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ENGINEERING DATA TRANSMITTAL

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HAZARD EVALUATION FOR TRANSFER OF WASTE FROM TANK 241-SY-101 TO TANK 241-SY-102

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Key Words: SY-101, Hazards Evaluation, Waste Transfer, Crust Level.

Abstract: This document presents the results of a hazards identification and evaluation performed on the transfer of waste from Tank 241-SY-101 to Tank 241-SY-102 as part of the activities to address crust level increase.

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HAZARD EVALUATION FOR TRANSFER OF WASTE FROM TANK 241-SY-101 TO TANK 241-SY-102

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CONTENTS

TABLES

FIGURES

APPENDIXES

LIST OF TERMS

AB	Authorization Basis
AIChE	American Institute of Chemical Engineers
BIO	Basis for Interim Operation
Cat	category
Con	consequence
DOE-RL	Department of Energy - Richland Operations Office
Env	environmental
FREQ	Frequency
GRE	gas release event
Grp	group
HAZOP	Hazards And Operability Analysis
ID	identification
Mit	mitigative
NC	No Controls
PHA	Preliminary Hazards Assessment
PPP	Prefabricated Pump Pit
Prev	preventive
REP ACC	representative accident
SSC	structure, system, and component
TBD	to be determined
TSR	Technical Safety Requirement
TWRS	Tank Waste Remediation System
USQ	Unreviewed Safety Question

1.0 INTRODUCTION

1.1 PURPOSE

Tank 241-SY-101 (SY-101) waste level growth is an emergent, high priority issue. The purpose of this document is to record the hazards evaluation process and document potential hazardous conditions that could lead to the release of radiological and toxicological material from the proposed transfer of a limited quantity (approximately 100,000 gallons) of waste from SY-101 to 241-SY-102 (SY-102).

The results of the hazards evaluation will be compared to the current Tank Waste Remediation System (TWRS) Basis for Interim Operation (HNF-SD-WM-BIO-001, 1998, Revision 1) to identify any hazardous conditions where Authorization Basis (AB) controls may not be sufficient or may not exist. Comparison to LA-UR-92-3196, A Safety Assessment for Proposed Pump Mixing Operations to Mitigate Episodic Gas Releases in Tank 241-SY-101. was also made in the case of transfer pump removal activities. This document is not intended to authorize the activity or determine the adequacy of controls; it is only intended to provide information about the hazardous conditions associated with this activity. The Unreviewed Safety Question (USQ) process will be used to determine the adequacy of controls and whether the proposed activity is within the AB. This hazard evaluation does not constitute an accident analysis.

1.2 BACKGROUND

Episodic gas releases had been occurring in SY-101 since shortly after it was placed in service in 1980. These episodic releases were prevented beginning in late 1993 with the installation of a mixer pump. However, between February and December 1997, the indicated waste level in SY-101 increased approximately 4 inches. In-tank monitoring equipment detected no change in the waste's hydrogen release rate, temperature or mixer pump operational characteristics.

Mixer pump run frequency was increased in late October 1997 and continued through early December 1997 to determine if more aggressive pump operation would slow the rate of indicated level rise. Data showed that such pump operation did not reduce the rate of indicated level increase.

In February 1998, a USQ (TF-97-0975, 1997, *Unreviewed Safety Question, Waste Surface Level Growth in Tank 241-SY-101*, Revision 1) was declared for this anomaly, and The US Department of Energy – Richland Operations Office (DOE-RL) and its contractor team developed a plan to investigate and analyze the level rise. As a result of the ongoing investigation and analysis activities, reduction of the waste level in SY-101 has been identified as

part of a mitigation program for the crust level increase phenomena. The intent is to regain sufficient head space within the tank to allow routine operations to occur without concern that the crust will impact the operation of equipment or reach unacceptable levels within the tank. In order to reduce the waste level, a dedicated transfer system is being designed to transfer approximately 100,000 gallons of waste from SY-101 to SY-102.

2.0 DESCRIPTION

SY-101 is an underground double shell high level radioactive waste storage tank located in the 200 West Area at the Hanford Site. It has a capacity of 1.16 million gallons and currently contains approximately 1 million gallons of waste. SY-102 is also an underground double shell high level radioactive waste storage tank located adjacent to, and West of, SY-101. It also has a capacity of 1.16 million gallons. SY-102 currently contains 1.1 million gallons (388 inches) of waste that is being staged for cross site transfer.

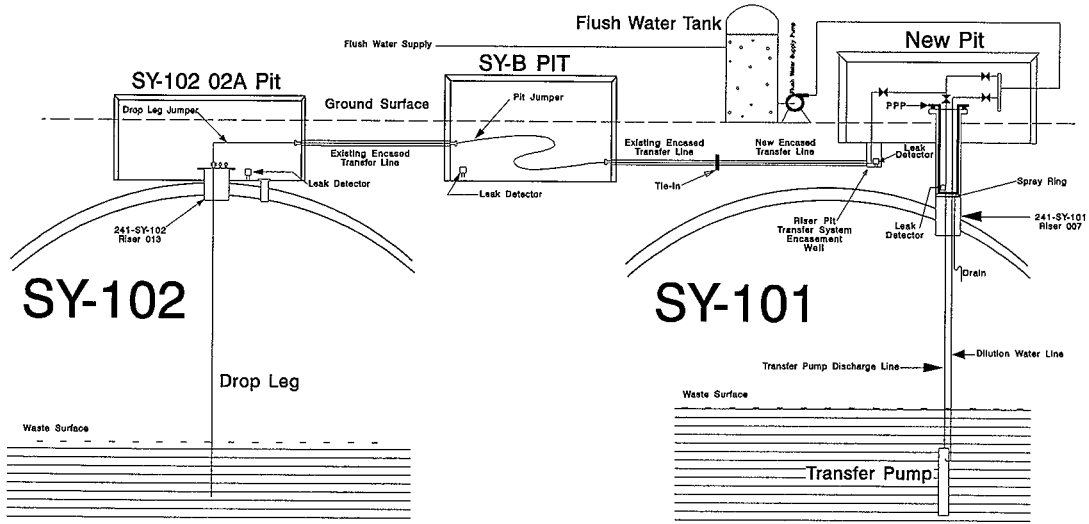
A system to transfer waste from SY-101 to SY-102 is being designed. This system will consist of a transfer pump that will be installed in SY-101, construction of a dedicated transfer line between SY-101 and SY-102, and installation of a drop leg in SY-102 to permit controlled introduction of waste into SY-102. The installation of a transfer pump in SY-101 will involve placing an assembly in a spare riser that will maintain tank confinement and support the transfer pump, and installation of a pit with cover block(s) to enclose the riser and associated transfer piping. The major components/assemblies associated with the system include:

- Transfer pump assembly
- Prefabricated Pump Pit (PPP)
- A pit with cover block(s) to surround the tank riser and PPP/transfer pump assembly
- Waste transfer line (ties into existing transfer line)
- Drop leg in receiver tank
- Necessary installation hardware
- Control system
- Facility upgrades

A diagram of the design concept of the waste transfer system is provided in Figure 2-1.

The presence of a mixer pump in the SY-101 pump pit riser makes the installation of a transfer pump in the tank unique because it must be installed in a riser not specifically dedicated to pumping activities. The riser selected for this purpose does not have any kind of pit surrounding it. A new pump pit will be required, thereby creating a change to the physical configuration of the facility. In order to determine hazardous conditions which exist, a Hazards and Operability Analysis (HAZOP) was performed on the proposed waste transfer system design on January 21, 1999.

Figure 2-1
SY-101 Transfer System General Schematic



3.0 HAZARD IDENTIFICATION AND EVALUATION

The hazards identification and evaluation for the transfer of waste from SY-101 to Tank SY-102 used the Hazards and Operability Analysis (HAZOP) method. In a HAZOP, a team leader systematically guides the HAZOP team through the system/process being evaluated using a fixed set of process parameters (e.g., flow, temperature, pressure) and guide words (e.g., high, low, less, more). The combination of the process parameters and guide words are applied at specific points or "nodes" in the system design to identify potential hazardous conditions associated with the operation of the system.

The waste transfer HAZOP was performed by an interdisciplinary team to identify the combinations of process parameters and guide words (the combination is generally referred to as deviations) associated with the installation and operation of waste transfer equipment that could potentially result in undesirable consequences. Process parameters, guide words, and deviations are listed in Table 3-1. During the HAZOP process potential consequences of the deviations were estimated, hazardous conditions formulated, and possible corrective and/or preventive measures identified and discussed. This process is recognized by the American Institute of Chemical Engineers (AIChE) and is described in AIChE, 1992, *Guidelines for Hazard Evaluation Procedures*. The HAZOP uses a tabular format to record the results of the systematic process.

Because the HAZOP process tends to be qualitative in nature, the expertise and experience of the team is of primary importance in establishing the credibility of the analysis. A short resume' of each team member is included in Appendix A to document the expertise and experience level of each team member.

3.1 METHODOLOGY

The HAZOP team met to develop the raw data. The information was recorded systematically in tabular format. The following sections describe the HAZOP table structure, information recording details, and process node descriptions.

3.1.1 HAZOP Table

The HAZOP table (Appendix B, Table B1) was structured to ensure a systematic and thorough evaluation of the potential hazards. The HAZOP table captured the following information:

Node description. A description of the node being evaluated. This information is captured in the table row preceding the first item for a given node, and is summarized in Section 3.1.2.

Item ID: The item identification (ID); used to record a unique identifier for the hazardous condition.

Node: Specific point in the system or process where the deviation from the desired condition of a process variable is evaluated. Nodes are chosen to ensure that no area where an undesirable condition could occur is left unevaluated.

Process Variable: The characteristics of a process, such as flow, pressure, or temperature, which are used to define proper operation.

Guide Word: Words that describe the variance in the process variable of concern such as high, low, more, or less. A complete summary of variables and guide words is given in Table 3-1.

Possible Causes of Deviation: The causes of the deviation that leads to the Hazardous Condition. Identifying causes is important to identifying potential preventive or mitigative controls or features for significant hazardous conditions as well as potential consequences. In many cases, multiple hardware or operational faults are required to produce a hazardous condition. This column identifies the sequence of hardware and operational faults required to produce the postulated hazardous condition.

Hazardous Condition: The hardware failures, operational faults, or conditions that could result in undesired consequences during waste transfer activities. The Hazardous Condition is a concise statement combining the Cause, Consequence, and mode of radioactive material release.

Consequence: The potential consequences that could result from the postulated deviation.

Suggested SSCs: Systems, structures, and components are existing engineered features (hardware items) identified by the HAZOP team that have the potential to mitigate or prevent the hazardous condition of concern. The engineered features are candidates for designation as Safety-Significant items for hazardous conditions that pose a significant threat to the health of facility workers and onsite personnel or Safety-Class for hazards that pose a significant threat to offsite individuals. These items should not be construed as being the "official" controls that would eventually be credited in the AB.

Suggested TSRs: Technical Safety Requirements are existing controls identified by the HAZOP team that have the potential to mitigate or prevent the hazardous condition of concern. These items should not be construed as being the "official" administrative features that would eventually be credited in the AB.

Con Cat The consequence category is a code designator for the level of consequence associated with a hazardous condition. The consequence ranking is a "first cut," qualitative estimate of the safety severity of the consequences assuming no controls are present. The following system is used:

S0 Negligible safety concerns for the facility worker.

S1 Potential industrial injury, low radiological or chemical exposure dose consequences to the facility worker.

S2 Potential significant radiological dose consequences or chemical exposure to onsite workers located outside the facility.

S3 Potential significant radiological dose consequences or chemical exposure to the offsite population.

Freq Cat: The frequency category is a "first cut," qualitative estimate of the likelihood of the hazardous condition assuming no controls are present. The following system is used:

F3 Events that are expected to occur one or more times during the lifetime of the facility, categorized as "anticipated" events. The frequency range associated with this category is 1E-02/yr to 0.1/yr.

F2 Events that could occur during the lifetime of the facility, but with low probability. Such events are categorized as "unlikely" and fall in the range of 1E-04/yr to 1E-02/yr.

F1 Events not expected to occur during the lifetime of the facility, categorized as "extremely unlikely." The frequency range associated with this category is 1E-06/yr to 1E-04/yr.

