Gas Monitoring Controls

Note: For this representative accident, the mixer pump controls were assumed to effectively control gas retention at depth and, therefore, the only postulated gas releases are from the crust.

Possible New Controls

Maximum Dilution Flow Rate – Based on the developed gas release model, the maximum water addition flow rate would have to be limited to less than around 30 gpm to ensure that the Lower Flammability Limit (LFL) would not be exceeded. (The actual flow rate is dependent on several factors including crust bubble slurry void fraction – see Appendix C.) This low dilution water flow rate would place a significant constraint on the Tank 241-SY-101 waste transfer. The consensus was that flammable gas monitoring was the preferred control because it provides a direct measure of the gas release hazard and addresses all gas release mechanisms from the crust.

Maximum Dilution Quantity without Waste Flow – This control was to limit the total quantity of dilution water that could inadvertently be added to Tank 241-SY-101. The control was based on the developed gas release model that showed it takes at least around 1500 gallons of water added under the crust to reach the LFL. (The actual quantity of water is dependent on several factors including the water flow rate and the crust bubble slurry void fraction – see Appendix C.) The concept for this control was to make the capacity of the water reservoir on the waste transfer dilution water skid the same as the maximum quantity of dilution water that could be added without waste transfer flow, and to provide an automatic interlock that shut off the service water supply to the dilution water skid on detecting loss of waste transfer flow. The design for this control would have been complex to address all of the postulated inadvertent water addition scenarios. It would also have required bypass of the interlock to refill the dilution skid water reservoir prior to each waste transfer pump startup. This would have introduced the opportunity for human errors. The consensus was that flammable gas monitoring with operator action to isolate water sources to Tank 241-SY-101 on high flammable gas concentration was the preferred control (see below).

Flammable Gas Monitoring – This selected control requires flammable gas monitoring whenever there is a planned water addition or whenever there is a potential for an inadvertent water addition to Tank 241-SY-101. If high flammable gas concentrations are detected (i.e., > 25% of the LFL), water sources that are or could be adding water to Tank 241-SY-101 would be isolated (i.e., valves closed and/or lines disconnected). There was considerable discussion on whether isolation of the waste transfer dilution

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water line should be automatic or could be done by operator action. The gas release model showed that there should be around 30 minutes between when 25% of the LFL is reached and when 100% of the LFL is reached. (The actual time is dependent on several factors including the water flow rate and the crust bubble slurry void fraction – see Appendix C.) Based on these conservative gas release model results, the consensus was that operator action to isolate the dilution water line was acceptable. Operator action also allowed the ability to backflush the waste transfer line into Tank 241-SY-102 while still isolating the dilution water line to Tank 241-SY-101. The Tank 241-SY-101 Surface-Level-Rise Remediation Project, however, assigned an action to develop a parallel path for the possible incorporation of an automatic dilution water line isolation interlock. Work on an automatic dilution water isolation interlock was subsequently terminated following receipt of French 1999 and TWRS Plant Review Committee (PRC) approval of the flammable gas monitoring control with operator action to isolate connected water sources.

Note: The original flammable gas monitoring control required continuous monitoring when water sources are connected to equipment for operations and activities that could add water to Tank 241-SY-101. At the September 9, 1999 control decision meeting, this control requirement was re-examined at the request of operations to consider a revision to exclude small water sources from the continuous monitoring requirement. There was consensus that continuous flammable gas monitoring was not required when connected water sources were ≤ 2000 gallons. The basis for this determination is that an addition of 2000 gallons of water will not cause gas releases that approach the LFL based on operating experience with water additions in Tank 241-SY-101 (Enclosure 15 – Part 18) and the conservative flammable gas calculations in Attachment A of Appendix C. Subsequently, however, as a result of their review, the TWRS PRC directed that the only exclusion allowed from the requirement for continuous flammable gas monitoring is for the waste transfer dilution water skid, whose water reservoir capacity is less than 2000 gallons, when the water skid is the only water source connected to the tank and the water skid is not connected to the service water system.

Minimum Ventilation System Flowrate (400 cfm or higher) – See the discussion for the flammable gas deflagration crust disturbance accident.

Attachment 3 is the control decision record of the safety SSCs, TSRs (or prudent contractor controls necessary for safe operation), and defense-in-depth controls selected to prevent potential flammable gas deflagration hazardous conditions and postulated accidents caused by induced gas releases from crust dissolution.

F3.3 FLAMMABLE GAS DEFLAGRATION – BUOYANT DISPLACEMENT GAS RELEASE EVENT PLUS ADDITIONAL GAS RELEASE FROM THE CRUST

The representative accident is a flammable gas deflagration due to an operation or activity that causes the mixer pump to become inoperable (e.g., waste transfer lowers waste below mixer pump suction) with a resulting subsequent BD GRE and ignition. A list of existing controls that may prevent or mitigate this representative accident was made (including controls selected above

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for the flammable gas deflagration crust disturbance and dissolution accidents), and then possible new controls were identified and evaluated. Following the selection of controls for the representative accident, the potential hazardous conditions represented by this accident (see Enclosure 6, Part 1) were reviewed and additional controls were selected, if necessary. The control decision discussions are summarized below, and the selected controls are presented in Attachment 4.

Existing Controls

Safety SSCs - SC: DST/AWF Ventilation
SC: Tank 241-SY-101 Hydrogen Monitor
SC: Tank 241-SY-101 Ammonia Monitor

TSRs - Tank 241-SY-101 Ignition Controls
Tank 241-SY-101 Flammable Gas Monitoring Controls

Possible New Controls

Waste Volume Transfer – This control was selected by consensus at the March 15 and 16, 1999 control decision meetings. The control requires the calculation of the quantity of waste that can be transferred and maintain mixer pump operability (i.e., maintain a sufficient distance between the bottom of the crust and the mixer pump suction to ensure that the mixer pump continues to perform its safety function of controlling gas retention at depth and preventing BD GREs). Based on analysis presented at the control decision meeting (Enclosure 13), mixer pump operability should not be affected as long as the bottom of the crust is at least one (1) foot above the mixer pump suction. However, there are uncertainties in measuring the bottom of the crust, including level monitoring system accuracy, and downward growth of the crust subsequent to the waste transfer that must be considered in calculating the maximum permissible waste transfer. The Tank 241-SY-101 waste transfer must then be monitored, and the transfer of waste limited to the maximum calculated quantity.

Because of concerns that this control may unnecessarily constrain Tank 241-SY-101 waste transfers, a workshop on the effects of crust ingestion on Tank 241-SY-101 mixer pump performance was conducted in August 1999 (PNNL-13039, *Effects of Crust Ingestion on Mixer Pump Performance in Tank 241-SY-101: Workshop Results*). At the September 9, 1999 control decision meeting, the findings of this workshop (Enclosure 15 – Part 5) provided the basis for re-examining the waste volume transfer control. Control options considered at the control decision meeting are identified in Enclosure 15 – Part 6. There was consensus based on the workshop findings that the waste volume transfer control be eliminated and replaced with a mixer pump operation monitoring control. The new control requires that the Tank 241-SY-101 Test Review Group (TRG) establish mixer pump parameters to be monitored during mixer pump operation and shutdown limits to prevent pump damage. (Note: This new control may already be satisfied by existing LA-UR-92-3196 Level II controls.) There was discussion at the control decision meeting on the need for an additional control on a lower Tank 241-SY-101 waste level limit to protect mixer pump operability. The concern was the possibility of “air-binding”

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the mixer pump if the waste level was lowered below the pump inlet. Based on information presented at the meeting that was subsequently confirmed and documented (Enclosure 15 – Part 17), it was concluded that “air-binding” the mixer pump is not credible and, therefore, no minimum Tank 241-SY-101 waste level control to protect mixer pump operability was necessary.

At the September 9, 1999 control decision meeting, the basis for eliminating and replacing the waste volume transfer control with a control on mixer pump operation monitoring included an assumption that restoration of mixer pump operation or performance could be accomplished, if necessary, simply by adding back dilution water low in Tank 241-SY-101 to raise the crust. Subsequent to the September 9, 1999 meeting, new and revised analysis of the effects of waste transfer and back dilution on crust buoyancy were completed that effected this assumption. The new and revised analysis (Enclosure 16 – Part 4 and PNNL-13066) showed that the crust could sink and prevent mixer pump operation/performance if the first waste transfer and subsequent back dilution with water lowers the specific gravity of the Tank 241-SY-101 slurry below the specific gravity of the crust. For this reason, at the October 13, 1999 control decision meeting, a waste volume transfer control was again selected to ensure that corrective action to raise the crust can be taken to restore mixer pump operation or performance, if needed, following the first Tank 241-SY-101 waste transfer. Based on operating experience, the mixer pump has operated and performed to control gas retention at depth and prevent BD GREs with the base of the crust as low as 295 inches from the bottom of the tank. Therefore, the maximum quantity of waste transferred for the first Tank 241-SY-101 transfer will be limited so that back dilution can raise the base of the crust back to at least 295 inches without the crust sinking. [Note: The quantity of back dilution water that can be added following the first waste transfer is also limited to ensure that the crust does not sink (see Section F3.8)]. The maximum quantity of waste transferred is to be determined prior to the first waste transfer by Process Engineering based on the crust buoyancy model in PNNL-13066 and current Tank 241-SY-101 conditions. The maximum allowed waste transfer quantity will be reviewed and approved by the Plant Review Committee (PRC).

Tank 241-SY-101 Waste Level – This control has the same objective as the selected control on calculating, monitoring, and limiting waste transfer volume. At the March 15 and 16, 1999 control decision meetings, the consensus was that the waste volume transfer control was preferred versus simply establishing a lower limit on the level of the crust bottom. (See also the above discussion on the waste volume transfer control from the September 9, 1999 control decision meeting.)

Mixer Pump Performance – Because it was judged as providing significant defense-in-depth with respect to ensuring mixer pump operability, the consensus was to elevate the monitoring of mixer performance to a TSR-level control. The control requires monitoring of mixer pump performance, including monitoring parameters such as pump motor current, pump discharge pressure, and the response of waste thermocouples to mixer pump operation. The monitoring results are to be reviewed periodically (at least quarterly) by the TRG for signs of mixer pump performance degradation (i.e., loss of mixer pump capability to control gas retention at depth and prevent BD GREs). If signs of degraded mixer pump

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performance are detected, the TRG would direct corrective action to restore mixer pump performance, such as the addition of water to Tank 241-SY-101. (Note: This control was integrated with the mixer pump operation monitoring control discussed above under waste volume transfer to become the Tank 241-SY-101 Mixer Pump Operation and Performance Monitoring control.)

Instrument Systems – At the March 15 and 16, 1999 control decision meetings, instrument systems required to implement the selected TSR-level control on calculating, monitoring, and limiting waste transfers from Tank 241-SY-101 to Tank 241-SY-102 (see above) were identified as Safety-Significant SSCs. Subsequent to the control decision meetings, the Safety-Significant classification was questioned by the TWRS Design Authority. On the basis that these instrument systems are essential to implement a control that protects against an accident with consequences that could exceed offsite risk evaluation guidelines, the instrument system classification was revised to Safety-Class. Also, the selection of the specific instrument systems to implement the control was made by cognizant design and operations personnel subsequent to the meetings (i.e., the Tank 241-SY-101 waste transfer flow totalizer^b and the dilution water flow totalizer). Because there is no installed system that can directly measure the bottom of the crust, no specific instrument system was identified as Safety-Class for this measurement. However, existing TSR AC 5.19 on process instrumentation and measuring and test equipment will ensure the performance of whatever instrument system(s) is (are) used to measure the level of the bottom of the crust.

At the September 9, 1999 control decision meeting, the consensus was to delete the earlier selected waste volume transfer control. However, at the October 13, 1999 control decision meeting, a waste volume transfer control was again selected (see the discussion above). The Tank 241-SY-101 waste transfer flow totalizer and the dilution water flow totalizer are required to implement the revised Tank 241-SY-101 waste transfer control, and, therefore, they remain designated as safety-class SSCs. (Note: The Tank 241-SY-101 waste transfer flow totalizer also has a safety-significant designation to implement the material balance requirements of TSR AC 5.12.)

Siphon Break –Siphoning of waste from Tank 241-SY-101 to Tank 241-SY-102 is a concern since it could lead to the inadvertent transfer of waste and mixer pump inoperability. At the time of the control decision meetings, the waste transfer system design required operator action to initiate a siphon break following shutdown of the waste transfer pump. With this design, the time to initiate the siphon break (30 minutes) was required to be accounted for in the implementation of the initially selected waste volume transfer control (see above). The Tank 241-SY-101 Surface-Level-Rise Remediation Project was assigned an action to assess the possibility of including a passive siphon break in the

^b Originally the Tank 241-SY-102 tank level detection system and the dilution water flow totalizer were selected as the instrument systems to implement the Tank 241-SY-101 waste transfer control. However, when the Tank 241-SY-101 waste transfer flow totalizer was later selected to implement the TSR AC 5.12 Transfer Control material balanced requirements (see Section F3.6), the decision was made to use it also for implementing the waste transfer control instead of the Tank 241-SY-102 tank level detection system.

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waste transfer system design. Based on the Project assessment, the waste transfer system design was revised to incorporate a passive siphon break in the Tank 241-SY-102 drop leg. The passive siphon break was designated Safety-Class since its failure could lead to inoperability of the mixer pump which could cause the representative accident whose consequences could exceed offsite risk evaluation guidelines.

The safety function and the need for the siphon break in the Tank 241-SY-102 drop leg was re-examined at the September 9, 1999 control decision meeting and again at the October 13, 1999 meeting. An analysis of potential siphon flow in the transfer line between Tanks 241-SY-101 and 241-SY-102 showed that a small siphon was possible under certain conditions with the final siphon break design (Enclosure 15 – Part 7 and HNF-4359, *Engineering Design Calculations for the SY-101 RAPID Mitigation Project*). That is, the siphon break does not strictly meet the originally defined safety function. At the September 9, 1999 control decision meeting, the need for the siphon break to prevent inadvertent lowering of the waste surface level and Tank 241-SY-101 mixer pump crust ingestion was determined as not critical to protecting the pump safety function. However, this decision was reversed at the October 13, 1999 control decision meeting because of concerns with the potential for sinking the crust (see the above waste volume transfer control discussion). Therefore, the siphon break remains designated as a safety-class SSC with a revised safety function. The revised siphon break safety function to prevent the siphoning of waste from Tank 241-SY-101 when the waste transfer pump is not operating and dilution water flow to the transfer pump is stopped is accounted for in the maximum quantity of waste that can be transferred in the first Tank 241-SY-101 waste transfer (see the Tank 241-SY-101 Waste Transfer Control).

Attachment 4 is the control decision record of the safety SSCs, TSRs (or prudent contractor controls necessary for safe operation), and defense-in-depth controls selected for this representative accident and the potential hazardous conditions represented by this accident.

F3.4 FLAMMABLE GAS DEFLAGRATION – GENERAL

The Tank 241-SY-101 waste transfer hazard analysis resulted in a hazardous condition that was represented by the existing representative flammable gas deflagration accident for double-shelled tanks (DSTs) (see Enclosure 6, Part 1). However, because the existing TSR AC 5.10 ignition controls and AC 5.11 flammable gas monitoring controls do not apply to Tank 241-SY-101, this hazardous condition was identified for consideration at the control decision meetings. With the existing flammability controls and the new Tank 241-SY-101 TSR-level ignition and flammable gas monitoring controls selected above for other Tank 241-SY-101 flammable gas deflagration accident scenarios, the control decision meeting consensus was that these controls (see Attachment 5) were sufficient to control this potential hazardous condition.

F3.5 SPRAY LEAK IN STRUCTURE OR FROM OVERGROUND TRANSFER LINE

The Tank 241-SY-101 waste transfer hazard analysis resulted in a number of hazardous conditions that were represented by the existing representative spray leak accident, but where issues were identified concerning whether existing controls acceptably prevented and/or

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mitigated these hazardous conditions (see Enclosure 6, Part 1). The concerns generally resulted because the Tank 241-SY 101 waste transfer design included an above ground Prefabricated Pump Pit (P3) and a special Tank 241-SY-102-007 riser drop leg enclosure design where the overground transfer line entered Tank 241-SY-102. Attachment 6 presents the consensus on controls that are unique to the Tank 241-SY-101 waste transfer. The safety-functions for the P3 and the riser 241-SY-102-007 drop leg enclosure included safety functions from the TWRS Final Safety Analysis Report (FSAR) for the above ground portion of waste transfer associated structures (e.g., pits).

There was discussion on whether the P3, overground transfer encasement and connections, and riser 241-SY-102-007 drop leg enclosure were required to maintain their safety function for design basis high wind and seismic events. The structures were already being designed to meet design basis high wind (and associated missiles) criteria and, therefore, this requirement was initially imposed on all three structures. Subsequent to the March 15 and 16, 1999 control decision meetings, the design of the overground transfer line changed from a hose-in-pipe design to a hose-in-hose design. At the May 18, 1999 control decision meeting the requirement that the overground transfer encasement and connections (now an EPDM hose) be designed to maintain its safety function following the impact of design basis high wind missile was re-examined and deleted. The basis for this control decision was (1) the unlikely occurrence of this event, (2) the time and cost to demonstrate either by analysis or testing that the EPDM hose meets the design basis high wind missile criteria, and (3) the unanimous belief that a design basis high wind missile would not cause a spray or pool leak. The later qualitative judgement considered the general toughness of the hose and that it would be covered by insulation and lead shield blankets.

The consensus on the P3, overground transfer encasement and connections, and riser 241-SY-102-007 drop leg enclosure maintaining their safety function for a design basis seismic event was that these structures need not be seismically qualified to Performance Category (PC)-3 criteria, and that the only control required for a design basis seismic event is the existing TSR AC 5.14 emergency preparedness control to mitigate the potential consequences. This was justified for several reasons. First, there is a low likelihood of a design basis seismic event during a Tank 241-SY-101 waste transfer. Second, designing the P3 and the riser 241-SY-102-007 drop leg enclosure to meet seismic PC-3 criteria would have had significant cost and schedule impacts.

Leak detection in the riser 241-SY-102-007 drop leg enclosure was also discussed for mitigating the consequences of spray and surface pool leaks. The consensus at the March 15 and 16, 1999 control decision meetings was that leak detection was not required for safety. This decision was based on the large drain area to Tank 241-SY-102, and the potential difficulty in designing a leak detector for the riser drop leg enclosure. A requirement was imposed, however, that the riser drop leg enclosure and the overground transfer encasement and connections be designed to withstand the maximum pressure resulting if the drain to Tank 241-SY-102 is plugged and the waste backs up the overground transfer encasement to the P3.

At the May 18, 1999 control decision meeting, the safety classification of the riser drop leg enclosure leak detection system was re-examined. A leak detection system was included in the final design of the riser drop leg enclosure to meet environmental requirements, and it meets the safety-class requirements of existing TWRS leak detection systems. Based on this, there was a

consensus that the riser drop leg enclosure leak detection system should be designated as a safety-class SSC for the Surface Leak Resulting in Pool accident and should be subject to TSR LCO 3.1.3. (Note: The leak detection system in both the P3 and in the riser drop leg enclosure are not considered as new controls, but as existing controls applied to the Tank 241-SY-101 waste transfer system design, and are, therefore, not listed in Attachments 6 and 7).

F3.6 SURFACE LEAK RESULTING IN POOL

See the control decision meeting discussion of the spray leak accident in Section 3.5 and Attachment 7 for the resulting safety SSCs, TSRs (or prudent contractor controls necessary for safe operation), and defense-in-depth controls that are unique to the Tank 241-SY-101 waste transfer for the Surface Leak Resulting in Pool accident. Attachment 7 also includes the control decision subsequent to the March 15 and 16, 1999 meetings that the Tank 241-SY-101 waste transfer flow totalizer be designated as a safety-significant SSC to implement the material balance requirements of TSR AC 5.12. The basis for this control decision is that Tank 241-SY-101 waste level change may not be an easily measured or reliable input for the material balance.

F3.7 MIXING OF INCOMPATIBLE MATERIAL – TOXIC VAPOR GENERATION

The potential for ammonia releases was identified in the hazard analysis of Tank 241-SY-101 waste transfers. At the time of the March 15 and 16, 1999 control decision meetings, potential hazardous conditions and postulated accidents involving ammonia releases were not considered because the hazard and accident analyses of ammonia release consequences showed that exposures were below risk evaluation guidelines. Subsequent analysis of the consequences of ammonia releases for Tank 241-SY-101 waste transfers showed that without controls onsite worker risk evaluation guidelines could be exceeded. This resulted in another control decision meeting on May 18, 1999 to select controls to prevent or mitigate postulated ammonia releases for Tank 241-SY-101 waste transfers.

Hazardous conditions involving ammonia releases are represented by the Mixing of Incompatible Material – Toxic Vapor Generation accident (see BIO Section 5.3.2.11). The representative accident is a rapid, uncontrolled addition of caustic (sodium hydroxide) to liquid waste of low pH that causes the release of ammonia as the waste becomes more basic. The analysis of this representative accident showed that onsite and offsite ammonia concentrations were below risk evaluation guidelines, and no controls were identified other than the Industrial Hygiene Program as a defense-in-depth control. Because the representative accident does not bound the potential consequences of potential hazardous conditions and postulated accidents for Tank 241-SY-101 waste transfers, the analysis of postulated ammonia releases contained in Appendix E provided the basis for the controls decisions.

Following presentations on the calculated ammonia concentrations during Tank 241-SY-101 remediation activities and operations (see Enclosure 14, Parts 3 and 4), possible controls were identified and evaluated. The control decision discussions are summarized below, and the selected controls are presented in Attachment 8.

Possible Controls

Elevated (stack) release (SSC) – There was consensus that the 241-SY Tank Farm primary tank ventilation system should be designated as a safety-significant SSC with its safety function being to ensure an elevated release of ammonia (that is, prevent a ground level release). An elevated or stack release versus a ground level release reduces the ammonia concentration at 100 meters (onsite worker) and also for facility workers.

Taller stack – Increasing the stack height would provide further mitigation of ammonia releases (i.e., decrease the ammonia concentration at 100 meters). Other controls were selected in preference to this control because of the time and cost to design and construct a taller stack and an estimated reduction of ammonia concentration by only a factor of 2 for a doubling of the stack height.

Ammonia monitoring – At the May 18, 1999 control decision meeting, ammonia monitoring was selected by consensus as a TSR-level control since it provided significant defense-in-depth to the controls of an elevated (stack) release and the Tank 241-SY-102 drop leg. With the subsequent decision not to designate the drop leg as a safety SSC (see below), ammonia monitoring together with an elevated release became the selected controls. The ammonia concentrations for initiating operator actions (3000 ppm for the Tank 241-SY-101 ammonia monitoring system and 1000 ppm for the 241-SY Tank Farm primary tank ventilation exhaust ammonia monitoring system) were conservatively selected to be consistent with the existing LA-UR-92-3196 Level I mixer pump operation ammonia monitoring control. At the May 18, 1999 meeting, it was decided that the existing ammonia monitoring systems not be designated as safety-significant SSCs. Instead, to provide operational flexibility, it was determined that the instrument systems used to monitor ammonia need only meet the requirements of TSR AC 5.19. This decision was subsequently questioned by the TWRS Design Authority and revised. Because of the special monitoring system requirements needed to ensure accurate measurement of ammonia concentrations, the Tank 241-SY-101 and the 241-SY Tank Farm primary tank ventilation exhaust ammonia monitoring systems were designated as a safety-significant SSC.

Note: The original ammonia monitoring control required continuous monitoring when water sources are connected to equipment for operations and activities that could add water to Tank 241-SY-101. At the September 9, 1999 control decision meeting, this control requirement was re-examined at the request of operations to consider a revision to exclude small water sources from the continuous monitoring requirement. There was consensus that continuous ammonia monitoring was not required when connected water sources were ≤ 2000 gallons. The basis for this determination is that an addition of 2000 gallons of water will not cause ammonia releases that approach risk evaluation guidelines based on operating experience with water additions in Tank 241-SY-101 (Enclosure 15 – Part 18) and the very conservative ammonia calculations in Appendix E.*

*This assumes that the occurrence of fumigation conditions coincident with this event is unlikely.

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Subsequently, however, as a result of their review, the PRC directed that the only exclusion allowed from the requirement for continuous ammonia monitoring is for the waste transfer dilution water skid, whose water reservoir capacity is less than 2000 gallons, when the water skid is the only water source connected to the tank and the water skid is not connected to the service water system.

Flammable Gas Monitoring – This control was simply to take credit for flammable gas monitoring controls (see TSR AC 5.11 and Section 3.1). This control was not selected because the correlation of flammable gas and ammonia releases from remediation activities and operations that disturb the waste in Tank 241-SY-101 is not well defined, and ammonia releases in Tank 241-SY-102 during a waste transfer from Tank 241-SY-101 are not associated with flammable gas releases.

Exclusion zone for onsite personnel – This control would mitigate potential ammonia releases by restricting personnel access within a specified distance of the 241-SY Tank Farm during Tank 241-SY-101 waste transfers (e.g., 200 meters, 300 meters). The consensus was that this control would be difficult to implement as a TSR-level control and could adversely impact other 200-West area operations. The reduction in ammonia concentration by increasing the 100 meter distance for the onsite worker is also small. (Note: Limiting and/or controlling personnel access in the vicinity of the 241-SY-Tank Farm is being considered for purposes of facility worker protection by the Industrial Hygiene Program.)

Ammonia monitoring/emergency evacuation – This control differs from the selected ammonia monitoring control in that if the ammonia concentration in Tank 241-SY-101 or in the 241-SY Tank Farm primary tank ventilation exhaust exceeded a specific limit, evacuation of workers would be required. The consensus was that the selected ammonia monitoring control was sufficient.

Tank 241-SY-102 drop leg (SSC) – At the May 18, 1999 control decision meeting, the Tank 241-SY-102 drop leg was designated as a safety-significant SSC by consensus. This passive design feature significantly mitigates ammonia releases in Tank 241-SY-102 by ensuring the waste transferred from Tank 241-SY-101 is discharged below the waste surface. The PRC subsequently requested that the initially selected controls for ammonia be reviewed to determine if ammonia monitoring and an elevated release were sufficient to protect the onsite and facility workers without credit for the Tank 241-SY-102 drop leg. Based on additional analysis of the bounding ammonia accident scenario for Tank 241-SY-101 waste transfers, it was demonstrated that ammonia exposures were controlled to within risk evaluation guidelines with just ammonia monitoring and an elevated release. The Tank 241-SY-102 drop leg was, therefore, revised from a safety-significant SSC to a defense-in-depth control.

Ammonia scrubber – This control was not selected based on the time and cost to design and install an ammonia scrubber on the 241-SY Tank Farm exhaust ventilation system, and the ability to adequately protect onsite and facility workers from potential ammonia release hazards by the selected controls.

Restrict Tank 241-SY-101 Waste Transfer during “fumigation” weather conditions – The most restrictive atmospheric dispersion condition (i.e., the weather condition resulting in the

highest ammonia concentration from an elevated release) is fumigation. Fumigation conditions occur for a short time following sunrise on clear days. This control was not selected since it would be required at least daily startup and shutdown of the waste transfer.

Air Injection at the Stack – This control would mitigate ammonia releases by providing dilution and increasing the effective stack height. The selected controls were preferred over this control because of the time and cost to implement this control.

Attachment 8 is the control decision record of the safety SSCs, TSRs (or prudent contractor controls necessary for safe operation), and defense-in-depth controls selected to protect against potential hazardous conditions and postulated accidents that may cause ammonia releases during Tank 241-SY-101 waste transfers.

F3.8 BACK DILUTION CONTROL DECISION DISCUSSIONS

The need for new controls for potential hazardous conditions and postulated accidents specific to back dilution of the Tank 241-SY-101 waste with water were discussed at the September 9 and October 13, 1999 control decision meetings. Control decisions focused on back dilution following the first waste transfer. The scope of the September 9, 1999 control decision meeting was restricted to the addition of back dilution water via either the Tank 241-SY-101 mixer pump burrowing ring or the waste transfer pump with the water heated and supplied from the same water skid used to supply the waste transfer dilution water. This scope was expanded at the October 13, 1999 meeting to include the addition of back dilution water on top of the waste (i.e., on top of the crust). Top back dilution would be via a 1-inch vent line located in riser 241-SY-101-007 from the PPP piping manifold to the Tank 241-SY-101 dome space. Future back dilution operations that add water at different locations (e.g., within or immediately below the crust) or with other significant differences from that evaluated for the first back dilution will require evaluation to determine whether additional controls are needed.

The Tank 241-SY-101 back dilution hazard analysis results identified that all hazardous conditions with potentially significant consequences to the offsite population (S3) or onsite workers (S2) are represented by the following representative accidents analyzed in the BIO (Enclosure 15 – Part 9).

- Mixing of Incompatible Material – Toxic Vapor Generation
- Flammable Gas Deflagrations
- Surface Leak Resulting in Pool
- HEPA Filter Failure – Exposure to High Temperature or Pressure

The hazard analysis also identified existing controls (including controls previously selected for Tank 241-SY-101 waste transfers – see Sections F3.1 to F3.7) that apply to the S3 and S2 back dilution hazardous conditions (Enclosure 15 – Part 9). Based on the analyses performed to support back dilution control decisions (see Sections F2.3 and F2.4), the control decision discussions identified possible new back dilution controls and determined whether they should

be selected. These control decision discussions are summarized below. Following the selection of new back dilution controls, all of the S3 and S2 back dilution hazardous conditions were reviewed to confirm that each was acceptably prevent or mitigated by the existing or new controls. [Note: This review also confirmed that anticipated hazardous conditions with potentially significant facility worker consequences (F3, S1) and hazardous conditions with potentially significant environmental consequences (E2 and E3) were also acceptably addressed by the existing or new back dilution controls.]

Possible New Controls

Control on maximum dilution water addition rate – The consensus at the September 9, 1999 control decision meeting was that no additional control on the dilution water addition rate was needed. This was supported by initial results of the mixing analysis of back dilution water with slurry reported at the control decision meeting and subsequently confirmed in PNNL-13038, the analysis of adverse structural effects from crust movement (Enclosure 15 – Part 11), and the analysis of flammable gas releases from the slurry (Enclosure 15 – Part 12) all of which addressed addition rates up to several hundreds of gallons per minute. The dilution water addition rate on top of the crust is limited by the delivery system (i.e., water skid and 1-inch line), and there was no need to reconsider this control decision at the October 13, 1999 meeting.

Control on maximum dilution water temperature – The open phenomenological issue from HNF-4891, *Hazard Evaluation for Back-Dilution of Tank 241-SY-101 Waste*, concerning the addition of hot dilution water was discussed at the September 9, 1999 control decision meeting. The issue was whether the addition of hot dilution water to Tank 241-SY-101 could increase the dissolution of the crust and upon re-formation of the crust, the crust may be less permeable than before. Historical tank farm experience does not support this “impermeable” crust theory, and there is insufficient understanding of this phenomena to establish a control. Therefore, the consensus was that no additional control on dilution water temperature was needed. Because water additions on top of the crust should not significantly affect the slurry waste temperature, water temperature is even less of a concern for top back dilution and there was no need to reconsider this control decision at the October 13, 1999 meeting. (Note: There will be a process control on dilution water temperature.)

Control on acceptable water addition location(s) – Addition of back dilution water low in Tank 241-SY-101 via either the mixer pump burrowing ring or the waste transfer pump were considered at the September 9, 1999 control decision meeting. At the October 13, 1999 control decision meeting, addition of back dilution water on top of the crust was considered. If subsequent back dilution water additions are proposed for other locations (e.g., within or at the base of the crust) additional analyses and/or controls may be necessary.

Control on maximum quantity of dilution water added – The consensus at the September 9, 1999 control decision meeting was that no control on dilution water quantity was needed. This was based on (1) the mixing analysis of back dilution water (PNNL-13038), (2) the analysis of flammable gas releases from the slurry (Enclosure 15 – Part 12), and

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(3) existing controls that address hazardous conditions caused by overfilling of Tank 241-SY-101. The consensus was also based on information presented at the time that the crust would not sink for the first waste transfer and subsequent low back dilution of 100,000 to 150,000 gallon of waste and water, respectively. This latter information was subsequently determined to be incorrect, and required reconsideration of the need for a control on the maximum quantity of dilution water added at the October 13, 1999 control decision meeting.

Based on new and revised information on the effects of waste transfer and back dilution on crust buoyancy (Enclosure 16 – Part 4) and the potential for flammable gas and ammonia hazards possible due to the addition of water on top of the crust, there was a consensus for a new Tank 241-SY-101 back dilution control. The new control limits the quantity of low and top back dilution water that can be added after the first waste transfer and requires that back dilution water additions be monitored and limited to these maximum quantities.

The maximum quantity of back dilution water that can be added low in the tank (i.e., via the mixer pump burrowing ring or waste transfer pump) is required to ensure that the crust does not sink and adversely affect mixer pump operation or performance following the first waste transfer (see also the discussion of waste volume transfer controls in Section F3.3). The maximum quantity of low back dilution water will be determined by Process Engineering following the first waste transfer based on the crust buoyancy model in PNNL-13066 and current Tank 241-SY-101 conditions and will be reviewed and approved by the PRC.

The maximum quantity of back dilution water that can be added on top of the waste will initially be limited to 30,000 gallons. This prevents a rapid release of flammable gas or ammonia caused by a sudden “roll over” of the crust. Crust roll over could result if water additions on top of the crust thin and weaken the crust. The 30,000 gallon limit is based on the analysis in PNNL-13066, that shows 30,000 gallons should dissolve the upper layers of the crust (i.e., the top, dry freeboard and the wet clay layers), but leave the crust thickness well above where experience has shown the crust to be very stable.

Control on mixer pump or waste transfer pump operation during back dilution – There are LA-UR-92-3196 Level II controls that restrict simultaneous waste disturbing operations in Tank 241-SY-101, and it was the consensus that these controls should remain at this level where they can be modified if necessary by the TRG.

Attachment 9 is the control decision record of new safety SSCs, TSRs (or prudent contractor controls necessary for safe operation), and defense-in-depth controls selected to protect against potential hazardous conditions and postulated accidents resulting from back dilution of Tank 241-SY-101 waste with water. The controls decisions documented in Attachment 9, however, only cover the initial back dilution of Tank 241-SY-101 following the first waste transfer. Additional controls may be required for subsequent back dilutions.

F4.0 REFERENCES

- French, R. T., 1999, *Contract No. DE-AC06-96RL13200 – Submittal of Updated Unreviewed Safety Question (USQ) Evaluation and Supplemental Controls for Tank 241-SY-101*, (Letter 99-TSD-051 to R. D. Hanson, Fluor Daniel Hanford, Inc.), U.S. Department of Energy, Office of River Protection, Richland, Washington.
- HNF-3824, 1999, *Tank 241-SY-101 Surface-Level-Rise Remediation Project Plan*, Rev. 0, Lockheed Martin Hanford Corporation, Richland, Washington.
- HNF-4159, 1999, *Engineering Design Calculations for the SY-101 RAPID Mitigation Project*, Rev. 0-E, Lockheed Martin Hanford Corporation, Richland, Washington.
- HNF-4891, 1999, *Hazard Evaluation for Back-Dilution of Tank 241-SY-101 Waste*, Rev. 0, Fluor Daniel Northwest, Inc., Richland, Washington.
- HNF-SD-WM-BIO-001, *Tank Waste Remediation System Basis for Interim Operation*, Lockheed Martin Hanford Corporation, Richland, Washington.
- HNF-SD-WM-SAR-067, *Tank Waste Remediation System Final Safety Analysis Report*, Lockheed Martin Hanford Corporation, Richland, Washington.
- LA-UR-92-3196, 1996, *A Safety Assessment for Proposed Pump Mixing Operations to Mitigate Episodic Gas Releases in Tank 241-SY-101: Hanford Site, Richland, Washington*, Rev. 14a, Los Alamos National Laboratory, Los Alamos, New Mexico.
- PNNL-13038, 1999, *Potential for Waste Stratification Resulting from Back Dilution in Tank SY-101*, Pacific Northwest National Laboratory, Richland, Washington.
- PNNL-13039, 1999, *Effects of Crust Ingestion on Mixer Pump Performance in Tank 241-SY-101: Workshop Results*, Pacific Northwest National Laboratory, Richland, Washington.
- PNNL-13066, 1999, *Buoyant Response of the SY-101 Crust to Transfer and Back Dilution*, Pacific Northwest National Laboratory, Richland, Washington.
- Wagoner, J. D., 1998, *Contract No. DE-AC06-96RL13200 – Supplemental Controls for Continued Operations in Tank 241-SY-241* (Letter 98-SCD-140 to R. D. Hanson, Fluor Daniel Hanford, Inc.), U.S. Department of Energy, Richland Operations Office, Richland, Washington.

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ATTACHMENT 1

**SUMMARY OF NEW CONTROLS FOR TANK 241-SY-101
WASTE TRANSFERS AND BACK DILUTION**

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Summary of New Controls for Tank 241-SY-101 Waste Transfers and Back Dilution¹ (5 Sheets)

Analyzed Accident	Safety Structures, Systems, and Components			Technical Safety Requirement ²	Comments
	Description	SC	SS		
Flammable Gas Deflagrations	Siphon break in Tank 241-SY-102 drop leg	X			Siphon break: The safety function of the siphon break is to prevent the siphoning of waste from Tank 241-SY-101 to Tank 241-SY-102 when the waste transfer pump is not operating and there is no dilution water flow to the transfer pump. (See Note 3)
	Tank 241-SY-101 waste transfer flow totalizer	X			Tank 241-SY-101 waste transfer flow totalizer: The safety function of the Tank 241-SY-101 waste transfer flow totalizer is to provide the volume of material transferred from Tank 241-SY-101 to Tank 241-SY-102 (waste plus dilution water) for implementation of the Tank 241-SY-101 Waste Transfer Control. (See Note 3)
	Dilution water flow totalizer	X			Dilution water flow totalizer: The safety function of the dilution water flow totalizer is to provide dilution water data for implementation of the Tank 241-SY-101 Waste Transfer Control. (See Note 3)

Summary of New Controls for Tank 241-SY-101 Waste Transfers and Back Dilution¹ (5 Sheets)

Analyzed Accident	Safety Structures, Systems, and Components			Technical Safety Requirement ²	Comments
	Description	SC	SS		
Flammable Gas Deflagration				AC: Tank 241-SY-101 Mixer Pump Operation and Performance Monitoring	<p>Program key elements are:</p> <ul style="list-style-type: none"> Mixer pump operating parameters (e.g., pump motor current, pump discharge pressure) identified by the Test Review Group (TRG) shall be monitored during mixer pump operation, and the mixer pump shall be shutdown if limits established by the TRG to prevent pump damage are exceeded. Mixer pump performance (e.g., pump motor current, pump discharge pressure, waste thermocouple response) shall be monitored, and the TRG shall review the data quarterly for signs of degradation that could affect continued control of gas retention at depth and prevention of buoyant displacement gas release events (BD GREs) The TRG shall direct corrective actions to restore mixer pump operation and performance, as necessary. The TRG shall direct corrective actions to restore mixer pump operation and performance, as necessary. If following the first waste transfer back dilution of the Tank 241-SY-101 waste with water is required to restore mixer pump operation or performance (e.g., to raise the crust), back dilution shall be in accordance with the requirements of the Tank 241-SY-101 Back Dilution Control (see below).

Summary of New Controls for Tank 241-SY-101 Waste Transfers and Back Dilution¹ (5 Sheets)

Analyzed Accident	Safety Structures, Systems, and Components			Technical Safety Requirement ²	Comments
	Description	SC	SS		
Flammable Gas Deflagration (Continued)				AC: Tank 241-SY-101 Back Dilution Control	<p>Program key elements are:</p> <ul style="list-style-type: none"> Following the first Tank 241-SY-101 waste transfer, the maximum quantity of water that can be added on top of the waste shall be 30,000 gallons. Following the first Tank 241-SY-101 waste transfer, the quantity of back dilution water that can be added low in the tank (i.e., via the Tank 241-SY-101 mixer pump burrowing ring or the waste transfer pump) shall be limited to ensure that the crust does not sink. The maximum quantity of back dilution water that can be added low in the tank following the first waste transfer shall be determined by Process Engineering and reviewed and approved by the Plant Review Committee (PRC). Back dilution water additions to Tank 241-SY-101 waste shall be monitored and limited to the maximum quantities specified above.
				AC: Tank 241-SY-101 Ignition Controls	Expand applicability of existing TSR AC 5.10 ignition controls to Tank 241-SY-101; elevate and augment LA-UR-92-3196 Level II ignition controls.

Summary of New Controls for Tank 241-SY-101 Waste Transfers and Back Dilution¹ (5 Sheets)

Analyzed Accident	Safety Structures, Systems, and Components			Technical Safety Requirement ²	Comments
	Description	SC	SS		
Flammable Gas Deflagration (Continued)				AC: Tank 241-SY-101 Flammable Gas Monitoring Controls	<p>Expand applicability of existing TSR AC 5.11 flammable gas monitoring controls to Tank 241-SY-101; elevate and augment LA-UR-92-3196 Level II flammable gas monitoring controls.</p> <p>Note: The flammable gas monitoring controls for Tank 241-SY-101 shall specify:</p> <ol style="list-style-type: none"> When the LA-UR-92-3196 Level I mixer pump hydrogen and ammonia monitoring controls are applicable, and That flammable gas monitoring is required whenever water sources are connected to Tank 241-SY-101, and that all sources of water shall be isolated on high flammable gas concentrations. Flammable gas monitoring is not required when the waste transfer dilution water skid is the only source connected to the tank and the water skid is not connected to the service water system.

Summary of New Controls for Tank 241-SY-101 Waste Transfers and Back Dilution¹ (5 Sheets)

Analyzed Accident	Safety Structures, Systems, and Components			Technical Safety Requirement ²	Comments
	Description	SC	SS		
Flammable Gas Deflagration (Continued)				AC: Tank 241-SY-101 Waste Transfer Control	<p>Program key elements are:</p> <ul style="list-style-type: none"> For the first waste transfer from Tank 241-SY-101, the quantity of waste transferred shall be limited. The maximum quantity of waste that can be transferred shall be calculated so that back dilution of the Tank 241-SY-101 waste with water following the first waste transfer can raise the base of the crust to at least 295 inches from the bottom of the tank without the crust sinking. The maximum quantity of waste transferred shall account for waste that could be siphoned from Tank 241-SY-101 after the waste transfer pump is turned off until dilution water flow to the transfer pump is stopped (e.g., the dilution water supply is disconnected). (Note that closed valves do not ensure that the dilution water flow is stopped.) The maximum quantity of waste transferred in the first waste transfer shall be determined by Process Engineering and reviewed and approved by the PRC. The first waste transfer from Tank 241-SY-101 shall be monitored and limited to the maximum quantity established above.

Summary of New Controls for Tank 241-SY-101 Waste Transfers and Back Dilution¹ (5 Sheets)

Analyzed Accident	Safety Structures, Systems, and Components			Technical Safety Requirement ²	Comments
	Description	SC	SS		
Spray Leak in Structure or from Overground Transfer Line	Prefabricated Pump Pit (P3)	X	-	None	P3: The safety function of the P3 is to knock down spray and limit release of aerosols to the environment. The P3 shall be designed to withstand design basis high wind and associated missiles. (See Note 3)
	OGT encasement and connections	X	-		OGT encasement and connections: The safety function of the OGT encasement and connections is to confine a leak from the primary piping and ensure that the leak is directed to the riser 241-SY-102-007 drop leg enclosure or to the P3 which contain leak detection systems. The OGT encasement and connections shall be designed to withstand (1) the maximum pressure resulting if the drain to Tank 241-SY-102 is plugged and the waste backs up the OGT encasement to the P3 and (2) design basis high wind, but not the associated missiles. (See Note 3)
	Riser 241-SY-102-007 drop leg enclosure	X	-		Riser 241-SY-102-007 drop leg enclosure: Same as OGT encasement and connections except that the riser 241-SY-102-007 drop leg enclosure shall be designed to withstand missiles associated with the design basis high wind. (See Note 3)

Summary of New Controls for Tank 241-SY-101 Waste Transfers and Back Dilution¹ (5 Sheets)

Analyzed Accident	Safety Structures, Systems, and Components			Technical Safety Requirement ²	Comments
	Description	SC	SS		
Surface Leak Resulting in Pool	Prefabricated Pump Pit (P3)	X	X	None	P3: The <i>safety-class safety function</i> of the P3 is to provide an intact boundary for the leaked waste, and when leak detector alarms and appropriate operator response times to shut off the transfer pump are credited, to prevent premature P3 overflow and the formation of a surface pool. The <i>safety-significant safety function</i> of the P3, including cover, is to limit release of aerosols generated by splatter inside the P3, and limit shine and skyshine dose to onsite receptors. The P3 shall be designed to withstand design basis high wind and associated missiles. (See Note 3)
	OGT encasement and connections	X	-		OGT Encasement and Connections: The safety function of the OGT encasement and connections is to provide secondary confinement for a leak from the primary line and route the leak to the riser 241-SY-102-007 drop leg enclosure or to the P3 which contain leak detection systems. The OGT encasement and connections shall be designed to withstand (1) the maximum pressure resulting if the drain to Tank 241 SY-102 is plugged and the waste backs up the OGT encasement to the P3 and (2) design basis high wind, but not the associated missiles. (See Note 3)
	Riser 241-SY-102-007 drop leg enclosure	X	-		Riser 241-SY-102-007 Drop Leg Enclosure: Same as OGT encasement and connections, except that the riser 241-SY-102-007 drop leg enclosure shall be designed to withstand missiles associated with the design basis high wind. (See Note 3)
	Tank 241-SY-101 waste transfer flow totalizer	-	X		Tank 241-SY-101 waste transfer flow totalizer: The safety function of the Tank 241-SY-101 waste transfer flow totalizer is to provide the volume of material transferred from Tank 241-SY-101 to Tank 241-SY-102 (waste plus dilution water) for implementation of the TSR AC 5.12 Transfer Controls material balance requirements.

