sta #16 (15) JUN 1 1999 ENGINEERING DATA TRANSMITTAL

Page 1 of 25
1. EDT 621492

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5. Proj./Prog./Dept./Div.: 242-A Evaporator/200E/LWPF/WMH	6. Design Authority/Design Agent/Cog. Engr.: Elvis Q. Le	7. Purchase Order No.: N/A
8. Originator Remarks: This EDT implements the Process Control Plan, providing a general description of activities which will take place during 242-A Evaporator Campaign 99-1 and to document analyses conducted to demonstrate that 102-AW waste is acceptable for processing.		9. Equip./Component No.: N/A
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Approval Designator (F)	Reason for Transmittal (G)	Disposition (H) & (I)
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(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date
		Design Authority	N/A			1	1	Operation Mgr. D. K. Smith		6-1-99
		Design Agent				1	2	Technical Review. M. D. Guthrie		5/29/99
1	1	Cog. Eng. E. Q. Le	<i>Elvis Q. Le</i>	5/27/99						
1	1	Cog. Mgr. R. R. Bloom	<i>R. R. Bloom</i>	6/1/99						
1	1	QA M. J. Warn	<i>M. J. Warn</i>	6/1/99						
1	1	Safety M. W. Clayton	<i>M. W. Clayton</i>	6/1/99						
1	1	Env. M. W. Bowman	<i>M. W. Bowman</i>	6-1-99						

18. Signature of EDT Originator <i>Elvis Q. Le</i> Date: 5/27/99	19. Authorized Representative for Receiving Organization Date:	20. Design Authority/Cognizant Manager <i>R. R. Bloom</i> Date: 6/1/99	21. DOE APPROVAL (if required) Ctrl No. _____ ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments
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**UNREVIEWED SAFETY QUESTION (USQ)
SCREENING AND EVALUATION**

1. Identification Number: LW-99-014

USQ SCREENING

Page 1 of 4

2. Title: Process Control Plan for 242-A Evaporator Campaign 99-1

Facility: 242-A Evaporator

ECN No.

PCA No.

Work Pkg No.

Other (Specify) EDT No. 621492

TITLE: Process Control Plan for 242-A Evaporator Campaign 99-1

Description of the proposed activity/reportable occurrence or PIAB:

EDT 621492 is used to issue the Process Control Plan (PCP) for the 242-A Evaporator Campaign 99-1. The purpose of the PCP is to provide a general description of activities, which will take place during 242-A Evaporator Campaign 99-1, and to document analyses conducted to demonstrate that the proposed waste is acceptable for processing.

Introduction:

The waste in tank 102-AW is designated as campaign feed for 242-A Evaporator Campaign 99-1, which is currently scheduled in June 1999. Tank 102-AW contains approximately 999,000 gallons of dilute non-complexed supernate and 36,000 gallons of sludge. The supernate currently stored in tank 102-AW is predominately comprised of water and waste from tanks 102-AY and 108-AP. These wastes are originated primarily from B Plant and aging waste condensate.

Scope:

Campaign 99-1 will process approximately one million gallons of processable dilute waste from tank 102-AW with a projected overall Waste Volume Reduction Factor (WVRF) of 77 percent after the completion of the campaign. This USQ document addresses the processing of this waste through the 242-A Evaporator. No additional processing or other waste streams are analyzed.

UNREVIEWED SAFETY QUESTION (USQ) SCREENING AND EVALUATION

1. Identification Number: LW-99-014

USQ SCREENING

Page 2 of 4

2. Title: Process Control Plan for 242-A Evaporator Campaign 99-1

Authorization basis:

The Authorization Basis for the 242-A Evaporator is contained in WHC-SD-WM-SAR-023, *242-A Evaporator/Crystallizer Safety Analysis Report*, Rev. 3D, (242-A SAR). The PCP documents that the operation of the 242-A Evaporator during campaign will meet all requirements specified in this document. The PCP also documents that any discharge streams will meet the acceptance criteria of the receiving facility. The Liquid Effluent Retention Facility (LERF) receives the process condensate from the Evaporator and the Treated Effluent Disposal Facility (TEDF) receives the steam condensate and used cooling water streams. Acceptance criteria for waste streams discharged to the LERF are specified in HNF-SD-LEF-ASA-002, *242AL Liquid Effluent Retention Facility Auditable Safety Analysis*, Rev. 1, (LERF ASA). Acceptance criteria for the TEDF are specified the *200 Area TEDF Interface Control Document*, HNF-SD-W049-ICD-001, Rev. 4. The PCP includes discussions and analyses to meet the requirements for discharge to these facilities.

The design basis accidents for the 242-A Evaporator are discussed in Chapter 9 of the SAR, with the consequences of these accidents summarized in Tables 9-11, 9-12, 9-13, 9-14, 9-16, and 9-17. These consequences are based on waste at the bounding radiological source strength as summarized in Chapter 9, Table 9-2. Operational Safety Requirements are contained in Chapter 11 of the SAR. These include restrictions on the feed and slurry streams such as the maximum radiological source strength and fissile radionuclide concentration control for criticality concerns. The PCP documents the analyses performed to verify that the feed and slurry product meet all composition requirements. It also documents the analyses used for verification of acceptability of the slurry product to the Double Shell Tank (DST) system.

Conclusion:

Analyses include comparisons of feed and expected slurry, process condensate, and gaseous effluent analyte concentrations or quantities to limits specified in the Authorization Basis documents. Where limits are of environmental or safety concern, the analyses include worst case values to ensure compliance with applicable limits. In all cases, both the feed and the resulting waste streams were shown to be within the limits specified in the Authorization Basis documents. Therefore, operation of the Evaporator under the conditions specified in the Process Control Plan may proceed at the discretion of the contractor. Additional DOE approvals for USQ concerns are not required.

References:

WHC-SD-WM-SAR-023, Rev. 3B, *242-A Evaporator/Crystallizer Safety Analysis Report*.

HNF-SD-LEF-ASA-002, Rev. 1, *242AL Liquid Effluent Retention Facility Auditable Safety Analysis*.

HNF-SD-W049-ICD-001, Rev. 4, *200 Area TEDF Interface Control Document*.

UNREVIEWED SAFETY QUESTION (USQ) SCREENING AND EVALUATION

1. Identification Number: LW-99-014

USQ SCREENING

Page 3 of 4

2. Title: Process Control Plan for 242-A Evaporator Campaign 99-1

INSTRUCTIONS:

Respond to each question and provide justification for each response. A restatement of the question does not constitute a satisfactory justification or basis. An adequate justification provides sufficient explanation such that an independent reviewer could reach the same conclusion based on the information provided [DOE 5480.21, 10.e.1].

QUESTIONS:

1. Does the PROPOSED CHANGE or OCCURRENCE represent a change to the facility or procedures as described in the AUTHORIZATION BASIS?

☐ N/A ☒ No ☐ Yes/Maybe

BASIS: No changes to the facility are being proposed by the EDT or the PCP. As stated above, the PCP documents that the feed and the resulting waste streams are within the limits specified in the Authorization Basis documentation. The PCP also describes the activities, which will take place during Campaign 99-1. None of the proposed activities involves physical changes to the facility or changes to the way that the facility is operated as described in the Authorization Basis documentation.

2. Does the PROPOSED CHANGE or OCCURRENCE represent conditions that have not been analyzed in the AUTHORIZATION BASIS?

☐ N/A ☒ No ☐ Yes/Maybe

BASIS: No changes to the facility are being proposed by the EDT or the PCP. . None of the proposed activities during campaign 99-1 involves physical changes to the facility or changes to the way that the facility is operated as described in the Authorization Basis documentation.

3. Does the PROPOSED CHANGE represent a test or experiment NOT described in the AUTHORIZATION BASIS that may affect the safe operation of the facility?

☒ N/A ☐ No ☐ Yes/Maybe

BASIS: No testing or experimentation is proposed by the EDT or PCP.

4. Does the proposed change or occurrence represent a change to the Technical Safety Requirements or a reduction in the margin of safety defined in the Technical Safety Requirements?

☐ N/A ☒ No ☐ Yes/Maybe

BASIS: Operational Safety Requirements (OSRs) and their bases are found in Chapter 11 of the SAR. The EDT and PCP are in compliance with all applicable OSRS.

UNREVIEWED SAFETY QUESTION (USQ) SCREENING AND EVALUATION

1. Identification Number: LW-99-014

USQ SCREENING

Page 4 of 4

2. Title: Process Control Plan for 242-A Evaporator Campaign 99-1

USQE #1 Elvis Q. Le

USQE #2

Mark W. Bowman

(Print Name)

(Print Name)

Signature

Date: 5/27/99

Signature

Date: 6-1-99

If there is a YES/MAYBE response to questions 1, 2, 3, or 4, then a USQ Evaluation must be completed.

The following guidance should be considered when completing this screening. This guidance should not be considered all-inclusive; additional factors may need to be considered depending on the nature of the proposed change.

Does the proposed change:

- 1) Modify, add, or delete a safety class function of a structure, system or component stated in the authorization basis?
- 2) Alter the design of a structure, system or component as described in the authorization basis?
- 3) Modify, add, or delete the description of operation, operating environment, or analyses of any system or component described in the authorization basis?
Modify, add, delete or conflict with any of the design bases stated in the authorization basis?
- 4) Conflict with the principle or general design criteria stated in the authorization basis?
- 5) Modify, add, or delete any plant design features described in the authorization basis?
- 6) Modify, add, or delete a flow diagram or facility drawing provided in the authorization basis?
- 7) Create the potential for new system or component interactions (e.g., seismic, electrical breaker coordination)?

242-A Campaign 99-1 Process Control Plan

Elvis Q. Le

Waste Management Federal Services of Hanford *6/1/99*
 Richland, WA 99352
 U.S. Department of Energy Contract DE-AC06-96RL13200

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Key Words: 242-A, Evaporator, Process Control Plan, Campaign 99-1, Radiological Bounding Source Strength, Compatibility, Process Control, Safety, Environmental Compliance

Abstract: 242-A Evaporator 99-1 will process approximately one million gallons of waste from tank 102-AW in June 1999. The process control Plan provides a general description of activities, which will occur during 242-A Evaporator Campaign 99-1 and to document analyses conducted to demonstrate that 102-AW waste is acceptable for processing. Predict is a registered trademark of Risk Decisions England Corporation, United Kingdom

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LIST OF TERMS

ACW	242-A cooling water
ALC	airlift circulator
APC	242-A process condensate
ASC	242-A steam condensate
CAM	continuous air monitor
DSC	differential scanning calorimetry
DDSSF	dilute double-shell slurry feed
DOH	Washington State Department of Health
DST	Double Shell Tank
EPA	Environmental Protection Agency
ETF	Effluent Treatment Facility
FD-A	242-A feed
ICP	inductively coupled plasma
LERF	Liquid Effluent Retention Facility
MCS	monitor and control system
NCRW	neutralized cladding removal waste
ND	not detectable
PM	preventive maintenance
PPM	part per million
PREDICT	refer to (Allison 1984)
SAR	safety analysis report
semi-VOA	semivolatile organic analysis
SLY-A	242-A slurry
SPG	specific gravity
TIC	total inorganic carbon
TOC	total organic carbon
TRU	transuranic
VOA	volatile organic analysis
WVRF	waste volume reduction factor

PROCESS CONTROL PLAN FOR 242-A EVAPORATOR CAMPAIGN 99-1

1.0 INTRODUCTION

The purpose of the 242-A Evaporator Campaign 99-1 Process Control Plan (hereafter referred to as PCP) is to ensure that the campaign feed is processed within established safety and regulatory requirements, and the evaporator slurry product is safe to transfer to and store in the slurry receiver double shell tank. The PCP also provides a general description of process strategies and activities which will take place during Campaign 99-1.

The PCP is required prior to the campaign per *WMH-331, Section 3.2, Process Control Plans* (WMH 1999). The processability of the campaign feed waste is addressed in the PCP based on the *242-A Evaporator Data Quality Objectives, (DQO) WHC-SD-WM-DQO-014* (Von Barga 1998). The processability requirements ensure: (1) campaign feed and slurry product are compatible with the 102-AW feed tank, 106-AW slurry receiver tank, and evaporator requirements; (2) operations will be performed within evaporator, LERF, and storage tank safety boundaries; (3) evaporator environmental and regulatory compliance is maintained.

The waste in tank 102-AW is designated as feed for 242-A Evaporator Campaign 99-1, which is scheduled to be in June 1999. Tank 102-AW contains approximately 999,000 gallons of dilute non-complexed supernate and 36,000 gallons of sludge. The supernate is predominately comprised of water and waste from tanks 102-AY and 108-AP. These wastes originated from B Plant and aging waste condensate.

Based on current characterization data from tank 102-AW and the assessment of waste processability presented in Section 5 of this PCP, the waste in tank 102-AW is acceptable for processing through the evaporator.

The Index of Technical Operating Controls (Appendix A) identifies safety and environmental related documents relevant to this campaign. Appendix B contains safety and environmental limits implemented during Campaign 99-1. Appendices C and D contain sampling information and sample results from the feed characterization analyses which are used to prepare this document. Feed composite and projected slurry data are in Appendix E. Appendices F through H contain calculations and printouts from the PREDICT computer model. Appendix I contains the DEFT sampling requirement results for the campaign and Appendix J contains the letters which were referenced in this document.

Campaign 99-1 will be the first "hot" operation of the 242-A Evaporator since construction of the Johnson Controls Incorporated (JCI) Package Boilers, which replace the old coal-fired powerplant (283-E). The new oil-fired boilers will considerably reduce effluent discharges by utilizing cleaner burning fuel and improved boiler efficiency. The boiler acceptance test was successfully completed on June 4, 1998. The test results confirmed its capacity in supplying adequate steam demand for evaporator operations.

A new state-of-the art D/3 computerized Monitor Control System (MCS) has been installed at the 242-A Evaporator to meet the DOE requirement for Year 2000 compliance. This MCS replaces the out-of-date keypad interface with a quick, efficient "mouse" driven interface.

2.0 CAMPAIGN OBJECTIVE

Campaign 99-1 will process approximately one million gallons of dilute waste in 102-AW with a projected overall Waste Volume Reduction Factor (WVRF) of 77%. This overall WVRF includes three percent WVRF loss due to water addition to evaporator vessel during flushing at the end of the campaign. The campaign will be controlled at 77% overall WVRF to prevent excessive solids buildup in 106-AW slurry receiver tank. Precampaign laboratory boildown studies indicate more than 60% precipitate solids by volume occurs at 80% overall WVRF (Beck 1999).

The WM 1.4.1 Performance Agreement requires WMH to complete at least 85% of the target overall WVRF of 77% for 242-A Evaporator Campaign 99-1. The performance agreement will be met if final WVRF of 65.5% is achieved at the end of the campaign.

Batch slurry transfers will be required to achieve a campaign WVRF of 77%. Throughout the campaign, slurry samples will be taken to verify the actual densities and compare them to evaporator slurry density indicators (DI-CA1-1 and DI-CA1-2). The SpG of the slurry product will be carefully monitored and controlled to obtain the campaign objective of 77% WVRF (slurry product SpG of 1.3).

The precampaign laboratory boildown studies indicate moderate foaming occurs at the beginning of boildown. Foaming reduces after 20% WVRF has been reached. To prevent potential operating problems caused by foaming, anti-foam chemicals will be added during initial transfer of feed into the Evaporator and throughout the campaign.

Throughput for the campaign is estimated to be 1.01 Mgal. The processing time for the campaign is estimated to be approximately thirteen (13) days, including startup and shutdown. The evaporator process is estimated to achieve a decontamination efficiency of approximately 10 million, based on Cs-137 feed concentration and evaporator flowsheet model.

Slurry generated from this campaign will consist of 228 Kgal of dilute double-shell slurry feed (DDSSF) waste with a SpG of 1.3. Slurry product will be temporarily stored in tank 106-AW. Approximately 935 Kgal of process condensate will be transferred to LERF Basin 42. TEDF discharges from steam condensate and cooling water were estimated to be 1.7 Mgal and 54 Mgal, respectively.

Evaporator campaign 99-1 will run with the ion exchange column off-line and process condensate recycle system on-line. Both slurry product and process condensate radionuclide concentrations are predicted to be well below their respective radionuclide dose consequence limits. The calculations and assumptions used to determine throughput, duration, and process condensate output are contained in Appendix G.

3.0 WASTE SAMPLE ACQUISITION

3.1 Precampaign Feed Sample Number Analysis

The strategy for determining the number of precampaign feed tank samples is specified in 242-A Evaporator Data Quality Objectives (Von Bargaen 1998). This document governs sampling decisions, such as number and location of samples to be pulled, based on preliminary information on primary analyte concentrations within the tank.

The number of required samples is calculated using power analyses (EPA 1994). Tank 102-AW preliminary concentrations of critical analytes are compared to evaporator waste acceptability limits to statistically determine the minimum number of samples necessary to verify the composition of the waste. The statistical analysis accounts for the desired confidence level and how close the critical concentrations are to the waste acceptance limits. Precampaign 99-1 analysis concluded that three sample locations from tank 102-AW would be adequate for characterization prior to processing in the 242-A Evaporator. The results of the precampaign analysis can be found in Table I-1 of Appendix I.

3.2 Sample Point Location Selection

The subsurface sampling locations from available tank risers were selected to get an estimate of the tank spatial variability. At each subsurface sampling location, four sample bottles were drawn: one for volatile analysis, one for semivolatile analysis, one for inorganic and radionuclide analyses, one for boildown and mixing study analyses. Additionally, one surface sample was collected to evaluate the potential presence of separable organics.

A review of available tank riser details (Anderson 1991) and field verification indicated that three risers for tank 102-AW were available for sampling. Risers 022 and 018 from tank 102-AW were randomly selected using the random number generator (Guthrie 1995). Riser 022 is located in the north section of the tank and is at 10 feet from the tank's center. Riser 018 is located in the southwest section of the tank and is at 28 feet from the tank's center. These sampling risers are at a distance of 35.8 feet from each other which is greater than the DQO minimum requirement distance of 15 feet. Within the 365 inches of supernatant liquid, two subsurface sample elevations (above tank bottom) from the first riser were randomly selected. One was at approximately the middle of the upper half of the tank and the other was at approximately the middle of the lower half. The third subsurface elevation from the second riser was selected randomly. The three sample point locations are identified in Appendix C.

3.3 Sample Collection

Sampling of the Evaporator Campaign 99-1 tank 102-AW was performed as directed by Tank 241-AW-102 Evaporator Grab Sampling and Analysis Plan, HNF-3758 (Sasaki 1999). A total of thirteen supernate sample bottles from tank 102-AW were collected on January 27 through January 28, 1999. The sampling duration was within the ten day QA sampling requirement. The samples were collected by the "bottle-on-a-string" method. Four field blanks and two trip blanks were also collected to provide an indication of contamination from sample collection, transport, preparation or extraction, and analysis. Sample identification for the tank 102-AW samples are presented in Appendix C.

4.0 SAMPLE CHARACTERIZATION AND DATA EVALUATION

4.1 DATA CALCULATION

Representative tank analyte concentrations are statistically determined and documented in Appendix D. The data was obtained from *Tank 241-AW-102 Grab Samples in Support of 242-A Evaporator Campaign 99-1*, Analytical Results for the Final Report, HNF-1665 (Bell 1999). For the purpose of waste modeling, safety and process control limit compliance, the weighted mean is used instead of sample average to better represent concentration gradient in the tank. For comparing the environmental and regulatory limits, the ninety percent confidence interval of organic values and highest ammonia concentrations were used to represent tank concentrations, when comparing with environmental and regulatory limits.

4.2 DATA ACCURACY AND PRECISION EVALUATION

All analytical data results for 102-AW were reviewed against Evaporator requirements of data precision and accuracy defined in the *242-A Evaporator Quality Project Plan*, HNF-SD-WM-QAPP-009, Rev. 3 (Bowman 1998). The precision and accuracy for all sample data except for sodium, Np-237, and polychlorinated biphenyls (PCB) met the Evaporator QA acceptance criteria.