F0 Events categorized as "beyond extremely unlikely," with a frequency less than 1E-06/yr. Events in this category (such as meteor strike) are so unlikely they generally do not require special controls.

Env Cat: The environmental consequence ranking is a "first cut," qualitative estimate of the environmental severity of the hazardous condition assuming no controls are present. The following system is used:

E0 No significant environmental effect outside the facility confinement systems.

E1 Limited environmental discharge of hazardous material outside the facility.

E2 Large environmental discharge of hazardous material within the plant site boundary.

E3 Significant environmental discharges of hazardous material outside the plant site boundary.

Remarks: Miscellaneous observations or clarifying comments for a given item.

3.1.2 HAZOP Node Description

The 241-SY-101 waste transfer system HAZOP was based on nodes chosen to capture points in the process where deviations could result in significant consequences. The nodes are:

Node 1: Install PPP and pump into Tank 241-SY-101 42-inch riser.

Node 2: Install drop leg into Tank 241-SY-102 02A pit riser.

Node 3: Tank 241-SY-101 radioactive waste.

Node 4: Waste transfer pump transfer line in Tank 241-SY-101, below the PPP, above waste surface.

Node 5: Transfer line within the Tank 241-SY-101 new riser pit.

Node 6: This node was deleted. The design was changed after the HAZOP was completed eliminating this part of the system. The original design did not have a pit surrounding the riser and the transfer line exited the PPP above ground. A node was identified at this exposed portion of the line.

Node 7: Encasement well in Tank 241-SY-101 new riser pit located at the low point of the line. This node had a different designation during the HAZOP but was changed due to a change in the design after the completion of the HAZOP. The original design had a swab riser outside the PPP assembly at the low point of the transfer line. A pit encasement well inside the new pit replaced the swab riser. The hazardous conditions at this node were modified appropriately to reflect the change in design.

Node 8: New transfer line tie-in to existing transfer line.

Node 9: New jumper in SY-B valve pit.

Node 10: Tank 241-SY-102 02A pump pit drop leg jumper.

Node 11: Tank 241-SY-102 radioactive waste.

Node 12: Flush/dilution water supply line downstream of supply pump.

Node 13: Decon spray ring.

The location of the nodes is shown on the SY-101 Transfer System HAZOP Node diagram, Figure 3-1.

3.2 MAJOR ASSUMPTIONS

The specific assumptions, as developed during the hazards identification/evaluation team meeting, that are unique to this hazard analysis are:

- The important features of the waste transfer system design are captured in the SY-101 Transfer System General Schematic, Figure 2-1 of the preceding section.

- Hazardous conditions associated with waste movement through existing transfer lines, moving pit cover blocks, opening tank risers, vehicle activity, and waste storage were considered to be adequately addressed by the existing AB Hazards Analysis and the hazard analysis performed to address crust growth (HNF-3645, *Hazard Evaluation For Tank 241-SY-101 Waste Surface Level Growth*). The intent of the HAZOP was to identify hazardous conditions related to the unique nature of installation of a transfer pump in an SY-101 riser not located in a pre-existing pit and the process and configuration for transferring the SY-101 waste to SY-102.

- The SY-101 new riser pit will be constructed to the same level of leak tightness as existing TWRS pits. Any penetrations above ground will be sealed (not including the cover block(s)).

- The transfer pump operation will have a maximum pressure less than the design capacity of the existing transfer lines and pit jumper connections.

- Sealing of the Prefabricated Pump Pit (PPP) assembly to the Tank 241-SY-101 42 inch riser and the design of the PPP drain will prevent flammable gas generated in Tank 241-SY-101 from collecting in the new pit.

- The design of the load bearing structure for the PPP assembly will prevent the weight of the PPP transfer pump assembly from exceeding concentrated load limits for the tank.

3.3 EVALUATION

A total of 77 hazardous conditions were identified as a result of the HAZOP process, and are shown in the HAZOP table, Table B1, Appendix B. Of these 77 hazardous conditions, 31 were assigned S2 or S3 consequences. All but 10 of the S2 and S3 hazardous conditions were found to have characteristics similar to the Representative Accidents under the BIO Accident category, as shown in Table B7, Appendix B. Hazardous condition frequency was not considered in assignment to an Representative Accident.

Tables B2, B3, B4, and B5 of Appendix B present the hazardous conditions grouped by consequence category (S3, S2, S1, and S0 respectively). These tables contain the Item ID, Hazardous Condition, Cause, Frequency Category Without Controls (Freq), and the Environmental Impact Category (Env Cat).

Table B6, Appendix B, is a presentation of the potential applicability of current TWRS AB controls to hazardous conditions with S2 or S3 consequences. This table is intended to demonstrate that potential controls for prevention or mitigation of the identified hazardous conditions exist in the TWRS AB. However, the specified controls are not to be construed as the approved set of controls for the hazardous condition. Designation of the approved set of controls is outside the scope of this analysis. The hazardous conditions are listed in order of Representative Accident number.

Ten hazardous conditions were found related to flammable gas ignition events involving potential flammable gas release from the crust. Although these hazardous conditions fall under the general category of Flammable Gas Deflagrations – DSTs, the potential for additional flammable gas being released from the crust makes these hazardous conditions unique compared to those identified in the AB. The unique nature of these hazardous conditions is being addressed in a quantitative analysis that has been initiated because of concerns issuing from the Hazards Evaluation documented in HNF-3645, 1998, *Hazard Evaluation For Tank 241-SY-101 Waste Surface Level Growth,* Rev 0. The results of this analysis will determine whether the consequences from such events are bounded by the TWRS AB and whether additional controls are required. The quantitative analysis is being based on the following hazardous conditions identified in HNF-3645:

- ID # 101SYWLV-15A, caused by mixer pump failing with subsequent buoyant displacement GRE combined with gas release from the crust with ignition source present.

- ID# 101SYWLV-14A1, caused by crust growth with self collapse which creates a GRE from the crust with ignition source present.

- ID# 101SYWLV-16A1, caused by a gas release event (GRE) during mixer pump removal operations with ignition source present that results in ejection of contaminated pump.

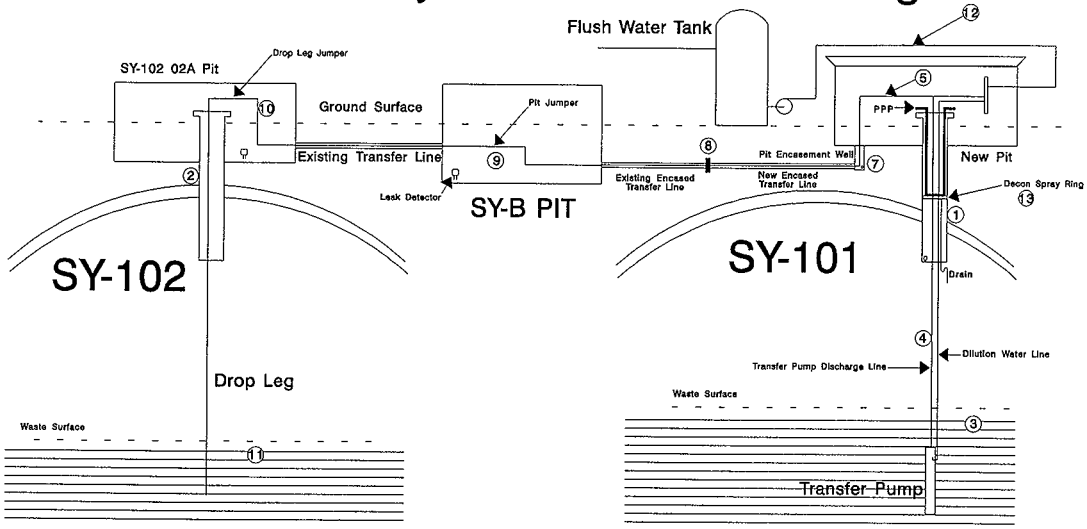
The 10 hazardous conditions are shown under the Representative Accident of Flammable Gas Deflagrations - DST (BIO Section 5.3.2.14) and are further grouped under the applicable HNF-3645 hazardous condition IDs. Because the quantitative analysis has not been completed the columns for these hazardous conditions in Table B6 for SSCs and TSRs are marked TBD (to be determined). Completion of the quantitative analysis will be subsequent to this HAZOP. This analysis will determine, among other things, if SSCs and TSRs are required to prevent or mitigate the accidents. The hazards evaluation is not intended to authorize an activity or determine the adequacy of controls; it is only intended to provide information about the hazardous conditions associated with the transfer of waste from SY-101 to SY-102. The AB control decision process will be used to determine the adequacy of controls and whether the proposed activity is within the AB. This result will assist in the closure of USQ TF-97-0975.

Table B7, Appendix B, presents the S2 and S3 category hazardous conditions grouped under the applicable BIO Accident Analysis Section. The Representative Accidents used in the BIO accident analyses are shown as shaded rows in Table B7. As indicated above, all hazardous conditions were found to fit under an existing Representative Accident in the BIO Accident Analysis.

Table 3-1. HAZOP DEVIATION GUIDE

Process Variables	Guide Words						
	NO, NOT, NONE	LESS, LOW, SHORT	MORE, HIGH, LONG	PART OF	AS WELL AS, ALSO	OTHER THAN	REVERSE
FLOW	No Flow	Low Rate, Low Total	High Rate, High Total	Missing Ingredient	Misdirection, Impurities	Wrong Material	Backflow
PRESSURE	Open to Atmosphere	Low Pressure	High Pressure				Vacuum
TEMPERATURE	Freezing	Low Temperature	High Temperature				Auto-refrigeration
LEVEL	Empty	Low Level	High Level	Low Interface	High Interface		
AGITATION	No Mixing	Poor Mixing	Excessive Mixing	Mixing Interruption	Foaming		Phase Separation
REACTION	No Reaction	Slow Reaction	Runaway Reaction	Partial Reaction	Side Reaction	Wrong Reaction	Decomposition
TIME PROCEDURE	Skipped or missing Step	Too Short, Too Little	Too Long, Too Much	Action(s) Skipped	Extra Action(s) (Shortcuts)	Wrong Action	Out of Order, Opposite
SPEED	Stopped	Too Slow	Too Fast	Out of Sync		Web or Belt Break	Backward
pH		Low pH	High pH		Additional Acid, Additional Base	Wrong Acid, Wrong Base	
CONCENTRATION		Low Concentration	High Concentration	Missing Ingredient		Additional Ingredient	
VISCOSITY		Low Viscosity	High Viscosity				
VOLTAGE	No Voltage	Voltage Low	Voltage High	Wrong Waveform	Interference Voltage	Wrong Frequency, AC instead of DC DC instead of AC	Wrong Polarity
CURRENT	No Current	Current High	Current Low			Current Fluctuating	Wrong Polarity
STATIC			Static Charge				
SPECIAL	Utility Failure	External Leak	External Rupture	Tube Leak	Tube Rupture	Startup, Shutdown, Maintenance	
STRUCTURAL STRENGTH	Structural Failure	Less Strength	More Strength				
SHIELDING		Less Shielding	More Shielding				

Figure 3-1
SY-101 Transfer System HAZOP Node Diagram



Node 1: Install PPP and Pump Into Tank 241-SY-101 42" Riser
Node 2: Install Drop Leg Into Tank 241-SY-102 02A Pit Riser
Node 3: Tank 241-SY-101 Radioactive Waste
Node 4: Waste Transfer Pump Line in Tank 241-Sy-101 Below PPP, Above Waste Surface
Node 5: Transfer Line Within the Tank 241-SY-101 New Riser Pit
Node 6: Deleted Due To Change In Design After the HAZOP Completed
Node 7: Encasement Well In Tank 241-SY-101 New Riser Pit Located At the Low Point of Line
Node 8: New Transfer Line Tie-In to Existing Transfer Line
Node 9: New Jumper in SY-B Valve Pit
Node 10: Tank 241-SY-102 02A Pump Pit Drop Leg Jumper
Node 11: Tank 241-SY-102 Radioactive Waste
Node 12: Flush/Dilution Water Supply Line Downstream of Supply Pump
Node 13: Decon Spray Ring

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4.0 CONCLUSIONS

The 241-SY-101 Waste Transfer HAZOP identified 31 hazardous conditions having S2 or S3 consequences. These hazardous conditions fit into five of the TWRS BIO Accident categories as shown in Table B7, Appendix B. All identified hazardous conditions were judged to be bounded by the Representative Accidents in the current TWRS AB with the exception of ten flammable gas deflagration hazardous conditions associated with crust gas retention and release. Quantitative analysis is being performed to determine if the consequences of such events exceed those specified in the TWRS BIO Accident Analysis and whether additional controls are needed.