Summary of New Controls for Tank 241-SY-101 Waste Transfers and Back Dilution¹ (5 Sheets)

Analyzed Accident	Safety Structures, Systems, and Components			Technical Safety Requirement ²	Comments
	Description	SC	SS		
Mixing of Incompatible Material – Toxic Vapor Generation	241-SY Tank Farm primary tank ventilation system	-	X		<p>241-SY Tank Farm primary tank ventilation system: The safety function of the 241-SY Tank Farm primary tank ventilation system is to provide an elevated release (versus a ground-level release) of ammonia from 241-SY Tank Farm tanks. The primary tank ventilation system for the 241-SY Tank Farm ensures an elevated release of ammonia by maintaining a vacuum in the vapor spaces of Tanks 241-SY-101, -102, and -103 and exhausting through a stack. (See Note 3).</p> <p>Ammonia monitoring systems: The safety function of the Tank 241-SY-101 ammonia monitoring system is to measure the ammonia concentration in the Tank 241-SY-101 vapor space and alarm at 3000 ppm. The safety function of the 241-SY Tank Farm primary tank ventilation exhaust ammonia monitoring system is to measure the ammonia concentration in the 241-SY Tank Farm ventilation exhaust and alarm at 1000 ppm.</p> <p>Ensures operation of the 241-SY Tank Farm primary tank ventilation system during <i>global waste disturbing</i> operations and activities in Tank 241-SY-101. TSR LCO 3.2.1 satisfies this requirement for ammonia releases.</p>
	Ammonia monitoring systems (Tank 241-SY-101 and 241-SY Tank Farm primary tank ventilation exhaust)	-	X	AC: 241-SY Tank Farm primary tank ventilation system	

Summary of New Controls for Tank 241-SY-101 Waste Transfers and Back Dilution¹ (5 Sheets)

Analyzed Accident	Safety Structures, Systems, and Components			Technical Safety Requirement ²	Comments
	Description	SC	SS		
Mixing of Incompatible Material – Toxic Vapor Generation (continued)				<p>AC: Ammonia monitoring (Tank 241-SY-101 and 241-SY Tank Farm primary tank ventilation exhaust)</p>	<p>The program key elements are:</p> <ul style="list-style-type: none"> During <i>global waste disturbing</i> operations and activities in Tank 241-SY-101 (except waste transfers) and when water sources are connected to equipment for operations and activities that could add water to Tank 241-SY-101, monitor the ammonia concentration in the tank vapor space <u>or</u> in the 241-SY Tank Farm primary tank ventilation exhaust and, if the ammonia concentration reaches 3000 ppm or 1000 ppm, respectively, stop <i>global waste disturbing</i> operations and activities in the tank and isolate all sources of water to the tank. Ammonia monitoring is not required when the waste transfer dilution water skid is the only source connected to the tank <u>and</u> the water skid is not connected to the service water system. During Tank 241-SY-101 waste transfers, monitor the ammonia concentration in the 241-SY Tank Farm primary tank ventilation exhaust and, if the ammonia concentration reaches 1000 ppm, stop the waste transfer and isolate all sources of water to Tank 241-SY-101. <p>Note: See HNF-SD-WM-TSR-006 for the definition of <i>global waste disturbing</i>.</p>

Notes:

1. This summary lists only the new controls selected for Tank 241-SY-101 waste transfers and back dilution.
2. As a result of direction received from the U.S. Department of Energy, Office of River Protection (French 1999), new TSR-level controls for Tank 241-SY-101 remediation activities will be imposed as prudent contractor controls necessary for safe operation.
3. The safety function for a safety-class or safety-significant SSC states the preventive and/or mitigative safety function(s) that the safety SSC is required to meet. Unless specifically stated in the safety function, the safety SSC is not required to perform its safety function during or following design basis natural phenomena (e.g., seismic events, high winds and associated missiles).

NEW DEFENSE IN DEPTH CONTROLS

New defense-in-depth controls identified for Tank 241-SY-101 waste transfers and back dilution are:

1. Video camera monitoring during waste transfers, back dilution, and associated activities that involve crust disturbance or dissolution.
2. Tank 241-SY-102 drop leg and associated Tank 241-SY-102 waste level control that ensure the waste transferred from Tank 241-SY-101 is discharged below the Tank 241-SY-101 waste surface to reduce the rate of ammonia release (i.e., evaporation).

ATTACHMENT 2

**CONTROL DECISION RECORD FOR
FLAMMABLE GAS DEFLAGRATION – INDUCED GAS RELEASE
FROM CRUST DISTURBANCE**

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**CONTROL DECISION RECORD FOR
FLAMMABLE GAS DEFLAGRATION – INDUCED GAS RELEASE
FROM CRUST DISTURBANCE**

HAZARD/ACCIDENT: Flammable Gas Deflagration – Induced gas release from crust disturbance

Structures, Systems, and Components (SSCs)

Note: The list of safety SSCs below does not include the Tank 241-SY-101 mixer pump, level monitoring system, pressure monitoring system, ventilation flowmeter, and temperature monitoring system which are required to implement the Los Alamos National Laboratory (LANL) Safety Assessment (SA) Level I mixer pump controls (LA-UR-92-3196, Rev. 14a., Table 6-3) since they do not directly prevent or mitigate potential hazardous conditions and postulated accidents related to Tank 241-SY-101 waste transfers and back dilution. Operation of the 241-SY-101 mixer pump to reduce the frequency of a flammable gas deflagration by mixing and releasing flammable gases generated and trapped in the waste is assumed in the hazard and accident analyses of Tank 241-SY-101 waste transfers and back dilution. The safety analysis of the waste transfer does, however, identify hazardous conditions and postulated accidents that could result in failure of the mixer pump to perform its safety function (see flammable gas deflagrations – buoyant displacement GRE plus additional crust release from the crust).

Structures, Systems, and Components	Classification		Safety Function	Comments
	SC	SS		
*DST/AWF Ventilation	X		Maintain flammable gas concentrations in tank dome spaces, due to steady state releases, below 25% of the LFL.	The DST and AWF ventilation systems also reduce the "time at risk" following a large gas release event (GRE).
*SY-101 Hydrogen Monitor	X		Provide indication and alarm for hydrogen gas concentration in the Tank 241-SY-101 vapor space to the operations staff.	An additional safety function of the SY-101 hydrogen monitor is to provide an interlock to stop mixer pump operation if hydrogen concentration reaches 0.75% (7,500 ppm) by volume.
*SY-101 Ammonia Detection System	X		Detect ammonia in the tank headspace/exhaust gas and alarm on the data acquisition system (DACS) when a high level of ammonia exists.	--

SC is safety class
SS is safety significant

*Existing control

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Technical Safety Requirements (TSRs)

Note: New controls appear in ***bold italics***.

Control	Safety Function	Comments
*DST and AWF Tank Ventilation (LCO 3.2.1)	Assure that steady state release of flammable gas does not accumulate in flammable concentrations in vapor spaces of TWRS facilities and structures.	DST and AWF ventilation system operation also reduces the "time at risk" following a large gas release event (GRE).
*Flammability Controls (i.e., LA-UR-92-3196 Level I mixer pump controls including supplemental controls) (AC 5.9)	Assure effective mitigation and safe operations of Tank 241-SY-101 with respect to flammable gas hazards.	The LA-UR-92-3196 Level I controls are primarily related to mixer pump operation. The Level I control on gas concentrations (i.e., maximum hydrogen concentration and maximum ammonia concentration) is the only control directly applicable to preventing or mitigating potential hazardous conditions and postulated accidents from Tank 241-SY-101 waste transfers and back dilution.
<i>Ignition controls (Revision to AC 5.10)</i>	<i>Prevent the ignition of flammable gases that may be present.</i>	<i>Expand applicability of existing TSR AC 5.10 ignition controls to Tank 241-SY-101; elevate and augment LA-UR-92-3196 Level II ignition controls.</i>
<i>Flammable Gas Monitoring Controls (Revision to AC 5.11)</i>	<i>Ensures flammable conditions caused by steady-state accumulation or as a results of a recent gas release event are not present in the work space before and during manned work activities and ensures that flammable conditions are not produced by waste intrusive activities in Tank 241-SY-101. This reduces frequency of flammable gas deflagrations.</i>	<i>Expand applicability of existing TSR AC 5.11 flammable gas monitoring controls to Tank 241-SY-101; elevate and augment LA-UR-92-3196 Level II flammable gas monitoring controls.</i> <i>Note: The flammable gas monitoring controls for Tank 241-SY-101 shall specify when the LA-UR-92-3196 Level I mixer pump hydrogen and ammonia monitoring controls are applicable.</i>
*Emergency Preparedness (AC 5.14)	Mitigate the consequences of a flammable gas deflagration.	--
*HEPA Filter Controls (AC 5.18)	Reduce consequences from a possible HEPA filter failure by limiting the inventory available for release.	--
*Process Instrumentation and Measuring and Test Equipment (AC 5.19)	Ensures instrumentation used to monitor the concentration of flammable gases is maintained.	--

*Existing control

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Defense-in Depth Controls

Note: New controls appear in ***bold italics***

Control	Safety Function	Comments
<i>Video camera monitor</i>	<i>Visual monitoring during waste transfers, back dilution, and associated activities that could involve crust disturbance to detect significant unexpected effects.</i>	- -

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ATTACHMENT 3

**CONTROL DECISION RECORD FOR
FLAMMABLE GAS DEFLAGRATION – INDUCED GAS RELEASE
FROM CRUST DISSOLUTION**

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**CONTROL DECISION RECORD FOR
FLAMMABLE GAS DEFLAGRATION – INDUCED GAS RELEASE
FROM CRUST DISSOLUTION**

HAZARD/ACCIDENT: Flammable Gas Deflagration – Induced gas release from crust dissolution

Structures, Systems, and Components (SSCs)

Note: The list of safety SSCs below does not include the Tank 241-SY-101 mixer pump, level monitoring system, pressure monitoring system, ventilation flowmeter, and temperature monitoring system which are required to implement the LANL SA Level I mixer pump controls (LA-UR-92-3196, Rev. 14a., Table 6-3) since they do not directly prevent or mitigate potential hazardous conditions and postulated accidents related to Tank 241-SY-101 waste transfers and back dilution. Operation of the 241-SY-101 mixer pump to reduce the frequency of a flammable gas deflagration by mixing and releasing flammable gases generated and trapped in the waste is assumed in the hazard and accident analyses of Tank 241-SY-101 waste transfers and back dilution. The safety analysis of the waste transfer does, however, identify hazardous conditions and postulated accidents that could result in failure of the mixer pump to perform its safety function (see flammable gas deflagrations – buoyant displacement GRE plus additional crust release from the crust).

Structures, Systems, and Components	Classification		Safety Function	Comments
	SC	SS		
*DST/AWF Ventilation	X		Maintain flammable gas concentrations in tank dome spaces, due to steady state releases, below 25% of the LFL.	The DST and AWF ventilation systems also reduce the "time at risk" following a large gas release event (GRE).
*SY-101 Hydrogen Monitor	X		Provide indication and alarm for hydrogen gas concentration in the Tank 241-SY-101 vapor space to the operations staff.	An additional safety function of the SY-101 hydrogen monitor is to provide an interlock to stop mixer pump operation if hydrogen concentration reaches 0.75% (7,500 ppm) by volume.
*SY-101 Ammonia Detection System	X		Detect ammonia in the tank headspace/exhaust gas and alarm on the data acquisition system (DACS) when a high level of ammonia exists.	--

SC is safety class
SS is safety significant
*Existing control

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Technical Safety Requirements (TSRs)

Note: New controls appear in *bold italics*.

Control	Safety Function	Comments
*DST and AWF Tank Ventilation (LCO 3.2.1)	Assure that steady state release of flammable gas does not accumulate in flammable concentrations in vapor spaces of TWRS facilities and structures.	DST and AWF ventilation system operation also reduces the "time at risk" following a large gas release event (GRE).
*Flammability Controls (i.e., LA-UR-92-3196 Level I mixer pump controls including supplemental controls) (AC 5.9)	Assure effective mitigation and safe operations of Tank 241-SY-101 with respect to flammable gas hazards.	The LA-UR-92-3196 Level I controls are primarily related to mixer pump operation. The Level I control on gas concentrations (i.e., maximum hydrogen concentration and maximum ammonia concentration) is the only control directly applicable to preventing or mitigating potential hazardous conditions and postulated accidents from Tank 241-SY-101 waste transfers and back dilution.
<i>Ignition controls (Revision to AC 5.10)</i>	<i>Prevent the ignition of flammable gases that may be present.</i>	<i>Expand applicability of existing TSR AC 5.10 ignition controls to Tank 241-SY-101; elevate and augment LA-UR-92-3196 Level II ignition controls.</i>
<i>Flammable Gas Monitoring Controls (Revision to AC 5.11)</i>	<i>Ensures flammable conditions caused by steady-state accumulation or as a results of a recent gas release event are not present in the work space before and during manned work activities and ensures that flammable conditions are not produced by waste intrusive activities in Tank 241-SY-101. This reduces frequency of flammable gas deflagrations.</i>	<i>Expand applicability of existing TSR AC 5.11 flammable gas monitoring controls to Tank 241-SY-101; elevate and augment LA-UR-92-3196 Level II flammable gas monitoring controls.</i> <i>Note: The flammable gas monitoring controls for Tank 241-SY-101 shall specify (1) when the LA-UR-92-3196 Level I mixer pump hydrogen and ammonia monitoring controls are applicable and (2) that flammable gas monitoring is required whenever water sources are connected to Tank 241-SY-101, and that all sources of water shall be isolated on high flammable gas concentrations. Flammable gas monitoring is not required when the waste transfer dilution water skid is the only source connected to the tank and the water skid is not connected to the service water system.</i>
*Emergency Preparedness (AC 5.14)	Mitigate the consequences of a flammable gas deflagration.	--
*HEPA Filter Controls (AC 5.18)	Reduce consequences from a possible HEPA filter failure by limiting the inventory available for release.	--
*Process Instrumentation and Measuring and Test Equipment (AC 5.19)	Ensures instrumentation used to monitor the concentration of flammable gases is maintained.	--

*Existing control

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Defense-in Depth Controls

Note: New controls appear in ***bold italics***

Control	Safety Function	Comments
<i>Video camera monitor</i>	<i>Visual monitoring during waste transfers, back dilution, and associated activities that could involve crust dissolution to detect significant unexpected effects.</i>	

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ATTACHMENT 4

**CONTROL DECISION RECORD FOR
FLAMMABLE GAS DEFLAGRATION – BUOYANT DISPLACEMENT GRE
PLUS ADDITIONAL GAS RELEASE FROM THE CRUST**

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**CONTROL DECISION RECORD FOR
FLAMMABLE GAS DEFLAGRATION – BUOYANT DISPLACEMENT GRE
PLUS ADDITIONAL GAS RELEASE FROM THE CRUST**

HAZARD/ACCIDENT: Flammable Gas Deflagration –Buoyant displacement GRE plus additional gas release from the crust

Structures, Systems, and Components (SSCs)

Notes:

1. The list of safety SSCs below does not include the Tank 241-SY-101 mixer pump, level monitoring system, pressure monitoring system, ventilation flowmeter, and temperature monitoring system which are required to implement the LANL SA Level I mixer pump controls (LA-UR-92-3196, Rev. 14a., Table 6-3) since they do not directly prevent or mitigate potential hazardous conditions and postulated accidents related to Tank 241-SY-101 waste transfers and back dilution. Operation of the 241-SY-101 mixer pump to reduce the frequency of a flammable gas deflagration by mixing and releasing flammable gases generated and trapped in the waste is assumed in the hazard and accident analyses of Tank 241-SY-101 waste transfers and back dilution. The safety analysis of the waste transfer does, however, identify hazardous conditions and postulated accidents that could result in failure of the mixer pump to perform its safety function.
2. New controls appear in *bold italics*.

Structures, Systems, and Components	Classification		Safety Function	Comments
	SC	SS		
*DST/AWF Ventilation	X		Maintain flammable gas concentrations in tank dome spaces, due to steady state releases, below 25% of the LFL.	The DST and AWF ventilation systems also reduce the "time at risk" following a large gas release event (GRE).
*SY-101 Hydrogen Monitor	X		Provide indication and alarm for hydrogen gas concentration in the Tank 241-SY-101 vapor space to the operations staff.	An additional safety function of the SY-101 hydrogen monitor is to provide an interlock to stop mixer pump operation if hydrogen concentration reaches 0.75% (7,500 ppm) by volume.
*SY-101 Ammonia Detection System	X		Detect ammonia in the tank headspace/exhaust gas and alarm on the data acquisition system (DACS) when a high level of ammonia exists.	--

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Structures, Systems, and Components	Classification		Safety Function	Comments
	SC	SS		
<i>Siphon break in Tank 241-SY-102 drop leg</i>	X		<i>Prevent the siphoning of waste from Tank 241-SY-101 to Tank 241-SY-102 when the waste transfer pump is not operating and there is no dilution water flow to the transfer pump.</i>	<i>The siphon break is a passive design feature.</i>
<i>Tank 241-SY-101 waste transfer flow totalizer</i>	X		<i>Provide the volume of material transferred from Tank 241-SY-101 to Tank 241-SY-102 (waste plus dilution water) for implementation of the Tank 241-SY-101 Waste Transfer Control.</i>	--
<i>Dilution water flow totalizer</i>	X		<i>Provide dilution water data for implementation of the Tank 241-SY-101 Waste Transfer Control.</i>	--

SC is safety class
SS is safety significant

*Existing control

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Technical Safety Requirements (TSRs)

Note: New controls appear in ***bold italics***.

Control	Safety Function	Comments
*DST and AWF Tank Ventilation (LCO 3.2.1)	Assure that steady state release of flammable gas does not accumulate in flammable concentrations in vapor spaces of TWRS facilities and structures.	DST and AWF ventilation system operation also reduces the "time at risk" following a large gas release event (GRE).
*Flammability Controls (i.e., LA-UR-92-3196 Level I mixer pump controls including supplemental controls) (AC 5.9)	Assure effective mitigation and safe operations of Tank 241-SY-101 with respect to flammable gas hazards.	The LA-UR-92-3196 Level I controls are primarily related to mixer pump operation. The Level I control on gas concentrations (i.e., maximum hydrogen concentration and maximum ammonia concentration) is the only control directly applicable to preventing or mitigating potential hazardous conditions and postulated accidents from Tank 241-SY-101 waste transfers and back dilution.
<i>Tank 241-SY-101 Mixer Pump Operation and Performance Monitoring (Revision to AC 5.9)</i>	<i>Identify and prevent or mitigate conditions that could damage or degrade Tank 241-SY 101 mixer pump operation or performance caused by interaction of the pump and the crust to ensure that the safety function of the mixer pump (control gas retention at depth and prevent buoyant displacement GRE) is maintained.</i>	<i>Program key elements are:</i> <ul style="list-style-type: none"> <i>Mixer pump operating parameters (e.g., pump motor current, pump discharge pressure) identified by the Test Review Group (TRG) shall be monitored during mixer pump operation, and the mixer pump shall be shutdown if limits established by the TRG to prevent pump damage are exceeded.</i> <i>Mixer pump performance (e.g., pump motor current, pump discharge pressure, waste thermocouple response) shall be monitored, and the TRG shall review the data quarterly for signs of degradation that could affect continued control of gas retention at depth and prevention of buoyant displacement gas release events (BD GREs)</i> <i>The TRG shall direct corrective actions to restore mixer pump operation and performance, as necessary (e.g., add water). If following the first waste transfer back dilution of the Tank 241-SY-101 waste with water is required to restore mixer pump operation or performance (e.g., to raise the crust), back dilution shall be in accordance with the requirements of the Tank 241-SY-101 Back Dilution Control (see Attachment 9).</i>
<i>Ignition controls (Revision to AC 5.10)</i>	<i>Prevent the ignition of flammable gases that may be present.</i>	<i>Expand applicability of existing TSR AC 5.10 ignition controls to Tank 241-SY-101; elevate and augment LA-UR-92-3196 Level II ignition controls.</i>

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Control	Safety Function	Comments
Flammable Gas Monitoring Controls (Revision to AC 5.11)	<i>Ensures flammable conditions caused by steady-state accumulation or as a results of a recent gas release event are not present in the work space before and during manned work activities and ensures that flammable conditions are not produced by waste intrusive activities in Tank 241-SY-101. This reduces frequency of flammable gas deflagrations.</i>	<p><i>Expand applicability of existing TSR AC 5.11 flammable gas monitoring controls to Tank 241-SY-101; elevate and augment LA-UR-92-3196 Level II flammable gas monitoring controls.</i></p> <p><i>Note: The flammable gas monitoring controls for Tank 241-SY-101 shall specify (1) when the LA-UR-92-3196 Level I mixer pump hydrogen and ammonia monitoring controls are applicable, and (2) that flammable gas monitoring is required whenever water sources are connected to Tank 241-SY-101, and that all sources of water shall be isolated on high flammable gas concentrations. Flammable gas monitoring is not required when the waste transfer dilution water skid is the only source connected to the tank <u>and</u> the water skid is not connected to the service water system.</i></p>
Tank 241-SY-101 Waste Transfer Control (Revision to AC 5.9 or AC 5.12)	<i>Limit the quantity of waste transferred from Tank 241-SY-101 to ensure that the mixer pump continues to perform its safety function (control of gas retention at depth and prevent buoyant displacement GREs).</i>	<p><i>Program key elements are:</i></p> <ul style="list-style-type: none"> <i>For the first waste transfer from Tank 241-SY-101, the quantity of waste transferred shall be limited. The maximum quantity of waste that can be transferred shall be calculated so that back dilution of the Tank 241-SY-101 waste with water following the first waste transfer can raise the base of the crust to at least 295 inches from the bottom of the tank without the crust sinking. The maximum quantity of waste transferred shall account for waste that could be siphoned from Tank 241-SY-101 after the waste transfer pump is turned off until dilution water flow to the transfer pump is stopped (e.g., the dilution water supply is disconnected). (Note that closed valves do not ensure that the dilution water flow is stopped.) The maximum quantity of waste transferred in the first waste transfer shall be determined by Process Engineering and reviewed and approved by the PRC.</i> <i>The first waste transfer from Tank 241-SY-101 shall be monitored and limited to the maximum quantity established above.</i>
*Emergency Preparedness (AC 5.14)	Mitigate the consequences of a flammable gas deflagration.	--

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Control	Safety Function	Comments
*HEPA Filter Control (AC 5.18)	Reduce consequences from a possible HEPA filter failure by limiting the inventory available for release.	--
*Process Instrumentation and Measuring and Test Equipment (AC 5.19)	Ensures instrumentation used to monitor the concentration of flammable gases is maintained.	--

*Existing control

Defense-in Depth Controls

Control	Safety Function	Comments
None identified		

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ATTACHMENT 5

**CONTROL DECISION RECORD FOR
FLAMMABLE GAS DEFLAGRATION – GENERAL**

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**CONTROL DECISION RECORD
FOR FLAMMABLE GAS DEFLAGRATION – GENERAL**

HAZARD/ACCIDENT: Flammable Gas Deflagration – General

Structures, Systems, and Components (SSCs)

Note: The list of safety SSCs below does not include the Tank 241-SY-101 mixer pump, level monitoring system, pressure monitoring system, ventilation flowmeter, and temperature monitoring system which are required to implement the LANL SA Level I mixer pump controls (LA-UR-92-3196, Rev. 14a, Table 6-3) since they do not directly prevent or mitigate potential hazardous conditions and postulated accidents related to Tank 241-SY-101 waste transfers and back dilution. Operation of the 241-SY-101 mixer pump to reduce the frequency of a flammable gas deflagration by mixing and releasing flammable gases generated and trapped in the waste is assumed in the hazard and accident analyses of Tank 241-SY-101 waste transfers and back dilution. The safety analysis of the waste transfer does, however, identify hazardous conditions and postulated accidents that could result in failure of the mixer pump to perform its safety function (see flammable gas deflagrations – buoyant displacement GRE plus additional crust release from the crust).

Structures, Systems, and Components	Classification		Safety Function	Comments
	SC	SS		
*DST/AWF Ventilation	X		Maintain flammable gas concentrations in tank dome spaces, due to steady state releases, below 25% of the LFL.	The DST and AWF ventilation systems also reduce the "time at risk" following a large gas release event (GRE).
*SY-101 Hydrogen Monitor	X		Provide indication and alarm for hydrogen gas concentration in the Tank 241-SY-101 vapor space to the operations staff.	An additional safety function of the SY-101 hydrogen monitor is to provide an interlock to stop mixer pump operation if hydrogen concentration reaches 0.75% (7,500 ppm) by volume.
*SY-101 Ammonia Detection System	X		Detect ammonia in the tank headspace/exhaust gas and alarm on the data acquisition system (DACS) when a high level of ammonia exists.	--

SC is safety class
SS is safety significant

* Existing control

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Technical Safety Requirements (TSRs)

Note: New controls appear in *bold italics*.

Control	Safety Function	Comments
*DST and AWF Tank Ventilation (LCO 3.2.1)	Assure that steady state release of flammable gas does not accumulate in flammable concentrations in vapor spaces of TWRS facilities and structures.	DST and AWF ventilation system operation also reduces the "time at risk" following a large gas release event (GRE).
*Flammability Controls (i.e., LA-UR-92-3196 Level I mixer pump controls, including supplemental controls) (AC 5.9)	Assure effective mitigation and safe operations of Tank 241-SY-101 with respect to flammable gas hazards.	The LA-UR-92-3196 Level I controls are primarily related to mixer pump operation. The Level I control on gas concentrations (i.e., maximum hydrogen concentration and maximum ammonia concentration) is the only control directly applicable to preventing or mitigating potential hazardous conditions and postulated accidents from Tank 241-SY-101 waste transfers and back dilution.
<i>Ignition controls (Revision to AC 5.10)</i>	<i>Prevent the ignition of flammable gases that may be present.</i>	<i>Expand applicability of existing TSR AC 5.10 ignition controls to Tank 241-SY-101; elevate and augment LA-UR-92-3196 Level II ignition controls.</i>
<i>Flammable Gas Monitoring Controls (Revision to AC 5.11)</i>	<i>Ensures flammable conditions caused by steady-state accumulation or as a results of a recent gas release event are not present in the work space before and during manned work activities and ensures that flammable conditions are not produced by waste intrusive activities in Tank 241-SY-101. This reduces frequency of flammable gas deflagrations.</i>	<i>Expand applicability of existing TSR AC 5.11 flammable gas monitoring controls to Tank 241-SY-101; elevate and augment LA-UR-92-3196 Level II flammable gas monitoring controls.</i> <i>Note: The flammable gas monitoring controls for Tank 241-SY-101 shall specify (1) when the LA-UR-92-3196 Level I mixer pump hydrogen and ammonia monitoring controls are applicable, and (2) that flammable gas monitoring is required whenever water sources are connected to Tank 241-SY-101, and that all sources of water shall be isolated on high flammable gas concentrations. Flammable gas monitoring is not required when the waste transfer dilution water skid is the only source connected to the tank <u>and</u> the water skid is not connected to the service water system.</i>
*Transfer Controls – Waste Compatibility Controls (AC 5.12)	Ensure final tank states remain within analyzed topography of the flammable gas deflagrations accident.	--

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Control	Safety Function	Comments
*Emergency Preparedness (AC 5.14)	Mitigate the consequences of a flammable gas deflagration.	--
*Excavation Controls (AC 5.17)	Prevent ignition of flammable gases.	--
*HEPA Filter Controls (AC 5.18)	Reduce consequences from a possible HEPA filter failure by limiting the inventory available for release.	--
*Process Instrumentation and Measuring and Test Equipment (AC 5.19)	Ensures instrumentation used to monitor the concentration of flammable gases is maintained.	--

* Existing control

Defense-in Depth Controls

Control	Safety Function	Comments
*Flush transfer lines after use	Reduce waste material in transfer lines to limit the production of flammable gases.	--

*Existing control

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as a single document. It has
been divided into smaller sections.**

Section 2 of 2

Document Information			
Document #	HNF-3737	Revision	1
Title	TANK 241SY101 SAFETY BASIS FOR REMEDIATION ACTIVITIES & OPERATIONS BEFORE CLOSURE OF THE UNREVIEWED SAFETY QUESTION ON WASTE SURFACE CHANGE		
Date	10/28/99		
Originator	FEIN KO,RYAN GW,SHULTZ MV,VANKEUREN JC,GRIGSBY JM,KRIPPS LJ	Originator Co.	FDNW,OTHER
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Keywords			
Projects			
Other Information			

ATTACHMENT 6

**CONTROL DECISION RECORD FOR
SPRAY LEAK IN STRUCTURE OR FROM OVERGROUND TRANSFER LINE**

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CONTROL DECISION RECORD FOR SPRAY LEAK IN STRUCTURE OR FROM OVERGROUND TRANSFER LINE

HAZARD/ACCIDENT: Spray Leak in Structure or from Overground Transfer (OGT) Line

Note: The below listed safety structures, systems, and components (SSCs), technical safety requirements (TSRs), and defense-in-depth controls only include those that are unique to Tank 241-SY-101 waste transfers and back dilution.

Structures, Systems, and Components (SSCs)

Structures, Systems, and Components	Classification		Safety Function	Comments
	SC	SS		
Prefabricated Pump Pit (PPP)*	X		Knock down spray and limit release of aerosols to the environment.	The P3 shall be designed to withstand design basis high wind and associated missiles.
OGT encasement and connections*	X		Confine a leak from the primary piping and ensure that the leak is directed to the riser 241-SY-102-007 drop leg enclosure or to the PPP which contain leak detection systems.	The OGT encasement and connections shall be designed to withstand (1) the maximum pressure resulting if the drain to Tank 241-SY-102 is plugged and the waste backs up the OGT encasement to the PPP and (2) design basis high wind, but not the associated missiles.
Riser 241-SY-102-007 Drop Leg Enclosure*	X		Same as OGT encasement and connections.	Comments for OGT encasement and connections above are also applicable to the riser 241-SY-102 drop leg enclosure except that it shall be designed to withstand missiles associated with the design basis high wind.

SC is safety class
SS is safety significant

* Additional temporary shielding and administrative controls shall be used to maintain facility worker radiation exposures ALARA.

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Technical Safety Requirements (TSRs)

Control	Safety Function	Comments
None Note: The PPP cover is considered a transfer system cover and existing LCO 3.1.1 and AC 5.22 apply.	--	--

Defense-in Depth Controls

Control	Safety Function	Comments
None identified	--	--

ATTACHMENT 7

**CONTROL DECISION RECORD FOR
SURFACE LEAK RESULTING IN POOL**

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**CONTROL DECISION RECORD FOR
SURFACE LEAK RESULTING IN POOL**

HAZARD/ACCIDENT: Surface Leak Resulting in Pool

Note: The below listed safety structures, systems, and components (SSCs), technical safety requirements (TSRs), and defense-in-depth controls only include those that are unique to Tank 241-SY-101 waste transfers and back dilution.

Structures, Systems, and Components (SSCs)

Structures, Systems, and Components	Classification		Safety Function	Comments
	SC	SS		
Prefabricated Pump Pit (P3)*	X	X	<p>The safety-class safety function of the P3 is to provide an intact boundary for the leaked waste, and when leak detector alarms and appropriate operator response times to shut off the transfer pump are credited, to prevent premature P3 overflow and the formation of a surface pool.</p> <p>The safety-significant safety function of the P3, including cover, is to limit release of aerosols generated by splatter inside the P3, and limit shine and skyshine dose to onsite receptors.</p>	The P3 shall be designed to withstand design basis high wind and associated missiles.
OGT encasement and connections*	X		Provide secondary confinement for leaks from the primary line and route the leak to the riser 241-SY-102-007 drop leg enclosure or to the P3 which contain leak detection systems.	The OGT encasement and connections shall be designed to withstand (1) the maximum pressure resulting if the drain to Tank 241-SY-102 is plugged and the waste backs up the OGT encasement to the P3 and (2) design basis high wind, but not the associated missiles.
Riser 241-SY-102-007 drop leg enclosure*	X		Same as OGT encasement and connections.	Comments for OGT encasement and connections above are also applicable to the riser 241-SY-102-007 drop leg enclosure, except that it shall be designed to withstand missiles associated with the design basis high wind.

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Structures, Systems, and Components	Classification		Safety Function	Comments
	SC	SS		
Tank 241-SY-101 waste transfer flow totalizer		X	Provide volume of material transferred from Tank 241-SY- 101 to Tank 241-SY-102 (waste plus dilution water) for implementation of the TSR AC 5.12 Transfer Controls material balance requirements.	--

SC is safety class
SS is safety significant

- * Additional temporary shielding and administrative controls shall be used to maintain facility worker radiation exposures ALARA.

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Technical Safety Requirements (TSRs)

Control	Safety Function	Comments
None	--	--
Notes:		
1. The P3 cover is considered a transfer system cover and existing LCO 3.1.1 and AC 5.22 apply.		
2. The riser 241-SY-102-007 drop leg enclosure leak detection system is subject to LCO 3.1.3.		

Defense-in Depth Controls

Control	Safety Function	Comments
*P3 and Riser 241-SY-102-007 drop leg enclosure drains.	Allow leak to drain back to Tanks 241-SY-101 or 241-SY-102.	--

*Existing control

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ATTACHMENT 8

**CONTROL DECISION RECORD FOR
MIXING OF INCOMPATIBLE MATERIAL – TOXIC VAPOR GENERATION**

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CONTROL DECISION RECORD FOR MIXING OF INCOMPATIBLE MATERIAL – TOXIC VAPOR GENERATION

HAZARD/ACCIDENT: Mixing of Incompatible Material – Toxic Vapor Generation

Structures, Systems, and Components (SSCs)

Note: New controls appear in *bold italics*.

Structures, Systems, and Components	Classification		Safety Function	Comments
	SC	SS		
<i>241-SY Tank Farm primary tank ventilation system</i>	-	X	<i>Provide an elevated release (versus a ground-level release) of ammonia from 241-SY Tank Farm tanks.</i>	<i>The primary tank ventilation system for the 241-SY Tank Farm ensures an elevated release of ammonia by maintaining a vacuum in the vapor spaces of Tanks 241-SY-101, -102, and -103 and exhausting through a stack.</i>
<i>Ammonia monitoring system:</i>				
<i>Tank 241-SY-101</i>	-	X	<i>Measure the ammonia concentration in the Tank 241- SY-101 vapor space and alarm at 3000 ppm.</i>	- -
<i>241-SY Tank Farm primary tank ventilation exhaust</i>	-	X	<i>Measure the ammonia concentration in the 241-SY Tank Farm primary tank ventilation exhaust and alarm at 1000 ppm.</i>	

SC is safety class

SS is safety significant

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Technical Safety Requirements (TSRs)

Note: New controls appear in *bold italics*.

Control	Safety Function	Comments
<i>241-SY Tank Farm primary tank ventilation system</i>	<i>Ensures operation of the 241-SY Tank Farm primary tank ventilation system during global waste disturbing operations and activities in Tank 241-SY-101.</i>	<p><i>The primary tank ventilation system for the 241-SY Tank Farm provides an elevated release of ammonia by maintaining a vacuum in the vapor spaces of Tanks 241-SY-101, -102, and -103 and exhausting through a stack.</i></p> <p><i>This TSR-level control for ammonia releases is an expansion of the basis of TSR LCO 3.2.1. Action statement A.1 of LCO 3.2.1 requires that all waste disturbing operations and activities be stopped when the primary tank ventilation system is not operating. This satisfies the safety function for ammonia releases.</i></p> <p><i>See HNF-SD-WM-TSR-006 for the definition of waste disturbing and global waste disturbing.</i></p>
<i>Ammonia Monitoring</i>	<p><i>During global waste disturbing operations and activities in Tank 241-SY-101 (except waste transfers - see below) and when water sources are connected to equipment for operations and activities that could add water to Tank 241-SY-101, monitor the ammonia concentration in the tank vapor space <u>or</u> in the 241-SY Tank Farm primary tank ventilation exhaust and, if the ammonia concentration reaches 3000 ppm or 1000 ppm, respectively, stop global waste disturbing operations and activities in the tank and isolate all sources of water to the tank. Ammonia monitoring is not required when the waste transfer dilution water skid is the only source connected to the tank <u>and</u> the water skid is not connected to the service water system.</i></p> <p><i>During Tank 241-SY-101 waste transfers, monitor the ammonia concentration in the 241-SY Tank Farm primary tank ventilation exhaust and, if the ammonia concentration reaches 1000 ppm, stop the waste transfer and isolate all sources of water to Tank 241-SY-101.</i></p>	<p><i>Stopping global waste disturbing operations and activities in Tank 241-SY-101 eliminates these causes of ammonia releases. Isolating sources of water to Tank 241-SY-101 prevents water additions (intentional or inadvertent) that can cause ammonia releases from the waste.</i></p> <p><i>(See HNF-SD-WM-TSR-006 for the definition of global waste disturbing.)</i></p>

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Defense-in Depth Controls

Note: New controls appear in *bold italics*.

Control	Safety Function	Comments
Industrial Hygiene Program*	Ensures personnel safety during activities and operations that could generate or release toxic vapor.	-
<i>Tank 241-SY-102 drop leg and associated Tank 241-SY-102 waste level control</i>	<i>The Tank 241-SY-102 drop leg discharges the waste transferred from Tank 241-SY-101 below the Tank 241-SY-102 waste surface to reduce the ammonia release (i.e., evaporation). The associated Tank 241-SY-102 waste level control ensures that during Tank 241-SY-101 transfers, the Tank 241-SY-102 waste surface is above the discharge of the drop leg by a minimum distance specified in a Process Memo or Process Control Plan.</i>	<i>The Tank 241-SY-102 drop leg and associated waste level control minimize the surface area of Tank 241-SY-101 waste exposed to air in Tank 241-SY-102 caused by falling waste, splashing, waste surface disturbance, and poor mixing with Tank 241-SY-102 waste.</i>

*Existing control

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ATTACHMENT 9

**CONTROL DECISION RECORD FOR
TANK 241-SY-101 BACK DILUTION**

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CONTROL DECISION RECORD FOR TANK 241-SY-101 BACK DILUTION

Note: This control decision record documents new controls selected for back dilution of Tank 241-SY-101 waste with water and includes consideration of all representative accidents that represent the potential hazardous conditions identified in HNF-4891, *Hazard Evaluation for Back-Dilution of Tank 241-SY-101 Waste* (see Section F3.8). The controls decisions, however, only cover the initial back dilution of Tank 241-SY-101 following the first waste transfer. Additional controls may be required for subsequent back dilutions.

HAZARD/ACCIDENT: Not applicable.

Structures, Systems, and Components (SSCs)

None identified.

Technical Safety Requirements (TSRs)

Control	Safety Function	Comments
<i>Tank 241-SY-101 Back Dilution Control (Revision to AC 5.9)</i>	<p><i>Limit the quantity of back dilution water that can be added to the Tank 241-SY-101 waste following the first waste transfer to:</i></p> <ol style="list-style-type: none"> <i>1. Prevent a crust "roll over" that could cause a sudden release of flammable gas (including ammonia) for top water additions</i> <i>2. Prevent the crust from sinking to ensure that the mixer pump continues to perform its safety function (control gas retention at depth and prevent BD GREs) for low tank water additions</i> 	<p><i>Program key elements are:</i></p> <ul style="list-style-type: none"> <i>Following the first Tank 241-SY-101 waste transfer, the maximum quantity of water that can be added on top of the waste shall be 30,000 gallons.</i> <i>Following the first Tank 241-SY-101 waste transfer, the quantity of back dilution water that can be added low in the tank (i.e., via the Tank 241-SY-101 mixer pump burrowing ring or the waste transfer pump) shall be limited to ensure that the crust does not sink. The maximum quantity of back dilution water that can be added low in the tank following the first waste transfer shall be determined by Process Engineering and reviewed and approved by the Plant Review Committed (PRC).</i> <i>Back dilution water additions to Tank 241-SY-101 waste shall be monitored and limited to the maximum quantities specified above.</i>

Defense-In-Depth Controls

None Identified

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ENCLOSURE 1

**AGENDA FOR CONTROL DECISION MEETINGS ON MARCH 15 AND 16, 1999
FOR TANK 241-SY-101 WASTE TRANSFER**

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**Agenda for Control Decision Meetings on March 15 and 16, 1999
for 241-SY-101 Waste Transfer**

March 15, 1999 1:00-4:30 PM

1:00-1:15 Introduction – Larry Kripps

- A. Purpose
- B. Scope
- C. Process

1:15-1:30 SY-101 Small Transfer Design and Operation – Tony Benegas

1:30-2:30 Hazard Analysis

- A. Hazard Analysis Overview – Milt Shultz
- B. Hazardous Conditions Addressed by the Existing Authorization Basis and Controls – John VanKeuren
 - Spray and Pool Leaks (transfer controls)
 - Excessive Loads on Tank
 - Toxic gas generation
 - Waste compatibility issues (SY-101 and 102 end states) – Nick Kirch
- D. Hazardous Conditions Addressed by the Existing Authorization Basis, but Issues Identified During Evaluation of Whether Existing Controls Acceptably Prevent or Mitigate the Hazardous Condition
- C. Hazardous Conditions Not Addressed by the Existing Authorization Basis and Controls (i.e., hazardous conditions involving potential flammable gas releases from the crust)– Milt Shultz

2:30-2:45 Break

2:45-3:45 Representative Flammable Gas Accident Analysis Results

- A. Existing Authorization Basis Representative Accidents – Mike Grigsby
 - 1. BIO Flammable Gas Deflagrations – DST
 - 2. LANL SA (LA-UR-92-3196) (natural rollover, mixer pump installation)
 - 3. Refined Analysis Tool Results – Scott Slezak
 - Overview of the Refined Analysis Tool
 - Results for the BIO/LANL SA representative accidents
- B. New Representative Accidents Involving Flammable Gas Releases from the Crust
 - 1. New Accident Scenarios and Flammable Gas Releases – Chuck Stewart
 - Induced gas release from crust disturbance
 - Induced gas release from crust dissolution
 - 2. Accident Analysis Results with Refined Analysis Tool – Scott Slezak

- Induced gas release from crust disturbance
- Induced gas release from crust dissolution

3:45-4:30 Control Decisions

1. *Flammable Gas Deflagration – Induced gas release from waste disturbance, including crust disturbance (e.g., waste transfer pump installation, crust disturbance as the waste level falls during the transfer)*

A. Existing Controls – Mike Grigsby

B. Possible Controls

- Elevate and augment LANL SA ignition and flammable gas monitoring controls to TSR ACs
- Increase minimum ventilation rate – TBD/Scott Slezak
- Inerting – Rick Tedeschi/Scott Slezak
- Limit on induced crust disturbance
- Slow/intermittent waste transfer rate
- Video camera monitoring
- Other possible controls

C. Selected controls (Safety SSCs, TSRs, defense-in-depth)

D. Review represented hazardous conditions to determine whether selected controls acceptably prevent or mitigate the hazardous condition, and if not select additional controls

March 16, 1999 1:00–4:30 PM

1:00-4:30 Control Decisions (continued)

2. *Flammable Gas Deflagration – Induced gas release from waste dissolution including crust dissolution (e.g., inadvertent water addition)*

A. Existing Controls – Mike Grigsby

B. Possible Controls

- Elevate and augment LANL SA ignition and flammable gas monitoring controls to TSR ACs
- Control/interlock on maximum water addition – Keith Witwer
- Control/interlock to shutoff water addition based on flammable gas concentration in the tank headspace
- Increase minimum ventilation rate – TBD/Scott Slezak
- Inerting – Rick Tedeschi/Scott Slezak
- Video camera monitoring
- Other possible controls?

C. Selected controls (Safety SSCs, TSRs, defense-in-depth)

- D. Review of represented hazardous conditions to determine whether selected controls acceptably prevent or mitigate the hazardous condition, and if not select additional controls
3. *Flammable Gas Deflagration – Buoyant displacement GRE plus additional gas release from the crust (e.g., waste transfer makes mixer pump inoperable)*
 - A. Existing Controls – Mike Grigsby
 - B. Possible Controls
 - Elevate and augment LANL SA ignition and flammable gas monitoring controls to TSR ACs
 - Waste level limit – Perry Meyer
 - Mixer pump performance monitoring and degraded performance actions (e.g., add water)
 - Dissolve crust
 - Other possible controls
 - C. Selected controls (Safety SSCs, TSRs, defense-in-depth)
 - D. Review of represented hazardous conditions to determine whether selected controls acceptably prevent or mitigate the hazardous condition, and if not select additional controls
 4. *Hazardous Conditions with Issues Identified During Evaluation of Whether Existing Controls Acceptably Prevent or Mitigate the Hazardous Condition*
 - A. Flammable Gas Deflagrations – General
 1. Possible additional Controls
 - Elevate and augment LANL SA Level II ignition and flammable gas monitoring controls to TSR Acs
 - Other possible controls
 2. Selected controls (Safety SSCs, TSRs, defense-in-depth)
 - B. Spray Leaks
 1. Possible additional controls
 - Identification of PPP as Safety Class SSC
 - Other possible controls
 2. Selected controls (Safety SSCs, TSRs, defense-in-depth)
 - C. Pool Leaks
 1. Possible additional controls
 - Identification of PPP as Safety Class SSC
 - seismic and extreme wind/missile qualification of OGT line and PPP
 - Other possible controls
 2. Selected controls (Safety SSCs, TSRs, defense-in-depth)

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ENCLOSURE 2

**ATTENDANCE RECORD OF CONTROL DECISION MEETINGS FOR
TANK 241-SY-101 TRANSFER**

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Attendance Record of Control Decision Meetings for 241-SY-101 Waste Transfer

Date: March 15, 1999

Name	Organization	Telephone Number
LARRY KRIMS	Nuclear Safety License	376-1061
RW Reed	SST Engr. Cog Mgr.	373-5546
M.H. Brown	SST Eng Cog Eng	372-1611
MIKE GRIGSBY	TWRS NSFL	372-1907
L.S. Kroghrud	TWRS Safety	372-2302
R.P. TRUE	TWRS QA	3-5192
Yusuf NOORANI	TWRS Safety Analysis	372-2018
SCOTT Slezak	Sandia Nat. Labs	505/844-2050
Bill Kubic	LANL	505/667-9199
NICK KIRCH	TWRS Process Engineering	373-2380
J.R. BIGGS	SY-101 PROJECT OPERATIONS	531-9310
D.C. LARSEN	TFED	373-5885
R.P. TUCKER	TFED	372-0910
John Van KUREN	FDNW	376-2920
MILTON V. SHULTZ	FDNW	376-2215
CHUCK STEWART	PNWL	372-4678
W.J. POWELL	LM HC/DSTE	376-0659
STEVE BARKER	TWRS PROCESS ENG	372-0489
Greg Gnauch	SST Engineering Cog Eng	373-1779
SURYA MARUVADA	FDH NUC SAFETY	376-3495
Ken Fein	FDNW Safety Analysis	372-0706

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Attendance Record of Control Decision Meetings for 241-SY-101 Waste Transfer

Date: March 16, 1999

Name	Organization	Telephone Number
LARRY KRIEBS	Nuclear Safety & Licensing	376 6010
MILTON V. SHULTZ	FDNW	376-2215
RON TUCKER	TFFO	372-0910
W. J. POWELL	DBTE	376-0659
John D Guberich	TWRS Eng	376-5084
Phil Miller	TWRS Eng	373-1520
Ken Fein	FDNW Safety Analysis	372-0706
SURYA MARYADA	FDN NUCLEAR SAFETY	376-3495
Scott Slezak	Sandia Labs	505/844-2050
STEVEN BARKER	TWRS PROCESS ENG	372-0489
Bill Kubic	LANL	505/667-9194
Cetin Unal	LANL	505/665-2539
MIKE GRIGSBY	TWRS NSFL	372-1907
Ron W Reed	SST Eng. (Cog Mgr.)	373-5546
CHUCK STEWART	PNNL	372-4678
L. S. Krogsrud	TWRS Safety	372-2302
M. H. Brown	SST Eng (Cog Eng)	372-1611
Tony BENEGAS	Project Engineering (Cog Eng)	376-4862
Doug Larsen	TFFO	373-5995
NICK KIRCH	TWRS PROCESS ENGINEERING	373-2380

ENCLOSURE 3

**PURPOSE, SCOPE, AND PROCESS FOR THE TANK 241-SY-101 WASTE
TRANSFER CONTROL DECISION MEETINGS**

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CONTROL DECISION MEETINGS FOR THE TANK 241-SY-101 WASTE TRANSFER

Note: Controls include safety-class and safety-significant structures, systems, and components (SSCs); technical safety requirements (TSRs); and other controls that provided defense-in-depth or environmental protection.