The accuracy check for sodium at the first sample dilution was higher than the DQO acceptance criteria of 75% - 125% due to high sodium concentration and low spike concentration. The sample was diluted an additional ten-fold and the sample was rerun. The accuracy was found to be 108.6%, within the 70% - 125% QA requirement. The sodium concentration is used in the PREDICT computer model for complexed waste determination. The boildown indicated that the waste was non-complexed.

No Np-237 was detected in any of the samples or in the blanks. The accuracy check for Np-237 was 68.3%, which is slightly below the 70% - 130% Evaporator QA requirement. The Np-237 analysis is used in comparison of projected process condensate concentration to its LERF radiological limit. Since no Np-237 was found in any of the samples and the detection limit for Np-237 was well below its LERF radiological limit, further analyses for Np-237 were not performed.

No PCBs were detected in any of the samples. The precision for PCBs was at 30.4%, which was slightly above the 25% Evaporator QA requirement for organics. Poor precision was due to matrix interferences and poor extraction performance. The Laboratory Control Standard (LCS) results for PCBs were within the laboratory 70% -130% limits. Because no PCBs were detected in any of the samples and the LCS recoveries were within the established QC limits, PCB re-runs were not performed.

4.3 SAMPLE BLANKS EVALUATION

The field and trip blanks for tank 102-AW were evaluated by comparing the concentration of an analyte in the blanks to that in the actual samples. Contamination is indicated when the concentration of an analyte exceeds 20% of the lowest sample concentration for the analyte. Ammonia was identified as a contaminant in the field and trip blanks. Ammonia measurements on field and trip blanks ranged from 34 to 65 ppm. These results were similar to the supernate samples, which ranged from 23 to 74 ppm ammonia. For conservatism, ammonia of 74 ppm will be used to represent tank concentrations, when comparing with environmental and regulatory limits.

In addition, sample method blanks were verified against sample analytes to determine if they are acceptable. No contamination was found in the laboratory, since all the method blank sample results were less than laboratory detection limits or less than 5% of the measured concentration present in the associated samples.

4.4 SAMPLE HOLDING TIME EVALUATION

Although strict adherence to SW-846 criteria was not required per the Evaporator DQO, holding times for samples must be reviewed and failures to meet holding times should be documented.

The 14-day sample extraction holding time for PCB and SVOA were not met because sample prioritization was such that the limited resources associated with PCB and SVOA sample extraction were not available until day 20 and day 40, respectively. The sample analyses holding times for PCB and SVOA were met.

The 14-day holding time for VOA analysis was not met because of preparation for shipping the samples to PNNL, preparation and approval of the Statement of Work, and the additional preparation time required at PNNL for handling radioactive samples.

4.5 TANK SAMPLE NUMBER REASSESSMENT

As required by Evaporator QA program (Bowman 1998), when final results of the sample analysis become available, a second statistical analysis must be performed using the new analyte data to verify if a sufficient number of samples was actually collected.

The sufficient number of samples that should have been collected is statistically determined by the Decision Error Feasibility Trials (DEFT) computer model (EPA 1994). The DEFT computer model is designed to determine the minimum number of samples required to obtain statistically defensible data. The DEFT computer model computes this minimum number of samples based on the mean concentration, sample variability, concentration limits, and confidence requirements of each analyte of concern.

Before power analysis is performed, the data must be tested against established rejection criteria. The Q-test with 90% confidence interval was chosen as a method to remove apparently erroneous data. Rejection tests were performed for Cs-137 and Acetone results from sample 2AW-99-3 (the sample with highest concentrations). Both these data points passed the Q-test data rejection criteria and were discarded. The sample results, averages, and variability used for power analysis are summarized in table I-2 of Appendix I.

Based on the power analyses on the 102-AW final data results, it is determined that the three samples, which were collected, met or exceeded the DQO minimum number of samples. The results of DEFT analysis can be found in Appendix I.

5.0 WASTE PROCESSABILITY EVALUATION

5.1 PROCESS CONTROL EVALUATION

5.1.1 Energetics

Wastes that exhibit exothermic reactions below 168 °C are not permitted in evaporator feed because when heated, these wastes may release energy through chemical reaction or by reducing their physical strain (Campbell 1998). Wastes that exhibit exotherms indicate the potential for self-heating and could enter into a propagating chemical reaction. Differential scanning calorimetry (DSC) test is used to evaluate the possibility of an uncontrolled reaction at the elevated temperatures in the evaporator vessel. All 102-AW supernate samples were analyzed in duplicate by DSC. Heat absorbed by the sample from a net endothermic reaction or process, or heat given up by the sample from a net exothermic reaction or process was measured as a function of temperature. DSC analysis indicated that there is no exotherm in 102-AW waste below the Evaporator OSD limit of 168 °C.

Wastes that exhibit energy releases from exotherms in excess of the energy absorption from endotherms are considered potentially hazardous to the 242-A Evaporator system. The net energy available for heating the waste from an exothermic chemical reaction is greatly diminished by endotherms. If the endotherms are greater, then a propagating reaction would be inhibited. All 102-AW samples were heated from approximately 25 to 500 °C. None of the sample exhibited any net exotherms.

Evaporator slurry product is limited to a maximum total fuel concentration of 480 J/g (Tardiff 1998). Slurry product having exotherms exceeding 480 J/g could sustain propagating chemical reactions at elevated temperatures, at reduced moisture levels or by the presence of spark sources. Based on thermal analysis results for 102-AW samples, evaporator slurry contains no fuel concentration. The DSC analysis results for 102-AW can be found in Appendix D.

5.1.2 Mixing and Compatibility Study

A mixing and compatibility study was performed on a composite of 102-AW samples to ensure waste compatibility and provide data to establish processing controls. Processing of incompatible waste through 242-A Evaporator can create an uncontrolled reaction that could damage the evaporator system structural integrity or threaten human health or the environment. The samples were mixed with no appearance of stratification, gas evolution, heat generation, precipitation, dissolution of solids, color change, clarity change, or any other visually determinable characteristic (Beck 1999). The letter containing the results from the mixing and compatibility study can be found in Appendix J.

5.1.3 Corrosivity

The evaporator slurry product must be controlled to inhibit uniform corrosion, pitting corrosion and stress corrosion in slurry storage tanks prior to transferring to the DSTs (Tardiff 1998). The nitrate, nitrite and hydroxide concentrations are limited in order to reduce the deterioration rate of the primary carbon steel DST's. The slurry product concentrations to tanks 102-AW and 106-AW are presented in Appendix E, Table E-1.

The nitrate, nitrite and hydroxide concentrations in the slurry product that will be transferred to 106-AW were estimated at a maximum WVRP of 82%, using a conservative assumption that all constituents concentrate at the same ratio. The resulting slurry stream meets DST corrosion limits in Table B-7.

The concentration of waste transferred to 102-AW at the end of the campaign was estimated based on a waste makeup of approximately 19.5 Kgal of campaign feed, 13.5 kgal of slurry, and 27.5 Kgal of water flush. The resulting slurry stream meets DST corrosion limits in Table B-7. Comparison of the feed composition and projected slurry to DST waste corrosion specifications can be found in Appendix F, Table F-11.

5.1.4 Flammable Gas

Waste density is limited to a weighted mean SpG less than 1.41 to reduce the potential for hydrogen or flammable gas accumulation (Von Barga 1998). The waste volume reduction required to generate a slurry with SpG of 1.41 is estimated to be 88%. At campaign maximum WVR of 82%, the slurry will be at 1.33 SpG which is well below the 1.41 SpG limit.

The product of slurry SpG times tank solids depth is limited to 148 inches due to a strong correlation between SpG and flammable gas tanks (Mulkey 1997). The SpG of slurry in 102-AW and 106-AW tanks at the end of the campaign is estimated to be 1.09 and 1.33, respectively (Appendix E). With the average solids depth of 15.6 inches in tank 102-AW and 82 inches in 106-AW, the products of SpG and tank solids depth are calculated to be 17 inches and 109 inches, respectively. These are well below the 148 inch limit.

5.1.5 High Phosphate Waste

The slurry product must have less than 8 M sodium and 0.1 M phosphate concentrations to prevent the formation of needle-shaped crystals of $\text{Na}_2\text{P}_2\text{O}_7 \cdot 12\text{H}_2\text{O}$ (Fowler 1995). These crystals increase the viscosity of the slurry product and can cause the formation of a gel-like matrix. The sodium and phosphate concentrations for the remaining slurry in tanks 102-AW and 106-AW at the end of the campaign are listed in Appendix E, Table E-1.

The sodium and phosphate concentrations in the slurry product transferred to 106-AW is conservatively estimated (at 82% WVR) to be 6.8 M and 0.05 M, using the formula $\text{slurry} = \text{feed} / (1 - \text{WVR})$. The concentrations of waste in 102-AW at the end of the campaign were estimated to be 1.9 M sodium and 0.01 M phosphate. The estimation was based upon the assumption that the final heel will consist of a 27.5 Kgal water flush, 19.3 Kgal of campaign feed, and 13.5 Kgal of slurry. These wastes are below the formation criteria of the gel-like sodium phosphate matrix at the end of the campaign. In addition, the precampaign boildown results did not indicate formation of rapid viscosity increasing crystals.

5.1.6 Organic Complexants

Wastes that contain organic complexants should not be concentrated beyond the nitrate/nitrite saturation level to reduce the potential for hydrogen or flammable gas accumulation. Because no analytical procedure is currently available to measure the complexants used on site, waste is classified as complexed if the total organic carbon (TOC) concentration exceeds 10 g/L if evaporated to the composition of double shell slurry. Double shell slurry is defined when sodium aluminate in solution reaches saturation or when the eight molar caustic point reached.

The PREDICT computer program was used to extrapolate the TOC for campaign feed to the double shell slurry concentration (Allison 1984). The PREDICT computer model was developed primarily to simulate the effect the evaporation process has on the solubilities of aluminate, carbonate, nitrate, nitrite, phosphate, and sulphate. PREDICT uses the conservative assumption that all organic constituents remain in the slurry product during the evaporation process. The concentrations in Table E-1 of Appendix E were used in the PREDICT program.

The campaign feed waste met the criteria for non-complex waste. TOC concentrations at the sodium aluminate boundary for campaign feed is predicted to be 9.4 g/L. In addition, observations of the 102-AW waste boildown indicated rapid forming and settling solids in a non-viscous liquid, confirming the non-complex behavior of the campaign 99-1 feed waste.

The solids in 102-AW and 106-AW are already designated as TRU since they contain greater than 100 nCi/g of transuranic elements. Mixing organic complex liquid waste with TRU solid waste could solubilize precipitated TRU constituents. This increases the mobility of the TRU, creating risks during interim storage. Since the slurry product is low in TOC, mobilization of TRU elements from the solids is not a concern.

5.1.7 Organic Reaction

Campaign feed that contains more than 4.5 wt% TOC on a dry weight basis is limited to no less than 20% free water content in the slurry product because of a higher risk of propagating organic reactions (LMH 1997). Mixtures of organic material with nitrite and nitrate salts can deflagrate if free water is less than 20 percent. There is no credible organic reaction if waste contains mostly liquid.

The estimated TOC value on a dry basis for campaign feed is 0.6 % TOC. Since the feed contains an insignificant amount of TOC, the condition which could potentially lead to organic reaction will not be created. The weight percent TOC calculations can be found in Appendix G.

5.1.8 Transfer Line Plugging

Waste should not be concentrated to a point where viscosity will reduce the transfer Reynolds number to less than 20,000, or the volume of solids is greater than 30% to prevent potential slurry transfer line plugging, unless a technical justification is provided (Fowler 1995). The Reynolds number calculated for the evaporator slurry to tank 106-AW transfer is 21,400 which is greater than the minimum Reynolds number of 20,000. PREDICT runs indicate that the slurry will contain approximately 2.4 percent solids, which has little likelihood to plug. The Reynolds number calculations can be found in Appendix G.

As a further precaution against transfer line plugging while transferring slurry to 106-AW, slurry pump PB-2 will be operated whenever the slurry SpG is greater than 1.3 (Nicholson 1991). The slurry pump PB-2 is designed for high pressures so the slurry product can be transferred at high velocities to alleviate this potential problem.

5.1.9 Transuranic (TRU) Waste

Non-transuranic feed waste should not be concentrated beyond 100 nCi/g in the slurry product stream to prevent creation of additional TRU waste (Fowler 1995). Disposal cost of the TRU waste is much more expensive than non-TRU waste due to the requirement of additional waste pretreatment steps needed to prepare the wastes for final disposal. The predominate radionuclide activity of TRU wastes are from Plutonium-239 and Americium-241.

The slurry products transferred to 102-AW and 106-AW were estimated to have TRU concentration of 0.24 and 0.68 nCi/g, respectively. The campaign slurry product is categorized as non-TRU waste since it does not meet the definition of TRU waste. The TRU calculations can be found in Appendix G.

5.1.10 Heat Generation

To prevent internal boiling in slurry receiver tanks, the maximum concentrations for Cesium-137 and Strontium-90 in waste is limited to 574 uCi/ml and 404 uCi/ml, respectively (Fowler 1995). These concentration limits are based on assumptions that the slurry receiver tanks holds one million gallons, and Cs-137 and Sr-90 are at 50 percent of the heat load limit of 70,000 Btu/hr (Fowler 1995). The Cs-137 and Sr-90 in the slurry product are estimated to have maximum concentrations of 184 uCi/ml and 0.13 uCi/ml which are well below their respective limits.

The combined heat generation of slurry product with existing sludge in tank 102-AW at the end of the campaign is estimated to be 4,190 Btu/hr and slurry product with existing sludge in tank 106-AW campaign is estimated to be 6,320 Btu/hr. They are well below the heat load limit of 70,000 Btu/hr. The heat load calculations can be found in Appendix G.

5.1.11 Slurry Product Segregation

Per Department of Energy directive, slurry product that does not meet waste segregation Envelope A screening criteria should not be transferred to a Envelope A waste receiver tank (Kinzer 1998). Envelope A waste is defined as waste that contains less than 0.5 moles TOC per mole sodium, less than $4.40\text{E}+07$ Bq Sr-90 per mole sodium, and less than $4.80\text{E}+05$ Bq TRU per mole sodium.

Because both evaporator slurry product (at 82% WVER) and tank 106-AW heel meet the criteria of Envelope A, the campaign 99-1 slurry product can be transferred to 106-AW tank for storage. The slurry product and 106-AW heel calculations for Envelope A waste can be found in Appendix G.

5.1.12 Separable Organic Layers

Separable organic phase can accumulate in condensate collection tank C-100 during evaporator operations if separable organic in the feed is processed. Fire or explosion could potentially result from the accumulations if the temperature is above 165 degree F and there is an ignition source. In addition, the presence of an immiscible organic layer in the process condensate would cause operational difficulties if transferred to ETF. Therefore, controls are implemented to prevent separable organics from being introduced into evaporator process. Detection of a surface organic layer restricts the operational minimum level in feed tank 102-AW to 100 inches to prevent the possible transfer of the organic layer to the Evaporator.

A surface sample was taken from 102-AW feed tank to determine if a separable organic layer was present. Visual observations from the Laboratories indicated that the surface sample appeared homogeneous. The sample was clear with no observable solids and no observable organic phase. The TOC analytical result for the 102-AW surface sample was 578 mg/L which is well below the 2600 mg/L definition of a separable organic layer (Von Barga 1998). Due to lack of a surface organic layer in sample, the minimum level in feed tank 102-AW will be set at 18 inches for this campaign.

5.1.13 LERF Fissile Material Control Limit

The Liquid Effluent Retention Facility (LERF) is limited to no more than three percent of a minimum critical mass and no more than 15 g of Pu-239 (WMH 1999). The combined Pu-239 from three LERF basins and projected process condensate is estimated to be $8.22\text{E}-04$ grams which is well below the 15 g Pu-239 limit. Calculations of fissile content in the LERF Basins and projected condensate can be found in appendix G.

5.2 SAFETY EVALUATION

5.2.1 Criticality Safety

Evaporator criticality prevention program limits the feed concentration to less than 0.005 g/L fissile material and pH greater than 8 to ensure the concentration of fissile material in evaporator feed is insufficient to cause a criticality hazard (Vail 1998). Fissile isotopes of primary concern are ^{239}Pu , ^{235}U and ^{238}U . Of these, ^{239}Pu is the most significant contributor to the criticality potential. For criticality prevention, ^{235}U and ^{238}U are all treated as if they were ^{239}Pu . Since ^{235}U and ^{238}U data was not available, they are estimated from total uranium. Fissile concentrations for feed campaign is estimated to be $3.02\text{E-}05$ g/L with pH of 13. This is within Evaporator criticality specifications.

There are additional controls on fissile concentration in the slurry to ensure criticality safety in the DSTs. If the slurry product has less than 0.001 g/L fissile material, a criticality will not occur and no further evaluation is necessary. If the fissile material in slurry product is greater than 0.001 g/L, then the effects of neutron absorbers must be shown to be sufficient to ensure adequate fissile poisoning. Since fissile concentration in slurry product for this campaign is estimated to be less than $1.68\text{E-}04$ g/L, criticality is not a concern.

The total plutonium inventory for the campaign feed/slurry product is calculated to be 8.8 grams. Fissile concentration calculations can be found in Appendix G.

5.2.2 Evaporator Radiological Source Term Dose Consequence

The 242-A Evaporator OSR Compliance Strategy for Radiological Source Strengths, HNF-SD-WM-OCD-016 (Campbell 1997) describes the method to determine if the 242-A Evaporator will operate within its radiological source term (RST). The RST is defined in the 242-A Safety Analysis Report. Prior to an Evaporator campaign, the Compliance Strategy requires a comparison of the feed and projected slurry concentrations to the RST limits for nineteen radionuclides.

The feed and slurry product values at 82% WVR were compared against each of the constituents in the Evaporator RST limits in Table B-6. Campaign feed and slurry product radionuclide concentrations are below the Evaporator RST limits. Using the assumption that all constituents concentrate at the same ratio, the radionuclide concentrations in slurry can be estimated by using the formula: $\text{slurry} = \text{feed} / (1 - \text{WVR})$. Cs-137 and Pu-238 concentrations were predicted in slurry product to be the most restrictive radionuclides at 23% and 19% of their respective RST limits. Other radionuclide concentrations are less than five percent of their RST limits.

HNF-SD-WM-OCD-016 also requires total dose consequences of radionuclides in the Evaporator feed and projected slurry streams are maintained below the SAR total inhaled dose consequence limit of 7,700 Sv/L. The total dose consequences for feed and slurry product were calculated to be 12.6 Sv/L and 69.8 Sv/L, which is two orders of magnitude below the 7,700 Sv/L SAR limit.

Isotopic plutonium analysis for ^{239}Pu cannot be performed at the 222-S Analytical Laboratories. HNF-SD-WM-OCD-016 contains formulas for ^{239}Pu which allow its calculation based upon the ^{238}Pu concentration. When the formulas are applied, ^{239}Pu in slurry product was found to be less than one percent of its RST limit.

For some constituents, the analytical method does not provide an accurate concentration because detection limits are altered due to interference from other radionuclides. In these cases, the analytical result is reported with a "less than" sign. The "less than" result for ^{226}Ra was reported to be greater than four percent of its respective RST limit. HNF-SD-WM-OCD-016 contains a formula for ^{226}Ra which provide a more realistic concentration. When the formula was applied to the projected slurry product, the ^{226}Ra value was calculated to be less than one percent of its respective RST limit.

The comparisons of campaign feed and slurry product radionuclide levels to source term limits and total allowable radionuclide dose consequences are contained in Tables F-4 to F-7 of Appendix F.