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5.0 REFERENCES

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Appendix A

HAZOP Team Biographical Information

HAZOP Team Biographical Information

Tony R. Benegas, PE – B.S., Mechanical Engineering; B.S., Engineering Science; PE, Mechanical Engineering. Thirteen years experience in mechanical design, testing and fabrication of pumping systems, remote equipment, and other various nuclear components and systems. Technical lead for the 241-SY-101 Mixer and Transfer Pumps.

Michael F. Erhart – B.S., Chemical Engineering. Eight years experience at Hanford at Tank Farms as a Cognizant Engineer and Test Engineer responsible for Safety Equipment associated with the mitigation of Flammable Gas Watchlist Tanks. Worked for two of those years analyzing and reporting the Tank 241-SY-101 Gas Release Event Reports for Process Engineering.

J. Michael Grigsby - B.S., Mechanical Engineering. Twenty years experience in nuclear safety and licensing, including commercial nuclear power and DOE Hanford. Extensive involvement in investigation, analysis and resolution of TWRS safety issues including ferrocyanide, organic solvents, organic-nitrates and flammable gases. Contributor to TWRS Basis for Interim Operation (BIO) for organic and flammable gas hazards and controls.

Edward C. Heubach II – B.S., Chemical Engineering. Twenty-one years experience at Hanford in the fields of nuclear waste management and nuclear safety. Specific experience includes Process Engineering, Project Management, and Safety Analysis. The majority of his experience is with the tank farms, including the past eight years in Safety Analysis. Among the key safety documents to which Mr Heubach has contributed are: the Tank Farm Interim Operational Safety Requirements (IOSR); the TWRS BIO; the Final Safety Analysis Report (FSAR); and, safety documentation for deployment of the Light Duty Utility Arm.

Surya N. Maruvada – M.S., Electrical Engineering. Over twenty-seven years experience in nuclear safety, reliability engineering, safety and hazard analysis, probabilistic risk assessment and regulatory compliance in nuclear power plants and DOE (Hanford) facilities. Four years in reviews of Basis for Interim Operation (BIOs) and Safety Analysis Reports (SARs), including Multifunction Waste Treatment Facility (MWTF), Accelerated Safety Assessment (ASA), TWRS BIO, and TWRS FSAR.

Daniel. A. Reynolds, B.E.S., M.S., Chemical Engineering. Over twenty years experience at Hanford with most time spent in tank farm process engineering. Has been involved in safety issue resolution for flammable gas, organic nitrate, high heat, source term and compatibility. Knowledgeable in waste chemistry.

Grant W. Ryan, PE - B.S., Physics; B.S., Nuclear Engineering; PE, Mechanical Engineering. Eight years experience in nuclear facility safety analysis and general engineering support. Have authored numerous documents at Hanford to support safe operations. These have included operating and alarm response procedures, safety analysis reports (TWRS BIO, TWRS FSAR), calculation notes, topical reports, and engineering studies.

Milton V. Shultz, Jr. - B.S., Nuclear Engineering Technology. Facilitator for Tank 241-SY-101 waste transfer HAZOP. More than twenty-four years experience in a broad range of engineering and technical assignments at the Hanford Site. Experience includes leading Preliminary Hazards Analysis (PHAs) and HAZOPs for a variety of TWRS projects, including several for the TWRS FSAR and BIO efforts, contributor to the hazards analysis work for the TWRS BIO. Has performed independent Nuclear Safety evaluations of reactor plant design and operation at Hanford's N Reactor.

Frederick A. Schmorde - B.S., Electrical Engineering. Thirty years of experience with nuclear facility operations, including twenty-one years in the Navy nuclear propulsion program, and nine years at DOE Hanford. Significant in-farm experiences, including field operations and Characterization Projects sampling operations. Currently certified as a Tank Waste Operations (TWO) Shift Manager and an Operations Engineer. Certified as an independent nuclear safety integrated audit team leader, sub-team leader, and auditor.

Ryan D. Smith – B.S., Mechanical Engineering. Five years of experience at the Hanford Site with the last two years specific to nuclear safety and licensing support. Extensive knowledge in flammable gas related issues related to pumping nuclear waste to and from TWRS facilities. Licensing engineer and key team member in establishing the Authorization Basis (AB) for Interim Stabilization and reconciliation of the LANL Safety Assessment (SA) with the TWRS BIO.

Robin S. Sullivan - B.S., Metallurgical Engineering. Assisted facilitation for Tank 241-SY-101 waste transfer HAZOP. Over six years of experience at the Hanford Site with the last two years specific to the TWRS BIO and FSAR development and AB maintenance and clarification. Has performed PHAs, HAZOPs and hazard evaluation reviews and is currently a contributor to the safety analysis and documentation for the TWRS AB and the International Safety Program.

John C. Van Keuren, B.S., M.S., Ph.D., Nuclear Engineering. Twenty-seven years experience in the Nuclear Industry. Experience in safety analysis areas includes extensive support for TWRS FSAR/BIO including source term preparation, toxic consequence methodology, and a number of accident consequence analyses including spray and pool leak consequences.

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Appendix B

Hazard Evaluation Tables

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Appendix B Table of Contents

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Table B1. HAZOP Table - SY-101 Waste Transfer System

Number of Pages =22

Item ID	Node	Process Variable	Guide Word	Possible causes of deviation	Hazardous Condition	Consequence	Suggested SSCs	Suggested TSRs	Con Cat	Freq Cat	Env Cat	Remarks
Node 1: Install PPP and pump into Tank 241-SY-101 42" Riser -Water Lance -Install PPP and pump as a unit -Install Instruments												
SYXFR01-01	1	Confinement (during the opening of riser)	None	Ventilation system failures result in positive pressure in tank white riser open resulting in release	Unfiltered release of radioactive aerosols from Tank 241-SY-101 dome space Accident addressed under BIO 5.3.2.2	Generalized loss of confinement with release of radioactive aerosols	None	None	S1	F3	E1	This is opening the riser to prepare for PPP installation.
SYXFR01-02	1	Confinement (during the opening of riser)	None	Flammable gas ignition	Flammable gas ignites in Tank 241-SY-101 when riser activities cause spark resulting in radioactive aerosol release BIO 5.3.2.14	Flammable gas ignition causes expulsion of radioactive aerosols - through open risers - through damaged risers	DST ventilation Tank 241-SY-101 hydrogen monitor	AC: 5.10 AC: 5.11	S3	F3	E3	This is opening the riser to prepare for PPP installation.
SYXFR01-03	1	Personnel Exposure	Excessive	Human error or inadequate protection from shine from open riser	Personnel are exposed to high levels of ionizing radiation during PPP installation activities	Personnel receive excessive radiation dose	None	None	S1	F3	E0	Covered by radiation protection program.

Table B1. HAZOP Table - SY-101 Waste Transfer System

Number of Pages =22

Item ID	Node	Process Variable	Guide Word	Possible causes of deviation	Hazardous Condition	Consequence	Suggested SSCs	Suggested TSRs	Con Cat	Freq Cat	Env Cat	Remarks
SYXFR01-04	1	Structural Integrity (installing PPP)	Less	Damage to riser due to - Jam - Drop on riser or tank dome - Vehicle impact	Dropped equipment during installation damages Tank 241-SY-101 riser and/or tank dome BIO 5.3.2.13	Release of radioactive aerosols to atmosphere	None	AC: 5.10 AC: 5.16	S2	F2	E2	Installing the Pump and PPP. Estimating 15,000 lbs (mixer pump is ~20,000 lbs). Load frame will be installed prior to PPP installation. Damage due to vehicle impact is of low likelihood due to the presence of the Tank 241-SY-101 new riser pit. Vehicle fuel fires covered in BIO 5.3.2.3.
SYXFR01-05	1	Structural Integrity (installing PPP)	Less	Overloaded tank dome due to PPP installation	Localized load potentially damages Tank 241-SY-101 dome/riser creating unfiltered path for aerosol release	Release of radioactive aerosols to atmosphere BIO 5.3.2.2 for consequences (unfiltered release)	DF: Load frame	AC: 5.16	S3	F1	E2	Load frame will be installed before installation of PPP assembly. See BIO ITK-FR-04 for consequences of riser damage.
SYXFR01-06	1	Structural Integrity (installing PPP)	Less	Pump assembly too long resulting in breaching tank bottom	Tank 241-SY-101 bottom punctured due to pump assembly being too long resulting in potential release to soil (leak into annulus)	Release of tank waste to annulus with potential of leak to soil	Primary tank leak detection systems	AC: 5.16	S0	F3	E3	Addressed by BIO ITK-07, ITK-07ID.

Table B1. HAZOP Table - SY-101 Waste Transfer System

Number of Pages =22

Item ID	Node	Process Variable	Guide Word	Possible causes of deviation	Hazardous Condition	Consequence	Suggested SSCs	Suggested TSRs	Con Cat	Freq Cat	Env Cat	Remarks
SYXFR01-07	1	Flammable Gas Generation (release from waste)	More	Insertion of PPP assembly into tank disturbs waste releasing flammable gas	Flammable gas generated and ignited in Tank 241-SY-101 due to intrusive activity resulting in release of radioactive aerosols BIO 5.3.2.14	Flammable gas ignition causes expulsion of radioactive aerosols - through open risers - through damaged risers	DST ventilation	AC: 5.10 AC: 5.11	S3	F3	E3	None
Node 2: Install Drop Leg into Tank 241-SY-102 Riser - Remove cover block and jumper, install drop leg, install new jumper (install Lk Detect)												
SYXFR02-08	2	Confinement (compare to SYXFR01-01)	None	Ventilation system failures result in positive pressure in tank while riser open resulting in release	Unfiltered release of radioactive aerosols from Tank 241-SY-102 dome space BIO 5.3.2.2	Generalized loss of confinement resulting in release of radioactive aerosols	None required	None required	S1	F3	E1	Hazards less for these hazardous conditions than those specified in the BIO.
SYXFR02-09	2	Confinement (compare to SYXFR01-02)	None	Flammable gas ignition	Flammable gas ignition during drop leg installation in Tank 241-SY-102 results in aerosol release of radioactive material BIO 5.3.2.14	Flammable gas ignition causes expulsion of radioactive aerosols - through open risers - through damaged risers	DST ventilation	AC: 5.10 AC: 5.11	S3	F3	E3	Hazards less for these hazardous conditions than those specified in the BIO.
SYXFR02-10	2	Personnel exposure (compare to item SYXFR01-03)	Excessive	Personnel not adequately protected from shine	Personnel are exposed to high levels of ionizing radiation during drop leg installation activities	Personnel receive excessive radiation dose	None	None	S1	F3	E0	Covered by radiation protection program.
SYXFR02-11	2	Structural Integrity (installing drop leg - compare to item SYXFR01-06)	Less	Design error results in drop leg being too long - bottom of tank punctured during installation	Tank 241-SY-102 bottom punctured due to drop leg assembly too long resulting in potential release to soil (leak into annulus)	Release of tank waste to annulus with potential of leak to soil	None required	AC: 5.16	S0	F2	E2	Addressed by BIO ITK-07, ITK-07ID.
Node 3: Tank 241-SY-101 Tank Waste												

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Number of Pages =22

Item ID	Node	Process Variable	Guide Word	Possible causes of deviation	Hazardous Condition	Consequence	Suggested SSCs	Suggested TSRs	Con Cat	Freq Cat	Env Cat	Remarks
SYXFR03-12a	3	Temperature	Low	Failure of service water heating resulting in addition of cold dilution water	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	More frequent or larger GREs creating higher likelihood of ignition events with radioactive material release BIO 5.3.2.14	SY-101 Mixer Pump	AC: 5.9	S3	F3	E3	None
SYXFR03-12b	3	Temperature	High	Hot flush/dilution water added (failure of temperature control) coupled with failure to transfer material	Ignition of significant quantities of flammable gas in Tank 241-SY-101 released from dissolution of crust causing radioactive aerosol release	Release of significant quantities of radioactive aerosols BIO 5.3.2.14	DST ventilation	AC: 5.9	S3	F1	E3	Not a significant contribution to flammable gas generation.
SYXFR03-13a	3	Level	Low - excessive	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	Release of radioactive aerosols due to ignition of large quantities of flammable gas in Tank 241-SY-101 released from buoyant displacement GRE	Buoyant Displacement GRE with ignition causes release of radioactive aerosols BIO 5.3.2.14 TSR Violation - Occurrence	Tank 241-SY-101 level monitoring system * Flow Totalizers on Transfer Line	AC: 5.12 Material Balance	S3	F2	E3	Transfer takes a long period of time, it would take a long period of time to remove excessive amount of waste.