Purpose:

Identify existing or new controls required to protect the public, onsite workers, facility workers, and the environment from potential hazardous conditions and postulated accidents for the Tank 241-SY-101 waste transfer.

Scope:

A series of waste transfers from Tank 241-SY-101 into Tank 241-SY-102, followed by back dilution with water into SY-101, as required, is planned to remediate the SY-101 surface-level rise condition (*Tank 241-SY-101 Surface-Level-Rise Remediation Project Plan*, HNF-3824, Rev. 0, February 1999). The first waste transfer will move approximately 380,000 to 570,000 liters (100,000 to 150,000 gallons) of waste and is the subject of the control decision meetings. The waste transfer is scheduled for September 1999.

A possible back dilution of SY-101 waste following the waste transfer, and subsequent SY-101 waste transfers and back dilutions, are not within the scope of the control decision meetings.

Process:

Control decisions for the Tank 241-SY-101 waste transfer will be made using the established, approved process in the existing Tank Waste Remediation System (TWRS) Authorization Basis. The control decision process and the criteria for control decisions are described in the TWRS Basis for Interim Operation (HNF-SD-WM-BIO-001) along with the methodology for the hazard and accident analyses whose results are used to identify controls. Control decision criteria are summarized in Attachment I.

Control decisions will be based on the best available information from the hazard and accident analyses and on the technical expertise and experience of the meeting participants. Decisions will be made by consensus.

Participants in the SY-101 waste transfer control decision meetings will include a chairperson selected by Tank 241-SY-101 Surface-Level-Rise Remediation Project (Project) management and personnel representing operations, engineering (including the Design Authority, 241-SY-101 cognizant engineer, and Project cognizant engineer), process engineering, nuclear safety and licensing, and LANL. The existing Test Review Group for 101-SY Mitigation (TRG) will provide the core of the above participants because of their experience and expertise on 241-SY-101. TRG members representing quality assurance and independent safety analysis, as well as a representative from Fluor Daniel Northwest, are also expected to attend the control decision meetings. In addition, hazard and accident analysts, engineers, and scientists will

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present information and participate in control decisions for specific potential hazardous conditions and postulated accidents.

The control decision meeting discussions will be documented, including the control decisions (see Attachment II). This documentation will serve as a reference for the amendment to the TWRS Authorization Basis for the 241-SY-101 waste transfer.

SUMMARY OF CONTROL DECISION CRITERIA

Note: TWRS BIO Section 5.4.1, "Control Decision Criteria," contains a complete discussion of control decision criteria

Control decision criteria are based on the following documents

DOE 5480.23, *Nuclear Safety Analysis*

DOE 5480.22, *Technical Safety Requirements*

DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*

WHC-CM-4-46, *Nonreactor Facility Safety Analysis Manual*, Section 6, "Technical Safety Requirements," Rev. 1, and Section 9, "Safety Classification of Structures, Systems, and Components,," Rev. 2.

Risk Evaluation Guidelines:

Radiological Risk Guidelines

Frequency category	Frequency range (yr-1)	Effective dose equivalent (rem)	
		Onsite	Offsite
Anticipated	$>10^{-2}$ to $\leq 10^0$	0.5	0.1
Unlikely	$>10^{-4}$ to $\leq 10^{-2}$	5	0.5
Extremely unlikely	$>10^{-6}$ to $\leq 10^{-4}$	10	4

Toxicological Risk Guidelines

Frequency category	Frequency range (yr-1)	Primary concentration guidelines	
		Onsite	Offsite
Anticipated	$>10^{-2}$ to $\leq 10^0$	$\leq$ ERPG-1	$\leq$ PEL-TWA
Unlikely	$>10^{-4}$ to $\leq 10^{-2}$	$\leq$ ERPG-2	$\leq$ ERPG-1
Extremely unlikely	$>10^{-6}$ to $\leq 10^{-4}$	$\leq$ ERPG-3	$\leq$ ERPG-2

ERPG = Emergency Response Planning Guideline

PEL-TWA = permissible exposure limit – time-weighted average

Additional criteria to guide control decisions are the following

- Control preferences are as follows:
 1. Controls that prevent the accident versus those that mitigate its consequences
 2. Passive engineered versus active engineered controls
 3. Engineered controls versus administrative controls
- Controls providing significant defense-in-depth are classified as safety SSCs or are elevated to TSR controls
- TSRs are not developed for postulated accidents resulting in only environmental consequences
- SSCs are not classified safety-class or safety-significant solely for preventing or mitigating postulated accidents resulting in environmental consequences

Other criteria that are important considerations in control decisions are listed below

- Control reliability, availability, and maintainability
- Control effects on facility workers (i.e., increased radiation doses or toxicological exposures – ALARA issues)
- Control optimization and integration
- Control cost/benefit
- Control human factors impacts
- Control impacts on TWRS mission

CONTROL DECISION RECORD

HAZARD/ACCIDENT TITLE:

Structures, Systems, and Components (SSCs)

Structures, Systems, and Components	Classification		Safety Function	Comments
	SC*	SS*		

- * SC is safety class
SS is safety significant

Technical Safety Requirements (TSRs)

Control	Safety Function	Comments

Defense-in Depth Controls

Control	Safety Function	Comments

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ENCLOSURE 4

**DESIGN AND OPERATION OF THE TANK 241-SY-101 RAPID
MITIGATION WASTE TRANSFER SYSTEM**

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241-SY-102

241-SY-101

RAPID MITIGATION SYSTEM
241-SY-101 TO 241-SY-102 TRANSFER

NOT TO SCALE

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QTY	PART / NO	DESCRIPTION	MATERIAL	ITEM
1	14-2-57331-1	MECHANICAL EQUIP LONG DOME		8
1	14-2-57331-2	MECHANICAL EQUIP SHORT DOME		9
1	ZELM2125	PPP SHIELD PLATE		10
1	-001	ENCLOSURE END-25 PL 1/2 THK	304 SST	11
1	-002	ENCLOSURE END-25 PL 1/2 THK	304 SST	12
2	-003	ENCLOSURE END-25 PL 1/2 THK	304 SST	13
1	-004	ENCLOSURE END-25 PL 1/2 THK	304 SST	14
1	-005	ENCLOSURE END-25 PL 1/2 THK	304 SST	15
1	-006	ENCLOSURE END-25 PL 1/2 THK	304 SST	16
1	-007	ENCLOSURE END-25 PL 1/2 THK	304 SST	17
2	-008	ENCLOSURE END-25 PL 1/2 THK	304 SST	18
2	-009	ENCLOSURE END-25 PL 1/2 THK	304 SST	19
2	-010	ENCLOSURE END-25 PL 1/2 THK	304 SST	20
2	-011	ENCLOSURE END-25 PL 1/2 THK	304 SST	21
2	-012	ENCLOSURE END-25 PL 1/2 THK	304 SST	22
2	-013	ENCLOSURE END-25 PL 1/2 THK	304 SST	23
2	-014	ENCLOSURE END-25 PL 1/2 THK	304 SST	24
12		TOTAL: 12 X 25 X 1/2 X 1/2 X 1/2		25

DOC. NO. ZELM2125 - 241-SV-101 PPP ENCLOSURE

1 PPP ENCLOSURE ASSEMBLY
SCALE: 1/16

14 REINFORCEMENT PLATE
SCALE: 1/8

15 REINFORCEMENT PLATE
SCALE: 1/8

SECTION A-A
SCALE: 1/16

* = CRITICAL DIMENSION

SECTION B-B
SCALE: 1/16

ENCLOSURE

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PRELIMINARY
NOT FOR FABRICATION
FOR COMMENT ONLY.
DATE: JUNE

12

U.S. DEPARTMENT OF ENERGY	
241-SY-102	
DROP LEG ASSEMBLY	
FIG. 14-1039810	1 OF 1

Option 2

③

U.S. DEPARTMENT OF TREASURY
Internal Security Unit
WASHINGTON, D.C. 20540-0001
241-SY-102
DROP LEG ASSEMBLY

4-14-1035940

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ENCLOSURE 5

TANK 241-SY-101 WASTE TRANSFER HAZARD ANALYSIS OVERVIEW

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241-SY-101 Small Waste Transfer Hazards Analysis

- **Performed according to the process specified in Authorization Basis (Chapter 5 of the TWRS BIO)**
- **Data developed from Hazards Analysis of Crust Growth and Waste Transfer System design**
- **131 Hazardous Conditions were identified with 108 Hazardous Conditions related to waste transfer activities**
- **Four new Representative Accidents were identified related to Flammable Gas Deflagrations of which three were associated with waste transfer activities**

241-SY-101 Small Waste Transfer Hazards Analysis (continued)

The Authorization Basis Hazards Analysis process consists of the following:

- **Hazard Evaluation**
- **Accident Selection**
- **Controls Identification**

241-SY-101 Small Waste Transfer Hazards Analysis (continued)

The 108 Hazardous Conditions related to waste transfer activities were grouped as follows:

- **Hazardous Conditions having potential Onsite or Offsite consequences that were adequately addressed by the Accident Analysis and established controls in the Authorization Basis – 16 items**
- **Hazardous Conditions having potential Onsite or Offsite consequences that were addressed by the Authorization Basis Accident Analysis but have control allocation concerns – 37 items**
- **Hazardous Conditions having no consequences or consequences impacting only the onsite worker – 55 items**

241-SY-101 Small Waste Transfer Hazards Analysis (continued)

The four new Representative Accidents were:

- **Flammable Gas Deflagration involving Buoyant Displacement GRE with concurrent crust gas release (waste transfer related)**
- **Flammable Gas Deflagration involving Induced Crust GRE due to crust disturbance (waste transfer related)**
- **Flammable Gas Deflagration involving Induced Crust GRE due to crust dissolution (waste transfer related)**
- **Flammable Gas Deflagration during Mixer Pump removal (potentially larger consequences due to flammable gas holdup in crust)**

ENCLOSURE 6

TANK 241-SY-101 WASTE TRANSFER HAZARDOUS CONDITIONS

Includes the following hazard evaluation tables:

- Part 1: Hazardous conditions having potential onsite or offsite consequences addressed by the Authorization Basis by presenting control allocation concerns
- Part 2: Hazardous conditions having potential onsite or offsite consequences addressed by the Authorization Basis
- Part 3: Hazardous conditions having no consequences or consequences impacting only the facility worker.

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ENCLOSURE 6 — PART I

**HAZARDOUS CONDITIONS HAVING POTENTIAL ONSITE OR OFFSITE
CONSEQUENCES ADDRESSED BY THE AUTHORIZATION BASIS BY
PRESENTING CONTROL ALLOCATION CONCERNS**

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Hazardous Conditions Having Potential Onsite (S2) or Offsite (S3) Consequences
Addressed by the AB But Presenting Control Allocation Concerns

Pages = 10

ID	Material at Risk	Hazardous Condition	Cause	Potential Preventive SSC	Potential Preventive TSR	Potential Mitigative SSC	Potential Mitigative TSR	Remarks	Con Cat	Freq Cat
Rep Acc 04, Flammable Gas Deflagrations - DST, Represented in Current AB Analysis										
SYXFR01-02	DST inventory	Flammable gas ignites in Tank 241-SY-101 when riser activities cause spark resulting in radioactive aerosol release	Flammable gas ignition	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detection Systems	LCO: 3.2.1 DST and AWF Tank Ventilation Systems AC: 5.9 Flammability Controls LANL SA Level 1 Control on Gas Concentrations	None required	None required	This is opening the riser to prepare for PPP assembly installation.	S3	F3
Rep Acc 04, Flammable Gas Deflagrations Represented by Item ID 101SYWLV-15A Identified in HNF-3645 (Buoyant Displacement GRE with Crust Gas Release)										
SYXFR03-12a	DST inventory	Change solubility causing larger quantity of precipitated material resulting in increase of flammable gas being trapped on particles with ignition in Tank 241-SY-101 resulting in BGRE	Failure of service water heating resulting in addition of cold dilution water with failure of transfer pump	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detection Systems	LCO: 3.2.1 DST and AWF Tank Ventilation Systems AC: 5.9 Flammability Controls LANL SA Level 1 Control on Gas Concentrations	TBD	TBD	None	S3	F2
SYXFR03-13a	DST inventory	Release of radioactive aerosols due to ignition of large quantities of flammable gas in Tank 241-SY-101 released from buoyant displacement GRE	Human error or instrument failure results in excessive transfer or siphoning Failure to continue GRE prevention due to inability to operate mixer pump - Mixer pump suction in crust - Mixer pump suction out of waste	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detection Systems	LCO: 3.2.1 DST and AWF Tank Ventilation Systems AC: 5.9 Flammability Controls LANL SA Level 1 Control on Gas Concentrations	TBD	TBD	Transfer is time intensive, it would take a long period of time to remove excessive amount of waste.	S3	F2

**Hazardous Conditions Having Potential Onsite (S2) or Offsite (S3) Consequences
Addressed by the AB But Presenting Control Allocation Concerns**

Pages = 10

ID	Material at Risk	Hazardous Condition	Cause	Potential Preventive SSC	Potential Preventive TSR	Potential Mitigative SSC	Potential Mitigative TSR	Remarks	Con Cat	Freq Cat
101SYWLV-4BT-SL	Aerosols and other radioactive material from Tank 241-SY-101	Release of radioactive/hazardous material from tank to atmosphere due to flammable gas deflagration	Buoyant displacement GRE from slurry layer with ignition	None required	None required	None required	None required	No additional controls due to low frequency	S3	F0
101SYWLV-24AT	Aerosols and other radioactive material from Tank 241-SY-101	Release of radioactive/hazardous material from tank to atmosphere due to flammable gas deflagration	Buoyant displacement GRE with ignition due to material transfer	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detection Systems	LCO: 3.2.1 DST and AWF Tank Ventilation Systems AC: 5.9 Flammability Controls <i>LANL SA Level 1 Control on Gas Concentrations</i>	TBD	TBD	Effects of transfer of waste from 101-SY. Introduction of Non-Flammable External Source of Gas- Dilutes flammable gas in tank waste, reduces flammability in all hazardous conditions previously identified.	S3	F0
101SYWLV-25AT	Aerosols and other radioactive material from Tank 241-SY-101	Release of radioactive/hazardous material from tank to atmosphere due to flammable gas deflagration	Buoyant displacement GRE with ignition due to material transfer	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detection Systems	LCO: 3.2.1 DST and AWF Tank Ventilation Systems AC: 5.9 Flammability Controls <i>LANL SA Level 1 Control on Gas Concentrations</i>	TBD	TBD	Effects of transfer of waste from 101-SY. Introduction of Non-Flammable External Source of Gas- Dilutes flammable gas in tank waste, reduces flammability in all hazardous conditions previously identified.	S3	F2

Hazardous Conditions Having Potential Onsite (S2) or Offsite (S3) Consequences
Addressed by the AB But Presenting Control Allocation Concerns

Pages = 10

ID	Material at Risk	Hazardous Condition	Cause	Potential Preventive SSC	Potential Preventive TSR	Potential Mitigative SSC	Potential Mitigative TSR	Remarks	Con Cat	Freq Cat
Rep Acc 04, Flammable Gas Deflagrations Represented by Item ID 101SYWLV-14A Identified in HNF-3645 Induced Crust GRE Due To Crust Disturbance										
101SYWLV-18A	Aerosols and other radioactive material from Tank 241-SY-101	Release of radioactive/hazardous material from tank to atmosphere due to flammable gas deflagration	Crust penetration/disturbance releasing flammable gas from the crust with ignition Sufficient gas release for tank LFL is not possible unless disturbance propagates quickly away from initiating point	SC: DST/AFW Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detection Systems	LCO: 3.2.1 DST and AWF Tank Ventilation Systems AC: 5.9 Flammability Controls <i>LANL SA Level 1 Control on Gas Concentrations</i>	TBD	TBD	Ignition controls	S3	F0
101SYWLV-22AT	Aerosols and other radioactive material from Tank 241-SY-101	Release of radioactive/hazardous material from tank to atmosphere due to flammable gas deflagration	Crust subsides during transfer creating GRE from crust with ignition	SC: DST/AFW Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detection Systems	LCO: 3.2.1 DST and AWF Tank Ventilation Systems AC: 5.9 Flammability Controls <i>LANL SA Level 1 Control on Gas Concentrations</i>	TBD	TBD	Tank ventilation Ignition controls Monitoring controls	S3	F1
SYXFR01-07	DST inventory	Flammable gas generated and ignited in Tank 241-SY-101 due to intrusive activity resulting in release of radioactive aerosols	Insertion of PPP assembly into tank disturbs waste releasing flammable gas	SC: DST/AFW Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detection Systems	LCO: 3.2.1 DST and AWF Tank Ventilation Systems AC: 5.9 Flammability Controls <i>LANL SA Level 1 Control on Gas Concentrations</i>	TBD	TBD	None	S3	F3
SYXFR04-18	DST inventory	Radioactive aerosol release due to ignition of flammable gas released from disturbed crust in Tank 241-SY-101. Also identified in HNF-3645, Item 101SY-WLV-22AT	Rapid transfer disturbs crust greater than postulated	SC: DST/AFW Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detection Systems	LCO: 3.2.1 DST and AWF Tank Ventilation Systems AC: 5.9 Flammability Controls <i>LANL SA Level 1 Control on Gas Concentrations</i>	TBD	TBD	Team feels this condition is bounded by dissolution accident.	S3	F1

Hazardous Conditions Having Potential Onsite (S2) or Offsite (S3) Consequences
Addressed by the AB But Presenting Control Allocation Concerns

Pages = 10

ID	Material at Risk	Hazardous Condition	Cause	Potential Preventive SSC	Potential Preventive TSR	Potential Mitigative SSC	Potential Mitigative TSR	Remarks	Con Cat	Freq Cat
SYXFR13-56	DST inventory	Release of radioactive aerosols due to ignition of flammable gas in Tank 241-SY-101 released due to crust disturbance	Nozzle breaks off decon spray ring creating minor disturbance of crust/waste	No controls required based on low accident frequency	No controls required based on low accident frequency	No controls required based on low accident frequency	No controls required based on low accident frequency	Covered by radiation protection program. Controls exist for mixer pump spray ring covered by LAUR-92-3196 (WHC-SD-WM-SAD-033), cover decon ring.	S3	F0
Rep Acc 04, Flammable Gas Deflagrations Represented by Item ID 101SYWLV-14A Identified in HNF-3645 Induced Crust GRE Due To Crust Dissolution										
101SYWLV-23AT	Aerosols and other radioactive material from Tank 241-SY-101	Release of radioactive/hazardous material from tank to atmosphere due to flammable gas deflagration	Injection of water into the transfer pump for in-line dilution releasing gas from crust with ignition	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detection Systems	LCO: 3.2.1 DST and AWF Tank Ventilation Systems AC: 5.9 Flammability Controls LANL SA Level 1 Control on Gas Concentrations	TBD	TBD	Tank ventilation Ignition controls Recommend monitoring waste transfer rate vs dilution flow	S3	F0
SYXFR03-12b	DST inventory	Ignition of significant quantities of flammable gas in Tank 241-SY-101 released from dissolution of crust causing radioactive aerosol release	Hot flush/dilution water added (failure of temperature control) coupled with failure to transfer material	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detection Systems	LCO: 3.2.1 DST and AWF Tank Ventilation Systems AC: 5.9 Flammability Controls LANL SA Level 1 Control on Gas Concentrations	TBD	TBD	Not a significant contribution to flammable gas generation.	S3	F1
SYXFR03-13a	DST inventory	Radioactive aerosol release due to water addition dissolving crust causing GRE with ignition in Tank 241-SY-101 (HNF-3645, 101SY-WLV-23AT)	Excessive dilution without transfer occurring-plugged transfer line-bed pump-bad flow meters-operator error coupled with instrument error	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detection Systems	LCO: 3.2.1 DST and AWF Tank Ventilation Systems AC: 5.9 Flammability Controls LANL SA Level 1 Control on Gas Concentrations	TBD	TBD	It is unclear how much waste dilution is significant to crust dissolving. Currently being considered as one of the analyzed accidents for mitigation.	S3	F2

**Hazardous Conditions Having Potential Onsite (S2) or Offsite (S3) Consequences
Addressed by the AB But Presenting Control Allocation Concerns**

Pages = 10

ID	Material at Risk	Hazardous Condition	Cause	Potential Preventive SSC	Potential Preventive TSR	Potential Mitigative SSC	Potential Mitigative TSR	Remarks	Con Cat	Freq Cat
SYXFR03-15b	DST inventory	Radioactive aerosol release due to water addition dissolving crust causing GRE with ignition in Tank 241-SY-101 (HNF-3645,101SY-WLV-23AT)	Inadvertent draining from flush tank	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detection Systems	LCO: 3.2.1 DST and AWF Tank Ventilation Systems AC: 5.9 Flammability Controls LANL SA Level 1 Control on Gas Concentrations	TBD	TBD	It is unclear how much waste dilution is significant to crust dissolving. Currently being considered as one of the analyzed accidents for mitigation.	S3	F2
SYXFR04-17	DST inventory	Radioactive aerosol release due to spray leak dissolving crust causing GRE with ignition in Tank 241-SY-101	Hole in pipe (spray leak) inside dome space	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detection Systems	LCO: 3.2.1 DST and AWF Tank Ventilation Systems AC: 5.9 Flammability Controls LANL SA Level 1 Control on Gas Concentrations	TBD	TBD	Team feels this condition is bounded by dissolution accident.	S3	F1
SYXFR04-22	DST inventory	Ignition of significant quantities of flammable gas released from dissolution of crust in Tank 241-SY-101 causing radioactive aerosol release	Hot flush/dilution water added (failure of temperature control) coupled with failure to transfer material heats tank waste	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detection Systems	LCO: 3.2.1 DST and AWF Tank Ventilation Systems AC: 5.9 Flammability Controls LANL SA Level 1 Control on Gas Concentrations	TBD	TBD	Overflow is captured in other accidents.	S3	F1
SYXFR12-32	DST inventory	Ignition of significant quantities of flammable gas released in Tank 241-SY-101 from dissolution of crust causing radioactive aerosol release	Hot flush/dilution water added (failure of temperature control) coupled with failure to transfer material	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detection Systems	LCO: 3.2.1 DST and AWF Tank Ventilation Systems AC: 5.9 Flammability Controls LANL SA Level 1 Control on Gas Concentrations	TBD	TBD	May not be a significant contribution to flammable gas generation.	S3	F3

**Hazardous Conditions Having Potential Onsite (S2) or Offsite (S3) Consequences
Addressed by the AB But Presenting Control Allocation Concerns**

Pages = 10

ID	Material at Risk	Hazardous Condition	Cause	Potential Preventive SSC	Potential Preventive TSR	Potential Mitigative SSC	Potential Mitigative TSR	Remarks	Con Cat	Freq Cat
Rep Acc 15, Spray Leak in Structure or from Overground Waste Transfer Lines										
SYXFR-N5-05b	DST Waste	Release of radioactive aerosols from PPP due to spray leak in PPP or OGT encasement	Primary line (hose) spray leak (break in PPP or OGT encasement)	None	None	SC: Transfer System Covers SC: OGT Encasements and Connections	LOO: 3.1.1 Transfer System Covers and Entry Doors AC: 5.22 Transfer system cover removal controls	OGT encasement is open to the PPP and the SY-102 tank.	S3	F3
SYXFR-N5-10b	DST Waste	Release of radioactive aerosols from PPP to atmosphere due to seismic event damaging PPP and primary pipe (hose)	Seismic event	None	None	SC: OGT Encasement and Connections	AC: 5.14 Emergency Preparedness - Response procedures	OGT encasement is open to the PPP and the SY-102 tank.	S3	F2
SYXFR-N5-12b	DST Waste	Release of radioactive aerosols from PPP to atmosphere due to wind driven missiles damaging PPP and primary pipe (hose)	Wind driven missiles	No SSCs required based on low frequency of event	No controls required based on low frequency of event	No SSCs required based on low frequency of event	No controls required based on low frequency of event	This may actually be an F0 due to the design strength of structure. Team agreed that this condition is not a likely threat.	S3	F1
SYXFR-N8-20b	DST Waste	Release of radioactive aerosols from OGT to atmosphere due to seismic event damaging OGT encasement and primary pipe (hose)	Seismic event	None	None	SC: OGT Encasement and Connections	AC: 5.14 Emergency Preparedness - Response procedures	OGT encasement is open to the PPP and the SY-102 tank.	S3	F2
SYXFR-N8-22b	DST Waste	Release of radioactive aerosols from OGT to atmosphere due to wind driven missiles breaching encasement and primary pipe (hose)	Wind driven missiles	No SSCs required based on low frequency of event	No controls required based on low frequency of event	No SSCs required based on low frequency of event	No controls required based on low frequency of event	Team agreed that this condition is not a likely threat. Wind driven missiles do not have sufficient energy to damage OGT to the degree necessary to create a release.	S3	F0

**Hazardous Conditions Having Potential Onsite (S2) or Offsite (S3) Consequences
Addressed by the AB But Presenting Control Allocation Concerns**

Pages = 10

ID	Material at Risk	Hazardous Condition	Cause	Potential Preventive SSC	Potential Preventive TSR	Potential Mitigative SSC	Potential Mitigative TSR	Remarks	Con Cat	Freq Cat
SYXFR05-24b1	DST waste	Release of radioactive aerosol released in Tank 241-SY-101 PPP due to leak from line, flange or valve	Ruptured line/leaking flange or valve inside Tank 241-SY-101 PPP	None required	None required	SC: Transfer system covers	LCO: 3.1.1 Transfer System Covers AC: 5.22 Transfer system cover removal controls	The function of the PPP is to ensure that a torturous path for aerosol escape is maintained.	S3	F3
SYXFR05-28b1	DST waste	Release of aerosol generated in Tank 241-SY-101 PPP due to spray leak from line, flange or valve	Ruptured line/leaking flange or valve inside Tank 241-SY-101 PPP	None required	None required	SC: Transfer system covers	LCO: 3.1.1 Transfer System Covers AC: 5.22 Transfer system cover removal controls	The function of the PPP is to ensure that a torturous path for aerosol escape is maintained. *The transfer system will have its own leak detection system.	S3	F3
SYXFR05-31	DST waste	Flush with high temperature flush water with preexisting spray leak causes release of high temperature aerosols in Tank 241-SY-101 PPP	Flush water too hot	None required	None required	SC: Transfer system covers	LCO: 3.1.1 Transfer System Covers AC: 5.22 Transfer system cover removal controls	The function of the PPP is to ensure that a torturous path for aerosol escape is maintained. Higher temperature flush water does not have a significant impact on consequences of this accident compared to cold flush water.	S3	F2

Hazardous Conditions Having Potential Onsite (S2) or Offsite (S3) Consequences
Addressed by the AB But Presenting Control Allocation Concerns

Pages = 10

ID	Material at Risk	Hazardous Condition	Cause	Potential Preventive SSC	Potential Preventive TSR	Potential Mitigative SSC	Potential Mitigative TSR	Remarks	Coa Cat	Freq Cat
Rep Acc 26, Surface Leak Resulting in Pool										
SYXFR-NS-09	DST Waste	Release of radioactive liquid from PPP to soil surface due to leak forming pool	Waste leak within the PPP enclosure (and plugged drain)	None	None	SC: Transfer Leak Detection Systems SC: OGT Encasement and Connections SS: Transfer System Covers	LCO: 3.1.1 Transfer System Covers/ LCO: 3.1.3 Transfer Leak Detection Systems AC: 5.14 Emergency Preparedness - Response procedures	The function of the PPP is to contain the leak to the full capacity of the box.	S3	F3
SYXFR-NS-10a	DST Waste	Release of radioactive waste from PPP to soil surface due to seismic event damaging PPP and primary pipe (hose)	Seismic event	None	None	SC: OGT Encasement and Connections	AC: 5.14 Emergency Preparedness - Response procedures	The function of the PPP is to contain the leak to the full capacity of the box.	S3	F2
SYXFR-NS-12a	DST Waste	Release of radioactive waste from PPP to soil surface due to wind driven missiles damaging PPP and primary pipe (hose)	Wind driven missiles	No SSCs required based on low frequency of event	No controls required based on low frequency of event	No SSCs required based on low frequency of event	No controls required based on low frequency of event	This may actually be an F0 due to the design strength of structure. Team agreed that this condition is not a likely threat.	S3	F1
SYXFR-NB-20a	DST Waste	Release of radioactive waste from OGT to soil surface due to seismic event damaging OGT encasement and primary pipe (hose)	Seismic event	None	None	SC: OGT Encasement and Connections	AC: 5.14 Emergency Preparedness - Response procedures	The function of the PPP is to contain the leak to the full capacity of the box.	S3	F2
SYXFR-NB-22a	DST Waste	Release of radioactive waste from OGT to soil surface due to wind driven missiles breaching encasement and primary pipe (hose)	Wind driven missiles	No SSCs required based on low frequency of event	No controls required based on low frequency of event	No SSCs required based on low frequency of event	No controls required based on low frequency of event	Team agreed that this condition is not a likely threat. Wind driven missiles do not have sufficient energy to damage OGT to the degree necessary to create a release.	S3	F0

Hazardous Conditions Having Potential Onsite (S2) or Offsite (S3) Consequences
Addressed by the AB But Presenting Control Allocation Concerns

Pages = 10

ID	Material at Risk	Hazardous Condition	Cause	Potential Preventive SSC	Potential Preventive TSR	Potential Mitigative SSC	Potential Mitigative TSR	Remarks	Con Cat	Freq Cat
SYXFR03-14a	DST waste	Release of radioactive material from waste tank due to overflow of Tank 241-SY-101 resulting in pool (see HNF-3645 for details)	Excessive dilution without transfer occurring-plugged transfer line-bad pump-bad flow meters-operator error coupled with instrument	None required	None required	SS: Tank Level Detection Systems SS: Service Water Flow Totalizers	AC: 5.12 Transfer Controls AC: 5.14 Emergency Preparedness AC: 5.21 Tank Service Water Intrusion Monitoring Program	Project has a dedicated line - no mistransfer from other facilities possible, or mistransfers out.	S2	F2
SYXFR03-14b	DST waste	Release of radioactive material from waste tank due to overflow of Tank 241-SY-101 resulting in pool (see HNF-3645 for details)	Inadvertent draining from flush tank	None required	None required	SS: Tank Level Detection Systems SS: Service Water Flow Totalizers	AC: 5.12 Transfer Controls AC: 5.14 Emergency Preparedness AC: 5.21 Tank Service Water Intrusion Monitoring Program	Project has a dedicated line - no mistransfer from other facilities possible, or mistransfers out.	S2	F2
SYXFR04-19	DST waste	Release of radioactive material from waste tank due to overflow of Tank 241-SY-101 resulting in pool (see HNF-3645 for details)	Human error or equipment failure results in running flush water into system, discharge valve closed on Tank 241-SY-102, backflow to Tank 241-SY-101	None required	None required	SC: Transfer Leak Detection Systems SS: Transfer System Covers	LCO: 3.1.1 Transfer System Covers LCO: 3.1.3 Transfer Leak Detection Systems AC: 5.12 Transfer Controls AC: 5.14 Emergency Preparedness	None	S2	F2
SYXFR-N5-05A	DST Waste	Release of radioactive liquid from PPP to the soil due to pool leak	Backflow of encasement from primary line (hose) leak (break near PPP or SY-102 encasement end plugged) - plus failure of PPP drain	None	None	SC: Transfer Leak Detection Systems SC: OGT Encasement and Connections SS: Transfer System Covers	LCO: 3.1.1 Transfer System Covers/ LCO: 3.1.3 Transfer Leak Detection Systems AC: 5.14 Emergency Preparedness - Response procedures	Encasement is sloped to direct encasement flow to Tank 241-SY-102. The function of the PPP is to contain the leak to the full capacity of the box.	S3	F3

**Hazardous Conditions Having Potential Onsite (S2) or Offsite (S3) Consequences
Addressed by the AB But Presenting Control Allocation Concerns**

Pages = 10

ID	Material at Risk	Hazardous Condition	Cause	Potential Preventive SSC	Potential Preventive TSR	Potential Mitigative SSC	Potential Mitigative TSR	Remarks	Con Cat	Freq Cat
SYXFR05-24b2	DST waste	Overflow of Tank 241-SY-101 PPP due to leak from line, flange or valve	Ruptured line/leaking flange or valve inside Tank 241-SY-101 PPP	None required	None required	SC: Transfer leak detection systems SS: Tank level detection systems SS: Transfer system covers	LCO: 3.1.1 Transfer System Covers LCO: 3.1.3 Transfer Leak Detection Systems AC: 5.12 Transfer Controls AC: 5.14 Emergency Preparedness	The function of the PPP is to contain the leak to the full capacity of the box.	S3	F3
SYXFR05-28b2	DST waste	Release of liquid waste in Tank 241-SY-101 PPP due to leak from line, flange or valve forming pool	Ruptured line/leaking flange or valve inside Tank 241-SY-101 PPP	None required	None required	SC: Transfer leak detection systems SS: Tank level detection systems SS: Transfer system covers	LCO: 3.1.1 Transfer System Covers AC: 5.12 Transfer Controls AC: 5.14 Emergency Preparedness	The function of the PPP is to contain the leak to the full capacity of the box. *The transfer system will have its own leak detection system.	S3	F2

ENCLOSURE 6 — PART 2

**HAZARDOUS CONDITIONS HAVING POTENTIAL ONSITE OR OFFSITE
CONSEQUENCES ADDRESSED BY THE AUTHORIZATION BASIS**

**HNF-3737 REV 1
APPENDIX F**

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Hazardous Conditions Having Potential Onsite (S2) or Offsite (S3) Consequences Addressed by the AB

Pages = 5

ID	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	Remarks	Con Cat	Freq Cat
Rep Acc 04, Flammable Gas Deflagrations - DST Represented in Current AB Analysis										
SYXFR02-09	DST inventory	Flammable gas ignition in Tank 241-SY-102 during drop leg installation results in aerosol release of radioactive material	Flammable gas ignition	SC: DST/AFW Ventilation	LCO: 3.2.1 DST and AWF Tank Ventilation Systems AC: 5.9 Flammability Controls AC: 5.10 Ignition Controls AC: 5.11 Flammable Gas Monitoring Controls	None required	None required	Hazards less for these hazardous conditions than those specified in the Authorization Basis.	S3	F3
101SYWLV-2BT-ML	Aerosols and other radioactive material from Tank 241-SY-102	Release of radioactive/hazardous material from receiver tank during transfer to atmosphere due to flammable gas deflagration	Release of entrained gas in receiver tank with ignition	SC: DST/AFW Ventilation	LCO: DST and AWF Tank Ventilation Syss AC: 5.9 Flammability Controls AC: 5.10 Ignition Controls AC: 5.11 Flammable Gas Monitoring Controls	None required	None required	Tank ventilation Potentially natural breathing	S3	F0
101SYWLV-3BT-ML	Aerosols and other radioactive material from Tank 241-SY-102	Release of radioactive/hazardous material from receiver tank to atmosphere due to flammable gas deflagration	Buoyant displacement GRE from mixed layer in receiver tank with ignition	SC: DST/AFW Ventilation	LCO: DST and AWF Tank Ventilation Syss AC: 5.9 Flammability Controls AC: 5.10 Ignition Controls AC: 5.11 Flammable Gas Monitoring Controls	None required	None required	Mixed layer - Can account for less than 20 percent of level growth (may even be less than 5 percent)	S3	F2

Hazardous Conditions Having Potential Onsite (S2) or Offsite (S3) Consequences Addressed by the AB

Pages = 5

ID	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	Remarks	Con Cat	Freq Cat
SYXFR11-46a	DST inventory	Release of radioactive aerosols due to flammable gas deflagration in Tank 241-SY-102	Drop leg design error results in waste level being below discharge point - entrained gasses are released as waste is discharged	SC: DST/WWF Ventilation	LOO: 3.2.1 DST and AWF Tank Ventilation Systems AC: 5.9 Flammability Controls AC: 5.10 Ignition Controls AC: 5.11 Flammable Gas Monitoring Controls	None required	None required	None	S3	F3
SYXFR11-48a	DST inventory	Flammable gas deflagration due to increased gas generation in Tank 241-SY-102 results in release of radioactive aerosols	Low liquid level prevents drop leg from distributing solids	SC: DST/WWF Ventilation	LOO: 3.2.1 DST and AWF Tank Ventilation Systems AC: 5.9 Flammability Controls AC: 5.10 Ignition Controls AC: 5.11 Flammable Gas Monitoring Controls	None required	None required	None	S3	F3

Rep Acc 07, Fire In Contaminated Area

SYXFR-N5-08	DST Waste	Release of rad particulates from PPP due to flammable gas accumulation and ignition Exposure of personnel to ionizing radiation	Flammable gas presence in PPP plus ignition	None	None	None	AC: 5.14 Emergency Preparedness - Response procedures	Assumes significant contamination present in PPP.	S2	F3
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Hazardous Conditions Having Potential Onsite (S2) or Offsite (S3) Consequences Addressed by the AB

Pages = 5

ID	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	Remarks	Con Cat	Freq Cat
Rep Acc 12, Tank Failure Due to Excessive Loads										
SYXFR01-04	Radioactive aerosols contained in Tank 241-SY-101 headspace	Dropped equipment during installation damages Tank 241-SY-101 riser and/or tank dome	Damage to riser due to Jan-Drop on riser or tank dome- Vehicle impact	None required	AC: 5.16 Dome Loading Controls	None required	None required	Installing the Pump and PPP. Estimating 15,000 lbs (mixer pump is ~20,000 lbs). Load frame will be installed prior to pump installation. Damage due to vehicle impact is of low likelihood due to the presence of the Tank 241-SY-101 PPP. Vehicle fuel fires covered in BIO 5.3.2.3.	S2	F2
SYXFR01-05	Radioactive aerosols contained in the tank headspace	Localized load potentially damages Tank 241-SY-101 dome/riser creating unfiltered path for aerosol release	Overloaded tank dome due to PPP assembly installation	None required	AC: 5.16 Dome Loading Controls	None required	None required	Load frame will be installed before installation of pump assembly. See BIO ITK-FR-04 for consequences of riser damage.	S3	F1
SYXFR03-13b	DST inventory	Dome failure due to overload from solidified waste suspended from intact equipment due to low liquid level in Tank 241-SY-101	Human error or instrument failure results in excessive transfer or siphoning	No SSCs required based on low frequency of event	No controls required based on low frequency of event	No SSCs required based on low frequency of event	No controls required based on low frequency of event	Lollipop issue addressed in Hazard Analysis for level increase, ID 101SY-WLV-8A, HNF-3645. Large solidified pieces of waste crust adhering to installed equipment suspended from the tank risers could represent significant concentrated load (lollipops have been observed in other tanks).	S2	F0

Hazardous Conditions Having Potential Onsite (S2) or Offsite (S3) Consequences Addressed by the AB

Pages = 5

ID	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	Remarks	Con Cat	Freq Cat
10ISYWL-V-8A	Tank inventory	Release of radioactive/hazardous material from tank to atmosphere due to excessive load on tank equipment	Crust adheres to suspended hardware with crust collapse or transfer out of sufficient amount creating release path through damaged tank dome	None required	None required	None required	None required	No additional controls required due to low frequency	S2	F0

Rep Acc 16, Spray Leak from Underground Waste Transfer Lines

ID	Material leaked from transfer line	Excavation activities damage excavation lines in vicinity of the new transfer line tie-in	Excavation activities damage transfer lines	None required	AC: 5.17 Excavation Controls	None required	AC: 5.17 Excavation Controls	This activity is covered by existing excavation controls.	S3	F3
SYXFR08-43										

Rep Acc 26, Surface Leak Resulting in Pool

ID	DST Waste	Release of radioactive waste from PPP to soil surface due to vehicle/equipment impact damaging PPP and primary pipe (hose)	Vehicle/equipment striking PPP	None	None	None	AC: 5.12 Transfer Controls - Use of concrete shielding system or vehicle restrictions around OGT lines	None	S3	F2
SYXFR-NS-11										
SYXFR-NS-16	DST Waste	Release of radioactive waste from PPP to soil surface due to primary line (hose) leak with plugged PPP drain	Extreme cold weather	No SSCs required based on low frequency of event	No controls required based on low frequency of event	No SSCs required based on low frequency of event	No controls required based on low frequency of event	Seal loop is situated above Tank 241-SY-101 headspace and the radiant heat associated with the tank should prevent freezing.	S3	F0
SYXFR-NB-21	DST Waste	Release of radioactive waste from PPP to soil surface due to vehicle/equipment impact damaging OGT and primary pipe (hose)	Vehicle/ Equipment impacting OGT	None		None	AC: 5.12 Transfer Controls - Use of concrete shielding system or vehicle restrictions around OGT lines	None	S3	F3

Hazardous Conditions Having Potential Onsite (S2) or Offsite (S3) Consequences Addressed by the AB

Pages = 5

ID	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	Remarks	Con Cat	Freq Cat
SYXFR05-24c	DST waste	Release of radioactive liquid from flush tank due to pool leak caused by backflow of waste into flush system	Human error causing incorrect valving (flush pump must be off)	SC: Pressure switch interlocks or alarms (water service lines)	LCO: 3.1.2 Service Water Pressure Detection Systems	SS: Tank level detection systems	AC: 5.14 Emergency Preparedness	Requires multiple events/failures to occur (flush pump inoperable, valve misposition, and transfer occurring.	S3	F2
SYXFR05-28c	DST waste	Release of radioactive liquid due to pool leak caused by backflow of waste into flush system overflowing flush tank	Human error causing incorrect valving (flush pump must be off)	SC: Pressure switch interlocks or alarms (water service lines)	LCO: 3.1.2 Service Water Pressure Detection Systems	SS: Tank level detection systems	AC: 5.12 Transfer Controls AC: 5.14 Emergency Preparedness	None	S3	F2

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ENCLOSURE 6 — PART 3

**HAZARDOUS CONDITIONS HAVING NO CONSEQUENCES OR CONSEQUENCES
IMPACTING ONLY THE FACILITY WORKER**

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101-SY Small Waste Transfer
S0 and S1 Consequence Hazardous Conditions
(sorted by decreasing consequence and frequency)

Pages = 4

ID	Hazardous Condition	Cause	Cons Cat	Freq Cat
SYXFR-N5-03	Minor release of radioactive/toxic contamination to atmosphere due to ventilation failure	Ventilation Failure	S1	F3
SYXFR-N5-04	Release of radioactive/toxic material due to pressurization in Tank 241-SY-102	SY-102 pressurization (tank bump, GRE)	S1	F3
SYXFR-N5-06	Exposure of personnel to ionizing radiation from presence of waste in PPP	Backflow of encasement from primary line (hose) leak (break near PPP or SY-102 encasement end plugged)	S1	F3
SYXFR-N8-23	Inability to transfer waste and personnel exposure to ionizing radiation	Failed heat trace	S1	F3
SYXFR-N8-24	Inability to transfer waste and personnel exposure to ionizing radiation	High velocity cold air drawn through encasement to Tank 241-SY-102 cooling the transfer line sufficiently to cause crystallization of the waste	S1	F3
SYXFR-N8-25	Inability to transfer waste and personnel exposure to ionizing radiation	Dilution water too cold	S1	F3
SYXFR-N8-26	Release to encasement from primary pipe (hose) due to high temperature damaging hose (drains to Tank 241-SY-102) Personnel exposure to ionizing radiation	Failed heat trace	S1	F3
SYXFR01-01	Unfiltered release of radioactive aerosols during PPP installation from Tank 241-SY-101 dome space	Ventilation system failures while riser open results in positive pressure in tank	S1	F3
SYXFR01-03	Personnel are exposed to high levels of ionizing radiation during PPP installation activities	Human error or inadequate protection from shine from open riser	S1	F3
SYXFR02-08	Unfiltered release of radioactive aerosols during drop leg installation from Tank 241-SY-101 dome space	Ventilation system failure while riser open results in positive pressure in tank	S1	F3
SYXFR02-10	Personnel are exposed to high levels of ionizing radiation during drop leg installation activities	Personnel not adequately protected from shine	S1	F3
SYXFR05-24a	Personnel exposure concern due to waste trapped in transfer line	Equipment failure resulting in valve acting as a blockage Transfer pump failure	S1	F3
SYXFR05-24d	Personnel exposure concern due to waste trapped in transfer line	Plugged line	S1	F3
SYXFR05-32	Personnel injured due to occupational hazards	Industrial hazard - hot valve handles etc	S1	F3
SYXFR05-33	Personnel exposed to high levels of ionizing radiation	Design problem - inadequate shielding	S1	F3

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101-SY Small Waste Transfer
S0 and S1 Consequence Hazardous Conditions
(sorted by decreasing consequence and frequency)

Pages = 4

ID	Hazardous Condition	Cause	Cons Cat	Freq Cat
SYXFR11-46b	Release of toxic gas to environment from Tank 241-SY-102 and exposure of personnel	Drop leg design error results in waste level being below discharge point - entrained gasses are released as waste is discharged	S1	F3
SYXFR13-55	Personnel exposure to excessive radiation due to insufficient decon	Human error or equipment failure	S1	F3
SYXFR-N5-13	Exposure of personnel to ionizing radiation due to PPP/OGT damage	Seismic event	S1	F2
SYXFR-N5-14	Exposure of personnel to ionizing radiation due to PPP/OGT damage from vehicle impact	Vehicle/ equipment impact	S1	F2
SYXFR-N8-27	Operational concern Personnel exposure to ionizing radiation	Pump controls set to maximum or pump controls failure when line (hose) plugged	S1	F2
SYXFR-N5-15	Exposure of personnel to ionizing radiation due to PPP/OGT damage from wind driven missile impact reducing shielding	Wind driven missiles	S1	F1
SYXFR12-49a	Release and ignition of flammable gas in transfer line resulting in generation of radioactive aerosols	Pump is not operating due to operator error or equipment failure	S1	F1
SYXFR12-49b	Release and ignition of flammable gas in transfer line resulting in generation of radioactive aerosols	Water supply tank is empty/no supply	S1	F1
SYXFR12-49c	Release and ignition of flammable gas in transfer line resulting in generation of radioactive aerosols	Frozen/damaged line	S1	F1
SYXFR12-49d	Release and ignition of flammable gas in transfer line resulting in generation of radioactive aerosols	Valve shut/failure	S1	F1
SYXFR12-53a	Release and ignition of flammable gas in transfer line resulting in generation of radioactive aerosols	Pump is not operating due to operator error or equipment failure	S1	F1
SYXFR12-53b	Release and ignition of flammable gas in transfer line resulting in generation of radioactive aerosols	Water supply tank is empty/no supply	S1	F1
SYXFR12-53c	Release and ignition of flammable gas in transfer line resulting in generation of radioactive aerosols	Frozen/damaged line	S1	F1
SYXFR12-53d	Release and ignition of flammable gas in transfer line resulting in generation of radioactive aerosols	Valve shut/failure	S1	F1
SYXFR-N5-07	Exposure of personnel to ionizing radiation	Ventilation isolated on SY-101 and SY-103, deadhead condition for exhauster	S1	F0

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101-SY Small Waste Transfer
S0 and S1 Consequence Hazardous Conditions
(sorted by decreasing consequence and frequency)

Pages = 4

ID	Hazardous Condition	Cause	Cons Cat	Freq Cat
SYXFR-N5-18	Release of unfiltered tank aerosols/gas to atmosphere due freezing of PPP connection seals -Requires failure of ventilation system for release to occur	Extreme cold weather	S1	F0
SYXFR-N5-17	Inability to transfer waste - operational upset	Extreme cold weather	S0	F3
SYXFR01-06	Tank 241-SY-101 bottom punctured due to pump assembly being too long resulting in potential release to soil (leak into annulus)	Pump assembly too long resulting in breaching tank bottom	S0	F3
SYXFR04-20	No hazardous condition, system is designed so that extreme pressures capable of breaching piping cannot occur	Transfer pump dead headed due to human error, plugging, or equipment failure	S0	F3
SYXFR04-21	No safety consequences	Transfer pump failed, human error caused pump misoperation, control system failure Causes similar to low flow	S0	F3
SYXFR04-23	No safety significance	Human error in flow setup, instrumentation miscalibration, or equipment failure	S0	F3
SYXFR05-25	No safety significance	Human error or equipment failure causes pump flow rate to be above desired point	S0	F3
SYXFR05-26	No safety significance	Siphon condition from receiving tank to supply tank	S0	F3
SYXFR05-28a	No safety significance	Equipment failure resulting in valve acting as a blockage Transfer pump failure	S0	F3
SYXFR05-28d	No safety significance	Plugged line	S0	F3
SYXFR05-29	Operational delay due to low flow	Line plug due to waste cooling (less than 110 degrees F due to low ambient temp)	S0	F3
SYXFR05-30	Freezing of dilution water lines results in operational delay	Cold weather causes lines to freeze	S0	F3
SYXFR07-41	Higher potential for plugging due to waste crystallization from cooling	Low ambient ground temperature	S0	F3
SYXFR07-42	Production of steam when waste transferred through overheated transfer line	Heat trace overheats pipe/boils waste	S0	F3
SYXFR11-47	No safety or operational impact	Back pressure on system due to increased head on drop leg	S0	F3
SYXFR12-50	Flush capability impaired due to vehicle impact with flush water line causing line failure	Vehicle impacting flush water supply line	S0	F3
SYXFR12-51	No safety significance	Operational concerns only (same as plugged line)	S0	F3
SYXFR12-54	Flush capability impaired	Plugged line/pump	S0	F3

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101-SY Small Waste Transfer
S0 and S1 Consequence Hazardous Conditions
(sorted by decreasing consequence and frequency)

Pages = 4

ID	Hazardous Condition	Cause	Cons Cat	Freq Cat
SYXFR02-11	Tank 241-SY-102 bottom punctured due to drop leg assembly too long resulting in potential release to soil (leak into annulus)	Design error results in drop leg being too long - bottom of tank punctured during installation	S0	F2
SYXFR11-45a	Creation of a tank with waste conditions not covered by current Authorization Basis	Transfer of heat generating waste from Tank 241-SY-101	S0	F2
SYXFR11-45b	Excessive heat up rate causes thermal stress in tank structural and potential leak	Transfer of heat generating waste from Tank 241-SY-101	S0	F2
SYXFR11-48b	Redissolve TRU causing redistribution of TRU location in waste	Low liquid level prevents drop leg from distributing solids	S0	F2
SYXFR11-48c	High phosphates from other operations causes potential for reaction causing solid phosphates	Low liquid level prevents drop leg from distributing solids	S0	F2
SYXFR11-48d	The pH may be lowered enough to precipitate aluminates	Low liquid level prevents drop leg from distributing solids	S0	F2
SYXFR11-48e	Lose volume of tank for future operations due to additional settled solids	Low liquid level prevents drop leg from distributing solids	S0	F2

ENCLOSURE 7

**TANK 241-SY-101 WASTE TRANSFER HAZARDOUS CONDITIONS ADDRESSED
BY THE EXISTING AUTHORIZATION BASIS**

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Hazardous Conditions Addressed by the Existing Authorization Basis

John Van Keuren

March 15, 1999

Hazardous Conditions

- Spray leaks
- Pool Leaks
- Excessive Load on Tanks
- Toxic Gas Generation
- Waste Compatability

Pools and Spray Leaks

Unmitigated Parameters

SY-101	
<u>Parameter</u>	<u>BIO</u>
Pressure	1300 psi
Flow	300 gpm
Source term	AWF mix
Solids content	33%

Mitigated Pool Leaks

- BIO Section 5.3.2.18 Surface Leak Resulting in a Pool
- Leak must be contained
- Leak must be detected and terminated
- Leak rate must be limited to 20 gpm
- Covers limit release of spill driven aerosol

Applicable BIO Controls

Pool Leaks-SSCs

- Leak detectors detect leak inside pit
- Transfer system covers
- Transfer system supplemental covers- not required
- Primary tanks leak detection
- Service water totalizers
- Tank level detection
- OGT encasements
- OGT concrete shielding (vehicle controls)
- Backflow prevention

Mitigated Spray Leaks

- BIO Section 5.3.2.20 Spray Leak in Structure or from Overground Waste Transfer Line
- No direct spray to the outside atmosphere - tortuous path
- Volume/temperature of pit must be considered

Applicable BIO Controls Spray Leaks-SSCs

- Transfer system covers
- Pressure switch interlock
- Backflow preventers
- OGT encasements
- OGT concrete shielding (vehicle controls)

Excessive Loads on Tanks

- The 241-SY-101 transfer operation is within tank load control program limits (AC 5.16)
- Lifts will be performed according to approved procedures (e.g. hoisting and rigging manual)

Toxic Gas Releases

- Transfer to 241-SY-102 is below waste surface level
- Toxic gas concentration meets risk guidelines at 100 m receptor even if transfer material enters headspace

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ENCLOSURE 8

EXISTING WASTE COMPATIBILITY CONTROLS

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HNF-SD-WM-TSR-006 REV 0-L

Transfer Controls
5.12

5.12 Transfer Controls (continued)

5.12.2
(continued)

b. Operating Requirements (continued)

- VERIFY that PHYSICALLY CONNECTED catch tanks which are not in the direct transfer route are < 50% full prior to WASTE transfer.
- VERIFY all pit drains associated with the cross-site transfer route are open prior to a cross-site WASTE transfer.
- Perform WASTE transfers during excavation activities in accordance with AC 5.17, "Excavation Controls."
- Inspect the 204-AR Waste Unloading Facility to ensure there is no spray or pool leakage in transfer and flush water piping during transfers PHYSICALLY CONNECTED to this facility using the following schedule: 1/2 hour after start of transfer, 1 hour after start of transfer, and every 2 hours thereafter. VERIFY that a CAM is OPERABLE and not alarming within the inspection area prior to these transfers. These temporary compensatory measures are valid through September 30, 1998.

c. WASTE Compatibility Controls

- Final Tank State Controls Application. Evaluate pumped and receiving tanks prior to WASTE transfers to ensure that controls for criticality, tank bumps, flammable gas deflagrations, organic solvent fires, and organic salt-nitrate reactions are applied to the final state of the tank. See also AC 5.15, "Moisture Controls."
- Chemical Compatibility. Ensure chemical additions are $\geq$ pH of 8 prior to transfer into tank farms (excluding water additions and drums containing caustic chemicals).