5.2.3 LERF Radiological Limits

The LERF radiological limits are governed by the *242-AL Evaporator Effluent Retention Facility Auditable Safety Analysis*, HNF-SD-LEF-ASA-002 (Le 1998). Prior to an evaporator campaign, HNF-SD-LEF-ASA-002 requires a comparison of the process condensate to the LERF basin maximum bounding concentration screening limits for twenty two radionuclide constituents. If a limit is exceeded, the total dose release consequences should be estimated and compared to pressurized spray and pool evaporation dose release limits in the *Liquid Effluent Retention Facility Final Hazard Category Determination* (Galioto 1997). The dose limits for spray release and pool evaporation release are $2.0\text{E-}01$ rem and $9.4\text{E-}01$ rem, respectively.

Values for each of the constituents in the LERF radiological limit were entered into the process flowsheet for the 242-A Evaporator (Campbell 1999). The process flowsheet was developed to model the partition of constituents during the evaporation process. The process condensate concentrations at 82% WVR from the flowsheet were compared against the maximum bounding concentration (MBC) in Table B-4.

Table F-8 lists the projected process condensate concentration using MBC ratios for each of the radionuclides in the LERF radiological limit. ^{137}Cs was predicted to be the most restrictive radionuclide for all detected radionuclides. It is estimated that ^{137}Cs concentration in the process condensate will be approximately 7% of its MBC limit. For undetected radionuclides, ^{137}Cs was the most restrictive radionuclide and at 78% of its MBC when the detection limit result is entered into the flowsheet.

The total spray release dose consequence and pool evaporation release dose for process condensate are estimated to be $2.56\text{E-}03$ rem and $1.22\text{E-}02$ rem which are below their dose release limits of $2.0\text{E-}01$ rem and $9.4\text{E-}01$ rem, respectively.

Isotopic plutonium analysis for ^{239}Pu cannot be performed at the 222-S Analytical Laboratories. HNF-SD-WM-OCD-016 contains formulas for ^{239}Pu which allow its calculation based upon the ^{238}Pu concentration. The calculated ^{239}Pu concentration was entered into the process flowsheet and the concentration was found to be less than one percent of its MBC. For some constituents, the analytical method does not provide an accurate concentration because detection limits are altered due to interference from other radionuclides. In these cases, the analytical result is reported with a "less than" sign. HNF-SD-WM-OCD-016 contains a formula for ^{226}Ra which provides more realistic concentrations. The calculated ^{226}Ra concentration was entered into the process flowsheet and the concentration was found to be less than one percent of its MBC limit.

The comparisons of projected process condensate radionuclide levels to LERF maximum bounding concentration limits, pressurized spray release limit, and pool evaporation release limit can be found in Appendix F, tables F-8 through F-10.

5.2.4 Process Condensate Ammonia Limit

Ammonia concentrations in the process condensate at the LERF must be maintained below 13,600 (Campbell 1999) to assure toxicological exposure remains within the safety limits as analyzed in 242-A FSAR accident analysis.

A validated model for estimating ammonia release as a function of the feed concentration and other critical parameters (e.g., feed rate, operating pressures, temperatures, condenser efficiencies, etc.) does not exist. Based on sampling data from Evaporator campaign 94-2 and conservatively assuming that all of the ammonia in the feed is volatilized in the Evaporator, it was estimated that approximately 94 percent of the ammonia in the feed was released to the LERF and remaining 6 percent released through the vessel vent system (Campbell 1995).

For conservatism, the highest ammonia concentration in tank 102-AW (74.3 ppm) was selected to estimate ammonium concentration in the process condensate which will be discharged to the LERF during campaign 99-1. Given a nominal feed rate at 80 gpm, 82% WVRP, and initial pot volume at 25 kgal, the highest possible ammonia concentration released to the LERF during the campaign was estimated to be 85 mg/L which is well below the limit of 13,600 mg/L. The calculation of ammonia level in the process condensate can be found in Appendix G.

5.2.5 Shield Design Limits

The Cs-137 concentrations in the feed stream and slurry product must be maintained below 0.8 Ci/L to prevent potential radiation fields that exceed the parameters of shielding design criteria which could pose a hazard to workers in the personnel-occupied areas of the 242-A Building (Campbell 1999).

The Cs-137 concentration from the campaign feed is listed in Table E-1 and compared against the Evaporator shielding design limit. The campaign feed Cs-137 concentration is about 4% of the Evaporator shielding design limit. Using the assumption that all constituents concentrate at the same ratio, the Cs-137 concentration in the slurry can be estimated by using the formula: $\text{slurry} = \text{feed} / (1 - \text{WVRP})$. The Cs-137 concentration in slurry product at the end of campaign is estimated to be approximately 23% of the 0.8 Ci/L shielding design limit.

5.3 ENVIRONMENTAL COMPLIANCE EVALUATION

5.3.1 Vessel Vent Organic Discharge Limits

The regulatory requirements in WAC 173-303-690 and 40 CFR 264, Subpart AA limit 242-A Evaporator and ETF to 3.0 lbs/hr and 6200 lbs organic emissions in 12 months. The individual constituent limits for evaporator feed in Table B-3 were chosen to ensure the vessel vent would not exceed the volatile emission limit of 3 lbs/hr. The vessel vent organic discharge limits are also based upon maintaining the sum of the ratio of concentration-to-limit value at less than one. The comparison of 102-AW feed waste to evaporator feed limits based on volatile emissions is contained in Table F-3. The feed to product ratio (R) was assumed to be 5.56 for this comparison.

For the target compounds, only acetone and 1-butanol were in detectable quantities. The upper 90 percent confidence interval for acetone and 1-butanol were two orders of magnitude below their vessel vent emission limits. None of the other organic analytes of concern (2-Butanone, 2-butoxyethanol, and tributyl phosphate) were detected in samples. The semi-volatile organic compound 2-butoxyethanol was at 13 percent of its volatile release limit when using its detection level of 20,000 ppb. The sum of the ratio of concentration to limit value for all five target organic compounds in evaporator feed was less than one.

The total organic emission for this campaign is estimated to be 240 lbs (Bowman 1999). ETF organic emissions for 1998 (Basin 43 processing) were 8 lbs. ETF organic emissions for 1999 are estimated to be 3.5 lbs (3.3 lbs from Basin 43 processing through May 1999 and 0.21 lbs from the Basin test). Combining the 11.5 lbs of organic emissions from ETF with the evaporator emissions, the overall organic emissions will be about 525 lbs for the last 12 months. This is well below the limit of 6200 lbs.

"TC-TIC" is the screening method which is used to determine whether or not additional organic species are unaccounted for in the analysis. The "TC-TIC" represents the total organic carbon (TOC) in a tank. If it were conservatively assumed that all the TOC is volatile and exists as acetone, then the limit would be 143 mg/L for the feed. Acetone was chosen because of its high volatility. The "TC-TIC" values for campaign feed was estimated to be 440 ppm, which exceeded the Evaporator DQO screen limit of 143 mg/L. However, based on data analyses from the precampaign boildown analyses, approximately 92 percent of "TC-TIC" are non-volatile organic. The percent non-volatile organic calculation can be found in appendix G.

As required per the DQO, further technical evaluation will be performed to determine if a particular volatile or semi-volatile organic analyte is not accounted for. In assessing the Gas Chromatography (GC) results, only one tentatively identified volatile organic compound, 2-heptanone, was detected in sample 2AW-99-2A. The 2-heptanone concentration was estimated to be at the quantitation limit of 1.0 mg/L. For conservatism, 2-heptanone is assumed to have partition factor similar to pentanone. The emission rate for 2-heptanone is estimated to be $1.7\text{E-}02$ kg/hr (Bowman 1999). Volatile organic triethylamine was also detected in the sample; however, it was found to be contamination in the laboratory sample blanks.

One unknown tentatively identified semi-volatile organic compound was detected at 6.7 mg/L in sample 2AW-99-4B. Conservatively assuming this compound has a high partition factor of 36.2 as methyl isobutyl ketone, the emission rate for this compound is estimated to be 0.24 Kg/h. Combining these organic emission with the emission of target compounds gives a maximum emission of 0.41 kg/hr (0.91 lbs/hr). This is less than the 40 CRF 265 Subpart AA limit of 1.4 kg/hr. The "TC minus TIC" assessment (Bowman 1999) can be found in Appendix K.

5.3.2 Vessel Vent Radionuclide Discharge Monitoring Requirements

The Washington State Department of Health (DOH) approved the downgrading of the 242-A vessel vent stack to a non-designated source (Conklin 1998). This allows periodic, confirmatory sampling instead of continuous sampling when the evaporator is not operating. The approval letter from DOH requires a sample within 90 days of the campaign start, a sample during the campaign, and a sample within 90 days after the campaign is completed. Sampling is for Cs-137, Sr-90, Pu-239, Pu-238, Am-241, and any other radionuclide which contributes more than 10% of the potential to emit.

The total dose for radiological release out the vessel vent was estimated to be $4.39\text{E-}09$ mrem/year for this campaign. None of the radionuclides are above one percent of the total dose except Cs-137, which is about 99.2% of the total dose. Vessel vent radiological release calculations can be found in Appendix G.

5.3.3 Gaseous Ammonia Discharge Limit

It is recommended that gaseous ammonia discharges from the vessel vent exhaust stack be maintained below the CERCLA reportable quantity of 100 pounds in any 24 hour period (40CFR 302). A validated model for estimating ammonia release as a function of the feed concentration and other critical parameters (e.g., feed rate, operating pressures, temperatures, condenser efficiencies, etc.) does not exist. Based on sampling data from evaporator Campaign 94-2 (which processed high NH₃ concentration waste) and conservatively assuming that all of the ammonia in the feed is converted to ammonia gas in the Evaporator, it was estimated that approximately six percent of the ammonia in the feed was released to the vessel vent (Campbell 1995).

For conservatism, the highest ammonia concentration in feed tank 102-AW (74.3 ppm) was used to estimate the ammonia concentration which would be discharged out the stack during Campaign 99-1. Given a nominal feed rate at 80 gpm, 82% WVRP, and initial pot volume at 25 kgal, the highest possible ammonia concentration released to the vessel vent during the campaign was estimated to be 5.3 lbs/day which is well below the notification limit of 100 lbs/day. The calculation of ammonia discharged from the vessel vent stack can be found in Appendix G.

5.3.4 LERF Liner Limits

Table B-2 contains the evaporator feed limits to ensure process condensate will meet the LERF compatibility limits. These limits will prevent degradation of the LERF HDPE liners. The process condensate organic discharge limit is based upon maintaining the sum of the ratio of concentration-to-limit value at less than one.

For the target compounds, only acetone and 1-butanol were in detectable quantities. Their concentrations are several orders of magnitude below their respective limits. None of the other organic analytes of concern, 2-Butanone, 2-butoxyethanol, tributyl phosphate were detected in samples. The semi-volatile organic compounds 2-butoxyethanol and tributylphosphate are most restrictive for undetected compounds. They are present at less than two percent of their volatile release limit when using their detection level of 20,000 ppb.

Ammonia was found to be a contaminant in field blank and trip blank samples. Ammonia results for two field blanks and one trip blank were as the same concentration level as in the three supernate samples, which ranged from 23.3 to 74.3 ug/ml. No ammonia was detected in the analytical blanks. For conservatism, the highest ammonia concentrations in feed tank 102-AW was used to compare against the LERF liner ammonia limit and is several orders of magnitude below its limit.

The sum of the ratio of concentrations to limit values for target organic compounds in the feed waste was less than three percent of the unity limit. The comparison of feed tank 102-AW to LERF liner acceptance limits can be found in Table F-2. The feed-to-product ratio (R) was assumed to be 5.56 for this comparison.

5.3.5 Polychlorinated Biphenyls (PCB) limit

The regulatory requirements in 40 CFR 761 limit waste concentrated in 242-A Evaporator to less than 50 ppm PCB. If Evaporator slurry product contains more than 50 ppm PCB, it will be classified as TSCA regulated and could not be accepted into slurry receiver tanks.

Because no PCBs were detected in any of the feed tank samples and the standard recoveries were within the established quality control limits, PCB is not a concern. Detection levels for PCBs were ranged from 10 to 15 ppb.

5.3.6 Slurry Product Waste Profile for Campaign 99-1

Evaporator slurry product transfers into the DST system must be pre-approved and must meet tank waste acceptance criteria (Mulkey 1997). A copy of waste profile for Evaporator Campaign 99-1 can be found in Appendix J.

6.0 CAMPAIGN DESCRIPTION

6.1 INVENTORIES

Tank 102-AW

The dilute non-complexed waste in tank 102-AW will be used as evaporator feed for this campaign. The waste is comprised of water, condensate from aging waste tanks, and B Plant waste from terminal cleanout. Tank 102-AW also received a small amount of contaminated rain water from the A-350 catch tank.

Source	Waste Originated	Feed Volume (%)
102-AW Heel	Evaporator Campaign 97-2 heel	8%
B-Plant	B Plant Cleanout	3%
Water	FY98 Evaporator Cold Run	4%
102-AY	Condensate from aging waste tanks	42%
108-AP	B Plant cleanout and previous evaporator slurry.	43%

As of May 27, 1999, the 102-AW liquid level is 380 inches, with sludge levels ranging from 10.5 to 18.5 inches of solids. Approximately 999 Kgal of 102-AW waste will be processed through Evaporator.

Tank 106-AW

Tank 106-AW will continue to be used as the evaporator slurry tank for this campaign. As of May 27, 1999, the 106-AW liquid level is 115 inches, with sludge levels ranging from 70 to 113 inches and a low spot at the 300 degree position of the slurry distributor.

LERF Basins

LERF Basin 42 will be used for storage of process condensate generated during Evaporator Campaign 99-1. As of May 18, 1999, LERF basin volumes are approximately 0.76 Mgal, 3.3 Mgal, and 4.1 Mgal, for Basins 42, 43, and 44, respectively. With continuation of the groundwater transfer to ETF, Basin 43 volume was conservatively assumed to be 6.5 Mgal. Campaign 99-1 is expected to generate a maximum of 1.01 Mgal of process condensate, which would result in a total LERF Basin volume of 12.4 Mgal. This is less than the overall 13 Mgal operating capacity limit, which allows for 6.5 Mgal of contingency space. The final LERF Basin 42 volume is expected to be 1.77 Mgal.

6.2 PROCESSING ACTIVITY DESCRIPTION

6.2.1 Campaign Duration

Processing time for Campaign 99-1 is anticipated to be 13 days including start-up and flushing at the end of the campaign. The campaign duration calculation can be found in Appendix G.

6.2.2 Campaign Operating Strategy

Because of the presence of Sr-90 flocculent in 102-AW, it is recommended that at least one day of tank mixing be performed prior to introduction of feed into 242-A Evaporator to homogenize the waste. Waste blending will be accomplished by simultaneous operation of the 102-AW air lift circulators (ALCs) and 102-AW feed recirculation pump.

Two ALCs are available in tank 102-AW: one ALC is 16 inches in diameter and the other is 24 inches in diameter. The 16-inch ALC is to be used when the liquid level in tank 102-AW is between 190 and 240 inches. The 24-inch ALC is to be used when the liquid level is greater than 240 inches. ALCs in tank 102-AW should be continuously operated, as practical based on liquid levels, throughout the campaign to ensure good mixing in the feed tank during the campaign. It is noted that the ALCs operation may occasionally give incorrect 102-AW tank liquid level, which can cause tank farm material balance discrepancy.

The precampaign laboratory boildown studies indicate moderate foaming at the beginning of boildown. Foaming was reduced after 20% WVR was reached. To control potential foaming, feed will be pumped initially to the evaporator with the simultaneous addition of anti-foam chemicals. To optimize the use of antifoam chemicals, a stepwise reduction of the addition of antifoam chemicals into the 242-A Evaporator will be implemented when the evaporator process reaches steady state condition.

The objective of this campaign is to concentrate waste to obtain 77% overall WVRF or an average slurry product SpG of 1.31 in one single pass. The WM 1.4.1 Performance Agreement requires WMH to complete at least 85% of the target overall WVRF of 77% for 242-A Evaporator Campaign 99-1. The performance agreement will be met if final WVRF of 65.5% is achieved at the end of the campaign.

Batch slurry transfers will be required to achieve this WVRF. To prevent potential excessive solids precipitation, as indicated from precampaign boildown studies, feed should be concentrated less than 82% WVRF (before vessel flushing) throughout the campaign. The campaign WVRF will be continuously monitored and controlled by using the slurry SpG to obtain the campaign objective.

A slurry sample will be taken early when a desired SpG has been reached for SpG and percent solids analyses. The laboratory results will be compared to evaporator density indicators (DI-CA1-1 and DI-CA1-2). Subsequent process adjustments will be made as necessary to obtain more precise WVRF control of the campaign. More slurry samples may be needed after the first slurry sample to maintain the slurry product at SpG of 1.29 - 1.32. Slurry pump PB-2 will be operated when slurrying out to 106-AW.

It is estimated, using the PREDICT program, that approximately 2.4 percent precipitated solids by volume will be generated during the campaign, so the slurry distributor in 106-AW should be set at the 300 degree position to balance the existing solids level.

No 106-AW to 102-AW recycle transfer is required for this campaign. When the feed tank is pumped down to approximately 18 inches, the evaporator will be shutdown for final evaporator flushing. The final level in tank 102-AW after evaporator flush will be approximately 32 inches. LERF Basin 42 will receive the process condensate from this campaign. All process control and sampling instructions will be specified by process memo.

6.2.3 Normal Evaporator Operation

Throughout the campaign, the process condensate recycle system should be operating. The ion exchange column and vessel vent ammonia monitor system shall remain off-line. Slurry pump PB-2 will be operated throughout the campaign to prevent a potential line plugging.

Feed rates are expected to be 70-110 gpm and boiloff rates are expected to be 40-65 gpm. Slurry flow rate should be controlled to maintain the SpG at 1.29 - 1.32. Steam condensate will be discharged to the 207-A North Retention Basins, which will be continuously transferred to Treated Effluent Disposal Facilities.

To monitor for a potential organic layer in tank C-100, the tank liquid level shall be maintained at approximately 50% weight factor during normal evaporator operation and tank C-100 agitator shall not be used. Overflowing Tank C-100 must be performed prior to the completion of the campaign to remove any organic or foam that may collect in the tank during the campaign.

6.2.4 Tank Farm Material Balance

A tank farm material balance was developed and will be performed when operations are ongoing in the 242-A Evaporator building to detect potential misroute or leakage. The tank farm material balance discrepancy can be calculated performed manually or automatically. The calculation is required just before the feed transfer starts, thirty minutes after the feed transfer started, one hour after the feed transfer started, and every two hours after the feed transfer started until the final transfer is completed.

6.2.5 Evaporator Vessel Flushing

At the end of the campaign, the evaporator vessel, recirculation line, feed line, dump line and slurry line shall be adequately flushed to reduce potential scale and residue buildup on pipe and vessel walls and to decrease radioactive dose rate in the pump room and evaporator room for future maintenance entries.

6.2.6 Post-campaign Sludge Measurements

Sludge level measurements in tanks 102-AW and 106-AW must be obtained after the completion of the campaign to provide necessary information for future evaporator campaigns.

6.2.7 Post Run Documentation

A post-run report will summarize the events and outcome of the 242-A Evaporator Campaign 99-1. This report will focus on the operating performance, process control, safety, and environmental compliance assessment after completion of the campaign.

6.3 SAMPLING AND MONITORING REQUIREMENTS

6.3.1 Building Stack Sampling and Monitoring

The 242-A Building ventilation exhaust stack 296-A-21 contains a typical Hanford stack monitoring system. One portion of the exhaust is diverted to a record sampler where radioactive particulates are collected on filter paper. The record sampler filter paper is removed biweekly and analyzed. The remaining portion of this stream is split between an alpha continuous air monitor (CAM) and a beta-gamma CAM.