Table B1. HAZOP Table - SY-101 Waste Transfer System

Number of Pages =22

Item ID	Node	Process Variable	Guide Word	Possible causes of deviation	Hazardous Condition	Consequence	Suggested SSCs	Suggested TSRs	Con Cat	Freq Cat	Env Cat	Remarks
SYXFR03-13b	3	Level	Low - excessive	Human error or instrument failure results in excessive transfer or siphoning	Dome failure due to overload from solidified waste suspended from intank equipment due to low liquid level in Tank 241-SY-101 BIO 5.3.2.13	Lollipops cause localized dome loading leading to dome failure and radioactive aerosol release See BIO 5.3.2.13	Tank 241-SY-101 level monitoring system	AC: 5.12	S2	F0	E2	Lollipop issue addressed in Hazard Analysis for level increase, ID 101SY-WLV-8A, HNF-3645. Large solidified pieces of waste crust adhering to installed quipment suspended from the tank risers could represent significant concentrated load (lollipops have been observed in other tanks).
SYXFR03-14	3	Level	High	1. Excessive dilution without transfer occurring - plugged transfer line - bad pump - bad flow meters - operator error coupled with instrument error 2. Inadvertent draining from flush tank 3. Inability to pump results in continued increase of waste level	Release of radioactive material from waste tank due to overfill of Tank 241-SY-101 resulting in pool (see HNF-3645 for details)	Radioactive material release due to pool leak, see HNF-3645 and BIO 5.3.2.18	ENRAF Level Detection Service Water Flow Totalizers Flow Totalizers on Transfer Line	AC: 5.21 AC: 5.12 Max level	S2	F2	E2	Project has a dedicated line - no mistransfer from other facilities possible, or mistransfers out.

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Number of Pages =22

Item ID	Node	Process Variable	Guide Word	Possible causes of deviation	Hazardous Condition	Consequence	Suggested SSCs	Suggested TSRs	Con Cat	Freq Cat	Env Cat	Remarks
SYXFR03-15	3	Composition/ Concentration	Additional ingredient - water	1. Excessive dilution (flush) water without transfer occurring - plugged transfer line - bad pump - bad flow meters - operator error coupled with instrument error 2. Inadvertent draining from dilution (flush) tank 3. Inability to pump results in continued increase of waste level Same as SYXFR03-14	Radioactive aerosol release due to water addition dissolving crust causing GRE with ignition in Tank 241-SY-101 (HNF-3645,101SY-WLV-23AT)	Radioactive material release due to flammable gas generation/burn BIO 5.3.2.14	ENRAF Level Detection Service Water Flow Totalizers Flow Totalizers on Transfer Line	AC: 5.21 AC: 5.12 Max level	S3	F2	E3	It is unsure how much waste dilution is significant to crust dissolving. Currently being considered as one of the analyzed accidents for mitigation.
Node 4: Pump Transfer Line in Tank 241-SY-101 Before PPP, Above Waste Surface												
SYXFR04-16	4	Flow	No	No waste flow due to pump not operating	No safety consequences	No safety consequences - operational delay of waste transfer	NA	NA	NA	NA	NA	None
SYXFR04-17	4	Flow	High	Hole in pipe (spray leak) inside dome space	Radioactive aerosol release due to spray leak dissolving crust causing GRE with ignition in Tank 241-SY-101 BIO 5.3.2.14	Flammable gas release and ignition due to spray on crust dissolving crust BIO 5.3.2.14	None	LCO: 3.1.4* AC: 5.9	S3	F1	E3	*Control list included those for spray leaks inside tanks. Team feels this condition is bounded by dissolution accident. (HNF-3645 Items 101SY-WLV-14A and 101SY-WLV-22AT)

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Number of Pages =22

Item ID	Node	Process Variable	Guide Word	Possible causes of deviation	Hazardous Condition	Consequence	Suggested SSCs	Suggested TSRs	Con Cat	Freq Cat	Env Cat	Remarks
SYXFR04-18	4	Flow	Excessive rate	Rapid transfer disturbs crust greater than postulated	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	Radioactive aerosol release from flammable gas ignition in dome space BIO 5.3.2.14	None	AC: 5.9 AC: 5.12 Material Balance	S3	F1	E3	Team feels this condition is bounded by dissolution accident. (HNF-3645 Items 101SY-WLV-14A and 101SY-WLV-22AT)
SYXFR04-19	4	Flow	Reverse	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 (See item SYXFR03-14)	Release of radioactive material from waste tank due to overfill of Tank 241-SY-101 resulting in pool (see HNF-3645 for details) Also see item SYXFR03-14	Radioactive material release due to pool leak See HNF-3645 and BIO 5.3.2.18	ENRAF Level Detection Service Water Flow Totalizers	AC: 5.21 AC: 5.12 Max level	S2	F2	E2	None
SYXFR04-20	4	Pressure	High	Transfer pump dead headed due to human error, plugging, or equipment failure	No hazardous condition, system is designed so that extreme pressures capable of breaching piping cannot be reached	No safety consequences	None	None	S0	F3	E0	None
SYXFR04-21	4	Pressure	Low	Transfer pump failed, human error caused pump misoperation, control system failure Causes similar to low flow	No safety consequences	Indication of transfer failure only - no safety consequences associated with low pressure	None	None	S0	F3	E0	None

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Number of Pages =22

Item ID	Node	Process Variable	Guide Word	Possible causes of deviation	Hazardous Condition	Consequence	Suggested SSCs	Suggested TSRs	Con Cat	Freq Cat	Env Cat	Remarks
SYXFR04-22	4	Temperature	High	Hot flush/dilution water added (failure of temperature control) coupled with failure to transfer material	Ignition of significant quantities of flammable gas released from dissolution of crust in Tank 241-SY-101 causing radioactive aerosol release	No high temperature concerns other than those identified for dilution	DST ventilation	AC: 5.12 Material balance	S3	F1	E3	Overflow is captured in other accidents.
SYXFR04-23	4	Concentration	Inadequate Dilution	Human error in flow setup, instrumentation miscalibration, or equipment failure	No safety significance	Potential for transfer line plugging	None	None	S0	F3	E0	Pump performance issue. Increased solids content of transfer may cause problems with Tank 241-SY-102.
Node 5: Transfer Line Within the Tank 241-SY-101 new Riser Pit												
SYXFR05-24a	5	Flow	No/Low	Equipment failure resulting in valve acting as a blockage Transfer pump failure	Personnel exposure concern due to waste trapped in transfer line	Significant personnel radiation exposure	None	None	S1	F3	E0	Covered by radiation protection program.
SYXFR05-24b1	5	Flow	No/Low	Ruptured line/leaking flange or valve inside Tank 241-SY-101 new riser pit	Release of radioactive liquid released in Tank 241-SY-101 new riser pit due to leak from line, flange or valve Spray leak BIO 5.3.2.20	Aerosol release of radioactive material Consequences bounded by BIO 5.3.2.20	Cover blocks *Tank 241-SY-101 new riser pit Leak detection *Drain in PPP *Pump Shutdown Interlock	LCO 3.1.1 AC: 5.22	S3	F3	E3	Tank 241-SY-101 new riser pit should be treated like any other transfer system pits.

Table B1. HAZOP Table - SY-101 Waste Transfer System

Number of Pages =22

Item ID	Node	Process Variable	Guide Word	Possible causes of deviation	Hazardous Condition	Consequence	Suggested SSCs	Suggested TSRs	Con Cat	Freq Cat	Env Cat	Remarks
SYXFR05-24b2	5	Flow	No/Low	Ruptured line/leaking flange or valve inside Tank 241-SY-101 new riser pit	Overflow of Tank 241-SY-101 new riser pit due to leak from line, flange or valve Pool release BIO 5.3.2.18	Pool of radioactive material Consequences bounded by BIO 5.3.2.18	Cover blocks *Tank 241-SY-101 new riser pit Leak detection *Drain in PPP *Pump Shutdown Interlock	LCO 3.1.1 AC: 5.22	S3	F2	E3	Tank 241-SY-101 new riser pit should be treated like any other transfer system pits.
SYXFR05-24c	5	Flow	No/Low	Human error causing incorrect valving (flush pump must be off)	Release of radioactive liquid from flush tank due to pool leak caused by backflow of waste into flush system BIO 5.3.2.18	Formation of surface pool due to overflow of flush tank	Service water backflow preventers Pressure Switch and alarm	LCO: 3.1.2	S3	F2	E3	Requires multiple events/failures to occur (flush pump inoperable, valve misposition, and transfer occurring.
SYXFR05-24d	5	Flow	No/Low	Plugged line	Personnel exposure concern due to waste trapped in transfer line	Significant personnel radiation exposure	None	None	S1	F3	E0	Covered by radiation protection program.
SYXFR05-25	5	Flow	High	Human error or equipment failure causes pump flow rate to be above desired point	No safety significance	Transfer rate above desired value	None	None	S0	F3	E0	None
SYXFR05-26	5	Flow	Reverse	Siphon condition from receiving tank to supply tank	No safety significance	No safety significant consequences - operational delay in order to restore tanks to desired state	DF: Antisiphon design	None	S0	F3	E0	Siphon event would only equalize the quantity of material in the two tanks - they are at the same elevation.

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Number of Pages =22

Item ID	Node	Process Variable	Guide Word	Possible causes of deviation	Hazardous Condition	Consequence	Suggested SSCs	Suggested TSRs	Con Cat	Freq Cat	Env Cat	Remarks
SYXFR05-27a	5	Pressure	High	Plugging at the Tank 241-SY-102 drop leg due to solidification of waste	Spray leaks at the 241-SY-B pit at jumper connections due to high pressure BIO 5.3.2.20	Aerosol release and pool formation as postulated by BIO 5.3.2.20	*New Leak Detectors installed	LCO: 3.1.1 AC: 5.22	S3	F3	E3	Jumper connections evaluated for the dead head pressure for the pumping system.
SYXFR05-27b	5	Pressure	High	Plugging at the Tank 241-SY-102 drop leg due to solidification of waste	Spray leaks at the Tank 241-102-SY 02A pump pit at jumper connections due to high pressure BIO 5.3.2.20	Aerosol release and pool formation as postulated by BIO 5.3.2.20	*New Leak Detectors installed	LCO: 3.1.1 AC: 5.22	S3	F3	E3	Jumper connections evaluated for the dead head pressure for the pumping system.
SYXFR05-28a	5	Pressure	Low	Equipment failure resulting in valve acting as a blockage Transfer pump failure	No safety significance	No significant safety consequences - operational delay	None	None	S0	F3	E0	None
SYXFR05-28b1	5	Pressure	Low	Ruptured line/leaking flange or valve inside Tank 241-SY-101 new riser pit	Release of aerosol generated in Tank 241-SY-101 new riser pit due to spray leak from line, flange or valve. Pool release BIO 5.3.2.18	Aerosol release of radioactive material (consequences less than high flow due to low pressure) Consequences bounded by BIO 5.3.2.18	Cover blocks *Tank 241-SY-101 new riser pit Leak detection in PPP and Encasement well in Tank 241-SY-101 new riser pit *Drain in PPP *Pump Shutdown Interlock	Transfer system supplemental cover JCO	S3	F3	E3	Tank 241-SY-101 new riser pit should be treated like any other transfer system pit. *The transfer system will have its own leak detection system.