(continued)

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Transfer Controls
5.12

5.12 Transfer Controls (continued)

5.12.2
(continued)

c. WASTE Compatibility Controls (continued)

- DST and AWF Tank Time to LFL Determination. VERIFY prior to any planned transfer(s) (including WASTE and other additions) into a DST and AWF tank, that the minimum time to reach 25% of the Lower Flammability Limit (LFL) for the tank vapor space, assuming loss of the primary tank ventilation, will remain ≥ 7 days, using the methodology contained in HNF-SD-WM-CN-117, *Calculations of Hydrogen Release Rate at Steady State for Double-Shell Tanks*.
- DCRT Time to LFL Determination. VERIFY prior to any planned saltwell transfer(s) into a DCRT, that the DCRT vapor space will remain $\leq 25\%$ of the LFL using the methodology contained in HNF-SD-WM-CN-118, *Calculation of Flammable Gas Mixtures in Double-Contained Receiver Tanks*.

d. Waste Retrieval Sluicing System Operations (WRSS) Controls

Note: The following controls apply only when Waste Retrieval Sluicing System operations (WRSS) are being performed.

- Prior to initiation of a WASTE transfer, establish communications between control rooms for Tanks 241-C-106 and 241-AY-102 to ensure immediate shutdown of WASTE transfers when leakage is indicated from mass flowmeter monitoring data, waste levels, or other observation.
- Perform WASTE transfers of sludge from Tank 241-C-106 to Tank 241-AY-102 in one foot increments, followed by a hold period to monitor tank and WASTE parameters to ensure that the tank is within analyzed thermal conditions. During the monitoring period, the heat load of the sludge in Tank 241-AY-102 will be determined based on the sludge volume transferred. The sludge volume determination will be made by calculation utilizing the ENRAF densitometer data, sample analysis results and mass flow meter monitoring data.

(continued)

5.12 TRANSFER CONTROLS (Cont.)

2. PRE-TRANSFER REQUIREMENTS

Prior to the start of any waste transfers, the following specific actions must be completed or accounted for.

- a. The Shift Manager shall verify on the official routing board appropriate jumpers are installed.
- b. The Shift Manager shall ensure that sufficient space is available in the receiving tank for the waste to be transferred.

AC

- c. An operator or Shift Manager/Operations Engineer (OE) shall independently field verify the applicable waste transfer route. This shall include verification that the route is appropriate for the intended transfer; piping is in place per the configuration status controls; the correct and operable pumps are specified; valves are properly aligned; and pit drains associated with the cross-site transfer route are open prior to a cross-site waste transfer.

AC

- d. Waste transfer paths connected to active waste transfer pumps, not under administrative lock, shall be isolated by at least two closed valves (including 3-way valves) in series, where valves exist and where feasible.

- 1. If the waste transfer route includes overground piping, Operations shall:

- A. Test the integrity of overground piping encasement by pneumatic pressure test per acceptance test procedure or operations test procedure. The pneumatic test also will confirm the integrity of the encased portions of the primary transfer line.

- B. Visually examine overground piping encasement system for damage or loss of integrity before concrete shielding is set in place.

AC

- C. Ensure that vehicle restrictions are in place or concrete shielding systems surround the overground portion of the transfer route prior to the waste transfer.

AC

- 2. Operations shall verify catch tanks and ~~DCRTs~~, which are physically connected to, but not in the direct transfer route, are less than 50% full prior to the waste transfer.

AC

- e. Using WHC-SD-WM-OCD-015, *Tank Farm Waste Transfer Compatibility Program*, Engineering shall evaluate the planned final state of the pumped tank and the receiving tank, prior to waste transfers to ensure that the tanks will still meet the controls for criticality, tank bumps, flammable gas deflagrations, organic solvent fires, organic salt-nitrate reaction, and moisture (Section 5.15) after the transfer.

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ENCLOSURE 9

EXISTING AUTHORIZATION BASIS REPRESENTATIVE ACCIDENTS

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ATTACHMENT I – HAZARD/ACCIDENT ANALYSIS RESULTS

Hazard/Accident Title: BD GRE with Crust Release (current AB representative accident is natural rollover GRE in LA-UR-92-3196 which does not bound but is an adequate representation for this new hazardous conditions).				
Hazard/Accident Scenario Summary: <u>New hazardous condition:</u> Mixer pump stops working or fails due to liquid level below pump intake, or ingestion by pump of solids with plugging. BD GRE occurs and breaks up crust adding crust release to BD GRE release, with ignition causes a deflagration. <u>AB Rep Accident:</u> Spontaneous release of stored gas due to a rollover, with ignition cause a deflagration in the tank headspace. Tank structural failure limits are exceeded. Waste material is entrained and released from unfiltered paths to the atmosphere				
Major Assumptions: <u>New hazardous condition:</u> Mixer pump off for long interval. BD GRE occurs. GRE breaks up crust and allows bubbly layer to be released. <u>AB Rep Accident:</u> Source term is based on SY-101 crust material. Gas release is 296.8 m ³ .				
Hazard/Accident Risk: <u>New hazardous condition:</u> Frequency: anticipated Consequences: May exceed AB representative accident due to additional gas release from the crust <u>AB Rep Accident:</u> Frequency: Without Control – not specified; With controls – prevented (operation of mixer pump prevents gas retention in NC layer thus preventing rollover GRE) Consequences: without controls - see below (Note: also see consequences using the refined analysis tool)				
Receptor/Hazard	Calculated/Dose Exposure*	Risk Guidelines		
		Anticipated	Unlikely	Extremely Unlikely
Off-Site/ Radiological	0.014 ¹ rem	0.1 rem	0.5 rem	4 rem
On-Site/ Radiological	17 ¹ rem	0.5 rem	5 rem	10 rem
Off-Site/ Toxicological	Not calculated	1** (≤ PEL-TWQ)	1 (≤ ERPG-1)	1 (≤ ERPG-2)
On-Site/ Toxicological	Not calculated	1 (≤ ERPG-1)	1 (≤ ERPG-2)	1 (≤ ERPG-3)

* Reference source.

** Sum of Fractions

¹ Doses using LA-UR-92-3196 waste release quantities and BIO dispersion and health effects

ERPG = Emergency Response Planning Guideline

PEL-TWA = Permissible Exposure Limit – Time-Weighted Average

ATTACHMENT III - EXISTING AND POSSIBLE CONTROLS
PART A

Hazard/Accident Title: BD GRE with Crust Release

Control Option	Control Function (Type)	Effect of the Control on Risk					Controls Optimization
		Off-Site Rad	On-Site Rad	Off-Site Toxic	On-Site Toxic	Facility Worker Safety	
I. Existing Ventilation On (LCO 3.2.1)	Mitigate						
Gas Concentration Monitoring (AC 5.9.2 Level I control)	Monitor						
Mixer Pump (SC SSC)	Prevent						
II. Possible Controls							
Elevate and augment LANL SA Level II ignition source controls to TSR AC	Prevent						
Minimum liquid waste level after transfer	Prevent						
Minimum Pump Operability Parameters	Prevent						
Back Dilution to raise crust	Prevent						

ATTACHMENT III – EXISTING AND POSSIBLE CONTROLS

PART B (Optional)

Hazard/Accident Title: BD GRE with Crust Release

Control Option	Capital Costs	Operating Costs	Facility Worker ALARA Impacts	Environmental Compliance Impacts	Mission Impacts
Elevate and augment LANL SA Level II ignition source controls to TSR AC	None	Minimal			
Minimum liquid waste level after transfer	Minimal	??			
Minimum Pump Operability Parameters	Minimal	??			
Back Dilution to raise crust	??	??			

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ATTACHMENT I – HAZARD/ACCIDENT ANALYSIS RESULTS

Hazard/Accident Title: Induced Release – Crust Disturbance (Current AB representative accident is Flammable Gas Deflagration in SY-101 due to an induced GRE [LA-UR-92-3196 as referenced from BIO Chapter 5.3.2.14])				
Hazard/Accident Scenario Summary: <u>New hazardous condition:</u> During equipment installation, a hole is made in the crust. The bubbly layer pours out and releases gas, with ignition causes a deflagration. <u>AB Rep accident:</u> Induced release of stored gas due to waste disturbance, with ignition causes a deflagration in the tank headspace. Tank structural failure limits are not exceeded. Waste material is entrained and released from unfiltered paths to the atmosphere.				
Major Assumptions: <u>New hazardous condition:</u> Disturbance didn't self seal. 2m radius "hole". 50/60/70% void fraction. <u>AB Rep Accident:</u> Source term is based on SY-101 crust material. Gas release is 113.3 m ³ . Ventilation system off, tank is closed.				
Hazard/Accident Risk: <u>New hazardous condition:</u> Frequency: anticipated to unlikely (see results from refined analysis tool) Consequences: see results from refined analysis tool <u>AB Rep Accident:</u> Frequency: Without Control – not specified; With controls – extremely unlikely Consequences: see below				
Receptor/Hazard	Calculated/Dose Exposure*	Risk Guidelines		
		Anticipated	Unlikely	Extremely Unlikely
Off-Site/ Radiological	0.01 ¹ rem	0.1 rem	0.5 rem	4 rem
On-Site/ Radiological	12 ¹ rem	0.5 rem	5 rem	10 rem
Off-Site/ Toxicological	Not calculated	1** (<PEL-TWQ)	1 (<ERPG-1)	1 (<ERPG-2)
On-Site/ Toxicological	Not calculated	1 (<ERPG-1)	1 (<ERPG-2)	1 (<ERPG-3)

* Reference source.

** Sum of Fractions

¹ Doses using LA-UR-92-3196 waste release quantities and BIO dispersion and health effects

ERPG = Emergency Response Planning Guideline

PEL-TWA = Permissible Exposure Limit – Time-Weighted Average

ATTACHMENT III – EXISTING AND POSSIBLE CONTROLS
PART A

Hazard/Accident Title: Induced Release – Crust Disturbance						
Control Option	Control Function (Type)	Effect of the Control on Risk				Controls Optimization
		Off-Site Rad	On-Site Rad	Off-Site Toxic	On-Site Toxic	Facility Worker Safety
I. Existing						
Ventilation On (LCO 3.2.1)	Mitigate					
Gas Concentration Monitoring (AC 5.9.2 Level I control)	Monitor					
II. Possible Controls						
Elevate and augment LANL SA Level II ignition source controls to TSR AC	Prevent					
Higher Ventilation	Mitigate					
Inert Vapor Space	Mitigate					
Limit size of Disturbance	Prevent					
Slow/intermittent waste transfer	Prevent					
Video camera monitoring	Monitor					

ATTACHMENT III - EXISTING AND POSSIBLE CONTROLS

PART B (Optional)

Hazard/Accident Title: Induced Release - Crust Disturbance

Control Option	Capital Costs	Operating Costs	Facility Worker ALARA Impacts	Environmental Compliance Impacts	Mission Impacts
Elevate and augment LANL SA Level II ignition source controls to TSR AC	None	Minimal			
Higher Ventilation Rate - Adjust current system - Install K1A	None Yes ??	Minimal Yes ??	No No	No Yes ??	No Installation time
Inert Vapor Space	Yes ??	Yes ??	No ?	Yes ??	Installation time/ money
Limit Size of Disturbance					
Slow/intermittent waste transfer					
Video camera monitoring					

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ATTACHMENT I – HAZARD/ACCIDENT ANALYSIS RESULTS

Hazard/Accident Title: Induced Release – Crust Dissolution (Current AB representative accident is Flammable Gas Deflagration in SY-101 due to an induced GRE [LA-UR-92-3196 as referenced from BIO Chapter 5.3.2.14])				
Hazard/Accident Scenario Summary: <u>New hazardous condition:</u> Water is inadvertently added to waste and dissolves solids in bubbly layer allowing gas to coalesce and then break through crust, with ignition causes a deflagration. <u>AB Rep Accident:</u> Induced release of stored gas due to waste disturbance, with ignition causes a deflagration in the tank headspace. Tank structural failure limits are not exceeded. Waste material is entrained and released from unfiltered paths to the atmosphere.				
Major Assumptions: <u>New hazardous condition:</u> Water rises without dissolving solids until it gets into bubbly layer. Bubbles released. Bubble release quantity proportional to water quantity added. 50/60/70% void fraction. 200 gpm water injected. <u>AB Rep Accident:</u> Source term is based on SY-101 crust material. Gas release is 113.3 m ³ . Ventilation system off, tank is closed.				
Hazard/Accident Risk: <u>New hazardous condition:</u> Frequency: anticipated to unlikely (see results from refined analysis tool) Consequences: See results using refined analysis tool <u>AB Rep Accident:</u> Frequency: Without Control – not specified; With controls – extremely unlikely Consequences: see below				
Receptor/Hazard	Calculated/Dose Exposure*	Risk Guidelines		
		Anticipated	Unlikely	Extremely Unlikely
Off-Site/ Radiological	0.01 ¹ rem	0.1 rem	0.5 rem	4 rem
On-Site/ Radiological	12 ¹ rem	0.5 rem	5 rem	10 rem
Off-Site/ Toxicological	Not calculated	1** (≤ PEL-TWQ)	1 (≤ ERPG-1)	1 (≤ ERPG-2)
On-Site/ Toxicological	Not calculated	1 (≤ ERPG-1)	1 (≤ ERPG-2)	1 (≤ ERPG-3)

* Reference source.

** Sum of Fractions

¹ Doses using LA-UR-92-3196 waste release quantities and BIO dispersion and health effects

ERPG = Emergency Response Planning Guideline

PEL-TWA = Permissible Exposure Limit – Time-Weighted Average

ATTACHMENT III - EXISTING AND POSSIBLE CONTROLS
PART A

Hazard/Accident Title: Induced Release - Crust Dissolution		Effect of the Control on Risk					Controls Optimization
Control Option	Control Function (Type)	Off-Site Rad	On-Site Rad	Off-Site Toxic	On-Site Toxic	Facility Worker Safety	
I. Existing Ventilation on (LCO 3.2.1)	Mitigate gas concentration						
Gas concentration monitoring	Monitor and mitigate gas concentration						
II. Possible Controls							
Elevate and augment LANL SA Level II ignition source controls to TSR AC	Prevent ignition						
Control/interlock to limit total water addition (e.g., to 1800 gallon)	Prevent						
Limit water flow and control/interlock to shutoff water addition on high gas concentration	Prevent						
Limit water addition rate to 35 gpm	Prevent						
Inert Vapor Space	Mitigate						
Higher Ventilation rate	Mitigate gas concentration						
Video camera monitoring	Monitoring						

ATTACHMENT III - EXISTING AND POSSIBLE CONTROLS

PART B (Optional)

Hazard/Accident Title: Induced Release - Crust Dissolution

Control Option	Capital Costs	Operating Costs	Facility Worker ALARA Impacts	Environmental Compliance Impacts	Mission Impacts
Elevate and augment LANL SA Level II ignition source controls to TSR AC	None	Minimal			
Control/interlock to limit total water addition (e.g., to 1800 gallon)	Minimal	None	None	None	?
Limit water flow and control/interlock to shutoff water addition on high gas concentration	Minimal	None	None	None	? Lower rate may impact flush efficiency
Limit water addition rate to 30 gpm					Yes
Inert Vapor Space	Yes ??	Yes ??	No ?	Yes ??	Installation time/ money
Higher Ventilation Rate - Adjust current system - Install K1A	Yes ??	Yes ??	No ?	Yes ??	Installation time/ money
Video camera monitoring	None	Minimal			

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ATTACHMENT I – HAZARD/ACCIDENT ANALYSIS RESULTS

Hazard/Accident Title: Flammable Gas Deflagration in a DST (BIO Chapter 5.3.2.14)				
Hazard/Accident Scenario Summary: Spontaneous release of stored gas, with ignition cause a deflagration in the tank headspace. Tank structural failure limits are reached but the tank does not collapse. Waste material is entrained and released from unfiltered paths to the atmosphere.				
Major Assumptions: Source term is based on DST liquids.				
Hazard/Accident Risk: Frequency: Without Control – anticipated. With controls – not addressed Consequences: see below				
Receptor/Hazard	Calculated/Dose Exposure*	Risk Guidelines		
		Anticipated	Unlikely	Extremely Unlikely
Off-Site/ Radiological	0.016 rem	0.1 rem	0.5 rem	4 rem
On-Site/ Radiological	19 rem	0.5 rem	5 rem	10 rem
Off-Site/ Toxicological	0.94	1** (≤ PEL-TWQ)	1 (≤ ERPG-1)	1 (≤ ERPG-2)
On-Site/ Toxicological	1,100	1 (≤ ERPG-1)	1 (≤ ERPG-2)	1 (≤ ERPG-3)

* Reference source.

** Sum of Fractions

ERPG = Emergency Response Planning Guideline

PEL-TWA = Permissible Exposure Limit – Time-Weighted Average

ENCLOSURE 10

TANK 241-SY-101 CRUST RELEASE MECHANISMS

**HNF-3737 REV 1
APPENDIX F**

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SY101 Crust Gas Release Mechanisms

Presentation to the Control Selection Committee

March 15, 1999

Chuck Stewart

Outline

- **Current Understanding of the Crust Layer**
- **Spontaneous Releases**
- **Induced Releases**

Lateral Instability

- Peak buoyant load ~7,000 Pa
- Yield stress is ~1,000 Pa below liquid level
- Sides of a hole will fail inward

Small Penetrations are Self Sealing

- Wall failure fills the hole
- Yield stress plugs the hole

Penetration (e.g. lance)

Sealed hole

Outline

- **Current Understanding of the Crust Layer**
- **Spontaneous Releases**
- **Induced Releases**

Spontaneous Release Mechanisms

- Collapse of layer above liquid level
- Local capsize or “rollover”, buoyant instability
- Mud pot: upwelling of the bubble slurry layer
- Co-Release with Buoyant Displacement (not considered)

Mud Pot

- Bubble slurry layer at $\alpha \sim 60\%$ coalesces into large bubble
- Bubble flows up a chimney per Gauglitz et al. (1999)
- Secondary flow of bubble slurry is prevented by the chimney self-sealing after the bubble passes.

1

Bubble slurry coalesces
into a flat bubble

2

Bubble flows through
chimney due to gravity head

Mud Pot Release Parameters

- Release area: point source
- Release volume:
 - postulate a bubble from coalescence of cylinder with diameter = $F_w \times$ thickness, T , of high void layer.

$$V_{GAS} = \frac{\pi}{4} (F_w T)^2 T \rho P = \frac{\pi}{4} \alpha F_w^2 T^3 P$$

- If $T = 0.5$ m, $F_w = 3$, $P = 1.3$ atm, and void = 0.7, $V_{GAS} = 4$ m³

- Release rate: Essentially instantaneous

Outline

- **Current Understanding of the Crust Layer**
- **Spontaneous Releases**
- **Induced Releases**

INDUCED

- Capsize cascade
- Geyser through small penetration
- Penetration of bubble or connected gas volume
- Bubble slurry flow through wall crack
- Bubble slurry flow from tilted berg at wall
- Failure of bubble slurry dome
- Dissolution of matrix by top spray
- Mechanical disruption of crust
- Bubble slurry flow through large hole
- Dissolution of matrix by bottom dilution

Local Mechanical Disruption

- Gas released from volume disrupted

$$V_{REL} = \alpha F_{REL} P V_D F_D$$

- Release fraction for return to neutral buoyancy

$$F_{REL} = 1 - \frac{1/\alpha_0 - 1}{P(1/\alpha_{NB} - 1)}$$

$$(F_{REL} = 0.86 \text{ for } \alpha_0=0.5, \alpha_{NB}=0.15, P=1.3)$$

- Release rate proportional to rate of disruption

Bubble Slurry Can Potentially Flow Through Large Hole

- Bubble slurry layer is weak ($\tau < 100$ Pa, pressure difference is high
- Since hydrostatic pressure $>$ shear stress, 100 Pa slurry at 50 % void will flow
- Hydrostatic pressure of 30 % avg. void can support a column of 50 % void extending 1 m above the liquid level

1

Large, clean, hole through
bubble slurry layer

2

Bubble slurry flows through
hole

Bubble Blurry Flow is Self-Limiting and Hypothetical

- It is impossible to create a "clean" hole: side walls will fail. Debris reduces flow area and pressure difference and may prevent flow altogether
- As bubble slurry is locally depleted by upflow, crust will subside and restrict lateral flow into the hole
- bubble slurry releases gas at the surface, solidifies, forms a mound: mound height reduces net driving head

Releasable Bubble Slurry Volume

Slope angle:

$$\theta = \frac{6\tau_y}{\Delta P g T_0}$$

Max. flow radius:

$$R_M = R_1 + \frac{g \Delta P T_0^2}{6\tau_y}$$

Slurry volume released:

$$V_{REL} = \pi T_0 R_1^2 \left[1 + \frac{3}{40} \left(\frac{T_0}{R_1} \right) + \frac{1}{40} \left(\frac{T_0}{R_1} \right)^2 \right]$$

Releasable Bubble Slurry Cone

Releasable Gas Volume from Bubble Slurry Flow

Bubble Slurry Flow Release Parameters

- **Release area:** Large, 20 - 50% surface area
- **Release volume:** 3-m dia. hole, 0.5 m depth, 70% void
 - <40% of total bubble slurry
 - <20 m³ gas
- **Release rate:**
 - Bubble slurry release is fast, 2-10 minutes
 - Gas release rate depends on bubble release from slurry, probably slower
 - Assume gas release rate = bubble slurry flow rate

Dissolution from Below

- Runaway inline dilution or back-dilution added below crust
- Water rises to crust base and dissolves solids in bubble slurry
- Gas is released immediately as a mud pot

1

Water contacts high
void layer

2

Solids dissolution
creates a flat bubble

3

Bubble flows through chimney
due to gravity head

Dilution Ratio to Release Gas

Dissolution from Below

- **Release Area:** Potentially several point sources
- **Release Volume:**
 - Assume gas release when solids volume fraction reduced to ~ 0.11
 - Critical dilution ratio based on data is $1/3$

$$V_{GAS} = \frac{\alpha}{1-\alpha} \frac{V_{WATER} p}{F_D}$$

- **Release Rate:**
 - Assume proportional to rate of water addition

Time to LFL

Water Flow for LFL

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ENCLOSURE 11

**SUMMARY DESCRIPTION OF THE REFINED ANALYSIS TOOL AND
TANK 241-SY-101 WASTE TRANSFER ACCIDENT
ANALYSIS RESULTS**

**HNF-3737 REV 1
APPENDIX F**

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Figure 1. Logic flow diagram for accident progression analysis in GRE analysis framework.

HNF-SD-WM-ES-410

**AB Base Case
Onsite Radiological Consequences
Spontaneous GREs**

AB Base case for SY-101
Tank: SY-101 Time Stamp: 03/11/1999

At Credit Risk: large, non-urgent equipment, operations

AF Base Case
Onsite Radiological Consequences
RED = Spontaneous, Blue = Induced

SY-101 AF/AT Base Case
Tank: SY-101 Time Stamp: 03/15/1999

AC: Onsite Radiological Consequences - Induced
BC: Onsite Radiological Consequences - Spontaneous

**AF Base Case
%LFL
RED=spontaneous, BLUE=induced**

SY-101 AF/AT Base Case
Tank: SY-101 Time Stamp: 03/15/1999

— A-LFL: Ignited displacement conditions
— B-LFL: Ignited displacement limits

SY-101 with Crust Level = 460"
Source Gas = 40% H₂, 35% N₂, 20% N₂O, 5% NH₃

SY-101 with Crust Level = 445"
Source Gas = 40% H₂, 35% N₂, 20% N₂O, 5% NH₃

SY-101 with Crust Level = 430"
Source Gas = 40% H₂, 35% N₂, 20% N₂O, 5% NH₃

SY-101 with Crust Level = 415"
Source Gas = 40% H₂, 35% N₂, 20% N₂O, 5% NH₃

SY-101 with Crust Level = 460"
Source Gas = 40% H₂, 35% N₂, 20% N₂O, 5% NH₃

Just Dissolution Cases

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95% confidence values 200 GPM water flow, no limit to water addition	133 m³3, 45 min, 400 cfm		133 m³3, 45 min, 600 cfm		160 m³3, 36 min, 400 cfm		160 m³3, 36 min, 600 cfm		187 m³3, 27 min, 400 cfm		187 m³3, 27 min, 600 cfm	
	air	inert	air	inert	air	inert	air	inert	air	inert	air	inert
	115	115	115	115	115	115	115	115	115	115	115	115
	246	76	261	74	221	81	237	78	204	85	208	84
70 GPM water flow, no limit to water addition	133 m³3, 129 min, 400 cfm		133 m³3, 129 min, 600 cfm		160 m³3, 103 min, 400 cfm		160 m³3, 103 min, 600 cfm		187 m³3, 78 min, 400 cfm		187 m³3, 78 min, 600 cfm	
	air	inert	air	inert	air	inert	air	inert	air	inert	air	inert
	201	70	141	68	115	115	115	115	115	115	115	115
	201	70	141	68	268	73	207	70	240	77	282	73
70 GPM water flow, 1800 gal max addition	27 m³3, 26 min, 400 cfm		27 m³3, 26 min, 600 cfm		40 m³3, 26 min, 400 cfm		40 m³3, 26 min, 600 cfm		62 m³3, 26 min, 400 cfm		62 m³3, 26 min, 600 cfm	
	air	inert	air	inert	air	inert	air	inert	air	inert	air	inert
	89	68	79	66	115	115	115	115	115	115	115	115
	89	68	79	66	134	67	119	70	209	70	185	69

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200 GPM water flow, no limit to water addition	133 m³, 45 min 400 cfm, air		133 m³, 45 min 400 cfm, inert		133 m³, 45 min 600 cfm, air		133 m³, 45 min 600 cfm, inert	
	Expected Risk	REG comparison	Expected Risk	REG comparison	Expected Risk	REG comparison	Expected Risk	REG comparison
Onsite Rad: plume: induced	2.40E-04	96.76	8.99E-05	98.62	2.40E-04	96.76	8.99E-05	98.62
Onsite Rad: well-mixed: induced	1.03E-02	92.98	2.35E-06	99.80	1.13E-02	92.63	2.57E-06	99.80
Onsite Rad: well-mixed: spontaneous	4.34E-06	97.84	4.31E-11	100.00	4.87E-08	97.74	4.59E-11	100.00
Onsite Rad: plume: spontaneous	2.49E-07	99.31	9.27E-08	99.71	2.49E-07	99.31	9.27E-08	99.71
70 GPM water flow, no limit to water addition	133 m³, 129 min 400 cfm, air		133 m³, 129 min 400 cfm, inert		133 m³, 129 min 600 cfm, air		133 m³, 129 min 600 cfm, inert	
	Expected Risk	REG comparison	Expected Risk	REG comparison	Expected Risk	REG comparison	Expected Risk	REG comparison
Onsite Rad: plume: induced	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Onsite Rad: well-mixed: induced	7.01E-03	95.28	3.06E-06	99.80	6.70E-03	96.02	2.78E-07	99.90
Onsite Rad: well-mixed: spontaneous	5.11E-06	98.23	5.67E-11	100.00	7.67E-07	99.12	3.03E-13	100.00
Onsite Rad: plume: spontaneous	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
70 GPM water flow, 1800 gal max addition	27 m³, 26 min 400 cfm, air		27 m³, 26 min 400 cfm, inert		27 m³, 26 min 600 cfm, air		27 m³, 26 min 600 cfm, inert	
	Expected Risk	REG comparison	Expected Risk	REG comparison	Expected Risk	REG comparison	Expected Risk	REG comparison
Onsite Rad: plume: induced	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Onsite Rad: well-mixed: induced	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Onsite Rad: well-mixed: spontaneous	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Onsite Rad: plume: spontaneous	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

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160 m³/3, 36 min 400 cfm, air			160 m³/3, 36 min 600 cfm, air			160 m³/3, 36 min 600 cfm, inert			167 m³/3, 27 min 400 cfm, air			167 m³/3, 27 min 400 cfm, inert			167 m³/3, 27 min 600 cfm, air			167 m³/3, 27 min 600 cfm, inert		
Expected Risk	REG comparison	Expected Risk	Expected Risk	REG comparison	Expected Risk	Expected Risk	REG comparison	Expected Risk	Expected Risk	REG comparison	Expected Risk	Expected Risk	REG comparison	Expected Risk	Expected Risk	REG comparison	Expected Risk	Expected Risk	REG comparison	Expected Risk
27E-04	98.61	1.14E-07	99.49	2.27E-04	98.61	8.28E-05	98.72	2.88E-04	97.33	8.85E-05	98.72	2.88E-04	98.72	2.88E-04	97.33	8.85E-05	98.72	2.88E-04	98.72	98.72
17E-02	84.48	4.57E-16	100.00	1.15E-02	93.27	5.03E-12	100.00	5.10E-02	83.18	5.78E-04	100.00	4.94E-02	83.42	5.67E-04	94.35	6.73E-21	100.00	4.94E-02	83.42	100.00
04E-06	94.04	4.47E-12	100.00	1.60E-08	98.77	6.21E-15	100.00	1.41E-05	94.25	6.87E-21	100.00	1.39E-05	94.35	6.73E-21	98.59	2.32E-07	98.59	1.39E-05	94.35	100.00
23E-07	99.28	8.28E-05	98.72	2.23E-07	98.28	1.14E-07	98.49	2.31E-07	98.38	2.39E-07	98.59	2.30E-07	98.59	2.30E-07	98.38	2.32E-07	98.59	2.30E-07	98.38	98.59
160 m³/3, 103 min 400 cfm, air			160 m³/3, 103 min 600 cfm, air			160 m³/3, 103 min 600 cfm, inert			167 m³/3, 78 min 400 cfm, air			167 m³/3, 78 min 400 cfm, inert			167 m³/3, 78 min 600 cfm, air			167 m³/3, 78 min 600 cfm, inert		
Expected Risk	REG comparison	Expected Risk	Expected Risk	REG comparison	Expected Risk	Expected Risk	REG comparison	Expected Risk	Expected Risk	REG comparison	Expected Risk	Expected Risk	REG comparison	Expected Risk	Expected Risk	REG comparison	Expected Risk	Expected Risk	REG comparison	Expected Risk
65E-04	98.58	9.16E-05	98.72	2.85E-04	98.58	9.16E-05	98.72	3.08E-04	97.18	9.94E-05	98.67	3.08E-04	97.18	9.94E-05	97.18	9.94E-05	98.67	3.08E-04	97.18	98.67
45E-02	92.39	5.94E-12	100.00	7.11E-03	93.01	8.74E-12	100.00	6.02E-03	83.33	2.95E-06	100.00	6.87E-03	92.76	3.52E-06	98.77	4.18E-23	100.00	6.87E-03	92.76	100.00
81E-06	98.58	1.19E-14	100.00	1.98E-08	98.77	9.79E-15	100.00	8.34E-07	98.87	3.51E-23	100.00	9.49E-07	98.59	2.32E-07	98.38	2.34E-07	98.59	9.49E-07	98.38	98.59
24E-07	99.28	1.15E-07	98.49	2.24E-07	98.28	1.15E-07	98.49	2.32E-07	98.38	2.34E-07	98.59	2.32E-07	98.38	2.34E-07	98.38	2.34E-07	98.59	2.32E-07	98.38	98.59
40 m³/3, 26 min 400 cfm, air			40 m³/3, 26 min 600 cfm, air			40 m³/3, 26 min 600 cfm, inert			62 m³/3, 26 min 400 cfm, air			62 m³/3, 26 min 400 cfm, inert			62 m³/3, 26 min 600 cfm, air			62 m³/3, 26 min 600 cfm, inert		
Expected Risk	REG comparison	Expected Risk	Expected Risk	REG comparison	Expected Risk	Expected Risk	REG comparison	Expected Risk	Expected Risk	REG comparison	Expected Risk	Expected Risk	REG comparison	Expected Risk	Expected Risk	REG comparison	Expected Risk	Expected Risk	REG comparison	Expected Risk
48E-04	97.12	8.48E-05	98.08	7.48E-04	97.12			2.84E-07	98.80	6.41E-05	98.78	5.28E-04	97.13	6.41E-05	98.78	5.28E-04	97.13	6.41E-05	98.78	98.78
20E-02	94.78	1.68E-11	100.00	6.98E-05	100.00			3.81E-06	97.82	3.18E-05	100.00	7.94E-03	95.84	3.08E-07	98.21	4.30E-24	100.00	7.94E-03	95.84	100.00
64E-05	99.01	2.76E-16	100.00	7.50E-08	100.00			4.16E-02	93.01	4.44E-22	100.00	3.67E-07	98.21	4.30E-24	98.60	2.85E-08	100.00	3.67E-07	98.21	100.00
22E-07	99.30	4.27E-08	98.80	9.22E-07	98.30			5.28E-04	97.13	2.85E-08	100.00	2.84E-07	98.60	2.85E-08	98.60	2.85E-08	100.00	2.84E-07	98.60	100.00

ENCLOSURE 12

TANK 241-SY-101 INERTING FEASIBILITY SUMMARY

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101-SY Level Mitigation Inerting Feasibility Summary

Concept

- 1.) Procure Nitrogen Generation Equipment
 - Sized for recovery from single GRE
 - No redundancy
 - Tie control into portable exhauster PLC
 - Tie-in with existing riser
- 2.) Utilize existing new portable exhauster
 - Meets Class 1 Division 1 requirements (except CAM)
 - 500 cfm capacity
 - Would only need sampling upgrade and PLC modification
 - Tie-in with existing riser
 - Leave existing ventilation system in place
- 3.) ROM \$2.0 M
 - Start design April 1
 - Phase design
 - Final Design Complete June 1
 - Construction complete August 1
- 4.) Final estimate/schedule: 2 engineers, estimator, and scheduler-2 weeks

File: 101-SY Option.PPT

AR Tedesch/3/16/99

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Present Worth and Life-Cycle Costs (in thousands of dollars -\$k)

Case 3 Inert Single 1M Gallon Storage Tank with Procured Portable Nitrogen Equipment
Cost Estimating Input Sheet # 030-995

Subactivity	CEIS	USCAF	SPCAF	SPPWF	Present Worth
"A" - Preconceptual/Conceptual	200				200.00
"B" - Construction/Installation	480				480.00
"C" - Operational Readiness	172				172.00
"D" - Ongoing Operation	115	38.459		0.14802	497.23
"E" - Disposal	18		2.0938	0.14802	5.50
SUBTOTAL PRESENT WORTH					1324.73
Contingency (15%)	0.15				198.71
TOTAL PRESENT WORTH					1523.44
TOTAL LIFE-CYCLE COST		6.8485			10433.3

Case 4 Inert Single Actively Ventilated DST Responding to a GRE (Procured Nitrogen Equipment)
Cost Estimating Input Sheet # 030-996

Subactivity	CEIS	USCAF	SPCAF	SPPWF	Present Worth
"A" - Preconceptual/Conceptual	312				312.00
"B" - Construction/Installation	1125				1125.00
"C" - Operational Readiness	179				179.00
"D" - Ongoing Operation	155	38.459		0.14802	670.18
"E" - Disposal	90		2.0938	0.14802	27.52
SUBTOTAL PRESENT WORTH					2313.70
Contingency (15%)	0.15				347.05
TOTAL PRESENT WORTH					2660.75
TOTAL LIFE-CYCLE COST		6.8485			18222.15

Case 4 Inert Single Actively Ventilated DST Responding to a GRE (Leased Nitrogen Equipment)
Cost Estimating Input Sheet # 030-996

Subactivity	CEIS	USCAF	SPCAF	SPPWF	Present Worth
"A" - Preconceptual/Conceptual	312				312.00
"B" - Construction/Installation	500				500.00
"C" - Operational Readiness	179				179.00
"D" - Ongoing Operation	273	38.459		0.14802	1180.38
"E" - Disposal	90		2.0938	0.14802	27.52
SUBTOTAL PRESENT WORTH					2198.90
Contingency (15%)	0.15				329.83
TOTAL PRESENT WORTH					2528.73
TOTAL LIFE-CYCLE COST		6.8485			17318.03

KEY

"CEIS"	The calculated sum from the Cost Estimating Input Sheets per Subactivity A-E
"USCAF"	Uniform series compound-amount factor (Reference Taylor, 1975) PW=25 years at 3% interest (escalation)
"SPCAF"	Single payment compound-amount factor (Reference Taylor, 1975) PW=25 years at 3% interest (escalation)
"SPPWF"	Also used for converting present worth value to Life-Cycle cost for 25 years at 6% interest
"Present Worth"	Single payment present-worth factor (Reference Taylor, 1975) for 25 years at 6% interest
	Subactivity costs converted to 1999 present worth values
	Subactivity "D" is calculated to a compounded value at 25 years using an escalation of 3% then converted back to 1999 dollars using IRR of 6%. Final present worth value subtracts cost for 1999 since operation is expected to start in year 2000.
	Subactivity "E" is calculated for a single fixed cost at 2024 from 1999 cost at 3% escalation, then converted to 1999 dollars using IRR of 6%.
"TOTAL PRESENT WORTH"	The sum of the corrected present worth values minus 1999 operating costs, 1999-"D" Value, plus contingency
"TOTAL LIFE-CYCLE COST"	Future value of the sum of all initial costs (plus contingency) and annual costs at year 2024 using an IRR of 6%

Figure 9-5. SY-101 Active Ventilation with Control System

17/98 WED 10:34 FAX 3760175

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ENCLOSURE 13

**MINIMUM TANK 241-SY-101 WASTE LEVEL FOR MIXER
PUMP OPERABILITY**

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Minimum Waste Level for Mixer Pump Operability

Presentation to the Controls Selection Committee for the
SY-101 Small Waste Transfer
March 16, 1999

Perry Meyer

Problem Definition

- **Assumption:** Crust continues to grow in thickness after September Transfer.
- If transfer too large, bottom of crust will reach mixer pump inlet prior to back dilution potentially degrading pump operation.
- **Question:** What is the largest 9/99 transfer allowable such that the crust will not negatively interfere with mixer pump prior to 5/00 back dilution?
 - What effects could the crust have on mixer pump operation?
 - How close can the crust get to the pump inlet?

Current Conditions

- Top of pump inlet: 258 in
- Bottom of crust: ~ 352 in
- 1 in = 2750 gals
- Therefore ~ 258 kgal between crust bottom & pump inlet today
-but the crust is growing

Crust Growth Projections

Available Transfer Volume

Negative Crust/Mixer Pump Interactions?

- Entrained Solids
- Entrained Bubbles
- Stalled Mixer Pump
- Suction Induced GRE

How Close Can the Crust Get?