6.3.2 Vessel Vent Stack Sampling and Monitoring

The vessel vent exhaust stack 296-A-22 has a monitoring system similar in design to that of 242-A Building stack. CAMs monitor total alpha and beta/gamma particulates discharged out the vessel vent stack. If total alpha exceeds 20 cpm, the cause will be investigated and the process is shutdown if necessary. If total beta/gamma exceeds 2000 cpm, high alarm will annunciate and an interlock will shutdown the vessel vent and the Evaporator process.

As required per Department of Health, the vessel vent filter is collected at least once during Campaign 99-1 for total alpha, total beta, and Cs-137. Additional filters will be collected during Campaign 99-1 and analyzed for total alpha, total beta, Cs-137, Sr-90, Pu-238, Pu-239, and Am-241. Because the I-129 is less than 10% of the potential emission the silver zeolite sampler will not be operated during the campaign.

The vessel vent stack also has an infrared gas analyzer to continuously monitor ammonia levels as it discharges out the stack. Because of the insignificant amount of ammonia in the feed, the vessel vent ammonia monitor (AM-NH3-1) will remain off-line for campaign 99-1. The highest possible ammonia concentration released from the vessel vent during the campaign was estimated to be 5.3 lbs/day, which is well below the CERCLA reportable quantity of 100 lbs/day. Vessel vent discharging stream will be sampled one time during the campaign to verify ammonia release.

No organic vapor sampling will be collected because engineering calculations show that organic emissions are well below the limits. The organic emission calculations can be found in Appendix J (Bowman 1999).

6.3.3 Steam Condensate Sampling and Monitoring

Steam condensate from the Evaporator reboiler will be discharged to the 200 Area TEDF via retention basins. The steam condensate stream flows past an in-line radiation monitor RIAS-EA1-1 on the inlet to the C-103 weir. A portion of the steam condensate in the C-103 weir is routed through the RC-1 radiation monitoring cell. Upon detection of high radiation in the steam condensate from the radiation monitors, an interlock will shut down steam to the evaporator process and divert the steam condensate stream to tank 102-AW. This ensures discharge limits are not exceeded.

In addition, instruments have been installed on the steam condensate stream to monitor pH of conductivity. The pH low and high alarm points are set at 5.5 and 8.5, respectively. The conductivity is monitored for information only. Contamination of the stream is detected if the pH and conductivity values continue to increase.

To comply with TEDF discharge reporting requirements listed in the 200 Area Treated Effluent Disposal Facility Interface Control document, HNF-SD-W049H-ICD-001, special TEDF protocol steam condensate samples will be collected one time during evaporator campaign. The samples will be sent to WSCF Laboratories for environmental analyses. Sampling frequency will be specified by process memo. No process control steam condensate samples are required prior to discharging to TEDF.

6.3.4 Cooling Water Sampling and Monitoring

Cooling water from the primary and after condensers will be directly discharged to the 200 Area TEDF. A portion of the used raw water stream is routed through the RC-2 radiation monitoring cell. This stream has no diversion capabilities. If high radiation conditions persist after flushing, the plant is shutdown and verification samples are collected to determine actual radionuclide levels in the cooling water.

In addition, instruments have been installed on the cooling water stream to monitor pH of conductivity. The pH low and high alarm points are set at 6.5 and 9.0, respectively. The conductivity is monitored for information only. Contamination of the stream is detected if the pH and conductivity values continue to increase.

To comply with TEDF discharge reporting requirements listed in HNF-SD-W-W049H-ICD-001, special TEDF protocol cooling water samples will be collected one time using the proportional sampler during evaporator campaign. The samples will be sent to WSCF Laboratories for environmental analyses. Sampling frequency will be specified by process memo. No process control cooling water samples will be collected.

6.3.5 Process Condensate Sampling and Monitoring

Process condensate generated during the campaign will be transferred to LERF Basin 42 from tank C-100. The process condensate stream flows past an in-line radiation monitor RIAS-CA1-1 on the inlet to the C-100 tank. Upon detection of high radiation from the in-line radiation monitor, an interlock will shut off feed to the evaporator process, shut down steam to the evaporator process, and terminate process condensate flow to LERF. A portion of the process condensate stream is also routed through the RC-3 radiation monitoring cell. On detection of high radiation from the RC-3 radiation monitor, an interlock will divert process condensate flow back to tank C-100. This will prevent exceeding the LERF source term limits.

Two process control samples will be taken during the campaign. The first sample will be sent to 222-S and analyzed for H-3, Sr-90, Nb-94, I-129, Cs-134, Cs-137 as a verification of radionuclide concentration in the process condensate. These radionuclide concentrations are predicted to contribute most of the dose in the process condensate. The sample will also be analyzed for Pu-239 and some inorganic concentrations for LERF inventory. The second sample will be sent to WSCF for environmental analyses. Sampling frequency will be specified by process memo.

6.3.6 Evaporator Feed Sampling

One sample will be taken from the feed sampler SAMP-F-1 and analyzed for Sr-90, Cs-137, Pu-238, and Am-241. These are most restrictive radionuclides as an indicator of source term concentration. Sample collection will be specified by process memo.

6.3.7 Evaporator Slurry Sampling

Slurry samples will be taken from the slurry sampler SAMP-F-2. A slurry sample will be taken early in the campaign and analyzed for slurry SpG. Efforts should be made to ensure representative slurry is routed to the sampler. The lab SpG result will be used to compare with evaporator density indicators. Subsequently, process adjustments will be performed to precisely control slurry SpG in order to obtain campaign WVERF objective.

Final slurry samples will be collected near the end of campaign. The sample analyses will primarily be used to characterize campaign slurry product and verify compliance with the process control and safety limits.

6.4 Quality Assurance

Operating records generated during Campaign 99-1 will be maintained. Process control sampling and analysis will be performed in accordance with FSS-T-630-00001 Rev D-0, *242-A Evaporator Sample Schedule For Campaign 99-1*. Following the completion of Campaign 99-1, a Process Evaluation Report (Post Run Document) will be issued summarizing the significant aspects of the campaign, and an evaluation of the process results, per requirements in *WMH-331, Section 3.2, Process Control Plans*.

6.5 PRODUCT/WASTE DISPOSITION

The slurry product from Campaign 99-1 will be transferred to tank 106-AW. Tank 106-AW is expected to contain approximately 228 Kgal of slurry at the completion of the campaign.

All process condensate from the campaign shall be transferred to LERF Basin 42 for interim storage. Approximately 935 Kgal of process condensate will be generated. Steam condensate and cooling water generation were estimated to be 1.7 Mgal and 54 Mgal, respectively. Under normal conditions, steam condensate and cooling water will be discharged to TEDF. In the unlikely event that radioactive contamination in the steam condensate or cooling water is above the discharge limits, the plant will be shutdown.

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APPENDIX A

INDEX OF TECHNICAL OPERATING CONTROLS

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INDEX OF TECHNICAL OPERATING CONTROLS

CPS-T-149-00010, Rev./Mod. I-0, Criticality Prevention Specification for Waste Storage Tanks and Associated Equipment.

HNF-SD-LEF-ASA-002, Rev. 1, 242-AL Liquid Effluent Retention Facility Auditable Safety Analysis.

HNF-SD-WM-DQO-001, Rev. C-2, Data Quality Objectives for Tank Farms Waste Compatibility Program.

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WHC-SD-WM-OCD-015, Rev. 1, Tank Farm Waste Compatibility Program.

HNF-SD-WM-OCD-016, Rev. 1, 242-A Evaporator OSR Compliance Strategy For Radiological Source Strengths.

HNF-SD-WM-DQO-014, Rev. 2, 242-A Evaporator Data Quality Objectives.

HNF-SD-WM-SAR-023, Rev. 3-B, 242-A Evaporator/Crystallizer Final Safety Analysis Report.

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APPENDIX B

242-A EVAPORATOR LIMITS

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Table B-1. Miscellaneous 242-A Evaporator Feed Limits¹

Constituent	Feed Limit ²
Exotherm ($< 168\text{ }^{\circ}\text{C}$)	$< 0\text{ J/g}$
Exotherm/Endotherm ($T < 500\text{ }^{\circ}\text{C}$)	< 1
Maximum Heat Load Concentration (uCi/ml)	Cs-137 $< 574 \cdot (R-1) / R$ Sr-90 $< 404 \cdot (R-1) / R$
Shielding Design (Ci/L)	Cs-137 $< 0.8 \cdot (R-1) / R$
Fissile Material Concentration	$< 0.005\text{ g/L}$

¹From 242-A Evaporator - Liquid Effluent Retention Data Quality Objectives (Von Bargaen 1998).

²R is the ratio of feed flow rate to boil off rate.

Table B-2. Evaporator Feed Limits for LERF Liner Compatibility¹

Chemical Family/Parameter	Current Target Compounds	Limit (mg/L) ^{2,3,6}
Alcohol/Glycol	1-butanol	$500,000 \times (R-1)/R$
Alkanone ⁴	Sum of acetone and 2-butanone.	$200,000 \times (R-1)/R$
Alkenone ⁵	none targeted	$2000 \times (R-1)/R$
Aromatic/Cyclic Hydrocarbon	none targeted	$2000 \times (R-1)/R$
Halogenated Hydrocarbon	none targeted	$2000 \times (R-1)/R$
Aliphatic Hydrocarbon	none targeted	$500,000 \times (R-1)/R$
Ether	2-Butoxyethanol	$2000 \times (R-1)/R$
Other Hydrocarbons	Tri-butyl Phosphate	$2000 \times (R-1)/R$
Oxidizers	none targeted	$1000 \times (R-1)/R$
Acids, Bases, Salts	Ammonia	$100,000 \times (R-1)/R$
TC, TIC	N/A	$(TC-TIC) < 1240 \times (R-1)/R$

¹From Table 4A.2 in 242-A Evaporator - Liquid Effluent Retention Data Quality Objectives (Von Barga 1998).

²R is the ratio of feed flow rate to boil off rate.

³The limits are applied using the sum of the fraction technique:

$$\sum_{n=1}^i \left(\frac{Conc_n}{LIMIT_n} \right) \leq 1$$

where i is the number of organic constituents detected in analysis of the waste fee tank. TC-TIC is not part of this summation.

⁴Ketone containing saturated alkyl group(s)

⁵Ketone containing unsaturated alkyl group(s)

⁶If a chemical fits in more than one chemical family, the more restrictive limit applies.

Table B-3. Evaporator Feed Limits For Vessel Vent Organic Discharge¹

Constituent	Limit (mg/L) ^{2,3,4}
Acetone	$174.4 \times (R-1) / R$
1-Butanol	$452 \times (R-1) / R$
2-Butoxyethanol	$190.4 \times (R-1) / R$
2-Butanone	$116 \times (R-1) / R$
Tri-Butyl Phosphate	$2.030 \text{ E}+4 \times (R-1) / R$
TC, TIC	$(TC - TIC) < 174.4 \times (R-1) / R$ (as acetone)

¹From Table 4A.1 in 242-A Evaporator - Liquid Effluent Retention Data Quality Objectives (Von Bargaen 1998).

²Limits in this table are based on a maximum continuous operating time equivalent to six months per year. If total operating time is expected to exceed six months per year, the limits must be evaluated.

³The limits are applied using the sum of the fraction technique

$$\sum_{n=1}^i \left(\frac{\text{Conc}_n}{\text{LIMIT}_n} \right) \leq 1$$

where i is the number of organic constituents detected in analysis of the waste feed tank. TC-TIC is not part of this summation.

⁴R is the ratio of feed flow rate to slurry flow rate.

Table B-4. Process Condensate Maximum Concentration Boundings¹

Radionuclide	MCB (Ci/L)
H-3	2.4E-04
C-14	1.6E-06
Co-60	2.4E-06
Se-79	1.5E-07
Sr-90	4.2E-05
Nb-94	2.6E-07
Tc-99	1.8E-05
Ru-106	6.5E-07
I-129	1.8E-06
Cs-134	4.1E-07
Cs-137	9.9E-06
Ce-144	8.3E-07
Eu-154	9.8E-06
Eu-155	6.3E-05
Ra-226	6.4E-08
U-234	2.1E-10
Np-237	2.1E-09
Pu-238	2.8E-09
Pu-239/240	1.7E-08
Pu-241	2.6E-08
Am-241	1.4E-09
Cm-244	2.5E-08

¹From 242-AL Liquid Effluent Retention Facility Auditable Safety Analysis, (Le 1998)

BOUNDING SOURCE STRENGTH LIMITS

Table B-5. 242-A Evaporator Bounding Source Strength¹

RADIONUCLIDE	BOUNDING SOURCE STRENGTH			DOSE CONVERSION FACTOR (Sv/Bq)	UNIT LITER DOSE (Sv/L) INHALED
	Ci/L	uCi/ml	Bq/L	Sv/Bq	Sv/L
C-14	2.6 E-04	2.6 E-01	9.6 E+06	5.6 E-10	5.4 E-03
Co-60	1.2 E-03	1.2 E+00	4.4 E+07	5.9 E-08	2.6 E+00
Se-79	7.8 E-05	7.8 E-02	2.9 E+06	2.7 E-09	7.7 E-03
Sr-90	2.2 E-01	2.2 E+02	8.1 E+09	6.5 E-08	5.3 E+02
Y-90	2.2 E-01	2.2 E+02	8.1 E+09	2.3 E-08	1.9 E+01
Nb-94	9.8 E-05	9.8 E-02	3.6 E+06	1.1 E-07	4.1 E-01
Tc-99	2.0 E-03	2.0 E+00	7.4 E+07	2.3 E-09	1.7 E-01
Ru-106	5.3 E-02	5.3 E+01	2.0 E+09	1.3 E-07	2.5 E+02
I-129	2.6 E-06	2.6 E-03	9.6 E+04	4.7 E-08	4.5 E-03
Cs-134	1.5 E-02	1.5 E+01	5.6 E+08	1.3 E-08	6.9 E+00
Cs-137	1.5 E+00	1.5 E+03	5.6 E+10	8.6 E-09	4.8 E+02
Eu-154	5.0 E-03	5.0 E+00	1.9 E+08	7.7 E-08	1.4 E+01
Eu-155	7.0 E-03	7.0 E+00	2.6 E+08	1.1 E-08	2.9 E+00
Ra-226	3.3 E-05	3.3 E-02	1.2 E+06	2.3 E-06	2.8 E+00
Pu-238	1.3 E-06	1.3 E-03	4.8 E+04	1.1 E-04	5.1 E+00
Pu-239/240	1.6 E-04	1.6 E-01	5.9 E+06	1.2 E-04	6.9 E+02
Pu-241	1.5 E-02	1.5 E+01	5.6 E+08	2.2 E-06	1.2 E+03
Am-241	1.0 E-03	1.0 E+00	3.7 E+07	1.2 E-04	4.4 E+03
Cm-244	1.3 E-05	1.3 E-02	4.8 E+05	6.7 E-05	3.2 E+01
Total					7.7 E+03

¹From 242-A Evaporator/Crystallizer Safety Analysis Report (Campbell 1999).

Table B-6. Double-Shell Tank Waste Corrosion Specifications¹

Constituent	Limit (M)
$[\text{NO}_2] \leq 1.0 \text{ M}$	
Hydroxide	$0.01\text{M} \leq [\text{OH}] \leq 8.0\text{M}$
Nitrite	$0.011\text{M} \leq [\text{NO}_2] \leq 5.5\text{M}$
Ratio	$[\text{NO}_2] / \{ [\text{OH}] + [\text{NO}_2] \} \leq 2.5$
$1.0 \text{ M} < [\text{NO}_2] \leq 3.0 \text{ M}$	
Hydroxide	$0.1 \times [\text{NO}_2] \leq [\text{OH}] \leq 10\text{M}$
Nitrite	$[\text{OH}] + [\text{NO}_2] \geq 0.4 \times [\text{NO}_2]$
$3.0 \text{ M} < [\text{NO}_2] \leq 5.5 \text{ M}$	
Hydroxide	$0.3\text{M} \leq [\text{OH}] \leq 10\text{M}$
Nitrite	$[\text{OH}] + [\text{NO}_2] \geq 1.2\text{M}$

¹From *Operating Specifications for the 241-AN, AP, AW, AY, AZ & SY Tank Farms* (Tardiff 1998).

Table B-7. Slurry Product Criticality Specifications¹

Constituent	Slurry Limit
Fissile Concentration ≤ 0.001 g/L	
pH	pH ≥ 8.0
0.001 g/L < Fissile Concentration ≤ 0.04 g/L	
pH	pH ≥ 8.0
X/Fissile	U/fissile ≥ 770 or Fe/fissile ≥ 160 or Mn/fissile ≥ 32 or Ni/fissile ≥ 105 or Cr/fissile ≥ 135 or Al/fissile ≥ 910 or Zr/fissile ≥ 4000

¹From Criticality Prevention Specification (Vail 1998).

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APPENDIX C

SAMPLE IDENTIFICATION, SAMPLING DATE, AND ANALYSIS REQUIREMENTS

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Table C-1. Tank 102-AW Sampling Information

SAMPLE NUMBER	LAB ID NUMBER	ANALYSES	SAMPLE TYPE	SAMPLE LOCATION	SAMPLE DATE	SAMPLE ELE ¹
2AW-99-IB1	S99T000187	Inorganic/Rad	Field Blank	Riser 018	1/28/99	444 in
2AW-99-IB2	S99T000188	Inorganic/Rad	Field Blank	Riser 018	1/28/99	444 in
2AW-99-OB1	S99T000189	Organic/VOA	Field Blank	Riser 018	1/28/99	444 in
2AW-99-OB2	S99T000185	Organic/SVOA	Field Blank	Riser 018	1/28/99	444 in
2AW-99-1	S99T000186	TOC	Surface	Riser 018	1/28/99	380 in
2AW-99-2A	S99T000184	Organic/VOA	Supernate	Riser 018	1/28/99	192 in
2AW-99-2B	S99T000183	Organic/SVOA	Supernate	Riser 018	1/28/99	192 in
2AW-99-2C	S99T000182	Inorg/Rad	Supernate	Riser 018	1/28/99	192 in
2AW-99-2D	S99T000180	Boildown	Supernate	Riser 018	1/28/99	192 in
2AW-99-3A	S99T000197	Organic/VOA	Supernate	Riser 022	1/28/99	264 in
2AW-99-3B	S99T000194	Organic/SVOA	Supernate	Riser 022	1/28/99	264 in
2AW-99-3C	S99T000198	Inorg/Rad	Supernate	Riser 022	1/28/99	264 in
2AW-99-3D	S99T000193	Boildown	Supernate	Riser 022	1/29/99	264 in
2AW-99-4A	S99T000196	Organic/VOA	Supernate	Riser 022	1/28/99	96 in
2AW-99-4B	S99T000195	Organic/SVOA	Supernate	Riser 022	1/29/99	96 in
2AW-99-4C	S99T000191	Inorg/Rad	Supernate	Riser 022	1/29/99	96 in
2AW-99-4D	S99T000196	Boildown	Supernate	Riser 022	1/29/99	96 in
2AW-99-TB1	S99T000199	Organic/VOA	Trip Blank	----	1/28/99	----
2AW-99-TB2	S99T000190	Organic/SVOA	Trip Blank	----	1/29/99	----

¹Sample elevation is defined as the distance from tank bottom.

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APPENDIX D

TANK 241-AW-102 ANALYTICAL RESULTS AND DATA EVALUATION

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APPENDIX D

TANK 241-AW-102 ANALYTICAL RESULTS AND DATA EVALUATION

Tables D-1 to D-49 contain the analytical data used in the preparation of this process control plan. The validated data package for tank 102-AW waste characterization is obtained from the Tank 241-AW-102 Grab Samples in Support of 242-A Evaporator Campaign 99-1, Analytical Results for the Final Report, HNF-1665, Rev. 0.