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Number of Pages =22

Item ID	Node	Process Variable	Guide Word	Possible causes of deviation	Hazardous Condition	Consequence	Suggested SSCs	Suggested TSRs	Con Cat	Freq Cat	Env Cat	Remarks
SYXFR05-28b2	5	Pressure	Low	Ruptured line/leaking flange or valve inside Tank 241-SY-101 new riser pit	Release of liquid waste in Tank 241-SY-101 new riser pit due to leak from line, flange or valve forming pool Pool leak BIO 5.3.2.20	Aerosol release of radioactive material (consequences less than high flow due to low pressure) Consequences bounded by BIO 5.3.2.20	Cover blocks *Tank 241-SY-101 new riser pit Leak detection in PPP and Encasement well in Tank 241-SY-101 new riser pit *Drain in PPP *Pump Shutdown Interlock	Transfer system supplemental cover JCO	S3	F3	E3	Tank 241-SY-101 new riser pit should be treated like any other transfer system pit. *The transfer system will have its own leak detection system.
SYXFR05-28c	5	Pressure	Low	Human error causing incorrect valving (flush pump must be off)	Release of radioactive liquid due to pool leak caused by backflow of waste into flush system overflowing flush tank	Formation of surface pool outside Tank 241-SY-101 new riser pit Consequences bounded by BIO 5.3.2.18	Backflow prevention devices (spray leak)	None	S3	F2	E3	None
SYXFR05-28d	5	Pressure	Low	Plugged line	No safety significance	No significant safety consequences	None	None	S0	F3	E0	None
SYXFR05-29	5	Temperature	Low	Line plug due to waste cooling (less than 110 degrees F due to low ambient temp)	Operational delay due to low flow	No significant safety consequence	None	None	S0	F3	E0	Currently no heat tracing in the Tank 241-SY-101 new riser pit.
SYXFR05-30	5	Temperature	Low	Cold weather causes lines to freeze	Freezing of dilution water lines results in operational delay	No significant safety consequence	None	None	S0	F3	E0	None

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Number of Pages =22

Item ID	Node	Process Variable	Guide Word	Possible causes of deviation	Hazardous Condition	Consequence	Suggested SSCs	Suggested TSRs	Con Cat	Freq Cat	Env Cat	Remarks
SYXFR05-31	5	Temperature	High	Flush water too hot	Flush with high temperature flush water with preexisting spray leak causes release of high temperature aerosols in Tank 241-SY-101 new riser pit BIO 5.3.2.20	Release of high temperature radioactive aerosols Bounded by BIO 5.3.2.20	*Tank 241-SY-101 new riser pit Leak detection in PPP and encasement well in Tank 241-SY-101 new riser pit *Drain in PPP *Pump Shutdown Interlock	None	S3	F2	E3	Tank 241-SY-101 new riser pit should be treated like any other transfer system pits. Higher temperature flush water does not have a significant impact on consequences of this accident compared to cold flush water.
SYXFR05-32	5	Temperature	High	Industrial hazard - hot valve handles etc.	Personnel injured due to occupational hazards (high temperature flush water)	Personnel injury	None	None	S1	F3	E0	Covered by Institutional Health and Safety Program.
SYXFR05-33	5	Shielding	Low	Design problem	Personnel exposed to high levels of ionizing radiation - Covered by Radiation Protection	Radiation overexposure	None	None	S1	F3	E0	Covered by radiation protection program. May be included in Tank 241-C-106 hazard identification.
Node 6: Deleted due to change in design after HAZOP completed												
Node 7: Encasement Well In Tank 241-SY-101 new Riser Pit Located at the Low Point of the Line (Includes Transfer Line Encasement)												
SYXFR07-38a	7	Flow	No	Desired condition	No flow inside the encasement well in Tank 241-SY-101 new riser pit is the desired condition for this system	None	NA	NA	NA	NA	NA	None

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SYXFR07-38b	7	Flow	Any	Primary line leak with pressurization (caused by encasement seal loop left closed after testing)	Release of radioactive aerosols due to spray leak from encasement well in Tank 241-SY-101 new riser pit due to primary line leak with encasement test port not fully open	Aerosol release into the Tank 241-SY-101 new riser pit BIO 5.3.2.20	Pit covers Leak Detection in encasement well in Tank 241-SY-101 new riser pit and PPP	*AC: Pressure test fixture in Tank 241-SY-101 new riser pit - verify open *LCO: Leak Detect	S3	F2	E3	Leak detector interlock to shut down pump.
SYXFR07-39	7	Pressure	No	Desired condition	No pressure inside encasement is the desired condition for this system	None	NA	NA	NA	NA	NA	None
SYXFR07-40	7	Pressure	Any	Primary line leak with pressurization (caused by encasement seal loop left closed after testing) Same as SYXFR07-38	Spray leak from encasement well in Tank 241-SY-101 new riser pit due to primary line leak with encasement test port not fully open	Aerosol release into the Tank 241-SY-101 new riser pit with potential for release outside the pit	Pit covers Leak Detection in encasement well in Tank 241-SY-101 new riser pit and PPP	*AC: Pressure test fixture in Tank 241-SY-101 new riser pit - verify open *LCO: Leak Detect	S3	F2	E3	Leak detector interlock to shut down pump.
SYXFR07-41	7	Temperature	Low	Low ambient ground temperature	Higher potential for plugging due to waste crystallization from cooling	Operational impact	None	None	S0	F3	E0	Heat tracing used to maintain operating temperature in pipe.
SYXFR07-42	7	Temperature	High	Heat trace overheats pipe/boils waste	Production of steam when waste transferred through overheated transfer line	Minimal operational impact - drop leg routes flow below the tank waste surface preventing aerosol production	DF: Self limiting heat trace	None	S0	F3	E0	None

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Number of Pages =22

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Node 8: New Transfer Line Tie-In to Existing Transfer Line												
SYXFR08-43	8	Structural Integrity	Low	Excavation activities damage transfer lines	Excavation activities damage excavation lines in vicinity of the new transfer line tie-in	No significant changes from BIO analysis Bounded by BIO 5.3.2.21	None	AC: 5.17	S3	F3	E3	This activity is covered by existing excavation controls.
Node 9: New Jumper in SY-B Valve Pit												
No unique features/hazards associated with new jumper- Project is installing new leak detection system in pit												
Node 10: 102-SY 02A Pump Pit, Drop Leg Jumper												
No unique features/hazards associated with new jumper- Project is installing new leak detection system in pit												
Node 11: Tank 241-SY-102 Tank Waste												
SYXFR11-44	11	Temperature	Low	Normal operating condition	Low temperature is the desired operating condition of the waste in Tank 241-SY-102	None	NA	NA	NA	NA	NA	None
SYXFR11-45a	11	Temperature	High	Transfer of heat generating waste from Tank 241-SY-101	Creation of a tank with waste conditions not covered by current Authorization Basis	No significant safety consequences - administrative concern	None	AC: 5.12 - Waste compatibility	S0	F2	E0	Thermal stress is not a safety issue - considered operational concern. BIO 5.3.2.13
SYXFR11-45b	11	Temperature	High	Transfer of heat generating waste from Tank 241-SY-101	Excessive heat up rate causes thermal stress in tank structural and potential leak	Leak into annulus of Tank 241-SY-102	Primary tank leak detection systems	AC: 5.12 - Waste compatibility	S0	F2	E3	Thermal stress is not a safety issue - considered operational concern. BIO 5.3.2.13
SYXFR11-46a	11	Level	Low	Drop leg design error results in waste level being below discharge point - entrained gasses are released as waste is discharged	Release of radioactive aerosols due to flammable gas deflagration in Tank 241-SY-102 BIO 5.3.2.14	Flammable gas evolution and ignition resulting in radioactive aerosol release	DST ventilation	AC: 5.9 AC: 5.10 LCO: 3.2.1	S3	F3	E3	None

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Number of Pages =22

Item ID	Node	Process Variable	Guide Word	Possible causes of deviation	Hazardous Condition	Consequence	Suggested SSCs	Suggested TSRs	Con Cat	Freq Cat	Env Cat	Remarks
SYXFR11-46b	11	Level	Low	Drop leg design error results in waste level being below discharge point - entrained gasses are released as waste is discharged	Release of toxic gas to environment from Tank 241-SY-102 and exposure of personnel	Personnel exposure to toxic material	None	None	S1	F3	E1	Occupational safety and health guidelines for toxic gas exposure. This accident is bounded by the analysis contained in BIO Section 5.3.2.11, Mixing of Incompatible Material-Toxic Vapor Generation.
SYXFR11-46c	11	Level	Low	Drop leg design error results in waste level being below discharge point	Poor distribution of solids due to low level to be covered under agitation, item SYXFR11-48 a through e	See SYXFR11-48 a through e	None	None	NA	NA	NA	None
SYXFR11-47	11	Level	High	Back pressure on system due to increased head on drop leg	No safety or operational impact	No safety or operational impact	None	None	S0	F3	E0	Overflow covered by BIO.
SYXFR11-48a	11	Agitation	Poor Mixing	Low liquid level prevents drop leg from distributing solids	Flammable gas deflagration due to increased gas generation in Tank 241-SY-102 results in release of radioactive aerosols	Flammable gas ignition due to increased gas generation from increase of solids layer Compatibility issues Addressed by BIO 5.3.2.14	DST ventilation	AC: 5.12	S3	F3	E3	None
SYXFR11-48b	11	Agitation	Poor Mixing	Low liquid level prevents drop leg from distributing solids	Redissolve TRU causing redistribution of TRU location in waste	Compatibility issues	None	None	S0	F2	E0	None

Table B1. HAZOP Table - SY-101 Waste Transfer System

Number of Pages =22

Item ID	Node	Process Variable	Guide Word	Possible causes of deviation	Hazardous Condition	Consequence	Suggested SSCs	Suggested TSRs	Con Cat	Freq Cat	Env Cat	Remarks
SYXFR11-48c	11	Agitation	Poor Mixing	Low liquid level prevents drop leg from distributing solids	High phosphates from other operations causes potential for reaction causing solid phosphates	Compatibility issues	None	None	S0	F2	E0	None
SYXFR11-48d	11	Agitation	Poor Mixing	Low liquid level prevents drop leg from distributing solids	The pH may be lowered enough to precipitate aluminates	Compatibility issues	None	AC: 5.12	S0	F2	E0	None
SYXFR11-48e	11	Agitation	Poor Mixing	Low liquid level prevents drop leg from distributing solids	Lose volume of tank for future operations due to additional settled solids	Compatibility issues	None	AC: 5.12	S0	F2	E0	None
Node 12: Flush/Dilution Water Supply Line Downstream of Supply Pump												
SYXFR12-49a	12	Flow	No\Low	Pump is not operating due to operator error or equipment failure	Release and ignition of flammable gas in transfer line resulting in generation of radioactive aerosols BIO 5.3.2.14 Plugged line from solidifying waste results in operational consequences and high radiation field in Tank 241-SY-101 new riser pit	1 Inability to flush line when desired creating potential for flammable gas generation in the transfer line and release with ignition BIO 5.3.2.14 2 Failure to provide adequate dilution for transfer resulting in plugging (see node 2)	None	AC: 5.10 AC: 5.11	S1	F1	E1	None

Table B1. HAZOP Table - SY-101 Waste Transfer System

Number of Pages =22

Item ID	Node	Process Variable	Guide Word	Possible causes of deviation	Hazardous Condition	Consequence	Suggested SSCs	Suggested TSRs	Con Cat	Freq Cat	Env Cat	Remarks
SYXFR12-49b	12	Flow	No\Low	Water supply tank is empty/no supply	Release and ignition of flammable gas in transfer line resulting in generation of radioactive aerosols BIO 5.3.2.14 Plugged line from solidifying waste results in operational consequences and high radiation field in Tank 241-SY-101 new riser pit	1 Inability to flush line when desired creating potential for flammable gas generation in the transfer line and release with ignition BIO 5.3.2.14 2 Failure to provide adequate dilution for transfer resulting in plugging (see node 2)	None	AC: 5.10 AC: 5.11	S1	F1	E1	None
SYXFR12-49c	12	Flow	No\Low	Frozen/damaged line	Release and ignition of flammable gas in transfer line resulting in generation of radioactive aerosols BIO 5.3.2.14 Plugged line from solidifying waste results in operational consequences and high radiation field in Tank 241-SY-101 new riser pit	1 Inability to flush line when desired creating potential for flammable gas generation in the transfer line and release with ignition BIO 5.3.2.14 2 Failure to provide adequate dilution for transfer resulting in plugging (see node 2)	None	AC: 5.10 AC: 5.11	S1	F1	E1	None

Table B1. HAZOP Table - SY-101 Waste Transfer System

Number of Pages =22

Item ID	Node	Process Variable	Guide Word	Possible causes of deviation	Hazardous Condition	Consequence	Suggested SSCs	Suggested TSRs	Con Cat	Freq Cat	Env Cat	Remarks
SYXFR12-49d	12	Flow	No\Low	Valve shut/failure	Release and ignition of flammable gas in transfer line resulting in generation of radioactive aerosols BIO 5.3.2.14 Plugged line from solidifying waste results in operational consequences and high radiation field in Tank 241-SY-101 new riser pit	1 Inability to flush line when desired creating potential for flammable gas generation in the transfer line and release with ignition BIO 5.3.2.14 2 Failure to provide adequate dilution for transfer resulting in plugging (see node 2)	None	AC: 5.10 AC: 5.11	S1	F1	E1	None
SYXFR12-50	12	Flow	High	Vehicle impacting flush water supply line	Flush capability impaired due to vehicle impact with flush water line causing line failure	Operational concern only	None	None	S0	F3	E0	None
SYXFR12-51	12	Temperature	Low	Operational concerns only (same as plugged line)	No safety significance	Operational concern only	None	None	S0	F3	E0	None
SYXFR12-52	12	Temperature	High	Hot flush/dilution water added (failure of temperature control) coupled with failure to transfer material (see Node 3)	Ignition of significant quantities of flammable gas in Tank 241-SY-101 released from dissolution of crust causing radioactive aerosol release	Release of significant quantities of radioactive aerosols (see also item SYXFR03-12b) BIO 5.3.2.14	DST ventilation	AC: 5.9	S3	F3	E3	May not be a significant contribution to flammable gas generation.