- **Two Types of Crust Disturbances:**
 - Pressure fluctuations
 - Shear stress
- **Crust Initially disturbed when $\tau_{\text{flow}} \sim \tau_{\text{yield}}$**
 - $\tau_{\text{yield}} \sim 10 \text{ Pa}$

Flow Simulations

- Existing Tempest model for SY-101
- Crust base elevation varied from 1 - 8ft from inlet (270 - 354in)
- 1000 & 10000 cp

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Conclusions

- Keep bottom of crust a minimum of 1 ft above inlet (270 in)
- Level forecast indicates crust base at 320 in on 5/00
- Therefore, $(320\text{in} - 270\text{in}) * 2750 \text{ gal/in} = 137\text{kgal}$ available for transfer on 9/99
- Transfer Budget
 - 258 kgal available today
 - 1 ft margin = 33 kgal
 - Crust growth between now and 9/99 = 12 in = 33 kgal
 - Crust growth between 9/99 and 5/00 = 20 in = 55 kgal
 - $258 - 33 - 33 - 55 = 137 \text{ kgal}$

ENCLOSURE 14

**CONTROL DECISION MEETING ON MAY 18, 1999 FOR
TANK 241-SY-101 WASTE TRANSFER**

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ENCLOSURE 14 – PART 1

**AGENDA FOR THE MAY 18, 1999 TANK 241-SY-101 WASTE
TRANSFER CONTROL DECISION MEETING.**

241-SY-101 Control Decision Meeting
Round Two (May 18, 1999)
Agenda

1. Summary of Ground Rules/Process (Larry Kripps)
2. Ammonia Exposures from Gas Releases
 - a. Crust disturbing activities in SY-101
 - Ammonia release mechanisms, calculation approach and results (Lenna Mahoney)
 - Exposures
 - Offsite and at 100 m receptor dilution factors (John VanKeuren)
 - Facility workers (Phil Bartley)
 - b. Waste Transfer to SY-102
 - Ammonia release mechanisms, approach and results (Dave Hedengren)
 - Exposures
 - Offsite and at 100 m receptor (John VanKeuren)
 - Facility workers (Phil Bartley)
 - c. Ammonia Exposure Controls (Group Discussion – all)
3. High Wind causes transfer system leak
 - Why a control may be desired (Tony Benegas)
 - Consequences of leak resulting from high winds (John VanKeuren)
 - Possible controls (Group Discussion - all)
4. Drop Leg Leak Detector – Revisit safety function (Tony Benegas)

ENCLOSURE 14 – PART 2

**ATTENDANCE RECORD OF THE MAY 18, 1999 TANK 241-SY-101
WASTE TRANSFER CONTROL DECISION MEETING**

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Attendance Record of Control Decision Meetings for 241-SY-101 Waste Transfer

Date: May 18, 1999

Name	Organization	Telephone Number
LAWRENCE T. KRIAB	NS&L	376-1061
JAMES R. BIGGS	SY PROJECT	531-9310
CHUCK STEGART	PNNL	372-4678
LENNA MAHONEY	PNNL	375-2558
Dave Hedengren	LMHC	373-5094
Dave Haring	ARES	372-1821
ROGER TRUE	LMHC/QA	373-5192
Steve Krogsrud	LMHC/Safety	372-2302
Philip Bartley	LMHC/Safety	372-2967
LEE M. LIVESBY	LMHC/EMERG. Mgmt	373-1975
Nicholas W. KIRCH	LMHC/Process Engr.	373-2380
John Schotfield	LMHC/CPO	373-2245
Doug Larsen	LMHC/TFFO	373-5945
Greg Gauch	LMHC/Eng	373-1779
TONY BENEAS	LOGEMA	376-4862
John Van Keuren	FDNW	376-2920
Gregory L Jones	MADEC/TWRS NS&L	373-3255
Mark H Brown	LMHC/SST Eng	372-1611
Ronald W Reed	LMHC/SST Engr	373-5546
W.P. Taha	LMHC/TFFO	372-0910
Mike Grigsby	TWRS NS&L	372-1907

ENCLOSURE 14 – PART 3

**AMMONIA RELEASES AND EXPOSURES FROM CRUST DISTURBING
ACTIVITIES (BUBBLE SLURRY FLOW)**

L.A. Mahoney
5/18/99

Gassy slurry escapes from the layer under the crust; the rate of flow is controlled by the bubble slurry viscosity and yield strength.

The retained gas (including some ammonia) is released to the domespace immediately.

The degassed slurry forms a cone of laminar flow; its proportions are controlled by the viscosity. The entire tank surface is calculated as being covered in 8.5 minutes, after which the surface area of the flow is nearly constant.

The dissolved ammonia in the degassed slurry evaporates, with the rate of evaporation decreasing as the dissolved ammonia is depleted.

Mass-transfer calculation is based on quasi-steady laminar flow.

L.A. Mahoney
5/18/99

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The retained gas (including some ammonia) is released to the domespace immediately.

The degassed slurry forms a cone of laminar flow; its proportions are controlled by the viscosity. The entire tank surface is calculated as being covered in 8.5 minutes, after which the surface area of the flow is nearly constant.

The dissolved ammonia in the degassed slurry evaporates, with the rate of evaporation decreasing as the dissolved ammonia is depleted.

Mass-transfer calculation is based on quasi-steady laminar flow.

ENCLOSURE 14 – PART 4

**AMMONIA RELEASES AND EXPOSURES FROM THE
TANK 241-SY-101 WASTE TRANSFER**

Modeling Ammonia Releases from the SY Tank Farm Stack from Waste Transfers from SY-101 to SY-102

**Dave Hedengren
May 18, 1999**

Henry's Law

- Equilibrium concentrations of a gas between the vapor phase and aqueous solutions:

$$C_G = K_h P \quad (\text{Henry's Law})$$

Where:

C_G = Concentration of Dissolved Gas in Liquid

P = Partial Pressure of Gas

K_h = Henry's Law Constant

Schumpe Model

For a specific gas, "G" (e.g. Ammonia):

$$\text{Log}(C_{G,w}/C_{G,s}) = \text{Log}(K_{h(G,w)}/K_{h(G,s)}) = \Sigma(h_i + h_G)C_i$$

Where: C_G = Concentration of gas "G" in liquid phase

W = Water

S = Salt solution

K_h = Henry's Law constant

h_i = Ion specific constant for ion "i"

h_G = Temperature dependent coefficient

(for gas "G")

C_i = Concentration of ion "i" in salt solution

Methodology (continued)

- For salt-free water in equilibrium with gaseous hydrogen, methane, or ammonia:

$$K_h = f(T)$$

- Therefore: $K_h(\text{water})$

$$K_h(\text{solution}) = \frac{K_h(\text{water})}{[K_h(\text{water})] / [K_h(\text{solutions})]}$$

LOCKHEED MARTIN

Ammonia Release to Vapor Space During Waste Transfers

- Reduce Ammonia Concentration
Predictions by Using Surface Controlled
Releases

Transfer Zones for Ammonia Releases:

- Falling Waste
- Turbulent Splash
- Secondary Disturbance
- Undisturbed Surface

LOCKHEED MARTIN

Figure A

- A=Falling Waste Zone
- B=Turbulent Splash Zone
- C=Secondary Disturbance Zone
- D=Undisturbed Surface Zone
- E=Bubbler Flow

LOCKHEED MARTIN

Overall Mass Transfer Coefficient (for each zone)

1

$$h = \frac{1}{\frac{1}{h_1} + \frac{HRT}{h_g}}$$

$$\frac{1}{h} = \frac{1}{h_1} + \frac{HRT}{h_g}$$

$$h_1$$

$$h_g$$

h = overall mass transfer coefficient

h_1 = liquid film coefficient

h_g = gas film coefficient

H = Henry's Law constant for ammonia

R = Universal gas constant

T = Liquid waste temperature

- **Determining Liquid and Gas Film Coefficients**
- **Calculating Time Dependent Ammonia Concentrations in a DST Vapor Space**

Case A:

**No Crust Dissolution in SY-101
1:1 Dilution in SY-101
Drop Leg in SY-102
Mixing in SY-102
Normal SY-103 Releases**

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[illegible]

No Crust Dissol. in SY-101, Drop Leg in SY-102 w/ dilution in SY-101, and Normal SY-103

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No Crust Dissol. in SY-101, Drop Leg in SY-102 w/ dilution in SY-101, and Normal SY-103

Case B:

No Crust Dissolution in SY-101

No Dilution in SY-101

Drop Leg in SY-102

Mixing in SY-102

Normal SY-103 Releases

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No Crust Dissol. in SY-101, Drop Leg in SY-102 w/no dilution in SY-101, and Normal SY-103

Case C:

Crust Dissolution in SY-101
No Dilution in SY-101
Drop Leg in SY-102
Mixing in SY-102
GRE in SY-103

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[illegible]

Crust Dissolution in SY-101, Drop Leg in SY-102 w/ no dilution in SY-101, and GRE in SY-103

Crust Dissolution in SY-101, Drop Leg in SY-102 w/ no dilution in SY-101, and GRE in SY-103

ENCLOSURE 14 - PART 5

**RISER 241-SY-102 DROP LEG ENCLOSURE LEAK DETECTION SYSTEM
AND EXISTING LEAK DETECTION SYSTEM CONTROLS**

NO. ZTCD1003 - 241-SY-102
ANTI-SIPHONING SLURRY DISTRIBUTOR GENERAL ARRANGEMENT

CADFILE: ZTCD1003
DATE: 4/1/99

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HNF-SD-WM-BIO-001 REV 1-C

Table 5.3.2.20-3. Safety Structures, Systems, and Components
for Spray Leaks. (2 sheets)

Structures, systems, or components	Safety classification		Safety function	Comments
	SC	SS		
1.0 Spray leaks inside process pits, diversion boxes, vaults, and cleanout boxes				
Transfer System Covers	X	--	Knockdown spray, limit release of aerosols to the atmosphere	Waste transfer-associated structure covers are also a mitigative feature for other accidents and provide radiation protection (i.e., shielding) for facility workers
2.0 Spray leaks from encasement risers (for pipe-in-pipe transfer lines)				
None required	--	--	--	See Table 5.3.2.21-4 for Technical Safety Requirement controls
3.0 Spray leaks from service water supply system components coincident with backflows of waste				
3.1 Pressure switch interlock to waste transfer pump(s) or alarm in service water system connections to the waste transfer system	X	--	Prevent backflow of waste into the service water line and potential leaks in structures (e.g. service pits) without mitigative safety structures, systems, and components preventing direct release to the atmosphere (i.e., covers, leak detectors)	The pressure switch in the service water lines connected to the waste transfer system are not automatically interlocked to some waste transfer pumps (e.g., waste transfer pumps in interfacing facilities that transfer waste to tank farms). An acceptable alternative is isolation of the service water line by two closed valves and a pressure switch with an alarm in a continuously monitored area. Pressure switch alarm procedures would require the immediate shutdown of the transfer pump on alarm
3.2 Backflow preventers in service water system connections to the waste transfer system	--	X	Prevent contamination of the service water system via backflow of waste into service water line	The hazardous condition of concern is contamination of the raw water system and not specifically a spray leak
4.0 Spray leaks from single-shell tank overground transfer lines				
4.1 OGT encasements and connections	X	--	Confine leak from the primary piping and ensure that a leak is directed to the <u>encasement leak detection system</u>	The OGT pipe encasement shall be designed to withstand the design basis earthquake and high wind
4.2 OGT concrete shielding system	X	--	Prevent vehicle collisions with the OGT system that could result in a loss of integrity of the primary and encasement pipe	The OGT pipe encasement shall be designed to withstand the design basis earthquake and high wind

5.3.2.20-7

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Table 5.3.2.18-3. Safety Structures, Systems, and Components for Surface Leak Resulting in Pool. (2 sheets)

Structures, systems, or components	Safety classification		Safety function	Comments
	SC	SS		
1.0 Overflows of waste transfer pits ^a due to transfer equipment leaks (all internal mechanisms)				
1.1 Transfer leak detector and interlock to transfer pump(s) or alarm	X	--	Detect leak inside pit; limit volume of waste spilled to pit	--
1.2 Transfer System Covers	X		Limit release of aerosols generated by splatter inside the pit; limit shine and skyshine dose to onsite receptor	--
1.3 Transfer System Supplemental Covers	X		Limit release of aerosols generated by spray in the COS/pit	--
1.4 Tank level detection systems and salt well flow totalizers	--	X	Support periodic material balances during transfers	See material balance TSR AC (next table)
1.5 Primary tank leak detection system	X	--	Detect misroutes into the annulus of DSTs and AUF tanks	--
2.0 Overflows of waste transfer pits due to misroutes through compromised transfer paths				
See item 1				See also TSR level controls to prevent misroutes
3.0 Overflows of process pits due to overfilling of underlying tanks ^a with waste				
3.1 Transfer leak detector and interlock to transfer pump(s) or alarm	X	--	Prevent overflow	See Defense-in-Depth controls
4.0 Overflows of process pits due to service water leaks that overflow connected waste storage tanks ^a				
4.1 Service water flow totalizers	--	X	Monitors flow of service water	--
4.2 Tank level detection systems	--	X	Indicate tank level increase due to service water line break	--
5.0 Overflows of slurry line cleanout boxes during transfers				
5.1 Cleanout box leak detectors and interlocks to transfer pump(s) or alarm	X	--	Detect leak, shut off transfer pump before cleanout box overflows	Cleanout box drains to encasement and then to process pit
5.2 Cleanout box covers	--	X	Mitigate release of aerosols generated due to splatter inside the box	See Section 1.3 of this table
6.0 Surface pools due to leaks from temporary SST OGT lines				
6.1 OGT encasements and connections	X	--	Provide secondary confinement for leaks from primary line; route leak from primary line back to process pit	--
6.2 OGT concrete shielding system	X	--	Protect OGT from vehicle impacts (if vehicle controls not implemented)	Shield blocks will be needed for shielding purposes during some transfers
6.3 Leak detectors in interfacing pits and their interlocks with the waste transfer pump(s) or alarm	X	--	Detect leak, shutdown transfer before interfacing pit(s) overflow	--

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Table 5.3.2.18-5. Defense-in-Depth Controls for Surface Leak Resulting in Pool.

Control	Safety Function	Comments
1.0 Overflows of waste transfer pits ^a due to transfer equipment leaks (all internal mechanisms)		
1.1 Pit drains, where open	Allow leak to drain back to storage or catch tank; prevents overflow of pit to soil surface	
2.0 Overflows of waste transfer pits due to misroutes through compromised transfer paths		
2.1 Pit drains, where open	Drain leak back to storage or catch tank; prevent overflow of pit due to misroute	
3.0 Overflows of process pits due to overfilling of underlying tanks with waste		
3.1 DCRT vault leak detectors	Detect overflow of DCRT	
3.2 DST waste level instrumentation (FICs, manual tapes)	Detect overfilling of storage tank	
3.3 Catch tank weight factor (level indication)	Detect overfilling of catch tank	
3.4 DCRT weight factor (level indication)	Detect overfilling of DCRT	
3.6 Storage tank high level alarms	Detect overfilling of storage tank	
4.0 Overflows of process pits due to service water leaks that overflow connected waste storage tanks ^b		
See controls for item 3.0		
4.1 Flow meters in service water supply	Monitor leak	
5.0 Overflows of slurry line cleanout boxes during transfers		
None identified		
6.0 Surface pools due to leaks from temporary SST OGT lines		
6.1 Encasement leak detectors and transfer pump interlocks	Detect leaks from primary line; limit leak volume	Redundant to interfacing pit leak detectors
7.0 Overflows through transfer line encasement risers		
7.1 Encasement leak detectors	Detect leak from primary line	Where available
8.0 Surface pools of waste due to backflows of waste into service water/flush water supply systems		
8.1 Backflow preventers	Prevent backflow	
8.2 Check valves	Prevent backflow	
8.3 Isolation valve limit switch/transfer pump interlock operability	Ensure limit switch and interlocks are operable during transfers	
9.0 Pool leaks inside interfacing facilities due to misroutes of waste from tank farms		
9.1 Facility instrumentation and procedures		

^aIncludes valve pits, central and feed pump pits, sluice pits, leak detection pits, annulus pump pits, flush pits, catch tank pump pits, diversion boxes, vault pits, vent station nozzle pit

^bWaste storage tanks include DSTs, SSTs, DCRTs, and catch tanks

DCRT = double-contained receiver tanks

DST = double-shell tank

FIC = Food Instrument Corporation

OGT = overground transfer

SST = single-shell tank

5.3.2.18-13

leak detector electrodes, an alarm is triggered. The wiring between the leak detector and the control panel is electrically supervised, making the circuit "fail safe." The alarm function associated with the leak detector is testable.

Conductivity probes have performed reliably as transfer pit leak detectors for many years, with mean time between failures measured in years.

6.8.1.6 Design Codes and Standards. To be determined.

6.8.2 Overground Transfer Encasement and Connections

6.8.2.1 Safety Classification. SC: The overground transfer system (OGT) Encasement and Connections are identified as safety-class SSCs for the Surface Leak Resulting in Pool accident and the Spray Leak in Structure or from Overground Waste Transfer Lines accident.

6.8.2.2 Location. SST farms.

6.8.2.3 Safety Function(s). Provide secondary confinement for leaks from primary line; route leak from primary line back to process pit.

6.8.2.4 Functional Requirements. The OGT Encasement and Connections system shall confine waste leaked from the primary pipe to the annulus between the encasement and the primary pipe and shall divert the leaked waste to a pit at either end of the OGT Encasement and Connections system.

6.8.2.5 Description. OGT systems are temporary structures; they are designed, built, tested, used to transfer waste, flushed, and then disassembled. After disassembly, the OGT components are either discarded as solid waste or stored for future use. The design of every OGT system is traceable to engineering design documents, which are kept current until the system is disassembled. Some of the components of an existing OGT system may be reused in later OGT system assemblies, but this is not a requirement. OGT systems, because they are arrangements of temporary piping, are not listed in this discussion, and are described only in general terms.

The principal safety feature of an OGT system is the secondary encasement pipe assembly, which jackets and provides a confinement for the primary waste transfer pipe. If the inner OGT pipe leaks, the encasement of the OGT system will confine the leaked waste and safely route it to a covered pit at the inlet or outlet end of the OGT system.

For corrosion resistance, the encasement sections are typically fabricated in short-length flanged sections from 8-cm (3-in.) schedule 40 stainless steel (304L) pipe. Typical encasement pipe sections include straight runs, 90-, 45-, and 22½-degree long-radius elbows, and other special bends as needed to construct the piping route.

Encasements for OGT lines have performed reliably whenever temporary OGT systems have been assembled and used.

6.8.2.6 Design Codes and Standards. To be determined.

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Transfer Leak
Detection Systems
LCO 3.1.3

3.1 CONFINEMENT

3.1.3 Transfer Leak Detection Systems

LCO 3.1.3 Transfer leak detection systems shall be OPERABLE.

MODE

APPLICABILITY: OPERATION and LIMITED.

PROCESS AREA All process pits, diversion boxes, vault pits, and cleanout
APPLICABILITY: boxes PHYSICALLY CONNECTED to an ACTIVE WASTE transfer pump that is not under administrative lock. (A temporary exemption to this control, valid through September 30, 1998, is provided for transfer leak detection systems not on the direct transfer path, which do not meet Ignition Source Control Sets #1 or #2 requirements. See BASES for discussion of compensatory actions.)

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Transfer leak detection system inoperable or alarming.	-----NOTE----- Transfer system draining and flushing may be performed. -----	
	A.1 Stop WASTE transfer(s) associated with PHYSICALLY CONNECTED WASTE transfer pumps.	Immediately
	AND	
	A.2.1 Place an administrative lock on PHYSICALLY CONNECTED WASTE transfer pumps. OR	8 hours
		(continued)

ENCLOSURE 14 – PART 6

**STANDING ORDER #TWO-99-19, PRECAUTIONS
FOR HIGH WIND CONDITIONS**

January 5, 1999

STANDING ORDER #TWO-99-19
PRECAUTIONS FOR HIGH WIND CONDITIONS

1. Shift Operators must remain continuously vigilant regarding housekeeping within their areas of responsibility so that the Tank Farms remain free of debris that may become airborne during high wind conditions. Within practical limitations, temporarily staged equipment (i.e., greenhouses, glovebags) shall be tightly secured to permanent fixtures within the farm.
2. When notified of a potential high wind condition (>25 mph sustained), the assigned operator will make an inspection of the farms and make recommendations to the Shift Manager regarding the need for specific action (i.e., additional tie-downs or collapsing a greenhouse). Action taken shall be logged in the Shift Manager log and discussed at turnover for the duration of the high wind condition.
3. During periods of high winds, the Shift Operations Manager (Shift Manager in his absence) and the East Tank Farm Health Physics Manager (Senior Health Physics Representative in his absence) will evaluate the need for additional personal protective equipment and the continuation of field activities involving intrusive work and excavation within SCAs. Specific actions outlined below are to be taken when actual wind conditions reach the following levels:
 - Sustained winds greater than 15 mph. The necessity for crane operations should be closely scrutinized.
 - Sustained winds greater than 25 mph and/or gusts greater than 40 mph. All personnel working outdoors will be required to don safety glasses. Crane operations will be secured.
 - Sustained winds greater than 30 mph and/or gusts greater than 45 mph.¹ Normal access through vehicle gates in the farms will be restricted unless specifically authorized by the Shift Manager. In these cases the Shift Manager will determine the action required at the work site to properly control the gates.
 - Sustained winds greater than 50 mph.¹ Tank Farm entry will be restricted to emergency response and critical operations only. The buddy system shall be used for these entries. Vehicle gates will not be used.
 - Sustained winds greater than 90 mph. This is an Alert Level Emergency. Proceed in accordance with the Tank Farm Building Emergency Plan.

APPROVAL:

R. J. Shupe, Manager
Tank Farm Shift Operations

Date

¹ Both of these conditions require a supervisory brief by the Shift Manager, PIC, Operations or Management Supervision. This brief should include but not be limited to potential dangers in a high winds situation posed by vehicle doors, change trailer doors, instrument buildings, instrument enclosures, etc. The intent of this brief is to raise the safety level of consciousness concerning wind hazards prior to conducting round surveillance, maintenance, etc.

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ENCLOSURE 15

**CONTROL DECISION MEETING ON SEPTEMBER 9, 1999 FOR
TANK 241-SY-101 WASTE TRANSFERS AND BACK DILUTION**

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ENCLOSURE 15 – PART 1

**AGENDA FOR CONTROL DECISION MEETING ON SEPTEMBER 9, 1999 FOR
TANK 241-SY-101 WASTE TRANSFERS AND BACK DILUTION**

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**Agenda for Control Decision Meeting on September 9, 1999
for 241-SY-101 Waste Transfers and Back Dilution**

8:30-8:45 Introduction – Larry Kripps

- A. Purpose
- B. Scope
- C. Process

8:45-10:00 Review/Revise Waste Transfer Control Decisions to Protect the Tank 241-SY-101 Mixer Pump Safety Function (i.e., control of gas retention at depth and prevention of buoyant displacement gas release events)

A. Present Controls – Larry Kripps

AC: Tank 241-SY-101 Waste Transfer Control
AC: Tank 241-SY-101 Mixer Pump Performance
SC: Tank 241-SY-101 Waste Transfer Flow Totalizer
SC: Dilution Water Flow Totalizer
SC: Siphon Break in Tank 241-SY-102 Drop Leg

B. New Engineering Analysis

- Crust Encroachment and Mixer Pump Operability – Perry Meyer

C. Possible Control Decisions – Mike Grigsby

1. No revision to present controls.
 2. Revise acceptable minimum waste level for calculating the maximum quantity of waste that can be transferred.
 3. Replace present controls with a Tank 241-SY-101 minimum waste level required for mixer pump operation.*
 4. Replace present controls with a Tank 241-SY-101 Mixer Pump Monitoring Control that requires (a) monitoring of mixer pump operation to detect crust encroachment effects that could damage the pump and (b) monitoring of mixer pump performance to identify signs of degradation that could affect continued control of gas retention at depth and prevention of buoyant displacement GREs.*
- The safety function of the siphon break in Tank 241-SY-102 drop leg requires review if this control is retained (see below).

D. Select Revised Controls

E. Review the identified hazardous conditions to determine whether the revised controls acceptably prevent or mitigate relevant hazardous conditions, and if not, reconsidered the revised controls

10:00-10:15 Break

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**Agenda for Control Decision Meeting on September 9, 1999
for 241-SY-101 Waste Transfers and Back Dilution**

10:15-11:00 Review/Revise Siphon Break in Tank 241-SY-102 Drop Leg Safety Function

- A. Present Siphon Break in Tank 241-SY-102 Drop Leg safety function - Larry Kripps
- B. Siphon analysis
 - "An Analysis of the Potential for Inadvertent Siphon Flow in the Transfer Line between Tanks 241-SY-101 and 241-SY-102" - Perry Meyer
 - Other siphon calculations - Bill Powell
- C. Possible Control Decisions - Mike Grigsby
 - 1. Revise the safety function to reflect the siphon calculations and select additional controls to address the possibility of some limited siphon flow.
 - 2. Delete as a safety SSC.
- D. Select Revised Controls
- E. Review the identified hazardous conditions to determine whether the revised controls acceptably prevent or mitigate the relevant hazardous condition, and if not, reconsidered the revised controls

11:00-11:15 Break

11:15-12:30 Back Dilution Control Decisions

- A. Description of planned back dilution operations - Blaine Barton
- B. Hazard analysis results- Larry Kripps
- C. Engineering analysis

Note: The engineering analysis supporting this control decision assume that the dilution water is added via either the mixer pump burrowing ring or the transfer pump.

 - Expected crust movement resulting from back dilution (including sensitivity to water addition rate) - Chuck Stewart
 - Mixing of back dilution water (i.e., TEMPEST analyses)- Perry Meyer
 - Flammable gas releases resulting from back dilution (including sensitivity to water addition rate) - Perry Meyer
 - Potential for adverse structural effects from back dilution (including sensitivity to water addition rate)- Perry Meyer
- D. Possible Control Decisions - Mike Grigsby
 - 1. No new controls.
 - 2. Maximum water addition rate control.
- E. Select Controls
- F. Review the identified hazardous conditions to determine whether the controls acceptably prevent or mitigate the relevant hazardous conditions, and if not select additional controls

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**Agenda for Control Decision Meeting on September 9, 1999
for 241-SY-101 Waste Transfers and Back Dilution**

- 12:30- Review/Revise Tank 241-SY-101 Flammable Gas Monitoring Control (i.e., Continuous Monitoring Requirement Whenever Water Sources are Connected to Tank)**
- A. Present Tank 241-SY-101 Flammable Gas Monitoring Control - Larry Kripps
 - B. Reasons for requesting control revision – Fred Schmorde
 - C. Possible Control Decisions – Mike Grigsby
 - 1. No revision to present control.
 - 2. Delete the specific requirement for continuous monitoring requirement whenever water sources are connected to Tank 241-SY-101.
 - 3. Revised the present control to identify exceptions (e.g., when the connected water source is <2000 gallons).
 - D. Select Revised Controls
 - E. Review the identified hazardous conditions to determine whether the revised controls acceptably prevent or mitigate the relevant hazardous condition, and if not, reconsidered the revised controls
- 12:30- Review/Revise the "Definitions" of Global and Local Waste Disturbing Operations to be >2000 and <2000 Gallons Versus >500 and <500 Gallons, Respectively**
- A. Present "definitions of global and local waste disturbing operations - Larry Kripps
 - B. Basis for requested revision –Mike Grigsby
 - D. Decision

ENCLOSURE 15 – PART 2

**ATTENDANCE RECORD OF CONTROL DECISION MEEING ON
SEPTEMBER 9, 1999 FOR TANK 241-SY-101 WASTE
TRANSFERS AND BACK DILUTION**

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**Attendance Record of Control Decision Meeting on September 9, 1999 for Tank
241-SY-101 Waste Transfer and Back Dilution**

[illegible]

ENCLOSURE 15 – PART 3

**PURPOSE, SCOPE, AND PROCESS FOR THE TANK 241-SY-101 WASTE
TRANSFERS AND BACK DILUTION CONTROL DECISION MEETING**

CONTROL DECISION MEETING FOR TANK 241-SY-101 WASTE TRANSFERS AND BACK DILUTION

Note: Controls include safety-class and safety-significant structures, systems, and components (SSCs); technical safety requirements (TSRs); and other controls that provided defense-in-depth or environmental protection.

Purpose:

Identify existing or new controls required to protect the public, onsite workers, facility workers, and the environment from potential hazardous conditions and postulated accidents for Tank 241-SY-101 waste transfers and back dilution.

Scope:

A series of waste transfers from Tank 241-SY-101 into Tank 241-SY-102, followed by back dilution with water into SY-101, is planned to remediate the SY-101 surface-level rise condition (*Tank 241-SY-101 Surface-Level-Rise Remediation Project Plan*, HNF-3824, Rev. 0, February 1999). Tank 241-SY-101 waste transfers have been the subject of previous control decisions meetings on March 15 and 16, 1999 and on May 18, 1999. The scope of this control decision meeting includes

1. Review/Revise to several controls previously selected for waste transfers and
2. The identification of existing or new controls for back dilution. The Tank 241-SY-101 mixer pump burrowing ring water injection point is assumed as the location for adding the water for back dilution.

Process:

Control decisions for the Tank 241-SY-101 waste transfer and back dilution will be made using the established, approved process in the existing River Protection Project (RPP) Authorization Basis. The control decision process and the criteria for control decisions are described in the RPP Basis for Interim Operation (HNF-SD-WM-BIO-001) and in the RPP Final Safety Analysis Report (FSAR) along with the methodology for the hazard and accident analyses whose results are used to identify controls. Control decision criteria are summarized in Attachment I.

Control decisions will be based on the best available information from the hazard and accident analyses and on the technical expertise and experience of the meeting participants. Decisions will be made by consensus.

Participants in the SY-101 waste transfer control decision meetings will include a chairperson selected by Tank 241-SY-101 Surface-Level-Rise Remediation Project (Project) management and personnel representing operations, engineering (including the Design Authority, 241-SY-101 cognizant engineer, and Project cognizant engineer), process engineering, and nuclear safety and licensing. Hazard and accident analysts, engineers, and scientists will present information and participate in control decisions for specific potential hazardous conditions and postulated accidents.

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The control decision meeting discussions will be documented, including the control decisions (see Attachment II). This documentation will serve as a reference for an amendment to the RPP Authorization Basis for 241-SY-101 waste transfers and back dilution.

SUMMARY OF CONTROL DECISION CRITERIA

Note: RPP BIO Section 5.4.1, "Control Decision Criteria," and RPP FSAR Section 3.3.1.5, "Control Identification," contain a complete discussion of control decision criteria

Control decision criteria are based on the following documents

DOE 5480.23, *Nuclear Safety Analysis*

DOE 5480.22, *Technical Safety Requirements*

DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*

WHC-CM-4-46, *Nonreactor Facility Safety Analysis Manual*, Section 6, "Technical Safety Requirements," Rev. 1, and Section 9, "Safety Classification of Structures, Systems, and Components," Rev. 2.

Risk Evaluation Guidelines:

Radiological Risk Guidelines

Frequency category	Frequency range (yr-1)	Effective dose equivalent (rem)	
		Onsite	Offsite
Anticipated	$>10^{-2}$ to $\leq 10^0$	0.5	0.1
Unlikely	$>10^{-4}$ to $\leq 10^{-2}$	5	0.5
Extremely unlikely	$>10^{-6}$ to $\leq 10^{-4}$	10	4

Toxicological Risk Guidelines

Frequency category	Frequency range (yr-1)	Primary concentration guidelines	
		Onsite	Offsite
Anticipated	$>10^{-2}$ to $\leq 10^0$	$\leq$ ERPG-1	$\leq$ PEL-TWA
Unlikely	$>10^{-4}$ to $\leq 10^{-2}$	$\leq$ ERPG-2	$\leq$ ERPG-1
Extremely unlikely	$>10^{-6}$ to $\leq 10^{-4}$	$\leq$ ERPG-3	$\leq$ ERPG-2

ERPG = Emergency Response Planning Guideline

PEL-TWA = permissible exposure limit – time-weighted average

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Additional criteria to guide control decisions are the following

- Control preferences are as follows:
 1. Controls that prevent the accident versus those that mitigate its consequences
 2. Passive engineered versus active engineered controls
 3. Engineered controls versus administrative controls
- Controls providing significant defense-in-depth are classified as safety SSCs or are elevated to TSR controls
- TSRs are not developed for postulated accidents resulting in only environmental consequences
- SSCs are not classified safety-class or safety-significant solely for preventing or mitigating postulated accidents resulting in environmental consequences

Other criteria that are important considerations in control decisions are listed below

- Control reliability, availability, and maintainability
- Control effects on facility workers (i.e., increased radiation doses or toxicological exposures – ALARA issues)
- Control optimization and integration
- Control cost/benefit
- Control human factors impacts
- Control impacts on TWRS mission

CONTROL DECISION RECORD

HAZARD/ACCIDENT TITLE:

Structures, Systems, and Components (SSCs)

Structures, Systems, and Components	Classification		Safety Function	Comments
	SC*	SS*		

- * SC is safety class
SS is safety significant

Technical Safety Requirements (TSRs)

Control	Safety Function	Comments

Defense-in Depth Controls

Control	Safety Function	Comments

ENCLOSURE 15 – PART 4

**SUMMARY OF CONTROLS TO PROTECT THE TANK 241-SY-101
MIXER PUMP SAFETY FUNCTION**

SUMMARY OF CONTROLS TO PROTECT THE TANK 241-SY-101 MIXER PUMP SAFETY FUNCTION

Page 1 of 2

Analyzed Accident	Safety Structures, Systems, and Components			Technical Safety Requirement	Comments
	Description	SC	SS		
Flammable Gas Deflagration				AC: Tank 241-SY-101 Waste Transfer Control	<p>Program key elements are:</p> <ul style="list-style-type: none"> For waste transfers from Tank 241-SY-101, the maximum quantity of waste that can be transferred and maintain a minimum of one (1) foot between the mixer pump section and the bottom of the crust (i.e., bottom of the bubble slurry layer) shall be calculated. The calculation shall consider uncertainties in measuring the bottom of the crust, including level monitoring system accuracy, and the growth of the crust subsequent to the transfer. The waste transfer from Tank 241-SY-101 shall then be monitored and limited to this maximum quantity <p>Program key elements are:</p> <ul style="list-style-type: none"> Mixer pump performance (e.g., pump motor current, pump discharge pressure, waste thermocouple response) shall be monitored, and the Test Review Group (TRG) shall review the data quarterly for signs of degradation that could affect continued control of gas retention at depth and prevention of buoyant displacement gas release events (BD GREs) The TRG shall direct corrective actions to restore mixer pump performance, as necessary.
				AC: Tank 241-SY-101 Mixer Pump Performance	

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SUMMARY OF CONTROLS TO PROTECT THE TANK 241-SY-101 MIXER PUMP SAFETY FUNCTION

Page 2 of 2

Analyzed Accident	Safety Structures, Systems, and Components			Technical Safety Requirement ²	Comments
	Description	SC	SS		
Flammable Gas Deflagration (Continued)	Tank 241-SY-101 waste transfer flow totalizer	X	-		Tank 241-SY-101 waste transfer flow totalizer: The safety function of the Tank 241-SY-101 waste transfer flow totalizer is to provide the volume of material transferred from Tank 241-SY-101 to Tank 241-SY-102 (waste plus dilution water) for implementation of the Tank 241-SY-101 Waste Transfer Control.
	Dilution water flow totalizer	X	-		Dilution water flow totalizer: The safety function of the dilution water flow totalizer is to provide dilution water data for implementation of the Tank 241-SY-101 Waste Transfer Control.
	Siphon break in Tank 241-SY-102 drop leg	X	-		Siphon break: The safety function of the siphon break is to prevent the siphoning of waste from Tank 241-SY-101 to Tank 241-SY-102 when the waste transfer pump is not operating.

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ENCLOSURE 15 – PART 5

**SUMMARY OF WORKSHOP ON THE EFFECTS OF CRUST INGESTION ON
TANK 241-SY-101 MIXER PUMP PERFORMANCE**

1.0 Summary

A workshop on the effects of crust ingestion on mixer pump performance in Hanford Waste Tank 241-SY-101 was held at Pacific Northwest National Laboratory in August 1999. The central purpose of the workshop was to evaluate the potential for crust ingestion to degrade mixing and/or damage the mixer pump. Specifically, the need for a previously determined 12-inch separation between the top of the mixer pump inlet and the crust base was evaluated. Participants included a representative from the pump manufacturer, an internationally known expert in centrifugal pump theory, Hanford scientists, engineers, and operational specialists representing relevant fields of expertise.

The workshop focused on developing an understanding of the pump design, addressing the physics of entrainment of solids and gases into the pump, and assessing the effects of solids and gases on pump performance. The major conclusions are summarized as follows:

- Entrainment of a moderate amount of solids or gas from the crust should not damage the pump or reduce its lifetime, though mixing effectiveness will be somewhat reduced.
- Air binding should not damage the pump. Vibrations due to ingestion of gas/solids/objects potentially could cause radial loads that might reduce lifetime of bearings/seals. But significant damage would require fairly extreme conditions not associated with small bubbles, fine solids, and chunks of relatively weak material typical of the crust.
- The pump inlet should be considered to be the inlet duct extension opening 235 inches from the tank bottom, and not the small gap at 262 inches.
- A suction vortex exists at the inlet of all pumps. The characteristics of the inlet suction vortex in the mixer pump are very hard to predict but its effect likely extends upward several feet. Because of this, the 12-inch limit is ineffective and should be replaced with criteria based on monitored pump performance. The most obvious criterion (in addition to current operational constraints) is to monitor discharge pressure and cease pump operation if it falls below a predetermined amount.
- There are no critically necessary tests that must be performed in order to prove pump operability or performance prior to initiation of the transfer/back dilution sequence.

ENCLOSURE 15 – PART 6

**CONTROL OPTIONS FOR ENSURING TANK 241-SY-101
MIXER PUMP OPERABILITY**

Control Options for Mixer Pump Operability

1. No revisions from current controls
3. Revise acceptable minimum crust base level and the basis for maximum waste transfer volume. Use in conjunction with revised pump monitoring control.
 - Use main pump suction inlet elevation rather than the slot elevation
 - Base the allowable crust base elevation on vortex ventilation rather than PNNL shear stress analysis (HNF-3737, App D)
3. Replace current transfer volume control with a minimum crust base elevation control (crust base must be above a certain level prior to operating the mixer pump). Use in conjunction with revised pump monitoring control
4. Replace current controls with pump performance monitoring control only that requires
 - Monitor pump during operation (Parameters and limits set by the TRG, e.g., pump discharge pressure, motor current, oil temperature) with shut down to protect equipment from damage
 - BD GRE mitigation performance (data reviewed by TRG monthly as part of tank data review, e.g., pump discharge pressure, thermocouple uncover, pump run duration, waste temperature profile, etc.)
5. Rely only on having a spare mixer pump and replacing a failed pump. Other controls (e.g., those above) can be process controls

Control Options for Mixer Pump Operability

Option	Thoughts For	Thoughts Against
1. No change <ul style="list-style-type: none"> • Max transfer volume based on 12" minimum crust base elevation above pump slot • Long term pump performance monitoring 	<ul style="list-style-type: none"> • Already approved and implemented in paperwork • 12" margin is really 36" margin to main inlet – conservative relative to pump operability 	<ul style="list-style-type: none"> • May prevent or extend schedule for crust growth remediation • 12" margin technical basis is inadequate (needs to be updated) – qualitative not quantitative • Drives SC status of dilution water flow totalizer and ASSD • Monitoring is only for long term effects, does not address pump survivability
2. Revise min crust elevation/max transfer volume basis	<ul style="list-style-type: none"> • Partially incorporates insights of mixer pump workshops • Can add conservatism to mixer pump operability 	<ul style="list-style-type: none"> • No quantitative basis for vortex ventilation point or consequences • Would drive SC status of dilution water flow totalizer and ASSD

3. Crust base elevation limit for mixer pump operation	<ul style="list-style-type: none"> Does not rely on transfer volume thus no need for SC dilution flow totalizer Can add conservatism to mixer pump operability 	<ul style="list-style-type: none"> Does rely on crust base elevation measurements (i.e., AC 5.19 applied to neutron scans) No quantitative basis for vortex ventilation point or consequences
4. Pump/mixing performance monitoring only	<ul style="list-style-type: none"> Monitors primary parameters of concern rather than speculation on concern Incorporates insights of pump operability workshop Provides near maximum envelop for crust mitigation Simplifies RAPID SC SSC list 	<ul style="list-style-type: none"> Places safety control reliance on (1) pump survivability, (2) ability to take quick corrective actions (days to weeks) and (3) spare mixer pump if wrong about survivability
5. Rely on spare pump only	<ul style="list-style-type: none"> Provides maximum envelop for crust mitigation 	<ul style="list-style-type: none"> If pump fails, crust mitigation may be delayed Puts emphasis on an operation that has not been analyzed in detail (i.e., pump replacement given crust growth)
Others?	<ul style="list-style-type: none"> 	<ul style="list-style-type: none">

ENCLOSURE 15 – PART 7

**ANALYSIS OF POTENTIAL SIPHON FLOW IN THE TRANSFER LINE BETWEEN
TANKS 241-SY-101 AND 241-SY-102**

The purpose of this analysis is to provide a conservative estimation of the potential waste removal rate in Tank SY-101 due to inadvertent siphoning. The approach is to match the driving head of the siphon to the transfer system head loss in order to determine the siphon flow rate as a function of known parameters. With the siphon flow rate known, the net waste reduction or accumulation in SY-101 can be determined.

Analysis

The relevant components of the transfer system are shown in Figure 1. Table 1 gives values for the various elevations of the transfer system. All elevations shown are referenced from the bottom of Tank SY-101.

Figure 1. Schematic of Transfer System Showing Relevant Elevations

Table 1. Parameter Values for Siphon Flow

Parameter	Description	Value
h_l	Transfer pump suction	2.60 m (102.25 in)
h_w	Nominal waste level in SY-101	11.0 m (433 in) before transfer 10.0 m (396 in) after 100kgal transfer
h_T	Maximum elevation of transfer line	17.38 m (684.3 in)
h_s	Siphon break	11.83 m (465.6 in)
h_c	Supported column of diluted waste	16.88 m (664.6 in)
γ_w	Waste specific gravity	1.7
γ	Specific gravity of diluted waste	1.0 – 1.7
A	Transfer system head loss coefficient	$5.88 \times 10^6 \text{ m}/(\text{m}^3/\text{s})^2$ (0.923 in/(gpm) ²)

Figure 2. Siphon Flow Rates due to Inadvertent Dilution Flow Prior to First Transfer

Figure 3. Siphon Flow Rates due to Inadvertent Dilution Flow after 100 kgal Transfer

ENCLOSURE 15 – PART 8

**CONTROL OPTIONS FOR THE SIPHON BREAK IN THE
TANK 241-SY-102 DROP LEG**

Control Options for Siphon Break

- 1. Revise safety function to state e.g., “prevents siphon of waste from SY-101 to SY-102 when waste transfer system is not in use (i.e., dilution/flush water is isolated)”**
 - Siphon flow during waste transfer (i.e., when dilution/flush water is not isolated”) will be accounted for in max. waste transfer volume process memo calculations
 - Isolation of dilution/flush water becomes part of the safety function critical characteristics for siphon break (e.g., SC isolation valves)?
- 2. Eliminate the anti-siphon safety function**
 - Transfer volume is not a safety control (see agenda item above)
 - No other hazardous conditions rely on siphon break as a safety control

ENCLOSURE 15 – PART 9

**SUMMARY OF THE TANK 241-SY-101 BACK DILUTION HAZARD
ANALYSIS RESULTS**

Tank 241-SY-101 Back Dilution Hazard Analysis Results

Hazard analysis of back dilution conducted on July 22, 1999

Results documented in HNF-4891, *Hazard Evaluation for Back Dilution of Tank 241-SY-101 Waste*, Revision 0, August 1999.

Scope of hazard analysis included the back dilution variables and variable options shown in Table 2.

The hazard analysis of back dilution identified:

- 43 potential hazardous conditions
- 33 hazardous conditions with potentially significant consequences to the offsite population (S3) or onsite workers (S2)
- 1 hazardous conditions that is anticipated with potentially significant consequences to the facility worker (F3, S1)
- 1 credible hazardous condition with potentially significant environmental consequences (E2 or E3) that does not have potentially significant consequences to the offsite population (S3) or onsite workers (S2).

The 33 hazardous conditions with potentially significant consequences to the offsite population (S3) or onsite workers (S2) are represented by the following representative accidents from the BIO/FSAR.

- Mixing of Incompatible Material –Toxic Vapor Generation
- Flammable Gas Deflagrations
- Surface Leak Resulting in Pool
- HEPA Filter Failure – Exposure to High Temperature or Pressure

The hazard analysis identified one specific phenomenological issue that required further study. That is, it was postulated that the addition of hot dilution water to Tank 241-SY-101 could increase the dissolution of the crust and upon reformation of the crust, the crust may be less permeable than before. This could create a condition where gas retention of the crust could be increased (over what was experienced prior to back dilution).

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Table 2. Back-Dilution Variables and Variable Options.