For the purpose of waste modeling, the weighted mean is used instead of sample average to better represent total ion/ion gradient in the tank. Weighted mean is calculated based on sample depths using formula:

Weighted mean = $(84/366) * (2AW-99-2C) + (152/366) * (2AW-99-3C) + (130/366) * (2AW-99-4C)$.

Table D-1. Tank 241-AW-102 Analytical Data: Aluminum

Sample I.D.	Data Result (ug/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (ug/ml)
2AW-99-2C	1.37E+03	0.0%	na	1.36E+03
2AW-99-3C	1.36E+03	0.0%	82.8%	
2AW-99-4C	1.36E+03	2.2%	na	

Table D-2. Tank 241-AW-102 Analytical Data: Sodium

Sample I.D.	Data Result (ug/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (ug/ml)
2AW-99-2C	2.88E+04	0.7%	na	2.84E+04
2AW-99-3C	2.82E+04	0.4%	326.7 ¹	
2AW-99-4C	2.83E+04	3.5%	na	

¹The accuracy for sodium at the first sample dilution was higher the DQO acceptance criteria of 75% - 125%. Initial accuracy failures due to high sodium concentration and low spike concentration. The sample was diluted an additional ten-fold and sample was rerun. The accuracy was found to be 108.6%, within the 70% - 125% QA requirement. Sodium was used in the PREDICT computer model for preliminary complexed waste determination. However, the boildown indicated that the waste was non-complexed so an accurate sodium concentration was not required.

Table D-3. Tank 241-AW-102 Analytical Data: Fluoride

Sample I.D.	Data Result (ug/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (ug/ml)
2AW-99-2C	1.32E+03	18.2%	na	1.51E+03
2AW-99-3C	1.54E+03	1.3%	na	
2AW-99-4C	1.59E+03	7.12%	90.4%	

Table D-4. Tank 241-AW-102 Analytical Data: Hydroxide

Sample I.D.	Data Result (ug/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (ug/ml)
2AW-99-2C	7.30E+03	0.0%	na	7.47E+03
2AW-99-3C	7.36E+03	0.0%	na	
2AW-99-4C	7.70E+03	1.7%	na	

Table D-5. Tank 241-AW-102 Analytical Data: Phosphate

Sample I.D.	Data Result (ug/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (ug/ml)
2AW-99-2C	8.03E+02	0.62%	na	7.86E+02
2AW-99-3C	7.73E+02	2.46%	na	
2AW-99-4C	7.91E+02	0.18%	103.3%	

Table D-6. Tank 241-AW-102 Analytical Data: Sulfate

Sample I.D.	Data Result (ug/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (ug/ml)
2AW-99-2C	1.28E+03	0.78%	na	1.22E+03
2AW-99-3C	1.20E+03	1.67%	NA	
2AW-99-4C	1.21E+03	0.45%	102.6%	

Table D-7. Tank 241-AW-102 Analytical Data: Nitrate

Sample I.D.	Data Result (ug/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (ug/ml)
2AW-99-2C	1.72E+04	1.16%	na	1.76E+04
2AW-99-3C	1.77E+04	0.00%	na	
2AW-99-4C	1.78E+04	1.79%	89.0%	

Table D-8. Tank 241-AW-102 Analytical Data: Nitrite

Sample I.D.	Data Result (ug/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (ug/ml)
2AW-99-2C	6.94E+03	5.76%	na	6.95E+03
2AW-99-3C	6.94E+03	1.01%	na	
2AW-99-4C	6.98E+03	8.27%	103.6	

Table D-9. Tank 241-AW-102 Analytical Data: Uranium

Sample I.D	Data Result (ug/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (ug/ml)
2AW-99-2C	1.31E+01	3.15%	100%	1.31E+01
2AW-99-3C	1.31E+01	6.11%	na	
2AW-99-4C	1.30E+01	0.0%	na	

Table D-10. Tank 241-AW-102 Analytical Data: Specific Gravity

Sample I.D	Data Result	Precision RPD	Accuracy % Rec.	Weighted Mean
2AW-99-2C	1.06	0.66%	na	1.05
2AW-99-3C	1.05	0.86%	na	
2AW-99-4C	1.05	0.10%	na	

Table D-11. Tank 241-AW-102 Analytical Data: pH

Sample I.D	Data Result	Precision unit diff.	Accuracy % Rec.	Lowest
2AW-99-2C	13.1	0.23%	na	13.1
2AW-99-3C	13.1	0.31%	na	
2AW-99-4C	13.1	0.15%	na	

Table D-12. Tank 241-AW-102 Analytical Data: Ammonia

Sample I.D	Data Result (ug/ml)	Precision RPD	Accuracy % Rec.	Highest (ug/ml)
2AP-99-2C	2.33E+01	na	na	7.43E+01
2AP-99-3C	7.43E+01	1.65%	133%	
2AP-99-4C	5.58E+01	na	na	

Table D-13. Tank 241-AW-102 Analytical Data: Subsurface Total Organic Carbon

Sample I.D.	Data Result (ug/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (ug/ml)
2AW-99-2C	5.83E+02	na	na	5.82E+02
2AW-99-3C	6.33E+02	na	na	
2AW-99-4C	5.23E+02	na	na	

Table D-14. Tank 241-AW-102 Analytical Data: Surface Total Organic Carbon

Sample I.D.	Data Result (ug/ml)	Precision RPD	Accuracy % Rec.
2AW-99-1	5.78E+02	0.22%	92.3%

Table D-15. Tank 241-AW-102 Analytical Data: Total Carbon

Sample I.D.	Data Result (ug/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (ug/ml)
2AW-99-2C	2.13E+03	3.13%	91.2%	2.33E+03
2AW-99-3C	2.40E+03	na	na	
2AW-99-4C	2.37E+03	na	na	

Table D-16. Tank 241-AW-102 Analytical Data: Total Inorganic Carbon

Sample I.D.	Data Result (ug/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (ug/ml)
2AW-99-2C	1.89E+03	0.22%	92.3%	1.89E+03
2AW-99-3C	1.92E+03	na	na	
2AW-99-4C	1.86E+03	na	na	

Table D-17. Tank 241-AW-102 Analytical Data: DSC-Exotherm

Sample I.D.	Data Result (J/g)	Precision RPD	Accuracy % Rec.	Weighted Mean (J/g)
2AW-99-2C	0	na	na	0
2AW-99-3C	0	na	na	
2AW-99-4C	0	na	na	

Table D-18. Tank 241-AW-102 Analytical Data: Percent Water

Sample I.D.	Data Result (% H ₂ O)	Precision RPD	Accuracy % Rec.	Weighted Mean (% H ₂ O)
2AW-99-2C	9.09E+01	0.22%	na	9.10E+01
2AW-99-3C	9.11E+01	0.01%	na	
2AW-99-4C	9.10E+01	0.47%	na	

Table D-19. Tank 241-AW-102 Analytical Data: Total Alpha

Sample I.D.	Data Result (uCi/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (uCi/ml)
2AW-99-2C	<6.76E-04	na	na	< 9.71E-04
2AW-99-3C	1.05E-03	1.85%	na	
2AW-99-4C	1.07E-03	3.45%	88.4%	

Table D-20. Tank 241-AW-102 Analytical Data: Total Beta

Sample I.D.	Data Result (uCi/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (uCi/ml)
2AW-99-2C	3.18E+01	1.57%	na	3.29E+01
2AW-99-3C	3.35E+01	1.49%	na	
2AW-99-4C	3.29E+01	2.16%	107.6%	

Table D-21. Tank 241-AW-102 Analytical Data: Tritium

Sample I.D	Data Result (uCi/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (uCi/ml)
2AW-99-2C	6.65E-03	na	na	6.19E-03
2AW-99-3C	6.35E-03	6.19%	109.6%	
2AW-99-4C	5.70E-03	na	na	

Table D-22. Tank 241-AW-102 Analytical Data: Carbon-14

Sample I.D	Data Result (uCi/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (uCi/ml)
2AW-99-2C	1.17E-04	12.8%	84.7%	1.16E-04
2AW-99-3C	1.16E-04	na	na	
2AW-99-4C	1.16E-04	7.79%	na	

Table D-23. Tank 241-AW-102 Analytical Data: Cobalt-60

Sample I.D	Data Result (uCi/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (uCi/ml)
2AW-99-2C	< 1.02E-03	na	na	< 1.05E-03
2AW-99-3C	< 1.05E-03	na	na	
2AW-99-4C	< 1.06E-03	na	na	

Table D-24. Tank 241-AW-102 Analytical Data: Selenium-79

Sample I.D	Data Result (uCi/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (uCi/ml)
2AW-99-2C	2.08E-05	0.96%	na	2.23E-05
2AW-99-3C	2.17E-05	na	na	
2AW-99-4C	2.41E-04	na	na	

Table D-25. Tank 241-AW-102 Analytical Data: Strontium-90

Sample I.D.	Data Result (uCi/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (uCi/ml)
2AW-99-2C	1.50E-02	1.33%	na	2.34E-02
2AW-99-3C	2.70E-02	4.44%	na	
2AW-99-4C	2.45E-02	13.9%	na	

Table D-26. Tank 241-AW-102 Analytical Data: Niobium-94

Sample I.D.	Data Result (uCi/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (uCi/ml)
2AW-99-2C	< 1.06E-03	na	na	< 1.05E-03
2AW-99-3C	< 1.40E-03	na	na	
2AW-99-4C	< 1.06E-03	na	na	

Table D-27. Tank 241-AW-102 Analytical Data: Technetium-99

Sample I.D.	Data Result (uCi/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (uCi/ml)
2AW-99-2C	9.21E-03	5.04	101%	8.74E-03
2AW-99-3C	8.57E-03	na	na	
2AW-99-4C	8.63E-03	na	na	

Table D-28. Tank 241-AW-102 Analytical Data: Ruthenium-106

Sample I.D.	Data Result (uCi/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (uCi/ml)
2AW-99-2C	< 1.15E-01	na	na	< 1.16E-01
2AW-99-3C	< 1.18E-01	na	na	
2AW-99-4C	< 1.15E-01	na	na	

Table D-29. Tank 241-AW-102 Analytical Data: Iodine-129

Sample I.D	Data Result (uCi/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (uCi/ml)
2AW-99-2C	2.06E-05	na	na	2.12E-05
2AW-99-3C	2.16E-05	na	na	
2AW-99-4C	2.11E-05	2.36%	na	

Table D-30. Tank 241-AW-102 Analytical Data: Cesium-134

Sample I.D	Data Result (uCi/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (uCi/ml)
2AW-99-2C	1.01E-02	na	na	1.08E-02
2AW-99-3C	1.14E-02	na	na	
2AW-99-4C	1.05E-02	6.7%	na	

Table D-31. Tank 241-AW-102 Analytical Data: Cesium-137

Sample I.D	Data Result (uCi/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (uCi/ml)
2AW-99-2C	1.10E+02	na	na	1.12E+02
2AW-99-3C	1.14E+02	na	na	
2AW-99-4C	1.12E+02	7.16%	na	

Table D-32. Tank 241-AW-102 Analytical Data: Cerium-144

Sample I.D	Data Result (uCi/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (uCi/ml)
2AW-99-2C	< 7.15E-02	na	na	< 7.15E-02
2AW-99-3C	< 7.17E-02	na	na	
2AW-99-4C	< 7.14E-02	na	na	

Table D-33. Tank 241-AW-102 Analytical Data: Europium-154

Sample I.D.	Data Result (uCi/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (uCi/ml)
2AW-99-2C	< 2.65E-03	na	na	< 2.70E-03
2AW-99-3C	< 2.73E-03	na	na	
2AW-99-4C	< 2.71E-03	na	na	

Table D-34. Tank 241-AW-102 Analytical Data: Europium-155

Sample I.D.	Data Result (uCi/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (uCi/ml)
2AW-99-2C	< 1.10E-02	na	na	< 1.10E-02
2AW-99-3C	< 1.11E-02	na	na	
2AW-99-4C	< 1.09E-02	na	na	

Table D-35. Tank 241-AW-102 Analytical Data: Radium-226

Sample I.D.	Data Result (uCi/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (uCi/ml)
2AW-99-2C	< 1.69E-01	na	na	< 1.70E-01
2AW-99-3C	< 1.71E-01	na	na	
2AW-99-4C	< 1.69E-01	na	na	

Table D-36. Tank 241-AW-102 Analytical Data: Neptunium-237

Sample I.D.	Data Result (uCi/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (uCi/ml)
2AW-99-2C	< 2.24E-05	na	na	< 2.24E-05
2AW-99-3C	< 2.24E-05	na	na	
2AW-99-4C	< 2.24E-05	5.55%	68.3% ¹	

¹The accuracy for Np-237 was slightly below the 70% - 130% Evaporator QA requirement. The Np-237 was used in comparison of projected process condensate concentration to its LERF radiological limit. Since no Np-237 was found in any of the samples and detection limit for Np-237 was well below its LERF radiological limit, further analyses for Np-237 was not required.

Table D-37. Tank 241-AW-102 Analytical Data: Plutonium-238

Sample I.D	Data Result (uCi/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (uCi/ml)
2AW-99-2C	5.37E-05	0.56%	na	4.41E-05
2AW-99-3C	4.33E-05	4.86%	na	
2AW-99-4C	3.88E-05	na	na	

Table D-38. Tank 241-AW-102 Analytical Data: Plutonium-239

Sample I.D	Data Result (uCi/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (uCi/ml)
2AW-99-2C	1.86E-04	1.08%	na	1.44E-04
2AW-99-3C	1.41E-04	6.36%	na	
2AW-99-4C	1.20E-04	na	na	

Table D-39. Tank 241-AW-102 Analytical Data: Americium-241

Sample I.D	Data Result (uCi/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (uCi/ml)
2AW-99-2C	7.07E-05	4.91%	na	1.83E-05
2AW-99-3C	1.75E-05	21.7%	na	
2AW-99-4C	4.73E-06	na	na	

Table D-40. Tank 241-AW-102 Analytical Data: Curium-244

Sample I.D	Data Result (uCi/ml)	Precision RPD	Accuracy % Rec.	Weighted Mean (uCi/ml)
2AW-99-2C	< 5.86E-06	na	na	< 5.06E-06
2AW-99-3C	< 5.25E-06	na	na	
2AW-99-4C	< 4.32E-06	na	na	

Table D-41. Tank 241-AW-102 Analytical Data: Acetone

Sample I.D	Data Result (ug/l)	Precision RPD	Accuracy % Rec.	90% C.I. ¹ (ug/l)
2AW-99-2A	1.00E+03	4.8%	96%	1.11E+03
2AW-99-3A	1.10E+03	na	na	
2AW-99-4A	1.00E+03	na	na	

¹90% Confidence Interval value is calculated using the formula: 90% C.I = Mean + 2.901 * Standard Deviation / Sqrt (3)

Table D-42. Tank 241-AW-102 Analytical Data: 1-Butanol

Sample I.D	Data Result (ug/l)	Precision RPD	Accuracy % Rec.	90% C.I. ¹ (ug/l)
2AW-99-2A	3.50E+03	5.0%	100%	3.76E+03
2AW-99-3A	3.60E+03	na	na	
2AW-99-4A	3.10E+03	na	na	

¹90% Confidence Interval value is calculated using the formula: 90% C.I = Mean + 2.901 * Standard Deviation / Sqrt (3)

Table D-43. Tank 241-AW-102 Analytical Data: 2-Butoxyethanol

Sample I.D	Data Result (ug/l)	Precision RPD	Accuracy % Rec.	Concentration (ug/l)
2AW-99-2B	< 2.00E+04	na	na	< 2.00E+04
2AW-99-3B	< 8.00E+04	na	na	
2AW-99-4B	< 4.00E+04	15%	75%	

Table D-44. Tank 241-AW-102 Analytical Data: 2-Butanone

Sample I.D	Data Result (ug/l)	Precision RPD	Accuracy % Rec.	Concentration (ug/l)
2AW-99-2A	< 1.00E+03	4.7%	94%	< 1.00E+03
2AW-99-3A	< 1.00E+03	na	na	
2AW-99-4A	< 1.00E+03	na	na	

Table D-45. Tank 241-AW-102 Analytical Data: Tributylphosphate

Sample I.D	Data Result (ug/l)	Precision RPD	Accuracy % Rec.	Concentration (ug/l)
2AW-99-2B	< 2.00E+04	4%	91.6%	< 2.00E+04
2AW-99-3B	< 8.00E+04	na	na	
2AW-99-4B	< 4.00E+04	na	na	

Table D-46. Tank 241-AW-102 Analytical Data: 2-Hexanone

Sample I.D	Data Result (ug/l)	Precision RPD	Accuracy % Rec.	Concentration (ug/l)
2AW-99-2A	< 1.00E+03	5.3%	106%	< 1.00E+03
2AW-99-3A	< 1.00E+03	na	na	
2AW-99-4A	< 1.00E+03	na	na	

Table D-47. Tank 241-AW-102 Analytical Data: 2-Pentanone

Sample I.D	Data Result (ug/l)	Precision RPD	Accuracy % Rec.	Concentration (ug/l)
2AW-99-2A	< 1.00E+03	5.0%	100%	< 1.00E+03
2AW-99-3A	< 1.00E+03	na	na	
2AW-99-4A	< 1.00E+03	na	na	

Table D-48. Tank 241-AW-102 Analytical Data: MIBK

Sample I.D	Data Result (ug/l)	Precision RPD	Accuracy % Rec.	Concentration (ug/l)
2AW-99-2A	< 1.00E+03	5.6%	112%	< 1.00E+03
2AW-99-3A	< 1.00E+03	na	na	
2AW-99-4A	< 1.00E+03	na	na	

Table D-49. Tank 241-AW-102 Analytical Data: Tetrahydrofuran

Sample I.D.	Data Result (ug/l)	Precision RPD	Accuracy % Rec.	Concentration (ug/l)
2AW-99-2A	< 1.00E+02	5%	100%	< 1.00E+03
2AW-99-3A	< 1.00E+02	na	na	
2AW-99-4A	< 1.00E+02	na	na	

Table D-50. Tank 241-AW-102 Analytical Data: Poly-Chlorinated Biphenyl

Sample I.D.	Data Result (ug/l)	Precision RPD	Accuracy % Rec.	Concentration (ug/l)
2AW-99-2B	< 1.00E+01	30.4% ¹	41.5%	< 1.00E+03
2AW-99-3B	< 1.50E+01	na	na	
2AW-99-4B	< 1.00E+01	na	na	

¹The precision for PCBs was slightly above the 25% Evaporator QA requirement. Poor precision was due to matrix interferences and poor extractor performance. The Laboratory Control Standard (LCS) results for PCBs were within the laboratory 70% -130% limits. The Continuing Calibration Verification (CCV) standard results for PCBs were also within the laboratory 85-115% limits. Because no PCBs were detected in any of the samples and the LCS and CCV standard recoveries were with the established QC limits, PCB re-runs were not necessary on a technical basis.

APPENDIX E

CAMPAIGN 99-1 CAMPAIGN FEED AND SLURRY PRODUCT DATA

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Table E-1. Campaign 99-1 Inorganic Feed and Slurry Product

Constituent	FEED ¹	SLURRY PRODUCT ² TO 102-AW	SLURRY PRODUCT ³ TO 106-AW
OH (M)	4.39E-01	6.94E-01	2.44E+00
Al (M)	5.04E-02	7.97E-02	2.80E-01
NO ₃ (M)	2.84E-01	4.49E-01	1.58E+00
NO ₂ (M)	1.51E-01	2.39E-01	8.39E-01
CO ₃ (M)	1.58E-01	2.50E-01	8.78E-01
PO ₄ (M)	8.27E-03	1.31E-02	4.59E-02
SO ₄ (M)	1.27E-02	2.01E-02	7.06E-02
F (M)	7.95E-02	1.26E-01	4.42E-01
Na (M)	1.23E+00	1.94E+00	6.83E+00
TOC (g/L)	5.82E-01	9.20E-01	3.23E+00
TC (g/L)	2.33E+00	3.68E+00	1.29E+01
U (g/L)	1.31E-02	2.07E-02	7.28E-02
SpG	1.06	1.09	1.33 ⁴

¹The feed composite concentrations are from Appendix D.