Table B1. HAZOP Table - SY-101 Waste Transfer System

Number of Pages =22

Item ID	Node	Process Variable	Guide Word	Possible causes of deviation	Hazardous Condition	Consequence	Suggested SSCs	Suggested TSRs	Con Cat	Freq Cat	Env Cat	Remarks
SYXFR12-53a	12	Pressure	Low	Pump is not operating due to operator error or equipment failure	Release and ignition of flammable gas in transfer line resulting in generation of radioactive aerosols BIO 5.3.2.14 Plugged line from solidifying waste results in operational consequences and high radiation field in Tank 241-SY-101 new riser pit	1 Inability to flush line when desired creating potential for flammable gas generation in the transfer line and release with ignition BIO 5.3.2.14 2 Failure to provide adequate dilution for transfer resulting in plugging (see node 2 and item SYXFR12-49 a through d)	None	AC: 5.10 AC: 5.11	S1	F1	E1	None

Table B1. HAZOP Table - SY-101 Waste Transfer System

Number of Pages =22

Item ID	Node	Process Variable	Guide Word	Possible causes of deviation	Hazardous Condition	Consequence	Suggested SSCs	Suggested TSRs	Con Cat	Freq Cat	Env Cat	Remarks
SYXFR12-53b	12	Pressure	Low	Water supply tank is empty/no supply	Release and ignition of flammable gas in transfer line resulting in generation of radioactive aerosols BIO 5.3.2.14 Plugged line from solidifying waste results in operational consequences and high radiation field in Tank 241-SY-101 new riser pit	1 Inability to flush line when desired creating potential for flammable gas generation in the transfer line and release with ignition BIO 5.3.2.14 2 Failure to provide adequate dilution for transfer resulting in plugging (see node 2 and item SYXFR12-49 a through d)	None	AC: 5.10 AC: 5.11	S1	F1	E1	None
SYXFR12-53c	12	Pressure	Low	Frozen/damaged line	Release and ignition of flammable gas in transfer line resulting in generation of radioactive aerosols BIO 5.3.2.14 Plugged line from solidifying waste results in operational consequences and high radiation field in Tank 241-SY-101 new riser pit	1 Inability to flush line when desired creating potential for flammable gas generation in the transfer line and release with ignition BIO 5.3.2.14 2 Failure to provide adequate dilution for transfer resulting in plugging (see node 2 and item 49 a-d)	None	AC: 5.10 AC: 5.11	S1	F1	E1	None

Table B1. HAZOP Table - SY-101 Waste Transfer System

Number of Pages =22

Item ID	Node	Process Variable	Guide Word	Possible causes of deviation	Hazardous Condition	Consequence	Suggested SSCs	Suggested TSRs	Con Cat	Freq Cat	Env Cat	Remarks
SYXFR12-53d	12	Pressure	Low	Valve shut/failure	Release and ignition of flammable gas in transfer line resulting in generation of radioactive aerosols BIO 5.3.2.14 Plugged line from solidifying waste results in operational consequences and high radiation field in Tank 241-SY-101 new riser pit	1 Inability to flush line when desired creating potential for flammable gas generation in the transfer line and release with ignition BIO 5.3.2.14 2 Failure to provide adequate dilution for transfer resulting in plugging (see node 2 and item 49 a-d)	None	AC: 5.10 AC: 5.11	S1	F1	E1	None
SYXFR12-54	12	Pressure	High	Plugged line/pump	Flush capability impaired	No significant safety consequences	None	None	S0	F3	E0	This condition has potential for increased personnel radiation exposure if inability to flush results in plugged lines.
Node 13: Decon Spray Ring												
SYXFR13-55	13	Flow	Low	Human error or equipment failure	Personnel exposure to excessive radiation due to insufficient decon	Transfer pump not adequately decontaminated during removal creating high exposure potential	None	None	S1	F3	E0	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.

Table B1. HAZOP Table - SY-101 Waste Transfer System

Number of Pages =22

Item ID	Node	Process Variable	Guide Word	Possible causes of deviation	Hazardous Condition	Consequence	Suggested SSCs	Suggested TSRs	Con Cat	Freq Cat	Env Cat	Remarks
SYXFR13-56	13	Flow	High	Nozzle breaks off creating minor disturbance of crust/waste	Release of radioactive aerosols due to ignition of flammable gas in Tank 241-SY-101 released due to crust disturbance	Potential for minor gas release, ignition and radioactive aerosol release BIO 5.3.2.14	DST ventilation	AC: 5.10 AC: 5.11	S3	F1	E3	500 gal flush raises hydrogen concentration by 25 ppm. Controls exist for mixer pump spray ring covered by LAUR-92-3196 (WHC-SD-WM-SAD-033), cover decon ring.

* represents new controls that may be required

Abbreviations:

AC – Administrative Control
BIO – Basis for Interim Operation
DF – Design Feature
LCO – Limiting Condition for Operation

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Table B2. Hazardous Conditions With Potential Significant Offsite Consequences (S3)

ID	Hazardous Condition	Cause	Freq	Env Cat
SYXFR01-02	Flammable gas ignites in Tank 241-SY-101 when riser activities cause spark resulting in radioactive aerosol release	Flammable gas ignition	F3	E3
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	F1	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 PPP assembly into tank disturbs waste releasing flammable gas	F3	E3
SYXFR02-09	Flammable gas ignition in Tank 241-SY-102 during drop leg installation results in aerosol release of radioactive material	Flammable gas ignition	F3	E3
SYXFR03-12a	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	Failure of service water heating resulting in addition of cold dilution water	F2	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	F1	E3
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	F2	E3
SYXFR03-15	Radioactive aerosol release due to water addition dissolving crust causing GRE with ignition in Tank 241-SY-101 (HNF-3645,101SY-WLV-23AT)	1. Excessive dilution without transfer occurring -plugged transfer line -bad pump -bad flow meters -operator error coupled with instrument error 2. Inadvertent draining from flush tank 3. Inability to pump results in continued increase of waste level	F2	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	F1	E3
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	F1	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	F1	E3

Table B2. Hazardous Conditions With Potential Significant Offsite Consequences (S3)

ID	Hazardous Condition	Cause	Freq	Env Cat
SYXFR05-24b1	Release of radioactive aerosol released in Tank 241-SY-101 new riser pit due to leak from line, flange or valve	Ruptured line/leaking flange or valve inside Tank 241-SY-101 new riser pit	F3	E3
SYXFR05-24b2	Overflow of Tank 241-SY-101 new riser pit due to leak from line, flange or valve	Ruptured line/leaking flange or valve inside Tank 241-SY-101 new riser pit	F3	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)	F2	E3
SYXFR05-27a	Spray leaks at the 241-SY-B pit at jumper connections due to high pressure	Plugging at the Tank 241-SY-102 drop leg due to solidification of waste results in pressures sufficient to cause degraded gaskets/connections to leak	F3	E3
SYXFR05-27b	Spray leaks at the 241-102-SY 02A pump pit at jumper connections due to high pressure	Plugging at the Tank 241-SY-102 drop leg due to solidification of waste results in pressures sufficient to cause degraded gaskets/connections to leak	F3	E3
SYXFR05-28b1	Release of aerosol generated in Tank 241-SY-101 new riser pit due to spray leak from line, flange or valve	Ruptured line/leaking flange or valve inside Tank 241-SY-101 new riser pit	F3	E3
SYXFR05-28b2	Release of liquid waste in Tank 241-SY-101 new riser pit due to leak from line, flange or valve forming pool	Ruptured line/leaking flange or valve inside Tank 241-SY-101 new riser pit	F2	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)	F2	E3
SYXFR05-31	Flush with high temperature flush water with preexisting spray leak causes release of high temperature aerosols in Tank 241-SY-101 new riser pit	Flush water too hot	F2	E3
SYXFR07-38b	Spray leak from encasement well in Tank 241-SY-101 new riser pit due to primary line leak with encasement test port not fully open	Primary line leak with pressurization (caused by encasement seal loop left closed after testing)	F2	E3
SYXFR07-40	Release of radioactive aerosols due to spray leak from encasement well in Tank 241-SY-101 new riser pit due to primary line leak with encasement test port not fully open	Primary line leak with pressurization (caused by encasement seal loop left closed after testing)	F2	E3
SYXFR08-43	Excavation activities damage excavation lines in vicinity of the new transfer line tie-in	Excavation activities damage transfer lines	F3	E3
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	F2	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	F3	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	F3	E3

Table B2. Hazardous Conditions With Potential Significant Offsite Consequences (S3)

ID	Hazardous Condition	Cause	Freq	Env Cat
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 creating minor disturbance of crust/waste	F1	E3

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Table B3. Hazardous Conditions With Potential Significant Onsite Consequences (S2)

ID	Hazardous Condition	Cause	Freq	Env Cat
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	F2	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	F0	E2
SYXFR03-14	Release of radioactive material from waste tank due to overfill of Tank 241-SY-101 resulting in pool (see HNF-3645 for details)	1. Excessive dilution without transfer occurring -plugged transfer line -bad pump -bad flow meters -operator error coupled with instrument error 2. Inadvertent draining from flush tank 3. Inability to pump results in continued increase of waste level	F2	E2
SYXFR04-19	Release of radioactive material from waste tank due to overfill 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	S2	E2

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Table B4. Hazardous Conditions With Potential Significant Facility Worker Consequences (S1)

ID	Hazardous Condition	Cause	Freq	Env Cat
SYXFR01-01	Unfiltered release of radioactive aerosols during PPP assembly installation from Tank 241-SY-101 dome space	Ventilation system failures results in positive pressure in tank while riser open resulting in release	F3	E1
SYXFR01-03	Personnel are exposed to high levels of ionizing radiation during PPP assembly installation activities	Human error or inadequate protection from shine from open riser	F3	E0
SYXFR02-08	Unfiltered release of radioactive aerosols during drop leg installation from Tank 241-SY-101 dome space	Ventilation system failures results in positive pressure in tank while riser open resulting in release	F3	E1
SYXFR02-10	Personnel are exposed to high levels of ionizing radiation during drop leg installation activities	Personnel not adequately protected from shine	F3	E0
SYXFR05-24a	Personnel exposure concern due to waste trapped in transfer line	Equipment failure resulting in valve acting as a blockage Transfer pump failure	F3	E0
SYXFR05-24d	Personnel exposure concern due to waste trapped in transfer line	Plugged line	F3	E0
SYXFR05-32	Personnel injured due to occupational hazards	Industrial hazard - hot valve handles etc	F3	E0
SYXFR05-33	Personnel exposed to high levels of ionizing radiation	Design problem - inadequate shielding	F3	E0
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	F3	E1
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	F1	E1
SYXFR12-49b	Release and ignition of flammable gas in transfer line resulting in generation of radioactive aerosols	Water supply tank is empty/no supply	F1	E1
SYXFR12-49c	Release and ignition of flammable gas in transfer line resulting in generation of radioactive aerosols	Frozen/damaged line	F1	E1
SYXFR12-49d	Release and ignition of flammable gas in transfer line resulting in generation of radioactive aerosols	Valve shut/failure	F1	E1
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	F1	E1
SYXFR12-53b	Release and ignition of flammable gas in transfer line resulting in generation of radioactive aerosols	Water supply tank is empty/no supply	F1	E1
SYXFR12-53c	Release and ignition of flammable gas in transfer line resulting in generation of radioactive aerosols	Frozen/damaged line	F1	E1