Variable	Variable Options
Location of Crust Base Prior to Start of Dilution Activities	Crust base above mixer pump inlet
	Crust base near mixer pump inlet (e.g., within 12" of pump inlet)
	Crust base below mixer pump inlet
Location of Dilution Water Addition	Water added to bulk slurry
	Water added at bottom of crust
	Water added within crust
	Water added on top of crust
Dilution Water Added With or Without Mixing	Active/continuous mixing during back-dilution (i.e., mixer pump operating continuously at low speed)
	Passive mixing (i.e., mixing due to natural convection and buoyancy)
	Active/intermittent mixing (i.e., mixer pump run intermittently)
Local versus Global Addition of Dilution Water	Local dilution water addition
	Global dilution water addition (e.g., sprinkler spray or local water addition to bulk slurry with active mixing)
Hot versus cold water	Temperature of dilution water added is colder than temperature of tank waste
	Temperature of dilution water added is the same as the temperature of tank waste
	Temperature of dilution water added is hotter than temperature of tank waste
Rate of Dilution Water Addition	Fast rate of dilution water addition (hundreds of gpm)
	Slow/continuous rate of dilution water addition
	Steps of quick dilution water addition
Hardware Used to Add Dilution Water	Using old (existing) hardware
	New hardware
Crust Gas Content Prior to Start of Dilution Activities	Little gas released from crust during transfer
	Significant gas released from crust during transfer

Table B-7. Controls From BIO SSCs and TSRs That Potentially Address Hazardous Conditions for Tank 241-SY-101
Back-Dilution With Potential S3 and S2 Consequences. (16 sheets)

Item ID	Rep Acc	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	Remarks	Cons Cat	Freq Cat
ABBREVIATION LIST: AC = Administrative Control Cons = Consequence Cntrls = Controls Detect = Detection Ign = Ignition LCO = Limiting Condition for Operation Mon = Monitoring Prep = Preparedness Syss = Systems											
Rep Acc 04, Flammable Gas Deflagrations - DST											
SYDIL-01	04X	Aerosols and other radioactive hazardous material from Tank 241-SY-101	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Water rises in base of crust with little mixing, causing crust dissolution and flammable gas release, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring Equipment SY-101 Ignition Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	No current controls on water addition rate or volume (except LA-UR-92-3196 Level II controls). Hazardous condition assumes a slow addition (less than 20 GPM). No active mixing (i.e., mixer pump not operating).	S3	F1
SYDIL-04	04X	Aerosols and other radioactive hazardous material from Tank 241-SY-101	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Excessive water addition causes water to rise to base of crust with little mixing, causing crust dissolution and flammable gas release, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	No current controls on water addition rate or volume (except LA-UR-92-3196 Level II controls).	S3	F1

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Table B-7. Controls From BIO SSCs and TSRs That Potentially Address Hazardous Conditions for Tank 241-SY-101
Back-Dilution With Potential S3 and S2 Consequences. (16 sheets)

Item ID	Rep Acc	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	Remarks	Cons Cat	Freq Cat
SYDIL-06	04X	Aerosols and other radioactive/hazardous material from Tank 241-SY-101	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Create stratification affecting mixer pump operation causing increased gas retention at depth with a return to DD GRE, ignition source present	SC: DST/WWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Sys	LCO: DST and AWF Tank Ventilation Sys AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	The stratification condition will not exist long enough to produce DD GRE condition.	S3	F0
SYDIL-08	04X	Aerosols and other radioactive/hazardous material from Tank 241-SY-101	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Mechanical disruption due to crust displacement from water addition resulting in flammable gas release, ignition source present	SC: DST/WWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Sys	LCO: DST and AWF Tank Ventilation Sys AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	Mechanical disruption of crust can be an ignition source.	S3	F1

Table B-7. Controls From BIO SSCs and TSRs That Potentially Address Hazardous Conditions for Tank 241-SY-101
Back-Dilution With Potential S3 and S2 Consequences. (16 sheets)

Item ID	Rep Acc	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	Remarks	Cons Cat	Freq Cat
SYDIL-09	Q4X	Aerosols and other radioactive hazardous material from Tank 241-SY-101	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Mechanical disruption due to crust displacement from water addition damaging mixer pump, causing increased gas retention at depth with a return to BD GRE. Ignition source present	SC: DST/AVF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Sys	LCO: DST and AWF Tank Ventilation Sys AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	None.	S3	F1
SYDIL-12	Q4X	Aerosols and other radioactive hazardous material from Tank 241-SY-101	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Dilution water does not float crust resulting in void ingestion in the mixer pump degrading pump performance or mechanically failing pump, causing increased gas retention at depth with a return to BD GRE. Ignition source present	SC: DST/AVF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Sys	LCO: DST and AWF Tank Ventilation Sys AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	The frequency assigned to the condition is dependent on the location of water addition. Adding the water above the crust surface will result in the higher assigned (worst case) frequency. Adding the water below the crust reduces the frequency significantly. Adding the water via the mixer pump while the mixer pump is operating reduces the frequency the most.	S3	F2

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Table B-7. Controls From BIO SSCs and TSRs That Potentially Address Hazardous Conditions for Tank 241-SY-101
Back-Dilution With Potential S3 and S2 Consequences. (16 sheets)

Item ID	Rep Acc	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	Remarks	Cons Cat	Freq Cat
SYDIL-13	04X	Aerosols and other radioactive/hazardous material from Tank 241-SY-101	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Mixer pump creates 'cavity' in crust which collects flammable gas during dilution resulting in a possible sudden significant release of gas, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	Water addition does not create the cavity; it facilitates the generation/collection of gas. The location of water addition supplied via the mixer pump is not anticipated to effect the frequency.	S3	F1
SYDIL-14	04X	Aerosols and other radioactive/hazardous material from Tank 241-SY-101	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Water addition releases crust gas decreasing the buoyancy of the crust causing the crust to sink resulting in additional gas release, ignition source present	None required	None required	None required	None required	No controls required based on low event frequency.	S3	F0

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Table B-7. Controls From BIO SSCs and TSRs That Potentially Address Hazardous Conditions for Tank 241-SY-101
Back-Dilution With Potential S3 and S2 Consequences. (16 sheets)

Item ID	Rep Acc	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	Remarks	Cons Cat	Freq Cat
SYDIL-16	04X	Aerosols and other radioactive /hazardous material from Tank 241-SY-101	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Water addition releases crust gas decreasing the buoyancy of the crust causing the crust to sink. The additional solids at depth affects mixer pump performance causing increased gas retention at depth with return to DID GREs, ignition source present	SC: DST/AVF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Sys	LCO: DST and AWF Tank Ventilation Sys AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls SY-101 Mixer Pump Performance	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	S3	F1	
SYDIL-17	04X	Aerosols and other radioactive /hazardous material from Tank 241-SY-101	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Water addition releases crust gas decreasing the buoyancy of the crust causing the crust to float lower affecting mixer pump performance/operation causing increased gas retention at depth with a return to DID GREs, ignition source present	SC: DST/AVF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Sys	LCO: DST and AWF Tank Ventilation Sys AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls SY-101 Mixer Pump Performance	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	S3	F1	

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Table B-7. Controls From BIO SSCs and TSRs That Potentially Address Hazardous Conditions for Tank 241-SY-101
Back-Dilution With Potential S3 and S2 Consequences. (16 sheets)

BACK-DILUTION WITH POTENTIAL S3 and S2 Consequences (10 sheets)											
Item ID	Item Acc	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	Remarks	Cons Cat	Freq Cat
SYDIL-19	04X	Aerosols and other radioactive /hazardous material from Tank 241-SY-101	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Dilution water does not float crust resulting in void ingestion in the mixer pump degrading pump performance or mechanically failing pump, causing increased gas retention at depth with a return to RO GREs, ignition source present	SC: DST/AVF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Charts (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Charts SY-101 Flammable Gas Mon Charts SY-101 Mixer Pump Performance	None required	AC: Emergency Prep AC: HEPA Filter Charts (Source Term)	Corrective action to replace damaged mixer pump would likely be completed before release from tank occurs.	S3	F2
SYDIL-20	04X	Aerosols and other radioactive /hazardous material from Tank 241-SY-101	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Mixer pump creates 'cavity' in crust which collects flammable gas during dilution resulting in a possible sudden significant release of gas, ignition source present	SC: DST/AVF Ventilation SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Charts (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Charts SY-101 Flammable Gas Mon Charts	None required	AC: Emergency Prep AC: HEPA Filter Charts (Source Term)	Water addition does not create the cavity; it facilitates the generation/collection of gas. The location of water addition supplied via the mixer pump is not anticipated to affect the frequency.	S3	F1

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Table B-7. Controls From BIO SSCs and TSRs That Potentially Address Hazardous Conditions for Tank 241-SY-101
Back-Dilution With Potential S3 and S2 Consequences. (16 sheets)

Item ID	Rep Acc	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	Remarks	Cons Cat	Freq Cat
SYDIL-21	04X	Aerosols and other radioactive hazardous material from Tank 241-SY- 101	Release of radioactive/hazar dous material from Tank 241- SY-101 to atmosphere due to flammable gas ignition	Water addition releases crust gas decreasing the buoyancy of the crust causing the crust to sink resulting in additional gas release, ignition source present	None required	None required	None required	None required	No controls based on low event frequency.	S3	F0
SYDIL-21	04X	Aerosols and other radioactive hazardous material from Tank 241-SY- 101	Release of radioactive/hazar dous material from Tank 241- SY-101 to atmosphere due to flammable gas ignition	Water addition releases crust gas decreasing the buoyancy of the crust causing the crust to sink. The additional solids at depth affects mixer pump performance causing increased gas retention at depth with return to BD GRLs, ignition source present	SC: DST/WWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Sys	LCO: DST and AWF Tank Ventilation Sys AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls SY-101 Mixer Pump Performance	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)		S3	F1

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Table B-7. Controls From BIO SSCs and TSRs That Potentially Address Hazardous Conditions for Tank 241-SY-101
Back-Dilution With Potential S3 and S2 Consequences. (16 sheets)

Back-Division With Potential S3 and S2 Consequences. (10 sheets)											
Item ID	Rep Acc	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	Remarks	Coast Cat	Freq Cat
SYDIL-24	04X	Aerosols and other radioactive/hazardous material from Tank 241-SY-101	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Water addition releases crust gas decreasing the buoyancy of the crust causing the crust to float lower affecting mixer pump performance/operation causing increased gas retention at depth with a return to BD CRGs, ignition source present	SC: DST/AVF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Controls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Chirts SY-101 Flammable Gas Mon Chirts SY-101 Mixer Pump Performance	None required	AC: Emergency Prep AC: HEPA Filter Controls (Source Term)	Lack of crust re-floatation is nearly assured of affecting mixer pump performance/operation with the crust at this location.	S3	P2
SYDIL-25	04X	Aerosols and other radioactive/hazardous material from Tank 241-SY-101	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Dissolved large hole allows for lateral crust motion causing waste berg turnover resulting in flammable gas release and ignition	None required	None required	None required	None required	No controls based on low event frequency.	S3	P0

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Table B-7. Controls From BIO SSCs and TSRs That Potentially Address Hazardous Conditions for Tank 241-SY-101
Back-Dilution With Potential S3 and S2 Consequences. (16 sheets)

Item ID	Rep Acc	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	Remarks	Cons Cat	Freq Cat
SYDIL-27	04X	Aerosols and other radioactive hazardous material from Tank 241-SY-101	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Dissolved large hole allows bubble slurry flow to top of crust resulting in flammable gas release and ignition.	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Sys	LCO: DST and AWF Tank Ventilation Sys AC: Flammability Curbs (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Curbs SY-101 Flammable Gas Mon Curbs	None required	AC: Emergency Prep AC: HEPA Filter Curbs (Source Term)	Layer of water beneath the crust could potentially "seal" up to 4 ft above the crust/liquid surface level.	S3	P2
SYDIL-28	04X	Aerosols and other radioactive hazardous material from Tank 241-SY-101	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Dissolved large hole allows for lateral motion causing waste berg turnover resulting in flammable gas release and ignition	None required	None required	None required	None required	No controls based on low event frequency.	S3	P9
SYDIL-31	04X	Aerosols and other radioactive hazardous material from Tank 241-SY-101	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Water addition in general increases the head (pressure) at any point in the waste compressing bubbles causing a portion of the crust to sink and release gas, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Sys	LCO: DST and AWF Tank Ventilation Sys AC: Flammability Curbs (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Curbs SY-101 Flammable Gas Mon Curbs	None required	AC: Emergency Prep AC: HEPA Filter Curbs (Source Term)	Pressure and rate of pressure increase dependent on the rate of water addition.	S3	P1

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Table B-7. Controls From BIO SSCs and TSRs That Potentially Address Hazardous Conditions for Tank 241-SY-101
Back-Dilution With Potential S3 and S2 Consequences. (16 sheets)

Item ID	Rep Act	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	Remarks	Cons Cat	Freq Cat
SYDIL-32	04X	Aerosols and other radioactive/hazardous material from Tank 241-SY-101	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Operation of mixer pump releases gas at depth which adds to gas release from crust increasing quantity of flammable gas available for burn, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Chrtis (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Chrtis SY-101 Flammable Gas Mon Chrtis	None required	AC: Emergency Prep AC: HEPA Filter Chrtis (Source Term)	Hazardous condition for situation shown except when dilution water is added deep in the tank.	S3	F1
SYDIL-34	04X	Aerosols and other radioactive/hazardous material from Tank 241-SY-101	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Spray on top results in weakened crust causing crust "roll over" and flammable gas release, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Chrtis (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Chrtis SY-101 Flammable Gas Mon Chrtis	None required	AC: Emergency Prep AC: HEPA Filter Chrtis (Source Term)	Spray may degrade effectiveness of gas monitoring and camera operation due to high humidity atmosphere in tank headspace. Electrostatic buildup from spray system may create ignition source that ignites flammable gas generated from crust dissolution.	S3	F1

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Table B-7. Controls From BIO SSCs and TSRs That Potentially Address Hazardous Conditions for Tank 241-SY-101
Back-Dilution With Potential S3 and S2 Consequences. (16 sheets)

Item ID	Rep Acc	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	Remarks	Caus Cat	Freq Cat
SYDIL-36	04X	Aerosols and other radioactive hazardous material from Tank 241-SY-101	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Cold water precipitates solids with deleterious properties; affects mixer pump operation causing increased gas retention at depth with a return to DD GRE, ignition source present	None required	None required	None required	None required	Increased solubility from added dilution water will overwhelm any solubility decrease from colder temperature. No controls based on low event frequency.	S3	P0
SYDIL-38	04X	Aerosols and other radioactive hazardous material from Tank 241-SY-101	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Introduction of higher temperature water increases tank temperature which reduces gas solubility causing release of flammable gas, ignition source present	SC: DST/AVF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Sys	LCO: DST and AWF Tank Ventilation Sys AC: Flammability Cards (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cards SY-101 Flammable Gas Mon Cards	None required	AC: Emergency Prep AC: HEPA Filter Cards (Source Term)	None.	S3	F1

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Table B-7. Controls From BIO SSCs and TSRs That Potentially Address Hazardous Conditions for Tank 241-SY-101
Back-Dilution With Potential S3 and S2 Consequences. (16 sheets)

Item ID	Rep Acc	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	Remarks	Cons Cat	Freq Cat
SYDIL-39	04X	Aerosols and other radioactive/hazardous material from Tank 241-SY-101	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Introduction of higher temperature water causes potentially large amount of adsorbed gas species to be released by the small temperature change (phase change from gas to liquid), ignition source present	None required	None required	None required	None required	No controls based on low event frequency.	S3	P0
SYDIL-40	04X	Aerosols and other radioactive/hazardous material from Tank 241-SY-101	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Excessive water addition rate causing rapid crust dissolution, ignition source present	SC: DST/AVF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Sys	LCO: DST and AWF Tank Ventilation Sys AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	No current controls on water addition rate or volume (except LA-UR-92-3196 Level II controls).	S3	P2

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Table B-7. Controls From BIO SSCs and TSRs That Potentially Address Hazardous Conditions for Tank 241-SY-101
Back-Dilution With Potential S3 and S2 Consequences. (16 sheets)

Item ID	Rep Acc	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	Remarks	Caus Cat	Freq Cat
SYDIL-41	04X	Aerosols and other radioactive/hazardous material from Tank 241-SY-101	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Excessive water addition rate could cause mechanical disruption of the crust, causing flammable gas release, ignition source present	SC: DST/AVF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Sys	LCO: DST and AWF Tank Ventilation Sys AC: Flammability Chtrts (SY-101) AC: Process Instrumentation and Measuring Equipment SY-101 Ign Chtrts SY-101 Flammable Gas Mon Chtrts	None required	AC: Emergency Prep AC: HEPA Filter Chtrts (Source Term)	None.	S3	F1
SYDIL-42	04X	Aerosols and other radioactive/hazardous material from Tank 241-SY-101	See all related hazardous conditions developed above related to crust sinking events	Water addition releases crust gas decreasing buoyancy causing crust to sink	SC: DST/AVF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Sys	LCO: DST and AWF Tank Ventilation Sys AC: Flammability Chtrts (SY-101) AC: Process Instrumentation and Measuring Equipment SY-101 Ign Chtrts SY-101 Flammable Gas Mon Chtrts SY-101 Mixer Pump Performance	None required	AC: Emergency Prep AC: HEPA Filter Chtrts (Source Term)	Frequency and consequence estimates shown are for the bounding crust sinking condition shown in this table. Consequences would be similar but frequency may increase for crust sinking hazardous conditions identified previously. May also reduce the frequency of crust gas release due to less gas being available for release.	S3	F1

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Table B-7. Controls From BIO SSCs and TSRs That Potentially Address Hazardous Conditions for Tank 241-SY-101

Back-Dilution With Potential S3 and S2 Consequences. (16 sheets)

Item ID	Rep Acc	Material at Risk	Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	Remarks	Cons Cat	Freq Cat
SYDIL-33	04X	Aerosols and other radioactive hazardous material from Tank 241-SY-101	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Crust dissolution releases embedded foreign objects which can become entrained in the mixer pump causing pump damage or failure causing increased gas retention at depth with a return to BID GRE, ignition source present	SC: DST/AVF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Chnrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Chnrls SY-101 Flammable Gas Mon Chnrls SY-101 Mixer Pump Performance	None required	AC: Emergency Prep AC: HEPA Filter Chnrls (Source Term)	Corrective action to replace damaged mixer pump would likely be completed before release from tank occurs.	S3	F1
Rep Acc 18B, Unfiltered Release											
SYDIL-33	18DX	Radioactive hazardous aerosols in tank atmosphere and surface contamination on HEPA filters	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to filter failure from increased loading and unfiltered release	High pressure crust spray nozzles increase radiological and toxicological aerosols in Tank 241-SY-101 headspace creating a greater potential for increased loading rate and failure of ventilation system filters	None required	None required	SS: Ventilation CAM Interlock Syss	LCO: Ventilation Stack CAM Interlock Syss AC: HEPA Filter Chnrls (Source Term)	Local dissolution is less likely to create a large gas release.	S2	F3

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Table B-7. Controls From BIO SSCs and TSRs That Potentially Address Hazardous Conditions for Tank 241-SY-101
Back-Dilution With Potential S3 and S2 Consequences. (16 sheets)

Item ID	Rep Acc	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	Remarks	Cons Cat	Freq Cat
Rep Acc 23, Mixing of Incompatible Material - Toxic Vapor Generation											
SYDIL-02	23X	Ammonia released from Tank 241-SY-101 waste	Release of ammonia gas from Tank 241-SY-101 to atmosphere due to gas release, no ignition postulated	Water rises to base of crust with little mixing, causing crust dissolution and flammable gas release, no ignition source present	None required	None required	SS: SY Farm Exhaust Ventilation Sys SS: SY Farm Ammonia Mon Sys	LCO: DST Tank Ventilation Sys SY Farm Ammonia Mon	Toxicological consequences due to high ammonia concentration.	S2	F1
SYDIL-11	23X	Ammonia released from Tank 241-SY-101 waste	Release of ammonia gas from Tank 241-SY-101 to atmosphere due to gas release, no ignition postulated	See hazardous conditions identified for Flammable Gas Deflagrations	None required	None required	SS: SY Farm Exhaust Ventilation Sys SS: SY Farm Ammonia Mon Sys	LCO: DST Tank Ventilation Sys SY Farm Ammonia Mon	For specific frequencies see entries for flammable gas releases (which include ammonia) caused by those hazardous conditions identified in the Flammable Gas Deflagrations section of this table. This hazardous condition was not developed during the hazard analysis meeting. However, all flammable gas releases include ammonia and all events resulting in a wetted surface result in ammonia evaporation that, in the absence of ignition, results in a potential toxic gas (ammonia) release that could affect the onsite worker.	S2	F2

Table B-7. Controls From BIO SSCs and TSRs That Potentially Address Hazardous Conditions for Tank 241-SY-101
Back-Dilution With Potential S3 and S2 Consequences. (16 sheets)

Item ID	Rep Acc	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	Remarks	Cons Cat	Freq Cat
Rep Acc 26, Surface Leak Resulting Pool											
SYDIL-03	26X	Radioactive/hazardous material contained in Tank 241-SY-101 waste	Release of radioactive/hazardous material from Tank 241-SY-101 to soil surface due to tank overflow	Excessive water addition	None required	None required	SS: Tank Level Detect Sys SS: Service Water Flow Totalizers	AC: Emergency Prep AC: Tank Service Water Intrusion Mon Program	May consider a control on amount of water added.	S2	F3
SYDIL-05	26X	Radioactive/hazardous material contained in Tank 241-SY-101 waste	Release of radioactive/hazardous material from Tank 241-SY-101 to soil surface due to tank overflow	Water addition has little effect on gas retention causing increased tank volume, crust continues to grow out riser	None required	None required	None required	None required	Hazardous condition and consequences similar to previously postulated hazardous condition in HNF-3645 (see IDM 101SYWL-V-21A, page B-26). No controls based on low event frequency.	S3	F0

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**Table B-5. Hazardous Conditions With Potentially
Significant Facility Worker Consequences (S1).**

ID	Hazardous Condition	Cause	Freq. Cat	Env Cat
SYDIL-07	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Excessive water addition, plugging exhaust duct resulting in no ventilation flow through tank resulting in a buildup of flammable gas in Tank 241-SY-101, ignition source present	F3	E1
SYDIL-10	Release of radioactive/hazardous material from tank to atmosphere due to excessive load on tank equipment	Mechanical disruption due to crust displacement damages in-tank equipment leading to tank dome damage	F1	E1
SYDIL-26	Release of radiological/hazardous material to atmosphere due to unfiltered release path due to damaged in-tank equipment	Dilution water dissolves large hole allowing for lateral motion resulting in mechanical damage of equipment (e.g., multi-function instrument tree, thermocouple tree, etc.)	F1	E1
SYDIL-29	Release of radiological/hazardous material to atmosphere due to unfiltered release path due to damaged in-tank equipment	Dilution water dissolves large hole allowing for lateral motion resulting in mechanical damage of equipment (e.g., multi-function instrument tree, thermocouple tree, etc.)	F1	E1

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Table B-6. Hazardous Conditions With No Significant Consequences (S0).

ID	Hazardous Condition	Cause	Freq Cat	Env Cat
SYDIL-15	Release of radioactive/hazardous material from Tank 241-SY-101 to tank annulus due to de-gassed crust falling to bottom of tank causing structural damage to tank liner (primary barrier)	Water addition releases crust gas decreasing the buoyancy of the crust causing the crust to sink to bottom of tank	F0	E2
SYDIL-18	See hazardous conditions related to crust growth documented in HNF-3645	Water addition releases crust gas decreasing the buoyancy of the crust causing the crust to sink interfering with the ability of the transfer pump to transfer waste out of Tank 241-SY-101	F0	E0
SYDIL-23	Release of radioactive/hazardous material from Tank 241-SY-101 to tank annulus due to de-gassed crust falling to bottom of tank causing structural damage to tank liner (primary barrier)	Water addition releases crust gas decreasing the buoyancy of the crust causing the crust to sink to bottom of tank	F0	E2
SYDIL-30	See hazardous conditions related to crust growth documented in HNF-3645	Mechanical disruption due to crust displacement from water addition damaging transfer pump preventing waste transfer out of the Tank 241-SY-101	F1	E0
SYDIL-35	Release of radioactive/hazardous material from Tank 241-SY-101 to annulus due to tank leak	Cold water induces thermal stress on tank liner that may fail weld(s)	F1	E2
SYDIL-37	Release of radioactive/hazardous material from Tank 241-SY-101 to annulus due to tank leak	Hot water induces thermal stress on tank liner that may fail weld(s)	F0	E2

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**ENCLOSURE 15 – PART 10
EFFECTS OF BACK DILUTION ON CRUST FLOATATION**

MIXING OF WATER AND SLURRY

EFFECT OF MIXING ON CRUST FLOATATION

ENCLOSURE 15 – PART 11

**POTENTIAL FOR ADVERSE STRUCTURAL EFFECTS FROM CRUST
MOVEMENT CAUSED BY BACK DILUTION**

ENCLOSURE 15 – PART 12

**ANALYSIS OF FLAMMABLE GAS RELEASES FROM SLURRY RESULTING
FROM BACK DILUTION**

Dilution Flow Rate Limitations due to Slurry Gas Release

- Dilution water could dissolve solids which are attached to bubbles causing slurry gas to be released.
- There is as much as 5700 scf of H₂ in the slurry: $5700/29,500 = 19\%$
- 162000 gal required to dissolve slurry solids
- Assume:
 - Dilution water is instantaneously well mixed
 - Release rate is proportional to dilution rate
 - All gas is released during dilution

Result from Ventilation Model

- 810 minutes duration required for water addition to keep below 0.625% in dome.
- Dilution flow rate < 125 gpm for 100,000 water addition.

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Kripps, Lawrence J

From: Stewart, Charles W [charles.stewart@pnl.gov]
Sent: Tuesday, September 14, 1999 3:11 PM
To: Grigsby, J M (Mike); Kripps, Lawrence J
Cc: Brothers, Joe W; Meyer, Perry A; Kuhn, William L
Subject: Time for LFL from Slurry Gas Release

Mike/Larry

I have expanded the slurry gas release calculation to include 100% LFL as well as the 7500 ppm limit. The simplified model assumes that the slurry gas release is directly proportional to the dilution flow rate and that the dilution process releases the entire volume of slurry gas. Results are given below.

Chuck

INPUTS:

slurry void fraction	0.035 (max implied by volute pressure. currently at 0.025)
slurry gas hydrogen fraction	0.031 (as measured by RGS from draft final report)
waste surface elevation	430 inches
free liquid level	410 inches
crust base elevation	310 inches (determines total volume of slurry available)
headspace vent rate	450 scfm
slurry degassed density	1600 kg/m ³
tank headspace	30200 ft ³ (at 430 inches waste level)

OUTPUTS:

Total hydrogen release from slurry	2440 scf
Release time to reach LFL	110 minutes
Max. dilution flow rate for 7500 ppm at end of 100000 gal.	139 gpm
" LFL "	922 gpm
Hydrogen concentration after 100000 gal at 70 gpm	3800 ppm
Max. dilution flow rate for 7500 ppm at end of 150000 gal.	208 gpm
" LFL "	1383 gpm
Hydrogen concentration after 150000 gal at 70 gpm	2500 ppm

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MODEL:

$$[H_2] = (R_{dot}/V_{ent}) * [1 - \exp(t * V_{ent}/D_{ome})]$$

where R_{dot} = hydrogen release rate, scfm

V_{ent} = headspace ventilation rate, scfm

t = time since start of dilution flow, min

D_{ome} = headspace volume, ft³

$$R_{dot} = \alpha * H_{sl} * A * P_{hyd}/time$$

where α = slurry void fraction

H_{sl} = height of slurry layer (in)

A = tank area, (368 ft²/in)

P_{hyd} = average slurry hydrostatic pressure, atm

$time$ = time for total gas release (assumed equal to time for dilution volume)

$$P_{hyd} = 1 + g * (H_{liq} - 0.5 * H_{sl}) * \rho_{hsl}/P_{atm}$$

where H_{liq} = height of free liquid level, m

g = gravity, 9.81 m/s²

ρ_{hsl} = slurry density, 1600 kg/m³

P_{atm} = 101320 Pa

$$time = DilVol/Dilflow$$

where $DilVol$ = total volume of dilution water to be added, gal.

$Dilflow$ = dilution water flow rate, gpm

ENCLOSURE 15 – PART 13
CONTROL OPTIONS FOR BACK DILUTION

Control Options for Back Dilution

- 1. Maximum dilution water addition rate**
- 2. Maximum dilution water temperature**
- 3. Control on acceptable water addition location(s)**
- 4. Others**
- 5. No new or modified controls**

Control Options for Back Dilution

Control Option	Thoughts For	Thoughts Against
1. Maximum dilution water addition rate	<ul style="list-style-type: none"> • Seems prudent to limit rate to a reasonable value • Waste transfer analysis assumed a 70 gpm "inadvertent" dilution rate 	<ul style="list-style-type: none"> • Low dilution not sensitive to water addition rate within reasonable values (controls for gas releases in place, no significant structural issues) • If desired, better as a process control and a key assumption in the safety basis (i.e., USQ higher flow rates)
2. Max. dilution water temperature	Seems prudent to limit dilution water temperature	<ul style="list-style-type: none"> • No significant hazardous condition identified for hot-hot water addition • If desired, better as a process control

<p>3. Control to specify water addition location</p>	<p>Gas release rate and structural effects assessments for back dilution assume low addition point (to date)</p>	<ul style="list-style-type: none"> • No significant hazardous condition identified for "high addition" "High addition" assessment is confirmatory • If desired, better as a process control and a key assumption in the safety basis (i.e., USQ different addition locations)
<p>4. Others?</p>		<ul style="list-style-type: none"> •
<p>5. No new or modified controls</p>	<p>See "Thoughts Against" for those above</p>	<p>See "Thoughts For" for those above</p>

ENCLOSURE 15 – PART 14
SUMMARY OF FLAMMABLE GAS MONITORING CONTROLS
FOR TANK 241-SY-101

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SUMMARY OF FLAMMABLE GAS MONITORING CONTROLS FOR THE TANK 241-SY-101

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Analyzed Accident	Safety Structures, Systems, and Components			Technical Safety Requirement	Comments
	Description	SC	SS		
Flammable Gas Deflagration				AC: Tank 241-SY-101 Flammable Gas Monitoring Controls	<p>Program key elements are:</p> <ul style="list-style-type: none"> The manned work activity controls of TSR AC 5.11.2a shall be implemented for Tank 241-SY-101 with Tank 241-SY-101 treated as if it were a flammable gas Facility Group 1 tank. Prior to initiating and during unmanned waste disturbing operations and activities, continuous flammable gas monitoring of the tank dome space is required. Waste disturbing operations and activities shall be stopped if the flammable gas concentration is >25% of the Lower Flammability Limit (LFL). When water sources are connected to equipment for operations and activities that could add water to Tank 241-SY-101, continuous flammable gas monitoring of the tank dome space is required. Water sources are not considered to be connected if they are disconnected by a removal of piping (i.e., air gap) or installation of a blind flange. Note that closed valves do not disconnect water sources. Water sources shall be immediately isolated if the flammable gas concentration is > 25% of the LFL. Isolation requires the shutoff valve in the line from the water source to be closed. If it cannot be verified that the valve is not leaking through, the water line shall be disconnected. <p>Note: For manned work activity controls and the unmanned operations controls in Tank 241-SY-101, 25% of the LFL is defined as 25% of the LFL as measured by a combustible gas monitor or, if measuring hydrogen only, as 7,500 ppm hydrogen.</p>

LJKripps
9/8/99

ENCLOSURE 15 – PART 15

**CONTROL OPTIONS FOR MONITORING WHEN A WATER
SOURCE IS CONNECTED**

Control Option for Monitoring when a Water Source is Connected (Control Optimization)

Control Option	Thoughts For	Thoughts Against
<p>1. No change</p> <ul style="list-style-type: none"> Continuous monitoring when a water source is connected to SY-101 Ignition controls are all times Ventilation control at all times 	<ul style="list-style-type: none"> Same controls as during waste transfer when "inadvertent" dilution is postulated (i.e., generalizes "inadvertent" dilution control) Control already implemented 	<ul style="list-style-type: none"> Onerous for situations where realistic water addition is limited in rate, quantity and location such that LFL can not be exceeded.
<p>2. Just follow TSR AC 5.11 as if SY-101 were a FG 1 tank (plus during unmanned global waste disturbing activities)</p> <ul style="list-style-type: none"> Continuous monitoring required during all intrusive manned activities Continuous monitoring during unmanned global waste disturbing activities 	<ul style="list-style-type: none"> More consistent with Controls for other tanks Increased control over TSRs for operations with significant crust gas release potential Low likelihood of inadvertent crust dissolution gas release when not transferring waste <ul style="list-style-type: none"> Rate must > 25 gpm Volume must > 1950 gal Water must be injected in or below BS layer 	<ul style="list-style-type: none"> Cost to change control (safety documentation, procedures) Less conservative (unquantified increase in risk of a deflagration)

ENCLOSURE 15 – PART 16

**WATER ADDITIONS CONSIDERED AS GLOBAL AND LOCAL WASTE
DISTURBING OPERATIONS**

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Table E4-2. Representative Tank Waste Remediation System Waste Management Operations and Activities. (2 sheets)

Representative Waste Disturbing Operations
Global Waste Disturbing Operations <ul style="list-style-type: none">• Salt well pumping• Submersible pump operation• Emergency pumping of supernatant• Mixer pump operation• Transfer pump operation• Air lift circulator operation• Jet pump operation• Chemical additions• Large water additions (for example, >500 gallons)• Waste addition/removal or transfers
Local Waste Disturbing Operations <ul style="list-style-type: none">• Lancing (<500 gallons of water added to waste)• Hydraulic jetting (with ultra-high-pressure)• LOW installation• Thermocouple (T/C) tree installation• Salt well installation• Multiple instrument tree (MIT) installation• Instrumentation Installation/Operation<ul style="list-style-type: none">Void meterViscometerDensitometer readingsSludge level (weight) measurementsPenetrometer testing• Mixer pump installations• Transfer pump installation• Equipment removal if inserted below the waste surface, including retrieval devices and de-con<ul style="list-style-type: none">Sludge weight removalAir lance removalSpecific gravity probe removalLOW removalT/C tree removalMIT removalPump removal• Sampling<ul style="list-style-type: none">Push mode core samplingAugerGrabLight Duty Utility Arm sampling missions

Notes:

¹ Within 15 ft or 18 opening diameters from the tank opening, whichever is less.

² ENRAF is a trademark of the ENRAF MONIUS Corporation.

ENCLOSURE 15 – PART 17

**ASSESSMENT OF SY-101 MIXER PUMP OPERATION IF WASTE LEVEL IN
TANK IS LOWERED BELOW INLET**

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APPENDIX F

Don't Say It... Write it!

To: SY-101 Level Rise Mitigation Project Files **Date:** September 16, 1999

From: Craig Shaw *Craig Shaw*

Subject: Assessment of SY-101 Mixer Pump Operation If Waste Level in Tank is Lowered Below Inlet

Cc: JM Grigsby
CE Hanson *CH*
LJ Kripps
CPS/lbf

Discussion

The SY-101 Level Rise Mitigation Project is preparing to transfer waste out of SY-101, to SY-102. In doing this, a question has been raised regarding the ability of the SY-101 Mixer Pump to be operated, if/when the waste level is lowered to a point below the mixer pump inlet. Please refer to the following items for this discussion: Attachment 1-Mixer Pump Impeller Area Sketch, Attachment 2-Mixer Pump Inlet Area Photo, and Attachment 3-Parts List & Drawing of Hazelton 10" GN SSB Pump/Mixer.

Once the waste level is lowered below the pump suction, waste can drain from the pump internals. As the tank is re-filled with back-dilution fluid, this fluid will begin to enter the suction bell. If the 3/16 -in. vent hole in the 2-in. ring header is clear (not plugged), any air that was in the volute, the two large crossover ducts, the discharge piping, the annular jacket, and in the 2-in. ring header, will be "vented" out, and the back-dilution fluid and waste will fill these areas...thus providing enough fluid for the pump to begin pumping, and maintain its ability to mix the tank.

If the 3/16-in. vent hole is not clear (plugged), the question is how will any air in the areas mentioned above be vented out, to allow the pump to be "primed", and start pumping? The answer to this question is that there is another vent avenue for the air that is trapped in the impeller housing (volute). This vent is the gap between the volute and the shaft spacer sleeve, PN 14, and water deflector, PN 15 (See Att. 3). This gap leads from the volute to the tank. Every time the pump is operated, this shaft turns, and thus would "break loose" any waste that could have been "plugging" this opening. Even if the 3/16-in. vent were plugged, this opening would allow the air in the impeller/volute volume to escape to the tank, allowing back-dilution fluid to fill up the volute, thus immersing the impeller in fluid.

If the impeller is immersed in fluid, and the other areas mentioned above have air trapped in them, when the pump is started, it will displace the air from those areas, and then operate normally.

Conclusion:

If the waste level in SY-101 is lowered below the mixer pump inlet suction, and then the waste level is increased, there will not be an issue with "air-binding" the pump. There will be sufficient hydrostatic head available as mentioned above to clear out any trapped air. The mixer pump will still be able to perform its safety function of controlling gas retention at depth and preventing buoyant displacement gas release events.

Attachment 1

Mixer Pump Impeller Area Sketch

(Consisting of 2 pages including this cover)

Attachment 2

Mixer Pump Inlet Area Photo

Photo No. 92070141-11cn

(Consisting of 2 pages including this cover)

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Attachment 2-Mixer Pump Inlet Photo (Photo No. 92070141-11cn)

Attachment 3

Parts List & Drawing of Hazelton 10" GN SSB Pump/Mixer

**Model # 447-150-1200(R)
R-273587 N-22679
Order No. MAP-XVV238548
Date 2-11-92 (From CVI File)**

(Consisting of 3 pages including this cover)

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WAZLETON LOGN-SSB PUMP/MIXER MODEL #447-150-1200 (R)

PUMP SERIAL NUMBER: W-20770

NO	PART	ITEM NO	DRAWING	PATTERN	MAT'L	QUAN/ PUMP	REMARKS
1	CASING	590472-087	10809D	10809	CDAMCU	1	
2	IMPELLER 17.875" T.	590473-087	17128A	16338	CDAMCU	1	(3) VANES #17128
3	IMPELLER LOCK NUT	586323-016	12053E	12053	316	1	
4	IMPELLER JAM NUT	590474-016	12053H	12053	316	1	
5	SUCTION HEAD	590476-087	17168	17168	CDAMCU	1	
6	CASING HEAD	590475-087	17167	17167	CDAMCU	1	
7	DISCHARGE NOZZLE	590477-087	17169	17169	CDAMCU	2	
8	STATOR HOUSING	590485-017	17194	17194	316L	1	
9	MECHANICAL SEAL HOUSING	590479-017	17191	17191	316L	1	
10	BALL BEARING HOUSING	590483-002	15487C	15487	C.T.	1	
11	TERMINAL COVER	590487-017	17196	17196	316L	1	
12	VIBR. TRANS. COVER	590561-017	17223	17223	316L	1	
13	PRESS. TRANS. COVER	590594-017	17240	17240	316L	1	
14	SPACER SLEEVE	590478-096	17171	SS	HAZ.450	1	
15	WATER DEFLECTOR	590489-096	17202	WD	HAZ.450	1	
16	MECHANICAL SEAL RETAINER	590480-016	16260B	MSR	316	1	
17	LOCK RING	590481-016	17192	LR	316	1	
18	STATOR COVER	590486-017	17195	SC	316L	1	
19	ACCESS COVER	590560-016	17222	AC	316	1	
20	BEVELED RETAINING RING-INTERNAL	830189-030	#5002-375		ST.	1	MECH. SEAL HSG.
21	SHAFT	590490-033	17203	S	17.4PH	1	
22	DUPLEX THRUST BEARING	830261-030	#PP8320DU		ST.	1	ABEC #1
23	SINGLE ROW RADIAL BEARING	801182-030	#321S		ST.	1	ABEC #1
24	BALL BEARING ADAPTER SLEEVE	590482-030	17190	BBAS	ST.	1	
25	QUICK-CONNECT ADAPTOR	830517-016	1.000 NPT		316	1	STATOR HSG.
26	QUICK-CONNECT DUST CAP	830518-016	1.000		316	1	STATOR HSG.
27	BALL BEARING LOCK NUT	808058-030	#FN-21		ST.	1	RADIAL BEARING
28	BALL BEARING LOCK WASHER	817682-030	#FW-21		ST.	1	RADIAL BEARING
29	BALL BEARING LOCK NUT	808136-030	#FN-20		ST.	1	THRUST BEARING
30	BALL BEARING LOCK WASHER	817676-030	#FW-20		ST.	1	THRUST BEARING
31	BALL BEARING LOCK NUT	808022-030	#FN-15		ST.	1	BALL BEG. ADAPT. SLEEVE
32	BALL BEARING LOCK WASHER	817646-030	#FW-15		ST.	1	BALL BEG. ADAPT. SLEEVE
33	BEVELED RETAINING RING-INTERNAL	811358-030	#N3002-850		ST.	1	BALL BEARING HOUSING
34	RETAINING RING - EXTERNAL	811404-030	#3100-437		ST.	1	PARTIAL MOTOR
35	DOUBLE MECHANICAL SEAL	830509-016	#04010581	0581	316	1	"JOHN CRANE"
36	SLINGER	590729-016	4703H	4082B	316	1	
37	OIL	829185-085	GULF HARMONY 68		MISC.	18.6 GALS.	STATOR HOUSING
38	OIL	829247-085	GULF HARMONY 32		MISC.	5.5 GALS.	BARRIER FLUID SYSTEM
39	TRANSITION PIPE	590615-015	17242	TP	304L	1	
40	FLUSH PORT PLUG	590616-015	17243	FPF	304L	1	
41	PARTIAL MOTOR	830444-000	150 HP-	1200 RPM	MISC.	1	"RELIANCE"
42	STATOR KEY	587270-030	17194B	SK	ST.	1	
43	BARRIER FLUID PIPING	590232-000	17193A	BFP	316	1	
44	QUICK-CONNECT ADAPTER	830519-016	.500 NPTF	x .750	316	2	DRAINS
45	QUICK-CONNECT DUST CAP	830520-016	.750		316	2	DRAINS
46	CAPSULE TEMP. SENSOR	830394-085	#007850IN	0900	MISC.	2	"ROSEMOUNT, INC."
47	INDUST. ACCELEROMETER - VIBR.	830397-085	#H99-3		MISC.	2	"SCIENTIFIC ATLANTA"
48	PRESSURE TRANSDUCER	830434-000	#F5-10		MISC.	1	"BOTTFINGER BALDWIN"
49	CORD GRIP - ASSEMBLY	590598-000	17226A	CGA	316	2	VIBR.CBL.-V.TRANS.CVR.
50	CORD GRIP ASSEMBLY	590598-000	17226A	CGA	316	1	PRESS.CBL.-P.TRANS.CVR.
51	CORD GRIP ASSEMBLY	590598-000	17226A	CGA	316	2	TEMP.CBL.-TERM.CVR.
52	CORD GRIP ASSEMBLY	591859-000	17225A	CGA	316	1	MOT.CBL.-TERM.CVR.
53	CORD GRIP ASSEMBLY	590598-000	17226A	CGA	316	1	M.ALARM CBL.-TERM.CVR.
54	CORD GRIP ASSEMBLY	590598-000	17226A	CGA	316	2	TEMP.CBL.-TRANS.PIPE
55	CORD GRIP ASSEMBLY	591859-000	17225A	CGA	316	1	MOT.CBL.-TRANS.PIPE
56	CORD GRIP ASSEMBLY	590598-000	17226A	CGA	316	1	M.ALARM CBL.-TRANS.PIPE
57	ELECTRIC FEED-THROUGH	806467-085	#F-330H	275 AMP	MISC.	3	MOTOR LEADS

*PARTS NOT SHOWN
THIS LIST IS TO BE USED WITH BULLETIN 48,048

(PAGE 1 of 2)

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ENCLOSURE 15 – PART 18

**MEASURED CONCENTRATIONS OF HYDROGEN AND AMMONIA
FROM TANK 241-SY-101 WATER ADDITIONS**

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-----Original Message-----

From: Schmorde, F A (Fred)
Sent: Wednesday, September 22, 1999 10:31 AM
To: Kripps, Lawrence J
Cc: Grigsby, J M (Mike); Hanson, Gregory N; Raymond, Richard E; Reed, Ronald W (Ron)
Subject: OPERATING EXPERIENCE (AMMONIA CONCENTRATIONS FROM WATER ADDITIONS TO 101-SY)

LARRY,

RECENT WATER ADDITIONS TO 101-SY HAVE RESULTED IN LOWER THE CALCULATED AMMONIA RELEASES. SPECIFICALLY;

1. MECHANICAL MITIGATION ARM (MMA) DEPLOYMENT (20 MAY 1999)
 - A. 900 GALLONS TOTAL ADDED (APPROX. 800 GAL. BENEATH THE CRUST)
 - B. RATE -- APPROX. 25 GPM
 - C. PEAK TANK AMMONIA -- 98 PPM (RISE OF APPROX. 40 PPM ABOVE INITIAL VALUE)
 - D. PEAK STACK AMMONIA -- NO EFFECTIVE CHANGE MEASURED (INITIAL APPROX. 120 PPM)
 - E. PEAK TANK HYDROGEN -- 230 PPM.
2. MMA DEPLOYMENT (26 MAY 1999)
 - A. 1000 GALLONS WATER ADDED (APPROX. 800 GAL. BENEATH THE CRUST)
 - B. RATE -- APPROX. 25 GPM
 - C. PEAK TANK AMMONIA -- 231 PPM (INITIAL VALUE APPROX. 60 PPM)
 - D. PEAK STACK AMMONIA -- 206 PPM (INITIAL VALUE 130 PPM)
 - E. PEAK TANK HYDROGEN -- 1300 PPM
3. CRUCIFORM LANCE DEPLOYMENT (10 SEPTEMBER 1999)
 - A. 1200 GALLONS WATER ADDED (APPROX. 800 GAL. BENEATH THE CRUST)
 - B. RATE -- APPROX. 30 GPM
 - C. PEAK TANK AMMONIA -- 217 PPM (INITIAL VALUE 70 PPM)
 - D. PEAK STACK AMMONIA -- 200 PPM (INITIAL APPROX. 160 PPM)
 - E. PEAK HYDROGEN -- 495 PPM

EACH OF THE EVENTS ABOVE WERE MECHANICALLY INTRUSIVE AS WELL AS SIMPLE WATER ADDITIONS INTO THE TANK WASTE. THESE ACTUAL TANK PARAMETERS SUGGEST THAT THE CALCULATED TANK RESPONSES AND SUBSEQUENT CONTROLS FOR WATER ADDITIONS MAY BE OVERLY CONSERVATIVE.

I RECOMMEND THAT WATER SOURCES LESS THAN 2000 GALLONS BE THE MONITORING CONTROL LIMIT UNTIL MORE TANK EXPERIENCE ALLOWS FURTHER RELAXATION.

FRED SCHMORDE

ENCLOSURE 16

**CONTROL DECISION MEETING ON OCTOBER 13, 1999 FOR
TANK 241-SY-101 WASTE TRANSFERS AND BACK DILUTION**

ENCLOSURE 16 – PART 1

**AGENDA FOR CONTROL DECISION MEETING ON OCTOBER 13, 1999 FOR TANK
241-SY-101 WASTE TRANSFERS AND BACK DILUTION**

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**Agenda for Control Decision Meeting on October 13, 1999
for Tank 241-SY-101 Waste Transfers and Back Dilution**

- 9:00-9:15 Introduction – Larry Kripps**
- A. Purpose
 - B. Scope
 - C. Process
- 9:15-9:30 Identify the Waste Transfer and Back Dilution Control Decisions That Need to be Reconsidered and Why– Larry Kripps**
- 1. Control decision on September 9, 1999 to delete the Tank 241-SY-101 Waste Transfer Control and replace it with a Tank 241-SY-101 Mixer Pump Operation and Performance Monitoring control. Reconsideration of a Tank 241-SY-101 Waste Transfer Control is required to ensure that corrective actions are available to restore mixer pump operation or performance following the first waste transfer.
 - 2. Control decision on September 9, 1999 that no back dilution controls are required. Reconsideration of back dilution controls (e.g., controls on the maximum quantity of dilution water added, controls on dilution water addition location) are required to address safety concerns associated with the potential for the crust to sink.
- Note:** Revised and new analysis of the response of the Tank 241-SY-101 crust to waste transfers and back dilution has been performed since the September 9, 1999 control decision meetings (see next agenda item).
- 9:30-10:30 Presentation on Expected Buoyant Response of the Tank 241-SY-101 Crust to Waste Transfers and Back Dilution – Chuck Stewart**
- 10:30-10:45 Break**
- 10:45-11:00 Possible Control Decisions – Larry Kripps**
- A. No revision to previous control decisions
 - B. New Tank 241-SY-101 Waste Transfer Control; back dilution not authorized except as a TRG directed corrective action to restore mixer pump operation or performance
 - C. New Tank 241-SY-101 Waste Transfer Control; new Tank 241-SY-101 Back Dilution Control (specific water addition limits for top back dilution)
 - D. New Tank 241-SY-101 Waste Transfer Control; new Tank 241-SY-101 Back Dilution Control (no specific water addition limits for top back dilution)
 - E. Other possible controls options
- 11:00-1:00 Control Decision Discussion - All**
- A. Discussion
 - B. Select Revised Controls
 - C. Review the identified hazardous conditions to determine whether the revised controls acceptably prevent or mitigate relevant hazardous conditions, and if not, reconsidered the revised controls

ENCLOSURE 16 – PART 2

**ATTENDANCE RECORD OF CONTROL DECISION MEETING FOR
TANK 241-SY-101 WASTE TRANSFERS AND BACK DILUTION ON
OCTOBER 13, 1999**

**Attendance Record of Control Decision Meeting for Tank 241-SY-101 Waste
Transfers and Back Dilution on October 13, 1999**

Enc 16-5

ENCLOSURE 16 – PART 3

**PURPOSE, SCOPE, AND PROCESS FOR THE TANK 241-SY-101 WASTE TRANSFER
AND BACK DILUTION CONTROL MEETING**

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**CONTROL DECISION MEETING FOR TANK 241-SY-101 WASTE TRANSFERS AND
BACK DILUTION**

Note: Controls include safety-class and safety-significant structures, systems, and components (SSCs); technical safety requirements (TSRs); and other controls that provided defense-in-depth or environmental protection.

Purpose:

Identify existing or new controls required to protect the public, onsite workers, facility workers, and the environment from potential hazardous conditions and postulated accidents for Tank 241-SY-101 waste transfers and back dilution.