²Tank 102-AW projected final mixture (liquid) concentration based upon the assumption that the remaining heel will consist of a 27,500 gallons water flush, 19,250 gallons of Campaign 99-1 feed, and 13,750 gallons of Campaign 99-1 slurry.

³Using assumption that all constituents concentrate at the same ratio, slurry values were conservatively calculated at maximum WVRF of 82% by using the formula, $\text{slurry} = \text{feed} / (1 - \text{WVRF})$.

⁴Slurry product SpG is calculated at maximum WVRF of 82% by using the formula, $\text{slurry SpG} = 1 + (\text{feed SpG} - 1) / (1 - \text{WVRF})$

Table E-2. Campaign 99-1 Radionuclide Campaign Feed and Slurry Product

Radionuclide	Feed ¹ (uCi/mL)	SLURRY PRODUCT ² TO 102-AW (uCi/ml)	SLURRY PRODUCT ³ TO 106-AW (uCi/ml)
Total Alpha	9.71E-04	1.53E-03	5.39E-03
Total Beta	3.29E+01	5.20E+01	1.83E+02
³ H	6.19E-03	9.79E-03	3.44E-02
¹⁴ C	1.16E-04	1.83E-04	6.44E-04
⁶⁰ Co	< 1.05E-03	< 1.66E-03	< 5.83E-03
⁷⁹ Se	2.23E-05	3.53E-05	1.24E-04
⁹⁰ Sr	2.34E-02	3.70E-02	1.30E-01
⁹⁰ Yr ⁴	2.34E-02	3.70E-02	1.30E-01
⁹⁴ Nb	< 1.06E-03	< 1.68E-03	< 5.89E-03
⁹⁹ Tc	8.74E-03	1.38E-02	4.86E-02
¹⁰⁶ Ru	< 1.16E-01	< 1.83E-01	< 6.44E-01
¹²⁹ I	2.12E-05	3.35E-05	1.18E-04
¹³⁴ Cs	1.08E-02	1.71E-02	6.00E-02
¹³⁷ Cs	3.31E+01	5.23E+01	1.84E+02
¹⁴⁴ Ce	< 7.33E-02	< 1.16E-01	< 4.07E-01
¹⁵⁴ Eu	< 2.70E-03	< 4.27E-03	< 1.50E-02
¹⁵⁵ Eu	< 1.10E-02	< 1.74E-02	< 6.11E-02
²²⁶ Ra ⁵	2.34E-06	3.70E-06	1.30E-05
²³⁷ Np	< 2.24E-05	< 3.54E-05	< 1.24E-04
²³⁸ Pu	4.41E-05	6.97E-05	2.45E-04
²³⁹ Pu	1.44E-04	2.28E-04	8.00E-04
²⁴¹ Pu ⁶	5.90E-03	9.33E-03	3.28E-02
²⁴¹ Am	1.83E-05	2.89E-05	1.02E-04
²⁴⁴ Cm	< 5.06E-06	< 8.00E-06	< 2.81E-05

¹The feed composite concentrations are from Appendix D.

²Tank 102-AW projected final mixture (liquid) concentration based upon the assumption that the remaining heel will consist of a 27,500 gallons water flush, 19,250 gallons of Campaign 99-1 feed, and 13,750 gallons of Campaign 99-1 slurry.

³Using assumption that all constituents concentrate at the same ratio, slurry values were conservatively calculated at maximum WVR of 82% by using the formula, slurry = feed / (1-WVR).

⁴Due to the difficulties associated with its analysis, ⁹⁰Y was conservatively assumed to have the same concentration as ⁹⁰Sr.

⁵Due to its relatively high detection limit, the ²²⁶Ra concentration is calculated using the formula, ⁹⁰Sr x 1.0E-04, taken from WHC-SD-WM-OCD-016 (Campbell 1997).

⁶Due to the difficulties associated with its analysis, ²⁴¹Pu concentration was calculated using the formula, ²³⁹Pu x 41, taken from WHC-SD-WM-OCD-016 (Campbell 1997).

APPENDIX F

COMPARISON OF CAMPAIGN 99-1 TO 242-A EVAPORATOR LIMITS

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Table F-1. Comparison of Miscellaneous Evaporator Limits to Campaign 99-1 Feed

CONSTITUENT	FEED DATA RESULTS ¹	FEED LIMIT ²	COMMENT
Differential Scanning Calorimetry	No exotherm below 168 °C	No exotherm at a temperature below 168 °C	IN COMPLIANCE
Exother/Endotherm	0	< 1	IN COMPLIANCE
Shielding Design	0.033 Ci/L Cs-137	< 0.144 Ci/L Cs-137	IN COMPLIANCE
Maximum Heat Load Concentration	33.1 uCi/ml Cs-137	< 103.3 uCi/ml Cs-137	IN COMPLIANCE
	0.023 uCi/ml Sr-90	< 72.7 uCi/ml Sr-90	
Fissile Material ³ Concentration	2.32E-06 g/L fissile 13.07 pH	< 0.005 g/L fissile > 8 pH	IN COMPLIANCE

¹Data is obtained from Appendix D

²From 242-A Evaporator - Liquid Effluent Retention Data quality Objectives (Von Barga 1998). Feed Limit is calculated based on maximum campaign WVERF of 82% by using formula: Feed Limit = Limit * (1 - WVERF)

³Data is obtained from Appendix G.

Table F-2. Comparison of Campaign Feed to Evaporator Feed Limits for LERF Liner Acceptance

CHEMICAL FAMILY/PARAMETER	CURRENT TARGET COMPOUNDS	LIMIT ¹ (mg/L)	FEED ² (mg/L)	FEED/LIMIT RATIO	COMMENT
Alcohol/Glycol	1-butanol	4.10E+05	3.76E+00	9.17E-06	In Compliance
Alkanone	Sum of acetone and 2-butanone	1.64E+05	< 2.11E+00	< 1.29E-05	In Compliance
Alkenone	none targeted	1.64E+03	NA	NA	In Compliance
Aromatic/Cyclic Hydrocarbon	none targeted	1.64E+03	NA	NA	In Compliance
Halogenated Hydrocarbon	none targeted	1.64E+03	NA	NA	In Compliance
Aliphatic Hydrocarbon	none targeted	4.10E+05	NA	NA	In Compliance
Ether	2-Butoxyethanol	1.64E+03	< 2.00E+01	< 1.22E-02	In Compliance
Other Hydrocarbons	Tributylphosphate	1.64E+03	< 2.00E+01	< 1.22E-02	In Compliance
Oxidizers	none targeted	8.20E+02	NA	NA	In Compliance
Acids, Bases, Salts	Ammonia	8.20E+04	7.43E+01	9.06E-04	In Compliance
TC, TIC	TC-TIC	1.02E+03	4.40E+02	4.33E-01	In Compliance
Unity Rule	Sum of Concentration to Limit ratios ³	1.00E+00	NA	< 2.44E-02	In Compliance

¹From 242-A Evaporator - Liquid Effluent Retention Data Quality Objectives (Von Bargaen 1998). The ratio of feed flow rate to slurry flow rate is assumed to be equal 5.56 (82% WVR).

²The upper 90% confidence values from Appendix D.

³TC-TIC and ammonia are not part of this summation

Table F-3. Comparison of Campaign Feed to Evaporator Feed Limits
Based on Volatile Emissions

Constituent	Limit ¹ (mg/L)	FEED ² (mg/L)	Ratio (FEED/Limit)	COMMENT
Acetone	1.43E+02	1.11E+00	7.76E-03	In Compliance
1-Butanol	3.71E+02	3.76E+00	1.01E-02	In Compliance
2-Butoxyethanol	1.56E+02	< 2.00E+01	< 1.28E-01	In Compliance
2-Butanone	9.51E+01	< 1.00E+00	< 1.05E-02	In Compliance
Tributyl Phosphate	1.66E+04	< 2.00E+01	< 1.21E-03	In Compliance
TC-TIC	1.43E+02	4.40E+02	3.08E+00	In Compliance ³
Sum of Concentration to Limit Ratios ⁴	1.00E+00	NA	< 1.58E-01	In Compliance

¹From 242-A Evaporator - Liquid Effluent Retention Data Quality Objectives (Von Bargaen 1998). The ratio of feed flow rate to slurry flow rate is assumed to be equal 5.56 (82% WVR).

²The upper 90% confidence values from Appendix D.

³The "TC-TIC" value exceeds the DQO limit of 143 ppm. However, the technical evaluation was performed to show in compliance with the DQO limit (Bowman 1999)

⁴TC-TIC is not part of this summation.

Table F-4. Comparison of Campaign Feed Radionuclide Concentrations to Evaporator Bounding Radiological Source Strength Screening Limit

RADIONUCLIDE	FEED ¹ ($\mu\text{Ci/mL}$)	LIMIT ² ($\mu\text{Ci/mL}$)	FEED/LIMIT Ratio	COMMENT
¹⁴ C	1.16E-04	2.6E-01	4.46E-04	IN COMPLIANCE
⁶⁰ Co	< 1.05E-03	1.2E+00	< 8.75E-04	IN COMPLIANCE
⁷⁶ Se	2.23E-05	7.8E-02	2.86E-04	IN COMPLIANCE
⁹⁰ Sr	2.34E-02	2.2E+02	1.06E-04	IN COMPLIANCE
⁹⁰ Y	2.34E-02	2.2E+02	1.06E-04	IN COMPLIANCE
⁹⁴ Nb	< 1.06E-03	9.8E-02	< 1.08E-02	IN COMPLIANCE
⁹⁹ Tc	8.74E-03	2.0E+00	4.37E-03	IN COMPLIANCE
¹⁰⁶ Ru	< 1.16E-01	5.3E+01	< 2.19E-03	IN COMPLIANCE
¹²⁹ I	2.12E-05	2.6E-03	8.15E-03	IN COMPLIANCE
¹³⁴ Cs	1.08E-02	1.5E+01	7.20E-04	IN COMPLIANCE
¹³⁷ Cs	3.31E+01	8.00+02	4.14E-02	IN COMPLIANCE
¹⁵⁴ Eu	< 2.70E-03	5.0E+00	< 5.40E-04	IN COMPLIANCE
¹⁵⁵ Eu	< 1.10E-02	7.0E+00	< 1.57E-03	IN COMPLIANCE
²²⁶ Ra	2.34E-06	3.3E-02	7.09E-05	IN COMPLIANCE
²³⁸ Pu	4.41E-05	1.3E-03	3.39E-02	IN COMPLIANCE
^{239/240} Pu	1.44E-04	1.6E-01	9.00E-04	IN COMPLIANCE
²⁴¹ Pu	5.90E-03	1.5E+01	3.93E-04	IN COMPLIANCE
²⁴¹ Am	1.83E-05	1.0E+00	1.83E-05	IN COMPLIANCE
²⁴⁴ Cm	< 5.06E-06	1.3E-02	3.89E-04	IN COMPLIANCE

¹Feed data from Appendix E, Table E-2.²From 242-A Evaporator Safety Analysis (Campbell 1999)

Table F-5. Comparison of Campaign Feed Radionuclide Concentrations to 242-A Evaporator Radionuclide Dose Consequence Limit

RADIONUCLIDE	FEED ¹ ($\mu\text{Ci/mL}$)	FEED (Bq/L)	DOSE CONVERSION (Sv/Bq)	FEED (Sv/L)
¹² C	1.16E-04	4.29E+03	5.6E-10	2.40E-06
⁶⁰ Co	< 1.05E-03	< 3.89E+04	5.9E-08	< 2.29E-03
⁷⁶ Se	2.23E-05	8.25E+02	2.7E-09	2.23E-06
⁸⁶ Sr	2.34E-02	8.66E+05	6.5E-08	5.63E-02
⁸⁹ Y	2.34E-02	8.66E+05	2.3E-09	1.99E-03
⁹³ Nb	< 1.06E-03	< 3.92E+04	1.1E-07	< 4.31E-03
⁹⁹ Tc	8.74E-03	5.11E+05	2.3E-09	7.44E-04
¹⁰⁶ Ru	< 1.16E-01	< 4.29E+06	1.3E-07	< 5.58E-01
¹²⁹ I	2.12E-05	7.84E+02	4.7E-08	3.69E-05
¹³⁴ Cs	1.08E-02	4.00E+05	1.3E-08	5.19E-03
¹³⁷ Cs	3.31E+01	1.22E+09	8.6E-09	1.05E+01
¹⁵⁴ Eu	< 2.70E-03	< 9.99E+04	7.7E-08	< 7.69E-03
¹⁵⁵ Eu	< 1.10E-02	< 4.07E+05	1.1E-08	< 4.48E-03
²²⁶ Ra	2.34E-06	8.66E+01	2.3E-06	1.99E-04
²³⁸ Pu	4.41E-05	1.63E+03	1.1E-04	1.79E-01
^{239/240} Pu	1.44E-04	5.33E+03	1.2E-04	6.39E-01
²⁴¹ Pu	5.90E-03	2.18E+05	2.2E-06	4.80E-01
²⁴¹ Am	1.83E-05	6.77E+02	1.2E-04	8.13E-02
²⁴⁴ Cm	< 5.06E-06	< 1.87E+02	6.7E-05	1.25E-02
TOTAL (LIMIT OF 7.7E+03 Sv/L ²)				< 1.26E+01

¹Feed data from Appendix E, Table E-2.²From 242-A Evaporator Safety Analysis Report (Campbell 1999)

Table F-6. Comparison of Slurry Radionuclide Concentrations to Evaporator Bounding Radiological Source Strength Screening Limit

RADIONUCLIDE	SLURRY ¹ ($\mu\text{Ci/mL}$)	LIMIT ² ($\mu\text{Ci/mL}$)	SLURRY/LIMIT Ratio	COMMENT
¹⁴ C	6.44E-04	2.6E-01	2.48E-03	IN COMPLIANCE
⁶⁰ Co	< 5.83E-03	1.2E+00	< 4.86E-03	IN COMPLIANCE
⁷⁶ Se	1.24E-04	7.8E-02	1.59E-03	IN COMPLIANCE
⁹⁰ Sr	1.30E-01	2.2E+02	5.91E-04	IN COMPLIANCE
⁹⁰ Y	1.30E-01	2.2E+02	5.91E-04	IN COMPLIANCE
⁹³ Nb	< 5.89E-03	9.8E-02	< 6.01E-02	IN COMPLIANCE
⁹⁹ Tc	4.86E-02	2.0E+00	2.43E-02	IN COMPLIANCE
¹⁰⁶ Ru	< 6.44E-01	5.3E+01	< 1.22E-02	IN COMPLIANCE
¹²⁹ I	1.18E-04	2.6E-03	4.53E-02	IN COMPLIANCE
¹³⁴ Cs	6.00E-02	1.5E+01	4.00E-03	IN COMPLIANCE
¹³⁷ Cs	1.84E+02	8.00+02	2.30E-01	IN COMPLIANCE
¹⁵⁴ Eu	< 1.50E-02	5.0E+00	< 3.00E-03	IN COMPLIANCE
¹⁵⁵ Eu	< 6.11E-02	7.0E+00	< 8.73E-03	IN COMPLIANCE
²²⁶ Ra	1.30E-05	3.3E-02	3.94E-04	IN COMPLIANCE
²³⁹ Pu	2.45E-04	1.3E-03	1.88E-01	IN COMPLIANCE
^{238/240} Pu	8.00E-04	1.6E-01	5.00E-03	IN COMPLIANCE
²⁴¹ Pu	3.28E-02	1.5E+01	2.19E-03	IN COMPLIANCE
²⁴¹ Am	1.02E-04	1.0E+00	1.02E-04	IN COMPLIANCE
²⁴⁴ Cm	< 2.81E-05	1.3E-02	2.16E-03	IN COMPLIANCE

¹Slurry data from Appendix E, Table E-2.²From 242-A Evaporator Safety Analysis Report (Campbell 1999)

Table F-7. Comparison of Slurry Radionuclide Concentrations
to 242-A Evaporator Radionuclide Dose Consequence Limit

RADIONUCLIDE	SLURRY ¹ ($\mu\text{Ci/mL}$)	SLURRY (Bq/L)	DOSE CONVERSION (Sv/Bq)	SLURRY (Sv/L)
¹⁴ C	6.44E-04	2.15E+04	5.6E-10	1.34E-05
⁶⁰ Co	< 5.83E-03	< 1.94E+05	5.9E-08	< 1.27E-02
⁷⁶ Se	1.24E-04	4.13E+03	2.7E-09	1.24E-05
⁹⁰ Sr	1.30E-01	4.33E+06	6.5E-08	3.13E-01
⁹⁰ Y	1.30E-01	4.33E+06	2.3E-09	1.11E-02
⁹³ Nb	< 5.89E-03	< 1.96E+05	1.1E-07	< 2.40E-02
⁹⁹ Tc	4.86E-02	2.55E+06	2.3E-09	4.13E-03
¹⁰⁶ Ru	< 6.44E-01	< 2.15E+07	1.3E-07	< 3.10E+00
¹²⁹ I	1.18E-04	3.92E+03	4.7E-08	2.05E-04
¹³⁴ Cs	6.00E-02	2.00E+06	1.3E-08	2.89E-02
¹³⁷ Cs	1.84E+02	6.12E+09	8.6E-09	5.85E+01
¹⁵⁴ Eu	< 1.50E-02	< 5.00E+05	7.7E-08	< 4.27E-02
¹⁵⁵ Eu	< 6.11E-02	< 2.04E+06	1.1E-08	< 2.49E-02
²²⁶ Ra	1.30E-05	4.33E+02	2.3E-06	1.11E-03
²³⁹ Pu	2.45E-04	8.16E+03	1.1E-04	9.97E-01
^{239/240} Pu	8.00E-04	2.66E+04	1.2E-04	3.55E+00
²⁴¹ Pu	3.28E-02	1.09E+06	2.2E-06	2.67E+00
²⁴¹ Am	1.02E-04	3.39E+03	1.2E-04	4.51E-01
²⁴⁴ Cm	< 2.81E-05	< 9.36E+02	6.7E-05	< 6.97E-02
TOTAL (LIMIT OF 7.7E+03 Sv/L ²)				< 6.98E+01

¹Slurry data from Appendix E, Table E-2.