Table B4. Hazardous Conditions With Potential Significant Facility Worker Consequences (S1)

ID	Hazardous Condition	Cause	Freq	Env Cat
SYXFR12-53d	Release and ignition of flammable gas in transfer line resulting in generation of radioactive aerosols	Valve shut/failure	F1	E1
SYXFR13-55	Personnel exposure to excessive radiation due to insufficient decon	Human error or equipment failure	F3	E0

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Table B5. Hazardous Conditions With No Significant Consequences (S0)

ID	Hazardous Condition	Cause	Freq	Env Cat
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	F3	E3
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	F2	E2
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	F3	E0
SYXFR04-21	No safety consequences	Transfer pump failed, human error caused pump misoperation, control system failure Causes similar to low flow	F3	E0
SYXFR04-23	No safety significance	Human error in flow setup, instrumentation miscalibration, or equipment failure	F3	E0
SYXFR05-25	No safety significance	Human error or equipment failure causes pump flow rate to be above desired point	F3	E0
SYXFR05-26	No safety significance	Siphon condition from receiving tank to supply tank	F3	E0
SYXFR05-28a	No safety significance	Equipment failure resulting in valve acting as a blockage Transfer pump failure	F3	E0
SYXFR05-28d	No safety significance	Plugged line	F3	E0
SYXFR05-29	Operational delay due to low flow	Line plug due to waste cooling (less than 110 degrees F due to low ambient temp)	F3	E0
SYXFR05-30	Freezing of dilution water lines results in operational delay	Cold weather causes lines to freeze	F3	E0
SYXFR07-41	Higher potential for plugging due to waste crystallization from cooling	Low ambient ground temperature	F3	E0
SYXFR07-42	Production of steam when waste transferred through overheated transfer line	Heat trace overheats pipe/boils waste	F3	E0
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	F2	E0
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	F2	E3
SYXFR11-47	No safety or operational impact	Back pressure on system due to increased head on drop leg	F3	E0
SYXFR11-48b	Redissolve TRU causing redistribution of TRU location in waste	Low liquid level prevents drop leg from distributing solids	F2	E0
SYXFR11-48c	High phosphates from other operations causes potential for reaction causing solid phosphates	Low liquid level prevents drop leg from distributing solids	F2	E0
SYXFR11-48d	The pH may be lowered enough to precipitate aluminates	Low liquid level prevents drop leg from distributing solids	F2	E0

Table B5. Hazardous Conditions With No Significant Consequences (S0)

ID	Hazardous Condition	Cause	Freq	Env Cat
SYXFR11-48e	Lose volume of tank for future operations due to additional settled solids	Low liquid level prevents drop leg from distributing solids	F2	E0
SYXFR12-50	Flush capability impaired due to vehicle impact with flush water line causing line failure	Vehicle impacting flush water supply line	F3	E0
SYXFR12-51	No safety significance	Operational concerns only (same as plugged line)	F3	E0
SYXFR12-54	Flush capability impaired	Plugged line/pump	F3	E0

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Table B6. Controls From BIO SSCs and TSRs That Potentially Address Hazardous Conditions for SY-101 Waste Transfers With Potential S3 and S2 Consequences

Number of Pages: 12

ID	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	HAZOP Remarks	Con Cat
Rep Acc 04, Flammable Gas Deflagrations - DST									
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 Level Monitoring System SC: SY-101 Ventilation Flow Meter SC: SY-101 Ammonia Detection Systems	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	This is opening the riser to prepare for PPP assembly installation.	S3
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/AWF 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 BIO.	S3
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/AWF 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	None	S3

Table B6. Controls From BIO SSCs and TSRs That Potentially Address Hazardous Conditions for SY-101 Waste Transfers With Potential S3 and S2 Consequences

Number of Pages: 12

ID	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	HAZOP Remarks	Con Cat
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/AWF 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	None	S3
Flammable Gas Deflagrations Represented by Analysis for ID 101SYWLV-15A Identified in HNF-3645									
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	Failure of service water heating resulting in addition of cold dilution water	TBD	TBD	None required	None required	None	S3
Flammable Gas Deflagrations Represented by Analysis for ID 101SYWLV-14A Identified in HNF-3645									
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	TBD	TBD	TBD	TBD	Not a significant contribution to flammable gas generation.	S3

Table B6. Controls From BIO SSCs and TSRs That Potentially Address Hazardous Conditions for SY-101 Waste Transfers With Potential S3 and S2 Consequences

Number of Pages: 12

ID	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	HAZOP Remarks	Con Cat
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	TBD	TBD	TBD	TBD	Transfer is time intensive, it would take a long period of time to remove excessive amount of waste.	S3
SYXFR03-15	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)	1. Excessive dilution without transfer occurring -plugged transfer line -bad pump -bad flow meters -operator error coupled with instrument error 2. Inadvertent draining from flush tank 3. Inability to pump results in continued increase of waste level	TBD	TBD	TBD	TBD	It is unsure how much waste dilution is significant to crust dissolving. Currently being considered as one of the analyzed accidents for mitigation.	S3

Table B6. Controls From BIO SSCs and TSRs That Potentially Address Hazardous Conditions for SY-101 Waste Transfers With Potential S3 and S2 Consequences

Number of Pages: 12

ID	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	HAZOP Remarks	Con Cat
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	TBD	TBD	TBD	TBD	*Control list included those for spray leaks inside tanks. Team feels this condition is bounded by dissolution accident.	S3
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	TBD	TBD	TBD	TBD	Team feels this condition is bounded by dissolution accident.	S3
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	TBD	TBD	TBD	TBD	Overflow is captured in other accidents.	S3

Table B6. Controls From BIO SSCs and TSRs That Potentially Address Hazardous Conditions for SY-101 Waste Transfers With Potential S3 and S2 Consequences

Number of Pages: 12

ID	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	HAZOP Remarks	Con Cat
SYXFR12-52	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	TBD	TBD	TBD	TBD	May not be a significant contribution to flammable gas generation.	S3
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 creating minor disturbance of crust/waste	TBD	TBD	TBD	TBD	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
Flammable Gas Deflagrations Represented by Analysis for ID 101SYWLV-16A1 Identified in HNF-3645									
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	TBD	TBD	TBD	TBD	None	S3
Rep Acc 12, Tank Failure Due to Excessive Loads									

Table B6. Controls From BIO SSCs and TSRs That Potentially Address Hazardous Conditions for SY-101 Waste Transfers With Potential S3 and S2 Consequences

Number of Pages: 12

ID	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	HAZOP Remarks	Con Cat
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 - Jam - 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 new riser pit. Vehicle fuel fires covered in BIO 5.3.2.3.	S2
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

Table B6. Controls From BIO SSCs and TSRs That Potentially Address Hazardous Conditions for SY-101 Waste Transfers With Potential S3 and S2 Consequences

Number of Pages: 12

ID	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	HAZOP Remarks	Con Cat
SYXFR03-13b	DST inventory	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	AC: 5.16 Dome Loading Controls	None required	None required	Lollipop issue addressed in Hazard Analysis for level increase, ID 101SY-WLV-8A, HNF-3645. Large solidified pieces of waste crust adhering to installed quipment suspended from the tank risers could represent significant concentrated load (lollipops have been observed in other tanks).	S2
Rep Acc 15, Spray Leak in Structure or from Overground Waste Transfer Lines									
SYXFR05-24b1	DST waste	Release of radioactive aerosol released in Tank 241-SY-101 new riser pit due to leak from line, flange or valve	Ruptured line/leaking flange or valve inside Tank 241-SY-101 new riser pit	None required	None required	SC: Transfer system covers	LCO: 3.1.1 Transfer System Covers AC: 5.22 Transfer system cover removal controls	Tank 241-SY-101 new riser pit should be treated like any other transfer system pits.	S3
SYXFR05-27a	DST waste	Spray leaks at the 241-SY-B pit at jumper connections due to high pressure	Plugging at the Tank 241-SY-102 drop leg due to solidification of waste results in pressures sufficient to cause degraded gaskets/connections to leak	None required	None required	SC: Transfer system covers	LCO: 3.1.1 Transfer System Covers AC: 5.22 Transfer system cover removal controls	Jumper connections evaluated for the dead head pressure for the pumping system.	S3

Table B6. Controls From BIO SSCs and TSRs That Potentially Address Hazardous Conditions for SY-101 Waste Transfers With Potential S3 and S2 Consequences

Number of Pages: 12

ID	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	HAZOP Remarks	Con Cat
SYXFR05-27b	DST waste	Spray leaks at the 241-102-SY 02A pump pit at jumper connections due to high pressure	Plugging at the Tank 241-SY-102 drop leg due to solidification of waste results in pressures sufficient to cause degraded gaskets/connections to leak	None required	None required	SC: Transfer system covers	LCO: 3.1.1 Transfer System Covers AC: 5.22 Transfer system cover removal controls	Jumper connections evaluated for the dead head pressure for the pumping system.	S3
SYXFR05-28b1	DST waste	Release of aerosol generated in Tank 241-SY-101 new riser pit due to spray leak from line, flange or valve	Ruptured line/leaking flange or valve inside Tank 241-SY-101 new riser pit	None required	None required	SC: Transfer system covers	LCO: 3.1.1 Transfer System Covers AC: 5.22 Transfer system cover removal controls	Tank 241-SY-101 new riser pit should be treated like any other transfer system pit. *The transfer system will have its own leak detection system.	S3
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 new riser pit	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	Tank 241-SY-101 new riser pit should be treated like any other transfer system pits. Higher temperature flush water does not have a significant impact on consequences of this accident compared to cold flush water.	S3

Table B6. Controls From BIO SSCs and TSRs That Potentially Address Hazardous Conditions for SY-101 Waste Transfers With Potential S3 and S2 Consequences

Number of Pages: 12

ID	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	HAZOP Remarks	Con Cat
SYXFR07-38b	DST waste	Spray leak from encasement well in Tank 241-SY-101 new riser pit due to primary line leak with encasement test port not fully open	Primary line leak with pressurization (caused by encasement seal loop left closed after testing)	None required	AC: 5.13 Encasement Seal Loop Controls	SC: Transfer system covers	LCO: 3.1.1 Transfer System Covers AC: 5.22 Transfer system cover removal controls	Leak detector interlock to shut down pump.	S3
SYXFR07-40	DST waste	Release of radioactive aerosols due to spray leak from encasement well in Tank 241-SY-101 new riser pit due to primary line leak with encasement test port not fully open	Primary line leak with pressurization (caused by encasement seal loop left closed after testing)	None required	AC: 5.13 Encasement Seal Loop Controls	SC: Transfer system covers	LCO: 3.1.1 Transfer System Covers AC: 5.22 Transfer system cover removal controls	Leak detector interlock to shut down pump.	S3
Rep Acc 16, Spray Leak from Underground Waste Transfer Lines									
SYXFR08-43	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

Table B6. Controls From BIO SSCs and TSRs That Potentially Address Hazardous Conditions for SY-101 Waste Transfers With Potential S3 and S2 Consequences

ID	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	HAZOP Remarks	Con Cat
Rep Acc 26, Surface Leak Resulting in Pool									
SYXFR03-14	DST waste	Release of radioactive material from waste tank due to overfill of Tank 241-SY-101 resulting in pool (see HNF-3645 for details)	1. Excessive dilution without transfer occurring -plugged transfer line -bad pump -bad flow meters -operator error coupled with instrument error 2. Inadvertent draining from flush tank 3. Inability to pump results in continued increase of waste level	None required	None required	None required	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	Project has a dedicated line - no mistransfer from other facilities possible, or mistransfers out.	S2
SYXFR04-19	DST waste	Release of radioactive material from waste tank due to overfill 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	None required	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