Scope:

A series of waste transfers from Tank 241-SY-101 to Tank 241-SY-102, followed by back dilution with water of the Tank 241-SY-101 waste, is planned to remediate the Tank 241-SY-101 surface-level rise condition (*Tank 241-SY-101 Surface-Level-Rise Remediation Project Plan*, HNF-3824, Rev. 0, February 1999). Tank 241-SY-101 waste transfers have been the subject of previous control decisions meetings on March 15 and 16, 1999; May 18, 1999; and September 9, 1999. Back dilution of Tank 241-SY-101 waste was also a subject of the September 9, 1999 control decision meeting. The scope of this control decision meeting is to review the need for a Tank 241-SY-101 waste transfer control and back dilution controls in light of new information that has been developed since the September 9, 1999 control decision meeting.

Process:

Control decisions for Tank 241-SY-101 waste transfers and back dilution will be made using the established, approved process in the existing River Protection Project (RPP) Authorization Basis. The control decision process and the criteria for control decisions are described in the RPP Basis for Interim Operation (HNF-SD-WM-BIO-001) and in the RPP Final Safety Analysis Report (FSAR) along with the methodology for the hazard and accident analyses whose results are used to identify controls. Control decision criteria are summarized in Attachment I.

Control decisions will be based on the best available information from the hazard and accident analyses and on the technical expertise and experience of the meeting participants. Decisions will be made by consensus.

Participants in the Tank 241-SY-101 waste transfer and back dilution control decision meetings will include a chairperson selected by Tank 241-SY-101 Surface-Level-Rise Remediation Project (Project) management and personnel representing operations, engineering (including the Design Authority, 241-SY-101 cognizant engineer, and Project cognizant engineer), process engineering, and nuclear safety and licensing. Hazard and accident analysts, engineers, and scientists will present information and participate in control decisions for specific potential hazardous conditions and postulated accidents.

The control decision meeting discussions will be documented, including the control decisions (see Attachment II). This documentation will be included in the RPP safety basis for 241-SY-101 waste transfers and back dilution (i.e., HNF-3737).

SUMMARY OF CONTROL DECISION CRITERIA

Note: RPP BIO Section 5.4.1, "Control Decision Criteria," and RPP FSAR Section 3.3.1.5, "Control Identification," contain a complete discussion of control decision criteria

Control decision criteria are based on the following documents

DOE 5480.23, *Nuclear Safety Analysis*

DOE 5480.22, *Technical Safety Requirements*

DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*

WHC-CM-4-46, *Nonreactor Facility Safety Analysis Manual*, Section 6, "Technical Safety Requirements," Rev. 1, and Section 9, "Safety Classification of Structures, Systems, and Components," Rev. 2.

Risk Evaluation Guidelines:

Radiological Risk Guidelines

Frequency category	Frequency range (yr-1)	Effective dose equivalent (rem)	
		Onsite	Offsite
Anticipated	$>10^{-2}$ to $\leq 10^0$	0.5	0.1
Unlikely	$>10^{-4}$ to $\leq 10^{-2}$	5	0.5
Extremely unlikely	$>10^{-6}$ to $\leq 10^{-4}$	10	4

Toxicological Risk Guidelines

Frequency category	Frequency range (yr-1)	Primary concentration guidelines	
		Onsite	Offsite
Anticipated	$>10^{-2}$ to $\leq 10^0$	$\leq$ ERPG-1	$\leq$ PEL-TWA
Unlikely	$>10^{-4}$ to $\leq 10^{-2}$	$\leq$ ERPG-2	$\leq$ ERPG-1
Extremely unlikely	$>10^{-6}$ to $\leq 10^{-4}$	$\leq$ ERPG-3	$\leq$ ERPG-2

ERPG = Emergency Response Planning Guideline

PEL-TWA = permissible exposure limit – time-weighted average

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Additional criteria to guide control decisions are the following

- Control preferences are as follows:
 1. Controls that prevent the accident versus those that mitigate its consequences
 2. Passive engineered versus active engineered controls
 3. Engineered controls versus administrative controls
- Controls providing significant defense-in-depth are classified as safety SSCs or are elevated to TSR controls
- TSRs are not developed for postulated accidents resulting in only environmental consequences
- SSCs are not classified safety-class or safety-significant solely for preventing or mitigating postulated accidents resulting in environmental consequences

Other criteria that are important considerations in control decisions are listed below

- Control reliability, availability, and maintainability
- Control effects on facility workers (i.e., increased radiation doses or toxicological exposures – ALARA issues)
- Control optimization and integration
- Control cost/benefit
- Control human factors impacts
- Control impacts on TWRS mission

CONTROL DECISION RECORD

HAZARD/ACCIDENT TITLE:

Structures, Systems, and Components (SSCs)

Structures, Systems, and Components	Classification		Safety Function	Comments
	SC*	SS*		

* SC is safety class
SS is safety significant

Technical Safety Requirements (TSRs)

Control	Safety Function	Comments

Defense-in Depth Controls

Control	Safety Function	Comments

ENCLOSURE 16 – PART 4

**ANALYSIS OF THE EXPECTED BUOYANT RESPONSE OF THE
TANK 241-SY-101 CRUST TO WASTE TRANSFERS AND BACK DILUTION**

Basic Critical Buoyancy Model

1000 Gall Advection from Water Pump

Water Addition at Mixer Pump

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ENCLOSURE 16 – PART 5

POSSIBLE WASTE TRANSFER AND BACK DILUTION CONTROL DECISIONS

CONTROL DECISIONS FROM SEPTEMBER 9, 1999

Flammable Gas Deflagration

AC: Tank 241-SY-101 Mixer Pump Operation and Performance Monitoring

AC: Tank 241-SY-101 Ignition Controls

AC: Tank 241-SY-101 Flammable Gas Monitoring Controls

Mixing of Incompatible Material – Toxic Vapor Generation

SS: 241-SY Tank Farm Primary Tank Ventilation System

SS: Ammonia Monitoring Systems (Tank 241-SY-101 and 241-SY Tank Farm Primary Tank Ventilation Exhaust)

AC: 241-SY Tank Farm Primary Tank Ventilation System

AC: Ammonia Monitoring (Tank 241-SY-101 and 241-SY Tank Farm Primary Tank Ventilation Exhaust)

Notes: Based on the information presented at the September 9, 1999 control decision meeting:

1. There were no waste transfer controls identified (i.e., no limit on the waste transfer volume).
2. There were no back dilution controls, but back dilution was limited to addition low in the tank (i.e., via the mixer pump burrowing ring or the waste transfer pump)

HNF-3737, HNF-IP-1266, and PRC reviews were completed on these controls.

**CONTROL DECISION OPTION A (BASED ON DIRECTION OF
OCTOBER 6, 1999, I.E., BACK DILUTION ONLY AS A
CORRECTIVE ACTION TO RESTORE MIXER PUMP
OPERATION OR PERFORMANCE)**

Flammable Gas Deflagration

SC: Siphon Break in Tank 241-SY-101 Drop Leg

SC: Tank 241-SY-101 Waste Transfer Flow Totalizer

SC: Dilution Water Flow Totalizer

AC: Tank 241-SY-101 Mixer Pump Operation and Performance
Monitoring (Revised to include restriction on back dilution if
required to restore mixer pump operation or performance)

AC: Tank 241-SY-101 Ignition Controls

AC: Tank 241-SY-101 Flammable Gas Monitoring Controls

AC: Tank 241-SY-101 Waste Transfer Control

Mixing of Incompatible Material – Toxic Vapor Generation

SS: 241-SY Tank Farm Primary Tank Ventilation System

SS: Ammonia Monitoring Systems (Tank 241-SY-101 and 241-SY
Tank Farm Primary Tank Ventilation Exhaust)

AC: 241-SY Tank Farm Primary Tank Ventilation System

AC: Ammonia Monitoring (Tank 241-SY-101 and 241-SY Tank
Farm Primary Tank Ventilation Exhaust)

CONTROL DECISION OPTION B (AUTHORIZATION BACK DILUTION WITH LIMITS ON TOP AND LOW ADDITIONS)

Flammable Gas Deflagration

SC: Siphon Break in Tank 241-SY-101 Drop Leg

SC: Tank 241-SY-101 Waste Transfer Flow Totalizer

SC: Dilution Water Flow Totalizer

AC: Tank 241-SY-101 Mixer Pump Operation and Performance
Monitoring

AC: Tank 241-SY-101 Back Dilution Control (includes limits on top
and low back dilution)

AC: Tank 241-SY-101 Ignition Controls

AC: Tank 241-SY-101 Flammable Gas Monitoring Controls

AC: Tank 241-SY-101 Waste Transfer Control

Mixing of Incompatible Material – Toxic Vapor Generation

SS: 241-SY Tank Farm Primary Tank Ventilation System

SS: Ammonia Monitoring Systems (Tank 241-SY-101 and 241-SY
Tank Farm Primary Tank Ventilation Exhaust)

AC: 241-SY Tank Farm Primary Tank Ventilation System

AC: Ammonia Monitoring (Tank 241-SY-101 and 241-SY Tank
Farm Primary Tank Ventilation Exhaust)

**CONTROL DECISION OPTION C (AUTHORIZATION OF BACK
DILUTION WITH NO LIMITS ON TOP ADDITION)**

Flammable Gas Deflagration

SC: Siphon Break in Tank 241-SY-101 Drop Leg

SC: Tank 241-SY-101 Waste Transfer Flow Totalizer

SC: Dilution Water Flow Totalizer

AC: Tank 241-SY-101 Mixer Pump Operation and Performance
Monitoring

AC: Tank 241-SY-101 Back Dilution Control (includes limits only
on low back dilution)

AC: Tank 241-SY-101 Ignition Controls

AC: Tank 241-SY-101 Flammable Gas Monitoring Controls

AC: Tank 241-SY-101 Waste Transfer Control

Mixing of Incompatible Material – Toxic Vapor Generation

SS: 241-SY Tank Farm Primary Tank Ventilation System

SS: Ammonia Monitoring Systems (Tank 241-SY-101 and 241-SY
Tank Farm Primary Tank Ventilation Exhaust)

AC: 241-SY Tank Farm Primary Tank Ventilation System

AC: Ammonia Monitoring (Tank 241-SY-101 and 241-SY Tank
Farm Primary Tank Ventilation Exhaust)

ENCLOSURE 16 – PART 6

TANK 241-SY-101 WASTE TRANSFER SIPHON CALCULATIONS

SY-101 Transfer Siphoning - WJP - 10/12/1999

Bubble Calculation (Reynolds)

- Proves that a bubble of dilution water will not stay around the inlet of SY-101 pump to be pulled in and siphoned to SY-102

Siphon Calculation (Meyer)

- A low sp. Gr. liquid can be siphoned from SY-101 to SY-102, but only with a continuing dilution source.
- Undiluted SY-101 liquid can not be siphoned to the SY-102 if the passive siphon break is operable.

Fluid Flow Up Through Drop Leg Air Gap (Thurgood)

- Establishes when liquid will flow out the siphon break air gap in SY-102.
- Process Variables are:
 - Sp gr. in SY-102, expected is 1.24 to 1.3
 - Sp gr. of waste in transfer line, expected is 1.3, (range 1.2 to 1.4)
 - Transfer flow rate, expected is 120 gpm, (range is 70 to 210)
- Transfer conditions which will may cause siphoning:
 - >210 gpm waste transfer at 1.2 sp. Gr. and
 - >380 inches of waste in SY-102 and
 - >1.3 sp gr in SY-102

Minimum Siphon Break Orifice Area (Adkins)

- Transfer flow of 1.4 sp gr. the orifice can be reduced to 45% of its original volume and still operate.
- If the orifice was wetted 84 times the ¼ inch orifice could be closed.
- 1.7 sp gr waste would rise to 284 inches in SY-101 when sp gr 1.4 fluid is siphoned over to SY-102.

Conclusions:

1. Assure that water is not left on to SY-101 system-existing control- admin. lock
2. Loss of Pump- expect a siphon to occur prior to water shut off.
3. If orifice is wetted and allowed to dry too much it could become progressively inoperable.
 - Prevent plugging by not wetting the orifice
 - Use manual siphon break.
 - If siphon becomes inoperable undiluted SY-101 waste could be siphoned through the pump and lines on pump shut down.

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JOHN MARVIN, INC.

Calculation Number: JMI-9907-3, Rev 1.

Analyst: Marvin J. Thurgood

Date: Sep 26, 1999

Reviewer: Harold E. Adkins

Date: Sep 26, 1999

Subject: Fluid Flow Up Through Drop Leg Air Gap

HNF-4359, Rev. 0-E

Figure 4.2 Allowable Waste Height In Tank SY-102
Assuming γ_{102} is 1.3 and Inlet Waste γ
varies (Waste Height Relative to Bottom of
SY-101, add 10 inches to above level for
level from bottom of SY-102).

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Appendix G

APPENDIX G

**ENGINEERED AND ADMINISTRATIVE CONTROLS FOR
HAZARDOUS CONDITIONS IDENTIFIED FOR
TANK 241-SY-101 WASTE TRANSFERS AND BACK DILUTION**

M. V. Shultz

The tables in this appendix include all potential hazardous conditions identified for Tank 241-SY-101 waste transfers and back dilution. Please note that although hazardous conditions are included for back dilution of Tank 241-SY-101 waste (i.e., SYDIL-XX), the safety analysis for back dilution activities subsequent to the initial back dilution has not been completed. Therefore, additional controls may be required to prevent or mitigate these potential hazardous conditions based on the results of ongoing analyses and subsequent control decisions.

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APPENDIX G

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Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Cons
ABBREVIATION LIST: Admin = Administrative Cause = Consequence Cons = Consequence Cntrl = Controls Detect = Detection Ign = Ignition Mon = Monitoring Prep = Preparedness Sys = Systems Trans = Transfer TSR = Technical Safety Requirement								
HEPA Filter Failure - Exposure to High Temperature or Pressure (BIO Section 5.3.2.2)								
SYDIL-33	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to filter failure from increased loading and unfiltered release	High pressure crust spray nozzles increase radiological and toxicological aerosols in Tank 241-SY-101 headspace creating a greater potential for increased loading rate and failure of ventilation system filters	None required	None required	SS: Ventilation CAM Interlock Syss	LCO: Ventilation Stack CAM Interlock Syss AC: HEPA Filter Cntrls (Source Term)	Controls based on accident analysis (Unfiltered Release). Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	S2
Fire in Contaminated Area (BIO Section 5.3.2.3)								
SYXFR-N5-08	Release of radioactive particulates from PPP due to flammable gas accumulation and ignition Exposure of personnel to ionizing radiation	Flammable gas presence in PPP plus ignition	SC: Trans Leak Detect Syss SS: Tank Level Detect Sys SS: SY-101 Waste Transfer Flow Totalizer	LCO: Trans Leak Detect Syss AC: Ign Cntrls AC: Flammable Gas Mon Cntrls AC: Trans Cntrls (Leak Prevention/Detect)	None required	AC: Emergency Prep (Response Procedures)	Controls based on BIO Appendix E and accident analysis (Surface Leak Resulting in Pool, and Fire in Contaminated Area).	S2

Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Mixing of Incompatible Material - Toxic Vapor Generation (BIO Section 5.3.2.11)	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Cons
SYDIL-02	Release of ammonia gas from Tank 241-SY-101 to atmosphere due to gas release, no ignition postulated	Water rises to base of crust with little mixing, causing crust dissolution and flammable gas release, no ignition source present	None required	None required	None required	SS: SY Farm Exhaust Ventilation Sys SS: SY Farm Ammonia Mon Sys	LCO: DST and AWF Tank Ventilation Sys SY Farm Ammonia Mon	Controls based on control decisions for Tank 241-SY-101 Waste Transfer. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	S2
SYDIL-11	Release of ammonia gas from Tank 241-SY-101 to atmosphere due to gas release, no ignition postulated	See hazardous conditions identified for Flammable Gas Deflagrations	None required	None required	None required	SS: SY Farm Exhaust Ventilation Sys SS: SY Farm Ammonia Mon Sys	LCO: DST and AWF Tank Ventilation Sys SY Farm Ammonia Mon	Controls based on control decisions for Tank 241-SY-101 Waste Transfer. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	S2
SYXFR11-46b	Release of toxic gas to environment from Tank 241-SY-102 and exposure of personnel	Drop leg design error results in waste level being below discharge point - entrained gasses are released as waste is discharged	None required	None required	None required	SS: SY Farm Exhaust Ventilation Sys SS: SY Farm Ammonia Mon Sys	LCO: DST and AWF Tank Ventilation Sys SY Farm Ammonia Mon	Controls based on control decisions for Tank 241-SY-101 Waste Transfer.	S2

Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Tank Failure Due to Excessive Loads (BIO Section 5.3.2.13)					Mit TSRs	Memo	Cons
			Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs				
101SYWLV-8A	Release of radioactive/hazardous material from tank to atmosphere due to excessive load on tank equipment	Crust adheres to suspended hardware with crust collapse or transfer out of sufficient amount creating release path through damaged tank dome	None required	None required	None required	None required	No controls required based on low event frequency.			S2
SYXFR01-04	Dropped equipment during installation damages Tank 241-SY-101 riser and/or tank dome	Damage to riser due to- Jam- Drop on riser or tank dome- Vehicle impact	None required	AC: Dome Loading Cntrls	None required	None required	Controls based on accident analysis (Tank Failure Due to Excessive Loads).			S2
SYXFR01-05	Localized load potentially damages Tank 241-SY-101 dome/riser creating unfiltered path for aerosol release	Overloaded tank dome due to PPP assembly installation	None required	AC: Dome Loading Cntrls	None required	None required	Controls based on accident analysis (Tank Failure Due to Excessive Loads).			S3
SYXFR03-13b	Dome failure due to overload from solidified waste suspended from intank equipment due to low liquid level in Tank 241-SY-101	Human error or instrument failure results in excessive transfer or siphoning	None required	None required	None required	None required	No controls required based on low event frequency.			S2

Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Cons
Flammable Gas Deflagrations - DST (BIO Section 5.3.2.14)								
101SYWLV-18A	Release of radioactive/hazardous material from tank to atmosphere due to flammable gas deflagration	Crust penetration/disturbance releasing flammable gas from the crust with ignition. Sufficient gas release for tank LFL is not possible unless disturbance propagates quickly away from initiating point	None required	None required	None required	None required	No controls required based on low event frequency.	S3
101SYWLV-22AT	Release of radioactive/hazardous material from tank to atmosphere due to flammable gas deflagration	Crust subsides during transfer creating GRE from crust with ignition	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101.	S3
101SYWLV-23AT	Release of radioactive/hazardous material from tank to atmosphere due to flammable gas deflagration	Injection of water into the transfer pump for in-line dilution coupled with a transfer failure results in releasing gas from crust with ignition	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101.	S3

Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Cons
101SYWLV-24AT	Release of radioactive/hazardous material from tank to atmosphere due to flammable gas deflagration	Buoyant displacement GRE with ignition due to change in hydrostatic pressure from reduction in tank level	None required	None required	None required	None required	No controls required based on low event frequency.	S3
101SYWLV-25AT	Release of radioactive/hazardous material from tank to atmosphere due to flammable gas deflagration	Buoyant displacement GRE with ignition due to change in hydrostatic pressure from reduction in tank level	None required	None required	None required	None required	No controls required based on low event frequency.	S3
101SYWLV-4BT-SL	Release of radioactive/hazardous material from tank to atmosphere due to flammable gas deflagration	Buoyant displacement GRE from slurry layer with ignition	None required	None required	None required	None required	No controls required based on low event frequency.	S3
SYDIL-01	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Water rises to base of crust with little mixing, causing crust dissolution and flammable gas release, ignition source present	SC: DST/AFW Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LC: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ignition Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	S3

Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Cons
SYDIL-04	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Excessive water addition causes water to rise to base of crust with little mixing, causing crust dissolution and flammable gas release, ignition source present	SC: DST/WWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	S3
SYDIL-06	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Create stratification affecting mixer pump operation causing increased gas retention at depth with a return to BD GRE, ignition source present	None required	None required	None required	None required	No controls required based on low event frequency.	S3

Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Cons
SYDIL-08	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Mechanical disruption due to crust displacement from water addition resulting in flammable gas release, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LSO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	S3
SYDIL-09	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Mechanical disruption due to crust displacement from water addition damaging mixer pump, causing increased gas retention at depth with a return to BD GRE, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss SC: Siphon Break SC: SY-101 Waste Transfer Flow Totalizer SC: Dilution Water Flow Totalizer	LSO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls SY-101 Waste Trans Control SY-101 Mixer Pump Operation and Performance Monitoring SY-101 Back Dilution Control	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	S3

Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Prev SSC's	Prev TSRs	Mit SSC's	Mit TSRs	Memo	Cons
SYDIL-12	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Dilution water does not float crust resulting in void ingestion in the mixer pump degrading pump performance or mechanically failing pump, causing increased gas retention at depth with a return to BD GRE, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss SC: Siphon Break SC: SY-101 Waste Transfer Flow Totalizer SC: Dilution Water Flow Totalizer	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls SY-101 Waste Trans Control SY-101 Mixer Pump Operation and Performance Monitoring SY-101 Back Dilution Control	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	S3
SYDIL-13	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Mixer pump creates 'cavity' in crust which collects flammable gas during dilution resulting in a possible sudden significant release of gas, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	S3

Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Cons
SYDIL-14	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Water addition releases crust gas decreasing the buoyancy of the crust causing the crust to sink resulting in additional gas release, ignition source present	None required	None required	None required	None required	No controls required based on low event frequency.	S3
SYDIL-16	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Water addition releases crust gas decreasing the buoyancy of the crust causing the crust to sink. The additional solids at depth affects mixer pump performance causing increased gas retention at depth with return to BD GREs, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss SC: Siphon Break SC: SY-101 Waste Transfer Flow Totalizer SC: Dilution Water Flow Totalizer	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls SY-101 Waste Trans Control SY-101 Mixer Pump Operation and Performance Monitoring SY-101 Back Dilution Control	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	S3

Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Cons
SYDIL-17	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Water addition releases crust gas decreasing the buoyancy of the crust causing the crust to float lower affecting mixer pump performance/operation causing increased gas retention at depth with a return to BD GREs, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss SC: Siphon Break SC: SY-101 Waste Transfer Flow Totalizer SC: Dilution Water Flow Totalizer	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls SY-101 Waste Trans Control SY-101 Mixer Pump Operation and Performance Monitoring SY-101 Back Dilution Control	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	S3
SYDIL-19	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Dilution water does not float crust resulting in void ingestion in the mixer pump degrading pump performance or mechanically failing pump, causing increased gas retention at depth with a return to BD GREs, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss SC: Siphon Break SC: SY-101 Waste Transfer Flow Totalizer SC: Dilution Water Flow Totalizer	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls SY-101 Waste Trans Control SY-101 Mixer Pump Operation and Performance Monitoring SY-101 Back Dilution Control	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	S3

Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Cons
SYDIL-20	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Mixer pump creates 'cavity' in crust which collects flammable gas during dilution resulting in a possible sudden significant release of gas, ignition source present	SC: DST/AFW Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	S3
SYDIL-21	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Water addition releases crust gas decreasing the buoyancy of the crust causing the crust to sink resulting in additional gas release, ignition source present	None required	None required	None required	None required	No controls required based on low event frequency.	S3

Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Cons
SYDIL-22	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Water addition releases crust gas decreasing the buoyancy of the crust causing the crust to sink. The additional solids at depth affects mixer pump performance causing increased gas retention at depth with return to BD GREs, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss SC: Siphon Break SC: SY-101 Waste Transfer Flow Totalizer SC: Dilution Water Flow Totalizer	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls SY-101 Waste Trans Control SY-101 Mixer Pump Operation and Performance Monitoring SY-101 Back Dilution Control	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	S3
SYDIL-24	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Water addition releases crust gas decreasing the buoyancy of the crust causing the crust to float lower affecting mixer pump performance/operation causing increased gas retention at depth with a return to BD GREs, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss SC: Siphon Break SC: SY-101 Waste Transfer Flow Totalizer SC: Dilution Water Flow Totalizer	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls SY-101 Waste Trans Control SY-101 Mixer Pump Operation and Performance Monitoring SY-101 Back Dilution Control	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	S3

Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Cons
SYDIL-25	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Dissolved large hole allows for lateral crust motion causing waste berg turnover resulting in flammable gas release and ignition	None required	None required	None required	None required	No controls required based on low event frequency.	S3
SYDIL-27	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Dissolved large hole allows bubble slurry flow to top of crust resulting in flammable gas release and ignition	SC: DST/WWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and WWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	S3
SYDIL-28	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Dissolved large hole allows for lateral motion causing waste berg turnover resulting in flammable gas release and ignition	None required	None required	None required	None required	No controls required based on low event frequency.	S3

Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Cons
SYDIL-31	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Water addition in general increases the head (pressure) at any point in the waste compressing bubbles causing a portion of the crust to sink and release gas, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	S3
SYDIL-32	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Operation of mixer pump releases gas at depth which adds to gas release from crust increasing quantity of flammable gas available for burn, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	S3

Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Cons
SYDIL-34	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Spray on top results in weakened crust causing crust "roll over" and flammable gas release, ignition source present	SC: DST/WWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls SY-101 Back Dilution Control	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	S3
SYDIL-36	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Cold water precipitates solids with deleterious properties; affects mixer pump operation causing increased gas retention at depth with a return to BD GRE; ignition source present	None required	None required	None required	None required	No controls required based on low event frequency.	S3

Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Cons
SYDIL-38	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Introduction of higher temperature water increases tank temperature which reduces gas solubility causing release of flammable gas, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	S3
SYDIL-39	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Introduction of higher temperature water causes potentially large amount of adsorbed gas species to be released by the small temperature change (phase change from gas to liquid), ignition source present	None required	None required	None required	None required	No controls required based on low event frequency.	S3

Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Cons
SYDIL-40	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Excessive water addition rate causing rapid crust dissolution, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	S3
SYDIL-41	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Excessive water addition rate could cause mechanical disruption of the crust, causing flammable gas release, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	S3

Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Cons
SYDIL-42	See all related hazardous conditions developed above related to crust sinking events	Water addition releases crust gas decreasing crust buoyancy causing crust to sink	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls SY-101 Mixer Pump Operation and Performance Monitoring	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	S3
SYDIL-43	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Crust dissolution releases imbedded foreign objects which can become entrained in the mixer pump causing pump damage or failure causing increased gas retention at depth with a return to BD GRE, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss SC: Siphon Break SC: SY-101 Waste Transfer Flow Totalizer SC: Dilution Water Flow Totalizer	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls SY-101 Waste Trans Control SY-101 Mixer Pump Operation and Performance Monitoring SY-101 Back Dilution Control	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	S3

Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Cons
SYXFR01-02	Flammable gas ignites in Tank 241-SY-101 when riser activities cause spark resulting in radioactive aerosol release	Flammable gas ignition	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101.	S3
SYXFR01-07	Flammable gas generated and ignited in Tank 241-SY-101 due to intrusive activity resulting in release of radioactive aerosols	Insertion of transfer pump into tank disturbs waste releasing flammable gas	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101.	S3
SYXFR02-09	Flammable gas ignition in Tank 241-SY-102 during drop leg installation results in aerosol release of radioactive material	Flammable gas ignition	SC: DST/AWF Ventilation	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls AC: Ign Cntrls AC: Flammable Gas Mon Cntrls AC: Process Instrumentation and Measuring and Test Equipment	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis.	S3

Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Cons
SYXFR03-12a	Aerosol release of radioactive material due to change of solubility causing larger quantity of precipitated material resulting in increase of flammable gas being trapped on particles in Tank 241-SY-101 resulting in BDGRE with ignition	Failure of service water heating resulting in addition of cold dilution water with failure of transfer pump cooling waste causing larger quantity of precipitated material, increased accumulation of flammable gas trapped	None required	None required	None required	None required	No controls required based on low event frequency.	S3
SYXFR03-12b	Ignition of significant quantities of flammable gas in Tank 241-SY-101 released from dissolution of crust causing radioactive aerosol release	Hot flush/dilution water added (failure of temperature control) coupled with failure to transfer material	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101.	S3

Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Cons
SYXFR03-13a	Release of radioactive aerosols due to ignition of large quantities of flammable gas in Tank 241-SY-101 released from buoyant displacement GRE	Human error or instrument failure results in excessive transfer or siphoning. Failure to continue GRE prevention due to inability to operate mixer pump - Mixer pump suction in crust - Mixer pump suction out of waste	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss SC: Siphon Break SC: SY-101 Waste Transfer Flow Totalizer SC: Dilution Water Flow Totalizer	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls SY-101 Waste Trans Control SY-101 Mixer Pump Operation and Performance Monitoring SY-101 Back Dilution Control	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101.	S3
SYXFR03-15a	Radioactive aerosol release due to water addition dissolving crust causing GRE with ignition in Tank 241-SY-101 (HNF-3645, 101SY-WLV-23AT)	Excessive dilution without transfer occurring -plugged transfer line -bad pump -bad flow meters -operator error coupled with instrument error	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101.	S3

Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Cons
SYXFR03-15b	Radioactive aerosol release due to water addition dissolving crust causing GRE with ignition in Tank 241-SY-101 (HNF-3645, 101SY-WLV-23AT)	Inadvertent draining from the flush tank	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101.	S3
SYXFR04-17	Radioactive aerosol release due to spray leak dissolving crust causing GRE with ignition in Tank 241-SY-101	Hole in pipe (spray leak) inside dome space	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101.	S3
SYXFR04-18	Radioactive aerosol release due to ignition of flammable gas released from disturbed crust in Tank 241-SY-101. Also identified in HNF-3645, Item 101SY-WLV-22AT	Rapid transfer disturbs crust greater than postulated	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101.	S3

Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Cons
SYXFR04-22	Ignition of significant quantities of flammable gas released from dissolution of crust in Tank 241-SY-101 causing radioactive aerosol release	Hot flush/dilution water added (failure of temperature control) coupled with failure to transfer material heats tank waste	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Sys	LCO: DST and AWF Tank Ventilation Sys AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101.	S3
SYXFR11-46a	Release of radioactive aerosols due to flammable gas deflagration in Tank 241-SY-102	Drop leg design error results in waste level being below discharge point - entrained gasses are released as waste is discharged	SC: DST/AWF Ventilation	LCO: DST and AWF Tank Ventilation Sys AC: Flammability Cntrls AC: Ign Cntrls AC: Flammable Gas Mon Cntrls AC: Process Instrumentation and Measuring and Test Equipment	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101.	S3
SYXFR11-48a	Flammable gas deflagration due to increased gas generation in Tank 241-SY-102 results in release of radioactive aerosols	Low liquid level prevents drop leg from distributing solids	SC: DST/AWF Ventilation	LCO: DST and AWF Tank Ventilation Sys AC: Flammability Cntrls AC: Ign Cntrls AC: Flammable Gas Mon Cntrls AC: Process Instrumentation and Measuring and Test Equipment	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101.	S3

Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Cons
SYXFR12-52	Ignition of significant quantities of flammable gas released in Tank 241-SY-101 from dissolution of crust causing radioactive aerosol release	Hot flush/dilution water added (failure of temperature control) coupled with failure to transfer material	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101.	S3
SYXFR13-56	Release of radioactive aerosols due to ignition of flammable gas in Tank 241-SY-101 released due to crust disturbance	Nozzle breaks off decon spray ring creating minor disturbance of crust/waste	None required	None required	None required	None required	No controls required based on low event frequency.	S3
Surface Leak Resulting in Pool (BIO Section 5.3.2.18)								
SYDIL-03	Release of radioactive/hazardous material from Tank 241-SY-101 to soil surface due to tank overflow	Excessive water addition	None required	None required	SS: Tank Level Detect Syss SS: Service Water Flow Totalizers	AC: Emergency Prep AC: Tank Service Water Intrusion Mon Program	Controls based on accident analyses (Surface Leak Resulting in Pool).	S2
SYDIL-05	Release of radioactive/hazardous material from Tank 241-SY-101 to soil surface due to tank overflow	Water addition has little effect on gas retention causing increased tank volume, crust continues to grow out riser	None required	None required	None required	None required	No controls required based on low event frequency.	S3

Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Cons
SYXFR-N5-05a	Release of radioactive liquid from PPP to the soil due to pool leak	Backflow of encasement from primary line (hose) leak (break near PPP or SY-102 encasement end plugged) - plus failure of PPP drain	None required	None required	SC: Trans Leak Detect Syss SC/SS: PPP SC: OGT Encasement and Connections SC: SY-102 Drop Leg Enclosure SS: Tank Level Detect Sys SS: SY-101 Waste Transfer Flow Totalizer	LCO: Trans Sys Cvr and Entry Doors LCO: Trans Leak Detect Syss AC: Trans Cntrls AC: Emergency Prep (Response Procedures) AC: Trans Pump Admin Lock Cntrls AC: Trans Sys Cvr Removal Cntrls	Controls based on accident analyses (Surface Leak Resulting in Pool).	S3
SYXFR-N5-09	Release of radioactive liquid from PPP to soil surface due to leak forming pool	Waste leak within the PPP enclosure or SY-102 drop leg enclosure (and plugged drain)	None required	None required	SC: Trans Leak Detect Syss SC/SS: PPP SC: OGT Encasement and Connections SC: SY-102 Drop Leg Enclosure SS: Tank Level Detect Sys SS: SY-101 Waste Transfer Flow Totalizer	LCO: Trans Sys Cvr and Entry Doors LCO: Trans Leak Detect Syss AC: Trans Cntrls AC: Emergency Prep (Response Procedures) AC: Trans Pump Admin Lock Cntrls AC: Trans Sys Cvr Removal Cntrls	Controls based on accident analyses (Surface Leak Resulting in Pool).	S3
SYXFR-N5-10a	Release of radioactive waste from PPP to soil surface due to seismic event damaging PPP and primary pipe (hose)	Seismic event	None required	None required	None required	AC: Emergency Prep (Response Procedures)	Controls based on control decision for Tank 241-SY-101 Waste Transfer.	S3

Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Cons
SYXFR-N5-11	Release of radioactive waste from PPP to soil surface due to vehicle/equipment impact damaging PPP and primary pipe (hose)	Vehicle/ equipment striking PPP	None required	AC: Ign Cntrls (Vehicle Cntrls) AC: Trans Cntrls (Vehicle Restrictions)	None required	AC: Emergency Prep (Response Procedures)	Controls based on accident analyses (Surface Leak Resulting in Pool).	S3
SYXFR-N5-12a	Release of radioactive waste from PPP to soil surface due to wind driven missiles damaging PPP and primary pipe (hose)	Wind driven missiles	SC: PPP SC: OGT Encasements and Connections SC: SY-102 Drop Leg Enclosure	None required	None required	AC: Emergency Prep (Response Procedures)	Controls based on control decision process for Tank 241-SY-101 Waste Transfer.	S3
SYXFR-N5-16	Release of radioactive waste from PPP to soil surface due to primary line (hose) leak with plugged PPP drain	Extreme cold weather	None required	None required	None required	None required	No controls required based on low event frequency.	S3
SYXFR-N8-20a	Release of radioactive waste from PPP to soil surface due to seismic event damaging OGT and primary pipe (hose)	Seismic event	None required	None required	None required	AC: Emergency Prep (Response Procedures)	Controls based on control decision for Tank 241-SY-101 waste transfer.	S3
SYXFR-N8-21	Release of radioactive waste from PPP to soil surface due to vehicle/equipment impact damaging OGT and primary pipe (hose)	Vehicle/ Equipment impacting OGT	None required	AC: Ign Cntrls (Vehicle Cntrls) AC: Trans Cntrls (Leak Detect and Vehicle Restrictions)	None required	AC: Emergency Prep (Response Procedures)	Controls based on accident analyses (Surface Leak Resulting in Pool).	S3

Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Cons
SYXFR-N8a-22a	Release of radioactive waste from OGT to soil surface due to wind driven missiles breaching encasement and primary pipe (hose)	Wind driven missiles	SC: PPP SC: OGT Encasements and Connections SC: SY-102 Drop Leg Enclosure	None required	None required	AC: Emergency Prep (Response Procedures)	Controls based on control decision for Tank 241-SY-101 Waste Transfer.	S3
SYXFR-N8a-03	Release of radioactive/hazardous material from transfer hose to soil surface due to freezing	Ambient temperature extremely low with failure during transfer	None required	None required	SC: OGT Encasement and Connections SS: Tank Level Detection Sys SS: SY-101 Waste Transfer Flow Totalizer	AC: Trans Cntrls (Material Balance) AC: Emergency Prep (Response Procedures)	Controls based on accident analysis (Surface Leak Resulting in Pool).	S3
SYXFR-N8a-04	Release of radioactive/hazardous material from transfer hose to soil surface due to high temperature	Runaway heat trace with transfer	None required	None required	SC: OGT Encasement and Connections SS: Tank Level Detection Sys SS: SY-101 Waste Transfer Flow Totalizer	AC: Trans Cntrls (Material Balance) AC: Emergency Prep (Response Procedures)	Controls based on accident analysis (Surface Leak Resulting in Pool).	S3
SYXFR-N8a-05	Release of radioactive/hazardous material from transfer hose to soil surface due to high temperature	High temperature waste transferred	None required	None required	SC: OGT Encasement and Connections SS: Tank Level Detection Sys SS: SY-101 Waste Transfer Flow Totalizer	AC: Trans Cntrls (Material Balance) AC: Emergency Prep (Response Procedures)	Controls based on accident analysis (Surface Leak Resulting in Pool).	S3
SYXFR-N8a-06	Release of radioactive/hazardous material from transfer hose to soil surface due to high temperature	External fire (range fire, fuel fire, etc.) during transfer	None required	AC: Ign Cntrls (Vehicle Cntrls) AC: Trans Cntrls (Vehicle Restrictions)	SC: OGT Encasement and Connections SS: Tank Level Detection Sys SS: SY-101 Waste Transfer Flow Totalizer	AC: Trans Cntrls (Material Balance) AC: Emergency Prep (Response Procedures)	Controls based on accident analysis (Surface Leak Resulting in Pool).	S3

Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Cons
SYXFR-N8a-07	Release of radioactive/hazardous material from transfer hose to soil surface due to mechanical abrasion	Mechanical abrasion with transfer	None required	None required	SC: OGT Encasement and Connections SS: Tank Level Detection Sys SS: SY-101 Waste Transfer Flow Totalizer	AC: Trans Cntrls (Material Balance) AC: Emergency Prep (Response Procedures)	Controls based on accident analysis (Surface Leak Resulting in Pool).	S3
SYXFR-N8a-08	Release of radioactive/hazardous material from transfer hose to soil surface due to radiation damage	Radiation damage	None required	None required	SC: OGT Encasement and Connections SS: Tank Level Detection Sys SS: SY-101 Waste Transfer Flow Totalizer	AC: Trans Cntrls (Material Balance) AC: Emergency Prep (Response Procedures)	Controls based on accident analysis (Surface Leak Resulting in Pool).	S3
SYXFR-N8a-09	Release of radioactive/hazardous material from transfer hose connections to soil surface due to pipe whip	Pipe whip due to slug flow	None required	None required	SC: OGT Encasement and Connections SS: Tank Level Detection Sys SS: SY-101 Waste Transfer Flow Totalizer	AC: Trans Cntrls (Material Balance) AC: Emergency Prep (Response Procedures)	Controls based on accident analysis (Surface Leak Resulting in Pool).	S3
SYXFR-N8a-11	Release of radioactive/hazardous material from transfer hose connections to soil surface due to vehicle collision	Vehicle collision with connection site with transfer	None required	AC: Ign Cntrls (Vehicle Cntrls) AC: Trans Cntrls (Vehicle Restrictions)	SC: OGT Encasement and Connections	AC: Emergency Prep (Response Procedures)	Controls based on accident analysis (Surface Leak Resulting in Pool).	S3
SYXFR-N8a-12	Release of radioactive/hazardous material from transfer hose to soil surface due to external event	Damage of inner and outer hose due to external event (crane, vehicle, airplane, etc.) with transfer	None required	AC: Trans Cntrls (OGT, Vehicle Access) AC: Trans Cntrls (Vehicle Restrictions) AC: Dome Loading (Hoisting and Rigging Manual)	SC: OGT Encasement and Connections	AC: Emergency Prep (Response Procedures)	Controls based on accident analysis (Surface Leak Resulting in Pool).	S3

Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Cons
SYXFR-N8a-14	Release of radioactive/hazardous material from transfer hose to soil surface due to incompatible material	Incompatible material (e.g. chemical attack) fails inner and outer hose	None required	None required	SC: OGT Encasement and Connections SS: Tank Level Detection Sys SS: SY-101 Waste Transfer Flow Totalizer	AC: Trans Cntrls (Material Balance) AC: Emergency Prep (Response Procedures)	Controls based on accident analyses (Surface Leak Resulting in Pool).	S3
SYXFR-N8a-15	Release of radioactive/hazardous material from transfer hose to soil surface due to freezing	Water fill freezes due to low ambient temperature and damages inner and outer hose with transfer	None required	None required	None required	None required	No controls required based on low event frequency.	S3
SYXFR03-14a	Release of radioactive material from waste tank due to overflow of Tank 241-SY-101 resulting in pool (see HNF-3645 for details)	Excessive dilution without transfer occurring - plugged transfer line - bad pump - bad flow meters - operator error coupled with instrument failure	None required	None required	SS: Tank Level Detect Syss SS: Service Water Flow Totalizers	AC: Emergency Prep AC: Tank Service Water Intrusion Mon Program	Controls based on accident analyses (Surface Leak Resulting in Pool).	S2
SYXFR03-14b	Release of radioactive material from waste tank due to overflow of Tank 241-SY-101 resulting in pool (see HNF-3645 for details)	Inadvertent draining from flush tank	None required	None required	SS: Tank Level Detect Syss SS: Service Water Flow Totalizers	AC: Emergency Prep AC: Tank Service Water Intrusion Mon Program	Controls based on accident analyses (Surface Leak Resulting in Pool).	S2
SYXFR04-19	Release of radioactive material from waste tank due to overflow of Tank 241-SY-101 resulting in pool (see HNF-3645 for details)	Human error or equipment failure results in running flush water into system, discharge valve closed on Tank 241-SY-102, backflow to Tank 241-SY-101	None required	None required	SS: Tank Level Detect Syss SS: Service Water Flow Totalizers	AC: Emergency Prep AC: Tank Service Water Intrusion Mon Program	Controls based on accident analyses (Surface Leak Resulting in Pool).	S2

Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Cons
SYXFR05-24b2	Overflow of Tank 241-SY-101 PPP due to leak from line, flange or valve	Ruptured line/leaking flange or valve inside Tank 241-SY-101 PPP	None required	None required	SC: Trans Leak Detect Syss SC/SS: PPP SC: OGT Encasement and Connections SC: SY-102 Drop Leg Enclosure SS: Tank Level Detect Sys SS: SY-101 Waste Transfer Flow Totalizer	LCO: Trans Sys Cvr and Entry Doors LCO: Trans Leak Detect Syss AC: Trans Cntrls AC: Emergency Prep (Response Procedures) AC: Trans Pump Admin Lock Cntrls AC: Trans Sys Cvr Removal Cntrls	Controls based on accident analyses (Surface Leak Resulting in Pool).	S3
SYXFR05-24c	Release of radioactive liquid from flush tank due to pool leak caused by backflow of waste into flush system	Human error causing incorrect valving (flush pump must be off)	SC: Pressure Switch Interlocks or Alarms (Water Service Lines) SS: Backflow Prevention Devices	LCO: Service Water Pressure Detect Syss	None required	None required	Controls based on accident analyses (Surface Leak Resulting in Pool).	S3
SYXFR05-28b2	Release of liquid waste in Tank 241-SY-101 PPP due to leak from line, flange or valve forming pool	Ruptured line/leaking flange or valve inside Tank 241-SY-101 PPP	None required	None required	SC: Trans Leak Detect Syss SC/SS: PPP SC: OGT Encasement and Connections SC: SY-102 Drop Leg Enclosure SS: Tank Level Detect Sys SS: SY-101 Waste Transfer Flow Totalizer	LCO: Trans Sys Cvr and Entry Doors LCO: Trans Leak Detect Syss AC: Trans Cntrls AC: Emergency Prep (Response Procedures) AC: Trans Pump Admin Lock Cntrls AC: Trans Sys Cvr Removal Cntrls	Controls based on accident analyses (Surface Leak Resulting in Pool).	S3

Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Cons
SYXFR05-28c	Release of radioactive liquid due to pool leak caused by backflow of waste into flush system overflowing flush tank	Human error causing incorrect valving (flush pump must be off)	SC: Pressure Switch Interlocks or Alarms (Water Service Lines) SS: Backflow Prevention Devices	LCO: Service Water Pressure Detect Syss	None required	None required	Controls based on accident analyses (Surface Leak Resulting in Pool).	S3
Spray Leak in Structure or from Overground Waste Transfer Lines (BIO Section 5.3.2.20)								
SYXFR-N5-05b	Release of radioactive aerosols from PPP due to spray leak in PPP or OGT encasement	Primary line (hose) spray leak (break in PPP, "Riser Extension", or OGT encasement)	None	None	SC: PPP SC: OGT Encasements and Connections SC: SY-102 Drop Leg Enclosure	LCO: Trans Sys Cvr and Entry Doors AC: Trans Sys Cvr Removal Cntrls	Controls based on accident analysis (Spray Leak in Structure or from Overground Waste Transfer Lines) and control decision for Tank 241-SY-101 Waste Transfer.	S3
SYXFR-N5-10b	Release of radioactive aerosols from PPP to atmosphere due to seismic event damaging PPP and primary pipe (hose)	Seismic event	None required	None required	None required	AC: Emergency Prep (Response Procedures)	Controls based on control decision for Tank 241-SY-101 Waste Transfer.	S3
SYXFR-N5-12b	Release of radioactive aerosols from PPP to atmosphere due to wind driven missiles damaging PPP and primary pipe (hose)	Wind driven missiles	SC: PPP SC: OGT Encasements and Connections SC: SY-102 Drop Leg Enclosure	None required	None required	AC: Emergency Prep (Response Procedures)	Controls based on control decision for Tank 241-SY-101 Waste Transfer.	S3
SYXFR-N8-20b	Release of radioactive aerosols from OGT to atmosphere due to seismic event damaging OGT encasement and primary pipe (hose)	Seismic event	None required	None required	None required	AC: Emergency Prep (Response Procedures)	Controls based on control decision for Tank 241-SY-101 Waste Transfer.	S3

Table G1. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S3 and S2 Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (32 Sheets)

ID	Hazardous Condition	Cause	Prev SSC's	Prev TSRs	Mit SSC's	Mit TSRs	Memo	Cons
SYXFR-N8-22b	Release of radioactive aerosols from OGT to atmosphere due to wind driven missiles breaching encasement and primary pipe (hose)	Wind driven missiles	SC: PPP SC: OGT Encasements and Connections SC: SY-102 Drop Leg Enclosure	None required	None required	AC: Emergency Prep (Response Procedures)	Controls based on control decision for Tank 241-SY-101 Waste Transfer.	S3
SYXFR05-24b1	Release of radioactive aerosol released in Tank 241-SY-101 PPP due to leak from line, flange or valve	Ruptured line/leaking flange or valve inside Tank 241-SY-101 PPP	None required	None required	SC: PPP SC: OGT Encasements and Connections SC: SY-102 Drop Leg Enclosure	LCO: Trans Sys Cvr and Entry Doors AC: Trans Sys Cvr Removal Cntrl	Controls based on accident analysis (Spray Leak in Structure or from Overground Waste Transfer Lines).	S3
SYXFR05-28b1	Release of aerosol generated in Tank 241-SY-101 PPP due to spray leak from line, flange or valve	Ruptured line/leaking flange or valve inside Tank 241-SY-101 PPP	None required	None required	SC: PPP SC: OGT Encasements and Connections SC: SY-102 Drop Leg Enclosure	LCO: Trans Sys Cvr and Entry Doors AC: Trans Sys Cvr Removal Cntrl	Controls based on accident analysis (Spray Leak in Structure or from Overground Waste Transfer Lines).	S3
SYXFR05-31	Flush with high temperature flush water with preexisting spray leak causes release of high temperature aerosols in Tank 241-SY-101 PPP	Flush water too hot	None required	None required	SC: PPP SC: OGT Encasements and Connections SC: SY-102 Drop Leg Enclosure	LCO: Trans Sys Cvr and Entry Doors AC: Trans Sys Cvr Removal Cntrl	Controls based on accident analysis (Spray Leak in Structure or from Overground Waste Transfer Lines).	S3
SYXFR08-43	Excavation activities during PPP and OGT installation damage waste transfer lines in vicinity of the PPP and OGT	Excavation activities damage transfer lines	None required	AC: Excavation Cntrl	None required	AC: Excavation Cntrl	Controls based on accident analysis (Spray Leak from Underground Waste Transfer Lines).	S3

Spray Leak from Underground Waste Transfer Lines (BIO Section 5.3.2.21)

AC = Administrative Control
AWF = Aging Waste Facility (tank)
BD GRE = buoyant displacement gas release event
DST = double-shell tank
GRE = gas release event
HEPA = high-efficiency particulate air (filter)
LCO = Limiting Condition of Operation
LFL = Lower Flammability Limit
OGT = overground transfer line
PPP = pre-fabricated pump pit
PRC = Plant Review Committee
SC = Safety-Class
SS = Safety-Significant

HNF-3645, 1998, *Hazard Evaluation for Tank 241-SY-101 Waste Surface Level Growth*, Rev. 0, Fluor Daniel Northwest, Inc., Richland, Washington.