²From 242-A Evaporator Safety Analysis Report (Campbell 1999)

Table F-8. Comparison of Projected Process Condensate (PC) Concentrations to LERF Radiological Limits

RADIONUCLIDE	PC ¹ (Ci/L)	LIMIT ² (Ci/L)	PC/LIMIT Ratio	COMMENT
³ H	6.83E-06	2.4E-04	2.85E-02	IN COMPLIANCE
¹⁴ C	1.00E-09	1.6E-06	6.25E-04	IN COMPLIANCE
⁶⁰ Co	< 9.30E-09	2.4E-06	< 3.88E-03	IN COMPLIANCE
⁷⁶ Se	2.00E-10	1.5E-07	1.33E-03	IN COMPLIANCE
⁹⁰ Sr	9.10E-10	4.2E-05	2.17E-05	IN COMPLIANCE
⁹⁵ Nb	< 9.40E-09	2.6E-07	< 3.62E-02	IN COMPLIANCE
⁹⁹ Tc	1.20E-07	1.8E-05	6.67E-03	IN COMPLIANCE
¹⁰⁶ Ru	< 1.30E-09	6.5E-07	< 2.00E-03	IN COMPLIANCE
¹²⁹ I	1.80E-08	1.8E-06	1.00E-02	IN COMPLIANCE
¹³⁴ Cs	2.70E-08	4.1E-07	6.59E-02	IN COMPLIANCE
¹³⁷ Cs	3.20E-09	9.9E-06	3.23E-04	IN COMPLIANCE
¹⁴⁴ Ce	< 6.50E-07	8.3E-07	< 7.83E-01	IN COMPLIANCE
¹⁵⁴ Eu	< 2.40E-08	9.8E-06	< 2.45E-03	IN COMPLIANCE
¹⁵⁶ Eu	< 9.70E-08	6.3E-05	< 1.54E-03	IN COMPLIANCE
²²⁶ Ra	2.10E-11	6.4E-08	3.28E-04	IN COMPLIANCE
²³⁴ U ³	6.92E-14	2.1E-10	3.30E-04	IN COMPLIANCE
²³⁷ Np	< 2.00E-10	2.1E-09	< 9.52E-02	IN COMPLIANCE
²³⁸ Pu	1.10E-13	2.8E-09	3.93E-05	IN COMPLIANCE
^{239/240} Pu	3.50E-13	1.7E-08	2.06E-05	IN COMPLIANCE
²⁴¹ Pu	1.40E-11	2.9E-05	4.83E-07	IN COMPLIANCE
²⁴¹ Am	1.20E-13	1.4E-09	8.57E-05	IN COMPLIANCE
²⁴⁴ Cm	< 4.50E-11	2.5E-08	1.80E-03	IN COMPLIANCE

¹The process condensate values were obtained at 82% WVR by entering the campaign feed from Table E-2 into the 242-A Evaporator Process Flowsheet.

²From 242AL Liquid Effluent Retention Facility Auditable Safety Analysis, HNF-SD-LEF-ASA-002 (Le 1998)

³The process condensate uranium-234 was obtained from uranium concentration by using its isotope activity.

Table F-9. Comparison of Projected Process Condensate Concentrations to LERF Final Hazard Category For A Pressurized Spray Release Limit

RADIONUCLIDE	PC ¹ (Ci/L)	Conversion Factor ² (REM per Ci/L)	Spray Release (REM)
³ H	6.83E-06	5.65E-01	3.86E-06
¹⁴ C	1.00E-09	1.31E+01	1.31E-08
⁶⁰ Co	< 9.30E-09	1.59E+03	< 1.48E-05
⁷⁶ Se	2.00E-10	6.15E+01	1.23E-08
⁹⁰ Sr	9.10E-10	1.29E+03	1.17E-06
⁹⁴ Nb	< 9.40E-09	2.68E+03	< 2.52E-05
⁹⁹ Tc	1.20E-07	5.50E+01	6.60E-06
¹⁰⁶ Ru	< 1.30E-09	2.94E+03	< 3.82E-06
¹²⁹ I	1.80E-08	9.63E+02	1.73E-05
¹³⁴ Cs	2.70E-08	5.05E+02	1.36E-05
¹³⁷ Cs	3.20E-09	2.74E+02	8.77E-07
¹⁴⁴ Ce	< 6.50E-07	2.33E+03	< 1.51E-03
¹⁵⁴ Eu	< 2.40E-08	1.95E+03	< 4.68E-05
¹⁵⁵ Eu	< 9.70E-08	2.64E+02	< 2.56E-05
²²⁴ Ra	2.10E-11	5.27E+04	1.11E-06
²³⁵ U ³	6.92E-14	8.36E+05	5.79E-08
²³⁷ Np	< 2.00E-10	4.07E+06	< 8.14E-04
²³⁹ Pu	1.10E-13	1.79E+06	1.97E-07
^{239/240} Pu	3.50E-13	1.95E+06	6.83E-07
²⁴¹ Pu	1.40E-11	3.09E+04	4.33E-07
²⁴¹ Am	1.20E-13	2.73E+06	3.28E-07
²⁴⁴ Cm	< 4.50E-11	1.53E+06	6.89E-05
TOTAL (LIMIT OF 2.0E-1 REM)			< 2.56E-03 IN COMPLIANCE

¹The process condensate values were obtained at 82% WVR by entering the campaign feed from Table E-2 into the 242-A Evaporator Process Flowsheet.

²Spray release conversion factors are obtained using the formula: conversion = maximum spray release / maximum bounding concentration from Liquid Effluent Retention Facility Final Hazard Category Determination (Galioto 1997)

³The process condensate uranium-234 was obtained from uranium concentration by using its isotope activity.

Table F-10. Comparison of Projected Process Condensate Concentrations to LERF Final Hazard Category For 12 hours Pool Evaporation Release Limit

RADIONUCLIDE	PC ¹ (Ci/L)	Conversion Factor ² (REM per Ci/L)	12 Hrs Pool Release (REM)
³ H	6.83E-06	2.51E+00	1.71E-05
¹⁴ C	1.00E-09	5.92E+01	5.92E-07
⁶⁰ Co	< 9.30E-09	7.08E+03	< 6.58E-05
⁷⁶ Se	2.00E-10	2.77E+02	5.54E-08
⁹⁰ Sr	9.10E-10	5.73E+03	5.21E-06
⁹⁴ Nb	< 9.40E-09	1.24E+04	< 1.17E-04
⁹⁹ Tc	1.20E-07	2.41E+02	2.89E-05
¹⁰⁶ Ru	< 1.30E-09	1.32E+04	< 1.72E-05
¹²⁹ I	1.80E-08	4.21E+04	7.58E-04
¹³⁴ Cs	2.70E-08	2.20E+03	5.94E-05
¹³⁷ Cs	3.20E-09	1.27E+03	4.06E-06
¹⁴⁴ Ce	< 6.50E-07	1.04E+04	< 6.76E-03
¹⁵⁴ Eu	< 2.40E-08	9.01E+03	< 2.16E-04
¹⁵⁶ Eu	< 9.70E-08	1.15E+03	< 1.12E-04
²²⁶ Ra	2.10E-11	2.33E+05	4.89E-06
²³⁴ U ³	6.92E-14	3.80E+06	2.63E-07
²³⁷ Np	< 2.00E-10	1.85E+07	< 3.70E-03
²³⁸ Pu	1.10E-13	8.08E+06	8.89E-07
^{239/240} Pu	3.50E-13	8.48E+06	2.97E-06
²⁴¹ Pu	1.40E-11	1.39E+05	1.95E-06
²⁴¹ Am	1.20E-13	1.18E+07	1.42E-06
²⁴⁴ Cm	< 4.50E-11	6.72E+06	3.02E-04
TOTAL (LIMIT OF 9.4E-1 REM)			< 1.22E-02 IN COMPLIANCE

¹The process condensate values were obtained at 82% WVR by entering the campaign feed from Table E-2 into the 242-A Evaporator Process Flowsheet.

²Spray release conversion factors are obtained using the formula: conversion = maximum 12 hours pool release / maximum bounding concentration from Liquid Effluent Retention Facility Final Hazard Category Determination (Galioto 1997)

³The process condensate uranium-234 was obtained from uranium concentration by using its isotope activity.

Table F-11: Comparison of Projected Slurry Concentrations to Double-Shell Tank Waste Corrosion Specifications¹

PARAMETER	CONDITION 1 $[\text{NO}_3] \leq 1.0 \text{ M}$	CONDITION 2 $1.0 \text{ M} < [\text{NO}_3] \leq 3.0 \text{ M}$	CONDITION 3 $3.0 \text{ M} < [\text{NO}_3] \leq 5.5 \text{ M}$
LIMIT ¹	$0.01\text{M} \leq [\text{OH}] \leq 5.0\text{M}$ $0.011\text{M} \leq [\text{NO}_2] \leq 5.5\text{M}$ $[\text{NO}_3] / \{ [\text{NO}_2] + [\text{OH}] \} < 2.5$	$0.1 \times [\text{NO}_3] \leq [\text{OH}] \leq 10\text{M}$ $[\text{OH}] + [\text{NO}_2] \geq 0.4 \times [\text{NO}_3]$	$0.3 \leq [\text{OH}] < 10\text{M}$ $[\text{OH}] + [\text{NO}_2] \geq 1.2$
PROJECTED SLURRY ² To Tank 102-AW	$[\text{NO}_3] = 0.45 \text{ M};$ $[\text{OH}] = 0.69 \text{ M}$ $[\text{NO}_2] = 0.24 \text{ M}$ $0.01\text{M} \leq [\text{OH}] = 0.69\text{M} \leq 10\text{M}$ $0.011\text{M} \leq [\text{NO}_2] = 0.24\text{M} \leq 5.5\text{M}$ $[\text{NO}_3] / \{ [\text{NO}_2] + [\text{OH}] \} = 0.48 < 2.5$	na	na
PROJECTED SLURRY ² To Tank 106-AW	na	$[\text{NO}_3] = 1.58 \text{ M};$ $[\text{OH}] = 2.44 \text{ M}$ $[\text{NO}_2] = 0.839 \text{ M}$ $0.158 \text{ M} \leq [\text{OH}] = 2.44\text{M} \leq 10\text{M}$ $[\text{OH}] + [\text{NO}_2] = 3.28\text{M} \geq 0.4 \times [\text{NO}_3] = 0.57\text{M}$	na
COMMENT	IN COMPLIANCE	IN COMPLIANCE	na

¹From Operating Specifications for the 241-AN, AP, AW, AY, AZ & SY Tank Farms (Tardiff 1998).

²The slurry values were obtained from Table E-1.

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APPENDIX G

CALCULATIONS

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FINAL WASTE VOLUME REDUCTION FACTOR CALCULATION

Assumptions:

Processable volume = 9.99E+05 gal

Initial WVRF = 80 %

WVRF loss due to final pot flush (10 inches of water addition)

$$WVRF_{loss} = \frac{\text{flush volume}}{\text{process volume}} \times 100\%$$

$$WVRF_{loss} = \frac{10 \text{ inch} \times 2750 \text{ gal/inch}}{9.99 \times 10^5 \text{ gal}} \times 100\%$$

$$WVRF_{loss} = 2.8\%$$

Final WVRF

$$WVRF_{final} = WVRF_{initial} - WVRF_{loss}$$

$$WVRF_{final} = 80\% - 2.8\% = 77.2\%$$

THROUGHPUT CALCULATION

Throughput = total material transferred through Evaporator feed line

$$THROUGHPUT = \sum_{n=1}^p \frac{V}{\left(\frac{1}{1-WVRF_{pass}} \right)^{n-1}} + W \times T$$

where T = processing time = throughput/feed rate (min)

V = amount of waste to be processed (gal)

p = number of evaporator passes

W = process condensate recycle for seal water systems (gpm)

WVRF_{pass} = waste volume reduction factor per evaporator pass

F = feed rate (gal/min)

Assuming one pass of 80% WVRF, the equation above can be simplified as

$$Throughput = V + \frac{V}{(F - W)} \times W$$

Assume: V = 9.99 x 10⁵ gal
 W = 1.6 gpm (seal water)
 F = 80 gpm

$$Throughput = 9.99 \times 10^5 \text{ gal} + \frac{9.99 \times 10^5 \text{ gal}}{(80 \text{ gpm} - 1.6 \text{ gpm})} \times 1.6 \text{ gpm}$$

$$\underline{Throughput} = 1.01 \times 10^6 \text{ gallons}$$

CAMPAIGN DURATION CALCULATION

$$\text{Duration} = \frac{\text{throughput}(\text{gal})}{\text{feedrate}(\text{gpm}) \times \text{operating efficiency} \times 1440 (\text{m/dy})} + 3 \text{ dy}$$

Assume: Throughput = 1.01×10^6 gal

Feed rate = 80 gpm

Operating efficiency¹ = 0.891

$$\text{Duration} = \frac{1.01 \times 10^6 \text{ gal}}{80 \text{ gpm} \times 0.891 \times 1440 \text{ min/dy}} + 3 \text{ dy}$$

Campaign Duration = 13 days

¹Operating efficiency was based on an average of evaporator campaigns 94-1, 94-2, 95-1 and 96-1 excluding outages.

Note: 3 days are included for startup, flushing, and, shutdown.

PROCESS CONDENSATE GENERATIONI. Process condensate generation without PC recycle.

Process Condensate Generation = PC/WVR ratio x WVR X Processable volume (gal)

Assume: PC/WVR ratio = 1.26¹
 Processable volume = 9.99×10^5 gal
 WVR = 0.80

Process Condensate Generation = $1.26 \times 0.80 \times 9.99 \times 10^5$ gal

Process Condensate Generation = 1.01×10^6 gal

¹The ratio of process condensate generation rate to feed rate is based on the 94-1 and 94-2 campaigns without PC recycle.

II. Process condensate generation with PC recycle system on line

Process Condensate Generation = PC/WVR ratio x WVR x Processable volume (gal)

Assume: PC/WVR ratio = $1.26 - 0.09^2 = 1.17$
 Processable volume = 9.99×10^5 gal
 WVR = 0.80

Process Condensate Generation = $1.17 \times 0.80 \times 9.99 \times 10^5$ gal

Process Condensate Generation = 9.35×10^5 gal

²The estimated efficiency improvement based on data taken during Campaign 95-1 with the PC recycle system on line.

CRITICALITY CALCULATION

Evaporator Feed Limit: Fissile < 0.005 g/L
pH > 8

Slurry Product Limit: Fissile < 0.001 g/L
pH > 8

OR

0.001 g/L < Fissile < 0.0033 g/L,
pH > 8.0
and at least one of the minimum subcritical ratios
shown in the table below

Neutron Absorber (x)	Neutron Absorber to Plutonium Mass Ratio (X/Pu)
Chromium (Cr)	135
Iron (Fe)	160
Manganese (Mn)	32
Nickel (Ni)	105
Total Uranium (U)	770

$$Fissile(g/L) = \frac{Pu^{239}(uCi/ml) \times 1E-06 (Ci/uCi)}{6.2E-02 (Ci/g) \times 1E-03 (L/ml)} + U_{gr}(g/L) \times [1.077E-10 + 2.13E-03]$$

Feed¹:

$$Pu^{239} = 1.44E-04 \text{ uCi/mL}$$

$$U_{gross} = 1.31E-02 \text{ g/L}$$

=====> Fissile = 3.02E-05 g/L < 0.005 g/L maximum limit

pH_{feed} = 13.07 > minimum pH of 8 limit

Slurry Product¹:

$$Pu^{239} = 8.00E-04 \text{ uCi/mL}$$

$$U_{gross} = 7.28E-02 \text{ g/L}$$

=====> Fissile = 1.68E-04 g/L < 0.001 g/L limit

pH_{slurry} = 13.07 > minimum pH of 8 limit

¹Feed and slurry values from Appendix E.

TRU CALCULATION

Waste Designation

TRU > 100 nCi/g

Non-TRU < 100 nCi/g

$$TRU(nCi/g)_{supernate} = \frac{[Pu^{239}(uCi/mL) + Am^{241}(uCi/mL)] \times 10^3 (nCi/uCi)}{SpG(g/mL)}$$

Supernate	Pu ²³⁹ (μ Ci/mL)	Am ²⁴¹ (μ Ci/mL)	SpG (g/mL)	Total (nCi/g)	Waste type
Tank 106-AW ¹	2.32E-03	1.25E-04	1.41	1.74E+00	non-TRU
Slurry to 6AW ²	8.00E-04	1.02E-04	1.33	6.78E-01	non-TRU
Slurry to 2AW ²	2.28E-04	2.90E-05	1.09	2.35E-01	non-TRU

¹Data is obtained from Compatibility Analyses Results For The 60-Day Report For Tank 241-AW-106 Grab Results, WMH-9854328, dated 05/18/98 (Steen 1998)

²Slurry data (to tanks 106-AW and 106-AW) is obtained from Appendix E.

$$TRU(nCi/g)_{solids} = [Pu^{239}(uCi/mL) + Am^{241}(uCi/mL)] \times 10^3 (nCi/uCi)$$

Solids	Pu ²³⁹ (μ Ci/g)	Am ²⁴¹ (μ Ci/g)	TRU (nCi/g)	TRU (nCi/g)
102-AW ³	4.95E-01	1.71E+00	2200	TRU
106-AW ³	4.45E-02	1.50E-01	195	TRU

³Result was obtained from the average of sludge samples 2AW-95-1 & 2AW-95-3 for tank 102-AW and 6AW-95-2 & 6AW-95-3 for tank 106AW.

HEAT GENERATION CALCULATION

Tank Limit < 70,000 BTU/hr
 Slurry Cs-137 < 574 uCi/ml
 Slurry Sr-90 < 404 uCi/ml

Parameter	Cs ¹³⁷ (μCi/mL)	Sr ⁹⁰ (μCi/mL)
Slurry to TK 106-AW ¹	1.84E+02	1.30E-01
Slurry to TK 102-AW ²	9.60E+01	6.78E-02
Max. Conc. Limit	5.74E+02	4.04E+02
Comment	in compliance	in compliance

¹Slurry concentration (to tank 102-AW) is obtained from Appendix E.

²Slurry concentration (to tank 106-AW) is obtained from Appendix E.

$$\text{Heat}_{\text{supernate}} \text{ (BTU/hr)} = [\text{Cs}^{137} \text{ (}\mu\text{Ci/mL)} \times 1.6\text{E-}02 \text{ (BTU/hr.Ci)} + \text{Sr}^{90} \text{ (}\mu\text{Ci/mL)} \times 2.3\text{E-}02 \text{ (BTU/hr.Ci)}] \times \text{volume (gal)} \times 3785 \text{ (ml/gal)} \times 1.0\text{E-}06 \text{ (Ci/}\mu\text{Ci)}$$

Parameter	Supernate (gal)	Cs ¹³⁷ (μCi/mL)	Sr ⁹⁰ (μCi/mL)	Heat _{supernate} (BTU/hr)
Slurry-2AW ³	6.05E+04	6.90E+01	6.78E-02	3.52E+02
Slurry-6AW ³	2.00E+04	1.66E+02	1.17E-01	2.01E+03
TK 106-AW ⁴	7.70E+04	2.76E+02	3.98E-01	1.29E+03

³Slurry values from Appendix E, Table E-2

⁴Data is obtained from Compatibility Analyses Results For The 60-Day Report For Tank 241-AW-106 Grab Results, WMH-9854328, dated 05/18/98 (Steen 1998).

$$\text{Heat}_{\text{shudge}} \text{ (BTU/hr)} = [\text{Cs}^{137} \text{ (}\mu\text{Ci/g)} \times 1.6\text{E-}02 \text{ (BTU/hr.Ci)} + \text{Sr}^{90} \text{ (}\mu\text{Ci/g)} \times 2.3\text{E-}02 \text{ (BTU/hr.Ci)}] \times 1.0\text{E-}06 \text{ (Ci/}\mu\text{Ci)} \times \text{sludge vol(in)} \times \text{Sp. G (g/ml)} \times 3785 \text{ (ml/gal)} \times 2750 \text{ (gal/in)}$$

Tank	Sludge (in)	Sp.G (g/ml)	Cs ¹³⁷ (μCi/g)	Sr ⁹⁰ (μCi/g)	Heat _{shudge} (BTU/hr)
102-AW ⁵	1.56E+01	1.42	8.64E+01	6.64E+02	3.84E+03
106-AW ⁵	8.70E+01	1.95	3.16E+01	5.25E+01	3.02E+03

⁵Result was obtained from the average of sludge samples 2AW-95 & 2AW-95-3 for tank 102-AW and 6AW-95-2 & 6AW-95-3 for tank 106-AW. The average sludge level of 87 " in tank 106-AW was used in determining the sludge heat load.

$$\text{TANK HEAT LOAD} = \text{HEAT}_{\text{supernate}} + \text{HEAT}_{\text{shudge}}$$

$$102\text{-AW TK Heat Load} = 3.52\text{E+}02 \text{ Btu/hr} + 3.84\text{E+}03 \text{ Btu/hr}$$

$$\text{====> } 102\text{-AW TK Heat Load} = 4.19\text{E+}03 \text{ Btu/hr} < 7.00\text{E+}04 \text{ Btu/hr Limit}$$

$$106\text{-AW TK Heat Load} = (2.01\text{E+}03 + 1.29\text{E+}03 + 3.02\text{E+}03) \text{ Btu/hr}$$

$$\text{====> } 106\text{-AW TK Heat Load} = 6.32\text{E+}03 \text{ Btu/hr} < 7.00\text{E+}04 \text{ Btu/hr Limit}$$

REYNOLDS CALCULATION

Slurry minimum Reynolds No. Limit $\geq 20,000$

$$Re = \frac{d \times v \times D}{n}$$

Assume: d = pipe diameter = 2 inch = 0.167 ft
 v = slurry velocity = 4.39 ft/s (based on worst case 43 gpm)
 D = slurry density = 1.33 = 82.99 lb/ft³ (80% WVRP)
 n¹ = slurry viscosity = 4.22 cP = 2.84E-03 lb/ft-s

$$Re = \frac{(0.167 \text{ ft}) (4.39 \text{ ft/s}) (82.99 \text{ lb/ft}^3)}{2.84 \text{ E-}03 \text{ lb/ft-s}} = 2.14 \times 10^4$$

Slurry Reynolds No. = 2.14E+04 > minimum Reynolds No. of 2.00E+04 Limit

In addition, no undissolved solids are anticipated during slurry product transfers to 106-AW, potential line plugging is not anticipated. Slurry pump PB-2 will be operated when the specific gravity greater than 1.3 to prevent any potential line plugging (Nicholson 1992).