Table B6. Controls From BIO SSCs and TSRs That Potentially Address Hazardous Conditions for SY-101 Waste Transfers With Potential S3 and S2 Consequences

ID	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	HAZOP Remarks	Con Cat
SYXFR05-24b2	DST waste	Overflow of Tank 241-SY-101 new riser pit due to leak from line, flange or valve	Ruptured line/leaking flange or valve inside Tank 241-SY-101 new riser pit	None required	None required	None required	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	Tank 241-SY-101 new riser pit should be treated like any other transfer system pit.	S3
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 SR: Verify service water pressure detection systems are operable	SC: Transfer leak detection systems SS: Tank level detection systems SS: Transfer system covers SS: Service water flow totalizers	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	Requires multiple events/failures to occur (flush pump inoperable, valve misposition, and transfer occurring.	S3
SYXFR05-28b2	DST waste	Release of liquid waste in Tank 241-SY-101 new riser pit due to leak from line, flange or valve forming pool	Ruptured line/leaking flange or valve inside Tank 241-SY-101 new riser pit	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: 5.13 Encasement Seal Loop Controls valve not closed AC: 5.14 Emergency Preparedness	Tank 241-SY-101 new riser pit should be treated like any other transfer system pit. *The transfer system will have its own leak detection system.	S3

Table B6. Controls From BIO SSCs and TSRs That Potentially Address Hazardous Conditions for SY-101 Waste Transfers With Potential S3 and S2 Consequences									
ID	Material at Risk	Hazardous Condition	Cause	Potential Prev SSC	Potential Prev TSR	Potential Mit SSC	Potential Mit TSR	HAZOP Remarks	Con Cat
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 SR: Verify service water pressure detection systems are operable	SS: Tank level detection systems SS: Transfer system covers SS: Service water flow totalizers	AC: 5.12 Transfer Controls AC: 5.14 Emergency Preparedness	None	S3

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Table B7. S2 and S3 Hazardous Conditions Ordered By BIO Accident Section

Number of Pages: 6

BIN	ID	Material at Risk	Hazardous Condition	Cause	Freq	Con Cat	Cause Grp	REP ACC
The frequency of the BIO Analyzed Accident is based on No Controls Present. The frequency category of the SY-101 Waste Transfer Hazardous Conditions is based on No Controls Present also. However, the frequency does take into consideration already present structures and components and their effect on the frequency. The consequence category is similarly specified.								
Tank Failure Due to Excessive Loads (BIO Section 5.3.2.13)								
B-1-a	CRN-03	Tank inventory	Release of radioactive and/or toxic materials from tank due to dome collapse	Human error results in excessive weight on dome	F3	S3	C10	12A
B-1-a	CRN-04	Tank inventory	Release of radioactive and/or toxic materials from tank due to dome collapse	Crane or rigging failures: drop load resulting in large impact to dome	F3	S3	C10	12A
B-1-a	CRN-11	Tank inventory	Radioactive or toxic material release from tank due to boom failure and tank/equipment damage and dome collapse	Human error: improper load assembly, rigging, crane overloaded	F3	S3	C10	12A
B-1-a	114SX-06.a.3	Radioactive material contained in the tank (this tank has a dry crust which may be composed of easily disturbed dusty material)	Release of radioactive aerosols from Tank 241-SY-114 waste to the atmosphere due to dome collapse caused by loss of strength due to aging	Long term aging resulting in tank degradation	F1	S3	C12	13
SY-101 WASTE TRANSFER HAZARDOUS CONDITIONS								
B-1-a	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 - Jam - Drop on riser or tank dome - Vehicle impact	F2	S2	D26	12X
B-1-a	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	F1	S3	D26	12X
B-1-a	SYXFR03-13b	DST inventory	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	F0	S2	D11	12X

Table B7. S2 and S3 Hazardous Conditions Ordered By BIO Accident Section

Number of Pages: 6

BIN	ID	Material at Risk	Hazardous Condition	Cause	Freq	Con Cat	Cause Grp	REP ACC
Flammable Gas Deflagrations - DST (BIO Section 5.3.2.14)								
A-1-a	ITK-10-b	DST tank inventory	Release of radioactive material from in-tank fire or explosion due to intrusive activity (dome collapse)	Spark from equipment or tools	F3	S3	B04	04
SY-101 WASTE TRANSFER HAZARDOUS CONDITIONS The following Hazardous Conditions have the character of Flammable Gas Deflagrations in DSTs - Two separate generalized groupings have been identified: 1. Hazardous Conditions having no significant difference from the Representative Accident (indicated as REP ACC 04X) 2. Hazardous Conditions involving potential Tank 241-101-SY crust flammable gas release not specifically analyzed under the Representative Accident (REP ACC column marked 04XX). These Hazardous Conditions are similar to Hazardous Conditions identified in HNF-3645 that are being analyzed to determine if consequences are greater than those specified in the current Authorization Basis analysis.								
A-1-a	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	F3	S3	B04	04X
A-1-a	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	F3	S3	B04	04X
A-1-a	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	F2	S3	B01	04X
A-1-a	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	F3	S3	B01	04X
Flammable Gas Deflagrations Represented by Analysis for ID 101SY WLV-15A Identified in HNF-3645								
A-1-a	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	Failure of service water heating resulting in addition of cold dilution water	F2	S3	B01	04XX
Flammable Gas Deflagrations Represented by Analysis for ID 101SY WLV-14A Identified in HNF-3645								

Table B7. S2 and S3 Hazardous Conditions Ordered By BIO Accident Section

Number of Pages: 6

BIN	ID	Material at Risk	Hazardous Condition	Cause	Freq	Con Cat	Cause Grp	REP ACC
A-1-a	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	F1	S3	B01	04XX
A-1-a	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	F2	S3	B06	04XX
A-1-a	SYXFR03-15	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)	1. Excessive dilution without transfer occurring -plugged transfer line -bad pump -bad flow meters -operator error coupled with instrument error 2. Inadvertent draining from flush tank 3. Inability to pump results in continued increase of waste level	F2	S3	B01	04XX
A-1-a	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	F1	S3	B01	04XX
A-1-a	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	F1	S3	B04	04XX

Table B7. S2 and S3 Hazardous Conditions Ordered By BIO Accident Section

Number of Pages: 6

BIN	ID	Material at Risk	Hazardous Condition	Cause	Freq	Con Cat	Cause Grp	REP ACC
A-1-a	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	F1	S3	B01	04XX
A-1-a	SYXFR12-52	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	F3	S3	B01	04XX
A-1-a	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 creating minor disturbance of crust/waste	F1	S3	B02	04XX
Flammable Gas Deflagrations Represented by Analysis for ID 101SYWLV-16A1 Identified in HNF-3645								
A-1-a	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	F3	S3	B04	04XX
Surface Leak Resulting in Pool (BIO Section 5.3.2.18)								
C-2-b	W058-PRES01	Amount of slurry transferred (20,000 to 1,000,000 gallons)	Release of radioactive slurry to the soil surface from overflow in the SY-A or SY-B valve pit due to piping system leak (pool)	Water hammer plus mitigative features failure	F3	S2	D17	26
SY-101 WASTE TRANSFER HAZARDOUS CONDITIONS								
C-2-b	SYXFR03-14	DST waste	Release of radioactive material from waste tank due to overfill of Tank 241-SY-101 resulting in pool (see HNF-3645 for details)	1. Excessive dilution without transfer occurring -plugged transfer line -bad pump -bad flow meters -operator error coupled with instrument error 2. Inadvertent draining from flush tank 3. Inability to pump results in continued increase of waste level	F2	S2	D06	26X

Table B7. S2 and S3 Hazardous Conditions Ordered By BIO Accident Section

Number of Pages: 6

BIN	ID	Material at Risk	Hazardous Condition	Cause	Freq	Con Cat	Cause Grp	REP ACC
C-2-b	SYXFR04-19	DST waste	Release of radioactive material from waste tank due to overfill 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	S2	S2	D06	26X
B-1-a	SYXFR05-24b2	DST waste	Overflow of Tank 241-SY-101 new riser pit due to leak from line, flange or valve	Ruptured line/leaking flange or valve inside Tank 241-SY-101 new riser pit	F3	S3	D12	26X
C-2-b	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)	F2	S3	E02	26X
C-2-b	SYXFR05-28b2	DST waste	Release of liquid waste in Tank 241-SY-101 new riser pit due to leak from line, flange or valve forming pool	Ruptured line/leaking flange or valve inside Tank 241-SY-101 new riser pit	F2	S3	D12	26X
C-2-b	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)	F2	S3	D02	26X
Spray Leak in Structure or from Overground Waste Transfer Lines (BIO Section 5.3.2.20)								
B-1-a	XS-06-FLOW02	DCRT waste being transferred to Tank 241-SY-102	Release of liquid radioactive waste from DCRT transfer piping to Tank 241-SY-102 due to spray leak in DCRT pump pit	Pipe failure in DCRT pump pit causing spray leak	F2	S3	D12	15
SY-101 WASTE TRANSFER HAZARDOUS CONDITIONS								
B-1-a	SYXFR05-24b1	DST waste	Release of radioactive aerosol released in Tank 241-SY-101 new riser pit due to leak from line, flange or valve	Ruptured line/leaking flange or valve inside Tank 241-SY-101 new riser pit	F3	S3	D02	15X
B-1-a	SYXFR05-27a	DST waste	Spray leaks at the 241-SY-B pit at jumper connections due to high pressure	Plugging at the Tank 241-SY-102 drop leg due to solidification of waste results in pressures sufficient to cause degraded gaskets/connections to leak	F3	S3	D02	15X
B-1-a	SYXFR05-27b	DST waste	Spray leaks at the 241-102-SY 02A pump pit at jumper connections due to high pressure	Plugging at the Tank 241-SY-102 drop leg due to solidification of waste results in pressures sufficient to cause degraded gaskets/connections to leak	F3	S3	D02	15X

Table B7. S2 and S3 Hazardous Conditions Ordered By BIO Accident Section

Number of Pages: 6

BIN	ID	Material at Risk	Hazardous Condition	Cause	Freq	Con Cat	Cause Grp	REP ACC
B-1-a	SYXFR05-28b1	DST waste	Release of aerosol generated in Tank 241-SY-101 new riser pit due to spray leak from line, flange or valve	Ruptured line/leaking flange or valve inside Tank 241-SY-101 new riser pit	F3	S3	D02	15X
B-1-a	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 new riser pit	Flush water too hot	F2	S3	D01	15X
B-1-a	SYXFR07-38b	DST waste	Spray leak from encasement well in Tank 241-SY-101 new riser pit due to primary line leak with encasement test port not fully open	Primary line leak with pressurization (caused by encasement seal loop left closed after testing)	F2	S3	E02	15X
B-1-a	SYXFR07-40	DST waste	Release of radioactive aerosols due to spray leak from encasement well in Tank 241-SY-101 new riser pit due to primary line leak with encasement test port not fully open	Primary line leak with pressurization (caused by encasement seal loop left closed after testing)	F2	S3	E02	15X
Spray Leak from Underground Waste Transfer Lines (B.O Section 5.3.2.21)								
B-1-a	EE-16	Material leaked from transfer line	Release of radioactive and hazardous material from transfer line spray leak due to excavation error	Excavation into waste transfer line during a transfer	F3	S3	D22	16
SY-101 WASTE TRANSFER HAZARDOUS CONDITIONS								
B-1-a	SYXFR08-43	Material leaked from transfer line	Excavation activities damage excavation lines in vicinity of the new transfer line tie-in	Excavation activities damage transfer lines	F3	S3	D22	16X

Appendix C

Peer Review Checklist

CHECKLIST FOR PEER REVIEW

Document Reviewed: Hazard Evaluation For Transfer Of Waste From Tank 241-SY-101 TO Tank 241-SY-102

Scope of Review: Assumptions, model applicability, correct input.

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

[X]	[ ]	[ ]	**Document approved.**

Don Porton Donald R. Porton 2/11/99

Reviewer (Printed Name and Signature) Date

*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.

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