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Table G2. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S1 Consequences with F3 Frequency for Tank 241-SY-101 Waste Transfers and Back Dilution. (4 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Detect = Detection	Mit SSRs	Memo
ABBREVIATION LIST: Admin = Administrative Cons = Consequence Cntrls = Controls Detect = Detection Ign = Ignition							
Mon = Monitoring Prep = Preparedness Sys = Systems Trans = Transfer TSR = Technical Safety Requirement							
SYDIL-07	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Excessive water addition, plugging exhaust duct resulting in no ventilation flow through tank resulting in a buildup of flammable gas in Tank 241-SY-101, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101.
SYXFR-N5-03	Minor release of radioactive/toxic contamination to atmosphere due to ventilation failure	Ventilation Failure	None	None	None	None	No applicable SSC's or TSR's - Facility worker exposure controlled by Radiation Protection Program. Facility worker injury controlled by Health and Safety Plan.
SYXFR-N5-04	Release of radioactive/toxic material due to pressurization in Tank 241-SY-102	SY-102 pressurization (tank bump, GRE)	None	None	SS: Ventilation Syss CAM Interlock	LCO: Ventilation Stack CAM Interlock Syss	Controls based on accident analysis (Unfiltered Release). Facility worker exposure controlled by Radiation Protection Program. Facility worker injury controlled by Health and Safety Plan.

Table G2. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S1 Consequences with F3 Frequency for Tank 241-SY-101 Waste Transfers and Back Dilution. (4 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo
SYXFR-N8-06	Exposure of personnel to ionizing radiation from presence of waste in PPP	Backflow of encasement from primary line (hose) leak (break near PPP or SY-102 encasement end plugged)	None	None	SC: Trans Leak Detect Syss SC/SS: PPP SC: OGT Encasement and Connections SC: SY-102 Drop Leg Enclosure SS: Tank Level Detect Sys SS: SY-101 Waste Transfer Flow Totalizer	LCO: Trans Sys Cvr and Entry Doors LCO: Trans Leak Detect Syss AC: Trans Cntrls AC: Emergency Prep (Response Procedures) AC: Trans Pump Admin Lock Cntrls AC: Trans Sys Cvr Removal Cntrls	Controls based on accident analysis (Surface Leak Pool). Facility worker exposure controlled by Radiation Protection Program.
SYXFR-N8-23	Inability to transfer waste and personnel exposure to ionizing radiation	Failed heat trace	None	None	None	None	No applicable SSC's or TSR's - Facility worker exposure controlled by Radiation Protection Program.
SYXFR-N8-24	Inability to transfer waste and personnel exposure to ionizing radiation	High velocity cold air drawn through encasement to Tank 241-SY-102 cooling the transfer line sufficiently to cause crystallization of the waste	None	None	None	None	No applicable SSC's or TSR's - Facility worker exposure controlled by Radiation Protection Program.
SYXFR-N8-25	Inability to transfer waste and personnel exposure to ionizing radiation	Dilution water too cold	None	None	None	None	No applicable SSC's or TSR's - Facility worker exposure controlled by Radiation Protection Program.
SYXFR-N8-26	Release to encasement from primary pipe (hose) due to high temperature damaging hose (drains to Tank 241-SY-102) Personnel exposure to ionizing radiation	Failed heat trace	None	None	SC: OGT Encasement and Connections	None	Controls based on accident analysis (Surface Leak Pool). Facility worker exposure controlled by Radiation Protection Program.

Table G2. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S1 Consequences with F3 Frequency for Tank 241-SY-101 Waste Transfers and Back Dilution. (4 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs AC: Trans Cnrls (Vehicle Restrictions)	Mit SSCs	Mit TSRs	Memo
SYXFR-N8a-01	Exposure of personnel to ionizing radiation due to block of waste flow in hose	Collapse of hose due to vehicle weight	None	None	None	None	Controls based on accident analysis (Surface Leak Resulting in Pool). Facility worker exposure controlled by Radiation Protection Program.
SYXFR-N8a-10	Release of radioactive/hazardous material from transfer hose connections to soil surface due to crane pulling out during draining	Crane stretches hose to failure of connections during draining/ or if flushing not possible	None	None	None	None	No applicable SSCs or TSRs - Facility worker exposure controlled by Radiation Protection Program.
SYXFR01-01	Unfiltered release of radioactive aerosols during PPP installation from Tank 241-SY-101 dome space	Ventilation system failures while riser open results in positive pressure in tank	None	None	None	None	No applicable SSCs or TSR's - Facility worker exposure controlled by Radiation Protection Program.
SYXFR01-03	Personnel are exposed to high levels of ionizing radiation during PPP installation activities	Human error or inadequate protection from shine from open riser	None	None	None	None	No applicable SSCs or TSR's - Facility worker exposure controlled by Radiation Protection Program.
SYXFR02-08	Unfiltered release of radioactive aerosols during drop leg installation from Tank 241-SY-102 dome space	Ventilation system failure while riser open results in positive pressure in tank	None	None	None	None	No applicable SSCs or TSR's - Facility worker exposure controlled by Radiation Protection Program.
SYXFR02-10	Personnel are exposed to high levels of ionizing radiation during drop leg installation activities	Personnel not adequately protected from shine	None	None	None	None	No applicable SSCs or TSR's - Facility worker exposure controlled by Radiation Protection Program.

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Table G2. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potential S1 Consequences with F3 Frequency for Tank 241-SY-101 Waste Transfers and Back Dilution. (4 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo
SYXFR05-24a	Personnel exposure concern due to waste trapped in transfer line	Equipment failure resulting in valve acting as a blockage Transfer pump failure	None	None	None	None	No applicable SSC's or TSR's - Facility worker exposure controlled by Radiation Protection Program.
SYXFR05-24d	Personnel exposure concern due to waste trapped in transfer line	Plugged line	None	None	None	None	No applicable SSC's or TSR's - Facility worker exposure controlled by Radiation Protection Program.
SYXFR05-32	Personnel injured due to occupational hazards	Industrial hazard - hot valve handles etc	None	None	None	None	No applicable SSC's or TSR's - Facility worker injury controlled by Health and Safety Plan.
SYXFR05-33	Personnel exposed to high levels of ionizing radiation	Design problem - inadequate shielding	None	None	None	None	No applicable SSC's or TSR's - Facility worker exposure controlled by Radiation Protection Program.
SYXFR13-55	Personnel exposure to excessive radiation due to insufficient decon	Human error or equipment failure	None	None	None	None	No applicable SSC's or TSR's - Facility worker injury controlled by Health and Safety Plan.

AC = Administrative Control
 AWF = Aging Waste Facility (tank)
 DST = double-shell tank
 LCO = Limiting Condition of Operation
 OGT = overground transfer line
 PPP = pre-fabricated pump pit
 SC = Safety-Class
 SS = Safety-Significant

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
ABBREVIATION LIST: Admin = Administrative Cons = Consequence Cntrls = Controls Detect = Detection Ign = Ignition								
Mon = Monitoring			Prep = Preparedness	Sys = Systems	Trans = Transfer	TSR = Technical Safety Requirement		
101SYWLV-18A	Release of radioactive/hazardous material from tank to atmosphere due to flammable gas deflagration	Crust penetration/disturbance releasing flammable gas from the crust with ignition. Sufficient gas release for tank LFL is not possible unless disturbance propagates quickly away from initiating point	None required	None required	None required	None required	No controls required based on low event frequency.	E3
101SYWLV-22AT	Release of radioactive/hazardous material from tank to atmosphere due to flammable gas deflagration	Crust subsides during transfer creating GRE from crust with ignition	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101.	E3
101SYWLV-23AT	Release of radioactive/hazardous material from tank to atmosphere due to flammable gas deflagration	Injection of water into the transfer pump for in-line dilution coupled with a transfer failure results in releasing gas from crust with ignition	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101.	E3

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
101SYWLV-24AT	Release of radioactive/hazardous material from tank to atmosphere due to flammable gas deflagration	Buoyant displacement GRE with ignition due to change in hydrostatic pressure from reduction in tank level	None required	None required	None required	None required	No controls required based on low event frequency.	E3
101SYWLV-25AT	Release of radioactive/hazardous material from tank to atmosphere due to flammable gas deflagration	Buoyant displacement GRE with ignition due to change in hydrostatic pressure from reduction in tank level	None required	None required	None required	None required	No controls required based on low event frequency.	E3
101SYWLV-4BT-SL	Release of radioactive/hazardous material from tank to atmosphere due to flammable gas deflagration	Buoyant displacement GRE from slurry layer with ignition	None required	None required	None required	None required	No controls required based on low event frequency.	E3
SYDIL-01	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Water rises to base of crust with little mixing, causing crust dissolution and flammable gas release, ignition source present	SC: DST/WWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LC: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ignition Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	E3

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYDIL-04	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Excessive water addition causes water to rise to base of crust with little mixing, causing crust dissolution and flammable gas release, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Test Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	E3
SYDIL-05	Release of radioactive/hazardous material from Tank 241-SY-101 to soil surface due to tank overflow	Water addition has little effect on gas retention causing increased tank volume, crust continues to grow out riser	None required	None required	None required	None required	No controls required based on low event frequency.	E3
SYDIL-06	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Create stratification affecting mixer pump operation causing increased gas retention at depth with a return to BD GRE, ignition source present	None required	None required	None required	None required	No controls required based on low event frequency.	E3

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYDIL-08	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Mechanical disruption due to crust displacement from water addition resulting in flammable gas release, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LSO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	E3

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYDIL-09	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Mechanical disruption due to crust displacement from water addition damaging mixer pump, causing increased gas retention at depth with a return to BD GRE, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss SC: Siphon Break SC: SY-101 Waste Transfer Flow Totalizer SC: Dilution Water Flow Totalizer	LSO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls SY-101 Waste Trans Control SY-101 Mixer Pump Operation and Performance Monitoring SY-101 Back Dilution Control	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	E3

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYDIL-12	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Dilution water does not float crust resulting in void ingestion in the mixer pump degrading pump performance or mechanically failing pump, causing increased gas retention at depth with a return to BD GRE, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss SC: Siphon Break SC: SY-101 Waste Transfer Flow Totalizer SC: Dilution Water Flow Totalizer	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls SY-101 Waste Trans Control SY-101 Mixer Pump Operation and Performance Monitoring SY-101 Back Dilution Control	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	E3

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYDIL-13	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Mixer pump creates 'cavity' in crust which collects flammable gas during dilution resulting in a possible sudden significant release of gas, ignition source present	SC: DST/AFW Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	E3
SYDIL-14	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Water addition releases crust gas decreasing the buoyancy of the crust causing the crust to sink resulting in additional gas release, ignition source present	None required	None required	None required	None required	No controls required based on low event frequency.	E3

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYDIL-16	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Water addition releases crust gas decreasing the buoyancy of the crust causing the crust to sink. The additional solids at depth affects mixer pump performance causing increased gas retention at depth with return to BD GRES, ignition source present	SC: DST/ADF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss SC: Siphon Break SC: SY-101 Waste Transfer Flow SC: Dilution Water Flow Totalizer	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls SY-101 Waste Trans Control SY-101 Mixer Pump Operation and Performance Monitoring SY-101 Back Dilution Control	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	E3

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYDIL-17	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Water addition releases crust gas decreasing the buoyancy of the crust causing the crust to float lower affecting mixer pump performance/operation causing increased gas retention at depth with a return to BD GRES, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss SC: Siphon Break SC: SY-101 Waste Transfer Flow Totalizer SC: Dilution Water Flow Totalizer	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls SY-101 Waste Trans Control SY-101 Mixer Pump Operation and Performance Monitoring SY-101 Back Dilution Control	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	E3

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Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYDIL-19	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Dilution water does not float crust resulting in void ingestion in the mixer pump degrading pump performance or mechanically failing pump, causing increased gas retention at depth with a return to BD GREs, ignition source present	SC: DST/AFW Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss SC: Siphon Break SC: SY-101 Waste Transfer Flow Totalizer SC: Dilution Water Flow Totalizer	LCO: DST and AWP Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls SY-101 Waste Trans Control SY-101 Mixer Pump Operation and Performance Monitoring SY-101 Back Dilution Control	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	E3

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYDIL-20	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Mixer pump creates 'cavity' in crust which collects flammable gas during dilution resulting in a possible sudden significant release of gas, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	E3
SYDIL-21	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Water addition releases crust gas decreasing the buoyancy of the crust causing the crust to sink resulting in additional gas release, ignition source present	None required	None required	None required	None required	No controls required based on low event frequency.	E3

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYDIL-22	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Water addition releases crust gas decreasing the buoyancy of the crust causing the crust to sink. The additional solids at depth affects mixer pump performance causing increased gas retention at depth with return to BD GREs, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss SC: Siphon Break SC: SY-101 Waste Transfer Flow Totalizer SC: Dilution Water Flow Totalizer	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls SY-101 Waste Trans Control SY-101 Mixer Pump Operation and Performance Monitoring SY-101 Back Dilution Control	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	E3

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYDIL-24	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Water addition releases crust gas decreasing the buoyancy of the crust causing the crust to float lower affecting mixer pump performance/operation causing increased gas retention at depth with a return to BD GREs, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss SC: Siphon Break SC: SY-101 Waste Transfer Flow Totalizer SC: Dilution Water Flow Totalizer	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls SY-101 Waste Trans Control SY-101 Mixer Pump Operation and Performance Monitoring SY-101 Back Dilution Control	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	E3
SYDIL-25	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Dissolved large hole allows for lateral crust motion causing waste berg turnover resulting in flammable gas release and ignition	None required	None required	None required	None required	No controls required based on low event frequency.	E3

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYDIL-27	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Dissolved large hole allows bubble slurry flow to top of crust resulting in flammable gas release and ignition	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	E3
SYDIL-28	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Dissolved large hole allows for lateral motion causing waste berg turnover resulting in flammable gas release and ignition	None required	None required	None required	None required	No controls required based on low event frequency.	E3

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Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYDIL-31	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Water addition in general increases the head (pressure) at any point in the waste compressing bubbles causing a portion of the crust to sink and release gas, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. The safety analysis of back dilution of Tank 241-SY-101 waste has not been completed. Therefore, additional controls may be required to prevent or mitigate this potential back dilution hazardous condition.	E3
SYDIL-32	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Operation of mixer pump releases gas at depth which adds to gas release from crust increasing quantity of flammable gas available for burn, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	E3

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYDIL-34	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Spray on top results in weakened crust causing crust "roll over" and flammable gas release, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls SY-101 Back Dilution Control	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	E3
SYDIL-36	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Cold water precipitates solids with deleterious properties; affects mixer pump operation causing increased gas retention at depth with a return to BD GRE, ignition source present	None required	None required	None required	None required	No controls required based on low event frequency.	E3

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYDIL-38	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Introduction of higher temperature water increases tank temperature which reduces gas solubility causing release of flammable gas, ignition source present	SC: DST/WWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and WWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	E3
SYDIL-39	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Introduction of higher temperature water causes potentially large amount of adsorbed gas species to be released by the small temperature change (phase change from gas to liquid), ignition source present	None required	None required	None required	None required	No controls required based on low event frequency.	E3

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYDIL-40	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Excessive water addition rate causing rapid crust dissolution, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	E3

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYDIL-41	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Excessive water addition rate could cause mechanical disruption of the crust, causing flammable gas release, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	E3

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYDIL-42	See all related hazardous conditions developed above related to crust sinking events	Water addition releases crust gas decreasing crust buoyancy causing crust to sink	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls SY-101 Mixer Pump Operation and Performance Monitoring	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	E3

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYDIL-43	Release of radioactive/hazardous material from Tank 241-SY-101 to atmosphere due to flammable gas ignition	Crust dissolution releases imbedded foreign objects which can become entrained in the mixer pump causing pump damage or failure causing increased gas retention at depth with a return to BD GRE, ignition source present	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss SC: Siphon Break SC: SY-101 Waste Transfer Flow Totalizer SC: Dilution Water Flow Totalizer	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls SY-101 Waste Trans Control SY-101 Mixer Pump Operation and Performance Monitoring SY-101 Back Dilution Control	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101. Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	E3
SYXFR-N5-05a	Release of radioactive liquid from PPP to the soil due to pool leak	Backflow of encasement from primary line (hose) leak (break near PPP or SY-102 encasement end plugged) - plus failure of PPP drain	None required	None required	SC: Trans Leak Detect Syss SC/SS: PPP SC: OGT Encasement and Connections SC: SY-102 Drop Leg Enclosure SS: Tank Level Detect Sys SS: SY-101 Waste Transfer Flow Totalizer	LCO: Trans Sys Cntrs and Entry Doors LCO: Trans Leak Detect Syss AC: Trans Cntrls AC: Emergency Prep (Response Procedures) AC: Trans Pump Admin Lock Cntrls AC: Trans Sys Cvr Removal Cntrls	Controls based on accident analyses (Surface Leak Resulting in Pool).	E3

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYXFR-N5-05b	Release of radioactive aerosols from PPP due to spray leak in PPP or OGT encasement	Primary line (hose) spray leak (break in PPP, "Riser Extension", or OGT encasement)	None	None	SC: PPP SC: OGT Encasements and Connections SC: SY-102 Drop Leg Enclosure	LCO: Trans Sys Cvr and Entry Doors AC: Trans Sys Cvr Removal Cntrls	Controls based on accident analysis (Spray Leak in Structure or from Overground Waste Transfer Lines) and control decision for Tank 241-SY-101 Waste Transfer.	E3
SYXFR-N5-08	Release of radioactive particulates from PPP due to flammable gas accumulation and ignition Exposure of personnel to ionizing radiation	Flammable gas presence in PPP plus ignition	SC: Trans Leak Detect Syss SS: Tank Level Detect Sys SS: SY-101 Waste Transfer Flow Totalizer	LCO: Trans Leak Detect Syss AC: Ign Cntrls AC: Flammable Gas Mon Cntrls AC: Trans Cntrls (Leak Prevention/Detect)	None required	AC: Emergency Prep (Response Procedures)	Controls based on Appendix E and accident analysis (Surface Leak Resulting in Pool; and Fire in Contaminated Area).	E3
SYXFR-N5-09	Release of radioactive liquid from PPP to soil surface due to leak forming pool	Waste leak within the PPP enclosure or SY-102 drop leg enclosure (and plugged drain)	None required	None required	SC: Trans Leak Detect Syss SC/SS: PPP Encasement and Connections SC: SY-102 Drop Leg Enclosure SS: Tank Level Detect Sys SS: SY-101 Waste Transfer Flow Totalizer	LCO: Trans Sys Cvr and Entry Doors LCO: Trans Leak Detect Syss AC: Trans Cntrls AC: Emergency Prep (Response Procedures) AC: Trans Pump Admin Lock Cntrls AC: Trans Sys Cvr Removal Cntrls	Controls based on accident analyses (Surface Leak Resulting in Pool).	E3
SYXFR-N5-10a	Release of radioactive waste from PPP to soil surface due to seismic event damaging PPP and primary pipe (hose)	Seismic event	None required	None required	None required	AC: Emergency Prep (Response Procedures)	Controls based on control decision for Tank 241-SY-101 Waste Transfer.	E3

APPENDIX G

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYXFR-N5-10b	Release of radioactive aerosols from PPP to atmosphere due to seismic event damaging PPP and primary pipe (hose)	Seismic event	None required	None required	None required	AC: Emergency Prep (Response Procedures)	Controls based on control decision for Tank 241-SY-101 Waste Transfer.	E3
SYXFR-N5-11	Release of radioactive waste from PPP to soil surface due to vehicle/equipment impact damaging PPP and primary pipe (hose)	Vehicle/equipment striking PPP	None required	AC: Ign Cntrls (Vehicle Cntrls) AC: Trans Cntrls (Vehicle Restrictions)	None required	AC: Emergency Prep (Response Procedures)	Controls based on accident analyses (Surface Leak Resulting in Pool).	E3
SYXFR-N5-12a	Release of radioactive waste from PPP to soil surface due to wind driven missiles damaging PPP and primary pipe (hose)	Wind driven missiles	SC: PPP SC: OGT Encasements and Connections SC: SY-102 Drop Leg Enclosure	None required	None required	AC: Emergency Prep (Response Procedures)	Controls based on control decision process for Tank 241-SY-101 Waste Transfer.	E3
SYXFR-N5-12b	Release of radioactive aerosols from PPP to atmosphere due to wind driven missiles damaging PPP and primary pipe (hose)	Wind driven missiles	SC: PPP SC: OGT Encasements and Connections SC: SY-102 Drop Leg Enclosure	None required	None required	AC: Emergency Prep (Response Procedures)	Controls based on control decision for Tank 241-SY-101 Waste Transfer.	E3
SYXFR-N5-16	Release of radioactive waste from PPP to soil surface due to primary line (hose) leak with plugged PPP drain	Extreme cold weather	None required	None required	None required	None required	No controls required based on low event frequency.	E3
SYXFR-N8-20a	Release of radioactive waste from PPP to soil surface due to seismic event damaging OGT and primary pipe (hose)	Seismic event	None required	None required	None required	AC: Emergency Prep (Response Procedures)	Controls based on control decision for Tank 241-SY-101 waste transfer.	E3

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYXFR-N8-20b	Release of radioactive aerosols from OGT to atmosphere due to seismic event damaging OGT encasement and primary pipe (hose)	Seismic event	None required	None required	None required	AC: Emergency Prep (Response Procedures)	Controls based on control decision for Tank 241-SY-101 Waste Transfer.	E3
SYXFR-N8-21	Release of radioactive waste from PPP to soil surface due to vehicle/equipment impact damaging OGT and primary pipe (hose)	Vehicle/ Equipment impacting OGT	None required	AC: Ign Cntrls (Vehicle Cntrls) AC: Trans Cntrls (Leak Detect and Vehicle Restrictions)	None required	AC: Emergency Prep (Response Procedures)	Controls based on accident analyses (Surface Leak Resulting in Pool).	E3
SYXFR-N8-22a	Release of radioactive waste from OGT to soil surface due to wind driven missiles breaching encasement and primary pipe (hose)	Wind driven missiles	SC: PPP SC: OGT Encasements and Connections SC: SY-102 Drop Leg Enclosure	None required	None required	AC: Emergency Prep (Response Procedures)	Controls based on control decision for Tank 241-SY-101 Waste Transfer.	E3
SYXFR-N8-22b	Release of radioactive aerosols from OGT to atmosphere due to wind driven missiles breaching encasement and primary pipe (hose)	Wind driven missiles	SC: PPP SC: OGT Encasements and Connections SC: SY-102 Drop Leg Enclosure	None required	None required	AC: Emergency Prep (Response Procedures)	Controls based on control decision for Tank 241-SY-101 Waste Transfer.	E3
SYXFR-N8a-03	Release of radioactive/hazardous material from transfer hose to soil surface due to freezing	Ambient temperature extremely low with failure during transfer	None required	None required	SC: OGT Encasement and Connections SS: Tank Level Detection Sys SS: SY-101 Waste Transfer Flow Totalizer	AC: Trans Cntrls (Material Balance) AC: Emergency Prep (Response Procedures)	Controls based on accident analysis (Surface Leak Resulting in Pool).	E3

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYXFR-N8a-04	Release of radioactive/hazardous material from transfer hose to soil surface due to high temperature	Runaway heat trace with transfer	None required	None required	SC: OGT Encasement and Connections SS: Tank Level Detection Sys SS: SY-101 Waste Transfer Flow Totalizer	AC: Trans Cntrls (Material Balance) AC: Emergency Prep (Response Procedures)	Controls based on accident analysis (Surface Leak Resulting in Pool).	E3
SYXFR-N8a-05	Release of radioactive/hazardous material from transfer hose to soil surface due to high temperature	High temperature waste transferred	None required	None required	SC: OGT Encasement and Connections SS: Tank Level Detection Sys SS: SY-101 Waste Transfer Flow Totalizer	AC: Trans Cntrls (Material Balance) AC: Emergency Prep (Response Procedures)	Controls based on accident analysis (Surface Leak Resulting in Pool).	E3
SYXFR-N8a-06	Release of radioactive/hazardous material from transfer hose to soil surface due to high temperature	External fire (range fire, fuel fire, etc.) during transfer	None required	AC: Ign Cntrls (Vehicle Cntrls) AC: Trans Cntrls (Vehicle Restrictions)	SC: OGT Encasement and Connections SS: Tank Level Detection Sys SS: SY-101 Waste Transfer Flow Totalizer	AC: Trans Cntrls (Material Balance) AC: Emergency Prep (Response Procedures)	Controls based on accident analysis (Surface Leak Resulting in Pool).	E3
SYXFR-N8a-07	Release of radioactive/hazardous material from transfer hose to soil surface due to mechanical abrasion	Mechanical abrasion with transfer	None required	None required	SC: OGT Encasement and Connections SS: Tank Level Detection Sys SS: SY-101 Waste Transfer Flow Totalizer	AC: Trans Cntrls (Material Balance) AC: Emergency Prep (Response Procedures)	Controls based on accident analysis (Surface Leak Resulting in Pool).	E3

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYXFR-N8a-08	Release of radioactive/hazardous material from transfer hose to soil surface due to radiation damage	Radiation damage	None required	None required	SC: OGT Encasement and Connections SS: Tank Level Detection Sys SS: SY-101 Waste Transfer Flow Totalizer	AC: Trans Cntrls (Material Balance) AC: Emergency Prep (Response Procedures)	Controls based on accident analysis (Surface Leak Resulting in Pool).	E3
SYXFR-N8a-09	Release of radioactive/hazardous material from transfer hose connections to soil surface due to pipe whip	Pipe whip due to slug flow	None required	None required	SC: OGT Encasement and Connections SS: Tank Level Detection Sys SS: SY-101 Waste Transfer Flow Totalizer	AC: Trans Cntrls (Material Balance) AC: Emergency Prep (Response Procedures)	Controls based on accident analysis (Surface Leak Resulting in Pool).	E3
SYXFR-N8a-11	Release of radioactive/hazardous material from transfer hose connections to soil surface due to vehicle collision	Vehicle collision with connection site with transfer	None required	AC: Ign Cntrls (Vehicle Cntrls) AC: Trans Cntrls (Vehicle Restrictions)	SC: OGT Encasement and Connections	AC: Emergency Prep (Response Procedures)	Controls based on accident analysis (Surface Leak Resulting in Pool).	E3
SYXFR-N8a-12	Release of radioactive/hazardous material from transfer hose to soil surface due to external event	Damage of inner and outer hose due to external event (crane, vehicle, airplane, etc.) with transfer	None required	AC: Trans Cntrls (OGT, Vehicle Access) AC: Trans Cntrls (Vehicle Restrictions) AC: Dome Loading (Hoisting and Rigging Manual)	SC: OGT Encasement and Connections	AC: Emergency Prep (Response Procedures)	Controls based on accident analysis (Surface Leak Resulting in Pool).	E3
SYXFR-N8a-14	Release of radioactive/hazardous material from transfer hose to soil surface due to incompatible material	Incompatible material (e.g. chemical attack) fails inner and outer hose	None required	None required	SC: OGT Encasement and Connections SS: Tank Level Detection Sys SS: SY-101 Waste Transfer Flow Totalizer	AC: Trans Cntrls (Material Balance) AC: Emergency Prep (Response Procedures)	Controls based on accident analysis (Surface Leak Resulting in Pool).	E3

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Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYXFR-N8a-15	Release of radioactive/hazardous material from transfer hose to soil surface due to freezing	Water fill freezes due to low ambient temperature and damages inner and outer hose with transfer	None required	None required	None required	None required	No controls required based on low event frequency.	E3
SYXFR01-02	Flammable gas ignites in Tank 241-SY-101 when riser activities cause spark resulting in radioactive aerosol release	Flammable gas ignition	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101.	E3
SYXFR01-06	Tank 241-SY-101 bottom punctured due to pump assembly being too long resulting in potential release to soil (leak into annulus)	Pump assembly too long resulting in breaching tank bottom	None	AC: Dome Loading Cntrls	None	None	Controls based on accident analysis (Tank Failure Due to Excessive Loads). Specific environmental controls contained in Section 5.4.4 of the BJO.	E3
SYXFR01-07	Flammable gas generated and ignited in Tank 241-SY-101 due to intrusive activity resulting in release of radioactive aerosols	Insertion of transfer pump into tank disturbs waste releasing flammable gas	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101.	E3

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYXFR02-09	Flammable gas ignition in Tank 241-SY-102 during drop leg installation results in aerosol release of radioactive material	Flammable gas ignition	SC: DST/AWF Ventilation	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls AC: Ign Cntrls AC: Flammable Gas Mon Cntrls AC: Process Instrumentation and Measuring and Test Equipment	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis.	E3
SYXFR03-12a	Aerosol release of radioactive material due to change of solubility causing larger quantity of precipitated material resulting in increase of flammable gas being trapped on particles in Tank 241-SY-101 resulting in BDGRE with ignition	Failure of service water heating resulting in addition of cold dilution water with failure of transfer pump cooling larger quantity of precipitated material, increased accumulation of flammable gas trapped	None required	None required	None required	None required	No controls required based on low event frequency.	E3
SYXFR03-12b	Ignition of significant quantities of flammable gas in Tank 241-SY-101 released from dissolution of crust causing radioactive aerosol release	Hot flush/dilution water added (failure of temperature control) coupled with failure to transfer material	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101.	E3

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYXFR03-13a	Release of radioactive aerosols due to ignition of large quantities of flammable gas in Tank 241-SY-101 released from buoyant displacement GRE	Human error or instrument failure results in excessive transfer or siphoning. Failure to continue GRE prevention due to inability to operate mixer pump - Mixer pump suction in crust - Mixer pump suction out of waste	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss SC: Siphon Break SC: SY-101 Waste Transfer Flow Totalizer SC: Dilution Water Flow Totalizer	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls SY-101 Waste Trans Control SY-101 Mixer Pump Operation and Performance Monitoring SY-101 Back Dilution Control	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101.	E3
SYXFR04-17	Radioactive aerosol release due to spray leak dissolving crust causing GRE with ignition in Tank 241-SY-101	Hole in pipe (spray leak) inside dome space	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101.	E3

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYXFR04-18	Radioactive aerosol release due to ignition of flammable gas released from disturbed crust in Tank 241-SY-101. Also identified in HNF-3645, Item 101SY-WLV-22AT	Rapid transfer disturbs crust greater than postulated	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101.	E3
SYXFR04-22	Ignition of significant quantities of flammable gas released from dissolution of crust in Tank 241-SY-101 causing radioactive aerosol release	Hot flush/dilution water added (failure of temperature control) coupled with failure to transfer material heats tank waste	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101.	E3
SYXFR05-24b1	Release of radioactive aerosol released in Tank 241-SY-101 ppp due to leak from line, flange or valve	Ruptured line/leaking flange or valve inside Tank 241-SY-101 ppp	None required	None required	SC: PPP SC: OGT Encasements and Connections SC: SY-102 Drop Leg Enclosure	LCO: Trans Sys Cntrls and Entry Doors AC: Trans Sys Cntrls Removal	Controls based on accident analysis (Spray Leak in Structure or from Overground Waste Transfer Lines).	E3

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYXFR05-24b2	Overflow of Tank 241-SY-101 PPP due to leak from line, flange or valve	Ruptured line/leaking flange or valve inside Tank 241-SY-101 PPP	None required	None required	SC: Trans Leak Detect Syss SC/SS: PPP SC: OGT Encasement and Connections SC: SY-102 Drop Leg Enclosure SS: Tank Level Detect Sys SS: SY-101 Waste Transfer Flow Totalizer	LCO: Trans Sys Cvr and Entry Doors LCO: Trans Leak Detect Syss AC: Trans Cntrls AC: Emergency Prep (Response Procedures) AC: Trans Pump Admin Lock Cntrls AC: Trans Sys Cvr Removal Cntrls	Controls based on accident analyses (Surface Leak Resulting in Pool).	E3
SYXFR05-24c	Release of radioactive liquid from flush tank due to pool leak caused by backflow of waste into flush system	Human error causing incorrect valving (flush pump must be off)	SC: Pressure Switch Interlocks or Alarms (Water Service Lines) SS: Backflow Prevention Devices	LCO: Service Water Pressure Detect Syss	None required	None required	Controls based on accident analyses (Surface Leak Resulting in Pool).	E3
SYXFR05-28b1	Release of aerosol generated in Tank 241-SY-101 PPP due to spray leak from line, flange or valve	Ruptured line/leaking flange or valve inside Tank 241-SY-101 PPP	None required	None required	SC: PPP SC: OGT Encasements and Connections SC: SY-102 Drop Leg Enclosure	LCO: Trans Sys Cvr and Entry Doors AC: Trans Sys Cvr Removal Cntrls	Controls based on accident analysis (Spray Leak in Structure or from Overground Waste Transfer Lines).	E3

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Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYXFR05-28b2	Release of liquid waste in Tank 241-SY-101 PPP due to leak from line, flange or valve forming pool	Ruptured line/leaking flange or valve inside Tank 241-SY-101 PPP	None required	None required	SC: Trans Leak Detect Syss SC/SS: PPP SC: OGT Encasement and Connections SC: SY-102 Drop Leg Enclosure SS: Tank Level Detect Sys SS: SY-101 Waste Transfer Flow Totalizer	LCO: Trans Sys Cvr and Entry Doors LCO: Trans Leak Detect Syss AC: Trans Cntrls AC: Emergency Prep (Response Procedures) AC: Trans Pump Admin Lock Cntrls AC: Trans Sys Cvr Removal Cntrls	Controls based on accident analyses (Surface Leak Resulting in Pool).	E3
SYXFR05-28c	Release of radioactive liquid due to pool leak caused by backflow of waste into flush system overflowing flush tank	Human error causing incorrect valving (flush pump must be off)	SC: Pressure Switch Interlocks or Alarms (Water Service Lines) SS: Backflow Prevention Devices	LCO: Service Water Pressure Detect Syss	None required	None required	Controls based on accident analyses (Surface Leak Resulting in Pool).	E3
SYXFR05-31	Flush with high temperature flush water with preexisting spray leak causes release of high temperature aerosols in Tank 241-SY-101 PPP	Flush water too hot	None required	None required	SC: PPP SC: OGT Encasements and Connections SC: SY-102 Drop Leg Enclosure	LCO: Trans Sys Cvr and Entry Doors AC: Trans Sys Cvr Removal Cntrls	Controls based on accident analysis (Spray Leak in Structure or from Overground Waste Transfer Lines).	E3
SYXFR08-43	Excavation activities during PPP and OGT installation damage waste transfer lines in vicinity of the PPP and OGT	Excavation activities damage transfer lines	None required	AC: Excavation Cntrls	None required	AC: Excavation Cntrls	Controls based on accident analysis (Spray Leak from Underground Waste Transfer Lines).	E3
SYXFR11-45b	Excessive heat up rate causes thermal stress in tank structural and potential leak	Transfer of heat generating waste from Tank 241-SY-101	None required	None required	None required	None required	No controls required based on low event frequency.	E3

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYXFR11-46a	Release of radioactive aerosols due to flammable gas deflagration in Tank 241-SY-102	Drop leg design error results in waste level being below discharge point - entrained gasses are released as waste is discharged	SC: DST/AWF Ventilation	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls AC: Ign Cntrls AC: Flammable Gas Mon Cntrls AC: Process Instrumentation and Measuring and Test Equipment	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101.	E3
SYXFR11-48a	Flammable gas deflagration due to increased gas generation in Tank 241-SY-102 results in release of radioactive aerosols	Low liquid level prevents drop leg from distributing solids	SC: DST/AWF Ventilation	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls AC: Ign Cntrls AC: Flammable Gas Mon Cntrls AC: Process Instrumentation and Measuring and Test Equipment	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101.	E3
SYXFR12-52	Ignition of significant quantities of flammable gas released in Tank 241-SY-101 from dissolution of crust causing radioactive aerosol release	Hot flush/dilution water added (failure of temperature control) coupled with failure to transfer material	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101.	E3
SYXFR13-56	Release of radioactive aerosols due to ignition of flammable gas in Tank 241-SY-101 released due to crust disturbance	Nozzle breaks off decon spray ring creating minor disturbance of crust/waste	None required	None required	None required	None required	No controls required based on low event frequency.	E3

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
101SYWLV-8A	Release of radioactive/hazardous material from tank to atmosphere due to excessive load on tank equipment	Crust adheres to suspended hardware with crust collapse or transfer out of sufficient amount creating release path through damaged tank dome	None required	None required	None required	None required	No controls required based on low event frequency.	E2
SYDIL-03	Release of radioactive/hazardous material from Tank 241-SY-101 to soil surface due to tank overflow	Excessive water addition	None required	None required	SS: Tank Level Detect Syss SS: Service Water Flow Totalizers	AC: Emergency Prep AC: Tank Service Water Intrusion Mon Program	Controls based on accident analyses (Surface Leak Resulting in Pool). Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	E2
SYDIL-15	Release of radioactive/hazardous material from Tank 241-SY-101 to tank annulus due to degassed crust falling to bottom of tank causing structural damage to tank liner (primary barrier)	Water addition releases crust gas decreasing the buoyancy of the crust causing the crust to sink to bottom of tank	None required	None required	None required	None required	No controls required based on low event frequency.	E2

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYDIL-23	Release of radioactive/hazardous material from Tank 241-SY-101 to tank annulus due to degassed crust falling to bottom of tank causing structural damage to tank liner (primary barrier)	Water addition releases crust gas decreasing the buoyancy of the crust causing the crust to sink to bottom of tank	None required	None required	None required	None required	No controls required based on low event frequency.	E2
SYDIL-35	Release of radioactive/hazardous material from Tank 241-SY-101 to annulus due to tank leak	Cold water induces thermal stress on tank liner that may fail weld(s)	None required	None required	SS: Primary Tank Leak Detection Sys	None required	Controls based on accident analyses (Subsurface Leak Remaining Subsurface). Safety analysis has been completed only for the initial back dilution following the first Tank 241-SY-101 waste transfer. Additional controls may be required to prevent or mitigate this potential back dilution hazardous condition for subsequent back dilution activities.	E2
SYDIL-37	Release of radioactive/hazardous material from Tank 241-SY-101 to annulus due to tank leak	Hot water induces thermal stress on tank liner that may fail weld(s)	None required	None required	None required	None required	No controls required based on low event frequency.	E2
SYXFR01-04	Dropped equipment during installation damages Tank 241-SY-101 riser and/or tank dome	Damage to riser due to- Jam- Drop on riser or tank dome- Vehicle impact	None required	AC: Dome Loading Cntrls	None required	None required	Controls based on accident analysis (Tank Failure Due to Excessive Loads).	E2

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Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYXFR01-05	Localized load potentially damages Tank 241-SY-101 dome/riser creating unfiltered path for aerosol release	Overloaded tank dome due to PPP assembly installation	None required	AC: Dome Loading Cntrls	None required	None required	Controls based on accident analysis (Tank Failure Due to Excessive Loads).	E2
SYXFR02-11	Tank 241-SY-102 bottom punctured due to drop leg assembly too long resulting in potential release to soil (leak into annulus)	Design error results in drop leg being too long - bottom of tank punctured during installation	None	AC: Dome Loading Cntrls	None	None	Controls based on accident analysis (Tank Failure Due to Excessive Loads). Specific environmental controls contained in Section 5.4.4 of the B/O.	E2
SYXFR03-13b	Dome failure due to overload from solidified waste suspended from intank equipment due to low liquid level in Tank 241-SY-101	Human error or instrument failure results in excessive transfer or siphoning	None required	None required	None required	None required	No controls required based on low event frequency.	E2
SYXFR03-14a	Release of radioactive material from waste tank due to overflow of Tank 241-SY-101 resulting in pool (see HNF-3645 for details)	Excessive dilution without transfer occurring - plugged transfer line - bad pump - bad flow meters - operator error coupled with instrument failure	None required	None required	SS: Tank Level Detect Syss SS: Service Water Flow Totalizers	AC: Emergency Prep AC: Tank Service Water Intrusion Mon Program	Controls based on accident analyses (Surface Leak Resulting in Pool).	E2
SYXFR03-14b	Release of radioactive material from waste tank due to overflow of Tank 241-SY-101 resulting in pool (see HNF-3645 for details)	Inadvertent draining from flush tank	None required	None required	SS: Tank Level Detect Syss SS: Service Water Flow Totalizers	AC: Emergency Prep AC: Tank Service Water Intrusion Mon Program	Controls based on accident analyses (Surface Leak Resulting in Pool).	E2

Table G3. Safety Structures, Systems, and Components and Technical Safety Requirements (or Prudent Contractor Controls Required for Safe Operation) for Potentially Severe (E3 and E2) Environmental Consequences for Tank 241-SY-101 Waste Transfers and Back Dilution. (36 Sheets)

ID	Hazardous Condition	Cause	Prev SSCs	Prev TSRs	Mit SSCs	Mit TSRs	Memo	Env Cons
SYXFR03-15a	Radioactive aerosol release due to water addition dissolving crust causing GRE with ignition in Tank 241-SY-101 (HNF-3645, 101SY-WLV-23AT)	Excessive dilution without transfer occurring -plugged transfer line -bad pump -bad flow meters -operator error coupled with instrument error	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101.	E2
SYXFR03-15b	Radioactive aerosol release due to water addition dissolving crust causing GRE with ignition in Tank 241-SY-101 (HNF-3645, 101SY-WLV-23AT)	Inadvertent draining from the flush tank	SC: DST/AWF Ventilation SC: SY-101 Hydrogen Monitor SC: SY-101 Ammonia Detect Syss	LCO: DST and AWF Tank Ventilation Syss AC: Flammability Cntrls (SY-101) AC: Process Instrumentation and Measuring and Test Equipment SY-101 Ign Cntrls SY-101 Flammable Gas Mon Cntrls	None required	AC: Emergency Prep AC: HEPA Filter Cntrls (Source Term)	These are applicable controls from the Flammable Gas Deflagrations - DST accident analysis and controls based on Plant Review Committee (PRC) prudent controls for safe operation of Tank 241-SY-101.	E2
SYXFR04-19	Release of radioactive material from waste tank due to overflow of Tank 241-SY-101 resulting in pool (see HNF-3645 for details)	Human error or equipment failure results in running flush water into system, discharge valve closed on Tank 241-SY-102, backflow to Tank 241-SY-101	None required	None required	SS: Tank Level Detect Syss SS: Service Water Flow Totalizers	AC: Emergency Prep AC: Tank Service Water Intrusion Mon Program	Controls based on accident analyses (Surface Leak Resulting in Pool).	E2

AC = Administrative Control
 AWF = Aging Waste Facility
 BIO = Basis for Interim Operation
 BD GRE = buoyant displacement gas release event
 DST = double-shell tank
 GRE = gas release event
 HEPA = high-efficiency particulate air (filter)
 HNF-3645, 1998, *Hazard Evaluation for Tank 241-SY-101 Waste Surface Level Growth*, Rev. 0, Fluor Daniel Northwest, Inc., Richland, Washington.
 HNF-SD-WM-BIO-001, 1999, *Tank Waste Remediation System Basis for Interim Operation*, Rev. 1-1, Fluor Daniel Hanford, Inc., Richland, Washington.

LFL = Lower Flammability Limit
 OGT = overground transfer line
 PPP = pre-fabricated pump pit
 PRC = Plant Review Committee
 SC = Safety-Class
 SS = Safety-Significant

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ATTACHMENT G1

TECHNICAL PEER REVIEW CHECKLIST

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Practice 134 290 1112
Publication Date 05Aug99
Attachment 02 - Sheet 1 of 1

FLUOR DANIEL NORTHWEST

TECHNICAL PEER REVIEWS

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: *HNF-3737 Appendix G*
Title: *Engineered and Administrative Controls for Hazardous Conditions Identified for Tank 241-SY-101*
Author: *Milt Schultz*
Date: *10/15/99*
Scope of Review: *Waste Transfer and Radio Disposition*

Yes No* NA

☐	☐	☒	**	Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
☐	☐	☒		Problem completely defined.
☐	☐	☒		Accident scenarios developed in a clear and logical manner.
☐	☐	☒		Necessary assumptions explicitly stated and supported.
☐	☐	☒		Computer codes and data files documented.
☐	☐	☒		Data used in calculations explicitly stated in document.
☒	☐	☐		Data checked for consistency with original source information as applicable.
☐	☐	☒		Mathematical derivations checked including dimensional consistency of results.
☐	☐	☒		Models appropriate and used within range of validity or use outside range of established validity justified.
☐	☐	☒		Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
☐	☐	☒		Software input correct and consistent with document reviewed.
☐	☐	☒		Software output consistent with input and with results reported in document reviewed.
☐	☐	☒		Limits/criteria/guidelines applied to analysis results are appropriate and referenced.
☐	☐	☒		Limits/criteria/guidelines checked against references.
☒	☐	☐		Safety margins consistent with good engineering practices.
☒	☐	☐		Conclusions consistent with analytical results and applicable limits.
☒	☐	☐		Results and conclusions address all points required in the problem statement.
☐	☐	☒		Format consistent with applicable guides or other standards.
☐	☐	☒	**	Review calculations, comments, and/or notes are attached.
☒	☐	☐		Document approved (for example, the reviewer affirms the technical accuracy of the document).

LAURENCE T. KRIPAS

Reviewer (printed name and signature)

10/15/99

Date

* All "no" responses must be explained below or on an additional sheet.

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

NUCLEAR ENGINEERING

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