¹Due to the unavailable data of its analysis, the temperature is conservatively assumed to be 43 degree celsius (110 degree F) and viscosity value was calculated using the formula, $[42.65 \times \text{SPG} - 0.3850 \times T - 35.82] \times (6.72 \text{ E-}04 \text{ lb/ft-s/cP})$ from IM-13314-88-105 (Reynolds 1988)

FLAMMABLE GAS GENERATION CALCULATION

1. Slurry SpG $\leq$ 1.41
 2. Product of Slurry SpG and Tank Solids Depth < 148 in
- For conservatism, slurry SpG at 82% WVRP calculation

$$SpG_{slurry} = 1 + \frac{SpG_{feed} - 1}{1 - WVRP}$$

$$SpG_{slurry} = 1 + \frac{1.06 - 1}{1 - 0.82}$$

$$SpG_{slurry} = 1.33 < 1.41 \text{ SpG limit}$$

- Slurry to tank 106-AW (Product_{SpG/Solids Depth} Calculation):

Assumption: 106-AW Solids Depth = 82 inches
 Slurry SpG = 1.33

$$\text{Product}_{SpG/Solids Depth} = 1.33 \times 82 \text{ inches}$$

$$\text{Product}_{SpG/Solids Depth} = 109 \text{ inches} < 148 \text{ inches limit}$$

- Slurry to tank 102-AW (Product_{SpG/Solids Depth} Calculation):

Assumption: 102-AW Solids Depth = 15.6 inches (for conservatism)
 Slurry SpG = 1.33

$$\text{Product}_{SpG/Solids Depth} = 1.33 \times 15.6 \text{ inches}$$

$$\text{Product}_{SpG/Solids Depth} = 21 \text{ inches} < 148 \text{ inches limit}$$

Organic and Energetic Reaction Calculation

1. Exotherm/Endotherm < 1.0
2. TOC $\leq$ 4.5 wt% dry weight waste contains < 20% water

A. Exotherm/Endotherm ratio calculation

Exotherm Feed & Slurry = 0 J/g

Exotherm/Endotherm = 0 < 1.0 limit

B. Percent water in slurry product calculation

Feed = 90.9 %water

WVRF = 82 %

$$\%Water_{slurry} = \frac{\%Water_{feed} - WVRF}{1 - WVRF} \times 100\%$$

$$\%Water_{slurry} = \frac{0.909 - 0.82}{1 - 0.82} \times 100\% = 49.4\%water$$

C. Percent dry weight TOC calculation

$TOC_{feed} = 0.582 \text{ g/L}$

$\%Water_{feed} = 90.9 \%$

$SpG_{feed} = 1.06$

$$\%TOC = \frac{TOC_{feed}}{(1 - \%Water_{feed}) \times SpG_{feed} \times 1000 \text{ mL/L}} \times 100\%$$

$$\%TOC = \frac{0.582 \text{ g/L}}{(1 - 0.909) \times 1.06 \text{ g/mL} \times 1000 \text{ mL/L}} \times 100\%$$

$\%TOC = 0.6\% \text{ dry weight} < 4.5 \% \text{ dry weight Limit}$

WASTE SEGREGATION CALCULATION

Segregation Criteria

1. TOC/Na mole ratio < 0.5
2. Sr-90/Na ratio < 4.4E+07 Bq/mole
3. TRU/Na ratio < 4.8E+05 Bq/mole

Parameter	Sr ⁹⁰ (μ Ci/mL)	TRU ¹ (nCi/g)	Na (moles/L)	TOC (g/L)
Slurry-2AW ²	6.78E-02	2.35E-01	1.94E+00	9.20E-01
Slurry-6AW ²	1.30E-01	6.78E-01	6.83E+00	3.23E+00
TK 106-AW ³	3.98E-01	1.74E+00	7.74E+00	4.46E+00

¹TRU values from Appendix G.²Slurry values from Appendix E, Table E-2³Data is obtained from Compatibility Analyses Results For The 60-Day Report For Tank 241-AW-106 Grab Results, WMH-9854328, dated 05/18/98 (Steen 1998).

Parameter	TOC/Na ⁴ (mole ratio)	Sr-90/Na Ratio ⁵ (Bq Sr90/mole Na)	TRU/Na Ratio ⁶ (Bq TRU/mole Na)
Slurry-2AW	8.33E-02	1.49E+06	1.03E+04
Slurry-6AW	8.33E-02	1.49E+06	1.03E+04
TK 106-AW	4.80E-02	1.90E+06	1.17E+04
Seg. Criteria	5.00E-01	4.40E+07	4.80E+05
Comment	IN COMPLIANCE	IN COMPLIANCE	IN COMPLIANCE

⁴TOC/Na mole ratio is calculated using formula: TOC/Na (mole ratio) = TOC (g/L) / 12 (g TOC/moles) / Na (moles/L).⁵Sr-90/Na ratio is calculated using formula: Sr-90/Na (Bq Sr-90/mole Na ratio) = Sr-90 (μ Ci/ml) * 1E-03 (Ci/L per μ Ci/ml) / (2.703E-11 Ci/Bq) / Na (moles/L)⁶TRU/Na ratio is calculated using formula: TRU/Na (Bq TRU/mole Na ratio) = TRU (nCi/g) * SpG (g/ml) * 1E-06 (Ci/L per nCi/ml) / (2.703E-11 Ci/Bq) / Na (moles/L)

AMMONIA RELEASE CALCULATIONS¹

I. Ammonia in Process Condensate Calculation

Limit $\text{NH}_3(\text{process condensate}) < 10,000 \text{ mg/L}$

$$\text{NH}_3(\text{process condensate}) = 0.939 \times \text{NH}_3(\text{feed}) \quad (\text{mass balance})$$

Assume (worst case during first 24 hrs)

pot volume = 25,000 gal/dy

feed rate = 80 gpm

WVRF = 82% (PC flow = 0.82 feed flow)

$\text{NH}_3(\text{feed})$ concentration² = 74.3 mg/L

Total feed volume = (25,000 gal/dy + 80 gal/min x 1440 min/dy) x 3.785 L/gal

$$\text{=====> Total feed volume} = 5.31\text{E}+05 \text{ L/dy}$$

$$\text{NH}_3(\text{feed}) = 74.3 \text{ mg/L} \times 5.31\text{E}+05 \text{ L/dy} = 3.95\text{E}+07 \text{ mg/dy}$$

$$\text{NH}_3(\text{process condensate}) = (0.939 \times 3.95\text{E}+07 \text{ mg/dy}) / (0.82 \times 5.31\text{E}+05 \text{ L/dy})$$

$$\text{=====> } \text{NH}_3(\text{process condensate}) = 8.52 \text{ mg/L}$$

I. Ammonia in Vessel Vent Calculation

Limit $\text{NH}_3(\text{vessel vent}) < 100 \text{ lbs/dy}$

$$\text{NH}_3(\text{vessel vent}) = 0.061 \times \text{NH}_3(\text{feed}) \quad (\text{mass balance})$$

Assume (worst case during first 24 hrs)

pot volume = 25,000 gal/dy

feed rate = 80 gpm

$\text{NH}_3(\text{feed})$ concentration² = 74.3 mg/L

Total feed volume = (25,000 gal/dy + 80 gal/min x 1440 min/dy) x 3.785 L/gal

$$\text{=====> Total feed volume} = 5.31\text{E}+05 \text{ L/dy}$$

$$\text{NH}_3(\text{feed}) = 74.3 \text{ mg/L} \times 1.0\text{E}-03 \text{ g/mg} \times 5.31\text{E}+05 \text{ L/dy} \times 1 \text{ lb}/454 \text{ g}$$

$$\text{NH}_3(\text{feed}) = 86.9 \text{ lbs/dy}$$

$$\text{NH}_3(\text{vessel vent}) = 0.061 \times 86.9 \text{ lbs/dy} = 5.30 \text{ lbs/dy}$$

¹the ammonia concentrations in process condensate and in vessel vent effluents are calculated using the formulas listed in I.M # 71730-95-95004.

²For conservatism, the highest ammonia concentration in tank 102-AW was used.

LERF FISSILE CALCULATION

LERF Exempt limit < 15 g Pu-239

$$\text{Total weight of Pu-239 (g)} = 2.33\text{E-13} * C_{\text{Pu-239}} \text{ (pCi/L)} * \text{Vol (gal)}$$

Parameter	Pu-239 ¹ (pCi/L)	Volume (gallons)	Pu-239 (g)
Basin 42	2.10E-01	7.60E+05	3.72E-08
Basin 43	7.80E-02	6.50E+06	1.18E-07
Basin 44	8.60E+02	4.10E+06	8.22E-04
Process condensate	3.50E-01	1.01E+06	8.24E-08
LERF TOTAL (after Campaign 99-1)			8.22E-04

¹Pu-239 concentration for each of the LERF Basins are obtained from LIMS database. Pu-239 concentration for process condensate is obtained at 82% WVRP by entering the feed composite from Table E-1 into the 242-A Evaporator Process flowsheet.

Vessel Vent Radiological Release Calculation

Rad.	Feed (uCi/ml)	Quantity ¹ (Ci)	Release Factor	Potential Release (Ci)	Dose Factor ²	Dose (mrem/yr)	Percent (%)
C-14	1.16E-04	4.39E-01	1.45E-12	6.37E-13	2.56E-03	1.63E-15	< 1%
Co-60	1.05E-03	3.97E+00	1.45E-12	5.76E-12	3.00E-02	1.73E-13	< 1%
Se-79	2.23E-05	8.44E-02	1.45E-12	1.22E-13	6.67E-08	8.16E-21	< 1%
Sr-90	2.34E-02	8.86E+01	1.45E-12	1.28E-10	4.45E-02	5.72E-12	< 1%
Nb-94	1.06E-03	4.01E+00	1.45E-12	5.82E-12	2.65E-02	1.54E-13	< 1%
Tc-99	1.38E-02	5.22E+01	1.45E-12	7.57E-11	1.10E-03	8.33E-14	< 1%
Ru-106	1.16E-01	4.39E+02	1.45E-12	6.37E-10	2.07E-02	1.32E-11	< 1%
I-129	2.12E-05	8.02E-02	1.45E-12	1.16E-13	2.92E-01	3.40E-14	< 1%
Cs-134	1.08E-02	4.09E+01	1.45E-12	5.93E-11	3.16E-02	1.87E-12	< 1%
Cs-137	3.31E+01	1.25E+05	1.45E-12	1.82E-07	2.37E-02	4.30E-09	99.2%
Eu-154	2.70E-03	1.02E+01	1.45E-12	1.48E-11	1.80E-02	2.67E-13	< 1%
Eu-155	1.10E-02	4.06E+01	1.45E-12	6.04E-11	1.80E-03	1.09E-13	< 1%
Ra-226	2.34E-06	8.86E-03	1.45E-12	1.28E-14	5.35E-01	6.87E-15	< 1%
Pu-238	4.41E-05	1.67E-01	1.45E-12	2.42E-13	8.03E-01	1.94E-13	< 1%
Pu-239	1.44E-04	5.45E-01	1.45E-12	7.90E-13	8.64E+00	6.83E-12	< 1%
Pu-241	5.90E-03	2.23E+01	1.45E-12	3.24E-11	1.32E-01	4.26E-12	< 1%
Am-241	1.83E-05	6.93E-02	1.45E-12	1.00E-13	1.32E+01	1.33E-12	< 1%
Cm-244	5.06E-06	1.92E-02	1.45E-12	2.78E-14	6.82E+00	1.89E-13	< 1%
TOTAL DOSE						4.34E-09	100%

¹Based on 1 Mgal processable volume.²Dose factor is calculated from *National Emission Standards for Hazardous Air Pollutants Federal Facility Compliance Agreement: Request for Redesignation of the 296-A-22 stack, WMH-9851950, dated March 6, 1998.*

Percent Non-Volatile Organic Calculation

From Boildown Data Results:

At 0% WVRF:

Total Carbon (TC) = 2570 ug/ml

Total Inorganic Carbon (TIC) = 2110 ug/ml

Therefore,

Total Organic Carbon (TOC) = TC - TIC

Total Organic Carbon (TOC) = 2570 ug/ml - 2110 ug/ml = 460 ug/ml

Equivalent TOC at 82.5% WVRF (if non-volatile organic)

$$\text{TOC}_{82.5\% \text{WVRF}} = \text{TOC}_{0\% \text{WVRF}} / (1 - \text{WVRF})$$

$$\text{TOC}_{82.5\% \text{WVRF}} = 460 / (1 - 0.825) = 2629 \text{ ug/ml}$$

At 82.5% WVRF:

Total Carbon (TC) = 10800 ug/ml

Total Inorganic Carbon (TIC) = 8370 ug/ml

Therefore,

Total Organic Carbon = TC - TIC

Total Organic Carbon = 10800 ug/ml - 8300 ug/ml = 2430 ug/ml

Percent non-volatile organics

Non-Volatile Organics = (2430 ug/ml TOC) / (2629 ug/ml TOC) * 100%

Non-Volatile Organics = 92.4%

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APPENDIX H
PREDICT RUNS

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PREDICT RUN

PASS ONE DOUBLE SHELL SLURRY FEED RUN

PASS STOPPED AT 50% WVR LIMIT.

TEMPERATURE 44.8 C 112.7 F PRESSURE 60.0 Torr

PASS WVR 50.0 TOTAL WVR 50.0

	FEED	SLURRY	EVAPORATOR CONDITIONS SUPERNATE	SOLIDS*	TANK CONDITIONS 20.0 C SUPERNATE	SOLIDS
VOLUME, gal	.100E+07	.500E+06	.500E+06	.000	.500E+06	.103E+04
HYDROXIDE,M	.439	.878	.878	.000	.878	.000
ALUMINATE,M	.051	.101	.101	.000	.101	.000
NITRATE,M	.284	.568	.568	.000	.568	.000
NITRITE,M	.151	.302	.302	.000	.302	.000
CARBONATE,M	.135	.270	.270	.000	.270	.000
PHOSPHATE,M	.008	.017	.017	.000	.000	.008
SULFATE,M	.013	.025	.025	.000	.025	.000
FLUORIDE,M	.079	.159	.159	.000	.159	.000
ORGANIC,G/L	.582	1.164	1.164	.000	1.164	.000

PASS TWO DOUBLE SHELL SLURRY FEED RUN

PASS STOPPED AT 50% WVR LIMIT.

TEMPERATURE 46.9 C 116.4 F PRESSURE 60.0 Torr

PASS WVR 50.0 TOTAL WVR 74.9

	FEED	SLURRY	EVAPORATOR CONDITIONS SUPERNATE	SOLIDS*	TANK CONDITIONS 20.0 C SUPERNATE	SOLIDS
VOLUME, gal	.499E+06	.250E+06	.249E+06	624.	.249E+06	624.
HYDROXIDE,M	.878	1.752	1.756	.000	1.756	.000
ALUMINATE,M	.101	.201	.202	.000	.202	.000
NITRATE,M	.568	1.133	1.136	.000	1.136	.000
NITRITE,M	.302	.602	.604	.000	.604	.000
CARBONATE,M	.270	.539	.540	.000	.540	.000
PHOSPHATE,M	.000	.000	.000	.000	.000	.000
SULFATE,M	.025	.051	.051	.000	.051	.000
FLUORIDE,M	.159	.317	.152	.083	.152	.083
ORGANIC,G/L	1.164	2.322	2.328	.000	2.328	.000

PASS THREE DOUBLE SHELL SLURRY FEED RUN

PASS STOPPED AT 50% WVR LIMIT.

TEMPERATURE 52.0 C 125.7 F PRESSURE 60.0 Torr

PASS WVR 50.0 TOTAL WVR 87.4

	FEED	SLURRY	EVAPORATOR CONDITIONS SUPERNATE	SOLIDS*	TANK CONDITIONS 20.0 C SUPERNATE	SOLIDS
VOLUME, gal	.249E+06	.133E+06	.124E+06	.896E+04	.124E+06	.941E+04
HYDROXIDE,M	1.756	3.276	3.512	.000	3.512	.000
ALUMINATE,M	.202	.377	.404	.000	.404	.000
NITRATE,M	1.136	2.119	2.272	.000	2.272	.000
NITRITE,M	.604	1.127	1.208	.000	1.208	.000
CARBONATE,M	.540	1.007	.224	.428	.179	.451
PHOSPHATE,M	.000	.000	.000	.000	.000	.000
SULFATE,M	.051	.095	.102	.000	.102	.000
FLUORIDE,M	.152	.283	.070	.117	.070	.117
ORGANIC,G/L	2.328	4.343	4.656	.000	4.656	.000

PREDICT RUN

PASS FOUR DOUBLE SHELL SLURRY FEED RUN

PASS STOPPED AT 50% WVR LIMIT.

TEMPERATURE 69.9 C 157.8 F PRESSURE 60.0 Torr

PASS WVR 50.0 TOTAL WVR 93.1

	FEED	SLURRY	EVAPORATOR CONDITIONS		TANK CONDITIONS 20.0 C	
			SUPERNATE	SOLIDS*	SUPERNATE	SOLIDS
VOLUME, gal	.115E+06	.603E+05	.575E+05	.283E+04	.575E+05	.103E+05
HYDROXIDE,M	3.512	6.695	7.024	.000	7.024	.000
ALUMINATE,M	.404	.770	.808	.000	.808	.000
NITRATE,M	2.272	4.331	3.937	.304	1.289	1.627
NITRITE,M	1.208	2.303	2.416	.000	1.555	.430
CARBONATE,M	.179	.341	.053	.153	.009	.175
PHOSPHATE,M	.000	.000	.000	.000	.000	.000
SULFATE,M	.102	.194	.203	.000	.203	.000
FLUORIDE,M	.070	.134	.016	.062	.016	.062
ORGANIC,G/L	4.656	8.876	9.312	.000	9.312	.000

PASS FIVE DOUBLE SHELL SLURRY FEED RUN

PASS STOPPED AT ALUMINATE BOUNDARY.

TEMPERATURE 58.0 C 136.3 F PRESSURE 60.0 Torr

PASS WVR 1.2 TOTAL WVR 93.2

	FEED	SLURRY	EVAPORATOR CONDITIONS		TANK CONDITIONS 20.0 C	
			SUPERNATE	SOLIDS*	SUPERNATE	SOLIDS
VOLUME, gal	.472E+05	.466E+05	.466E+05	.000	.466E+05	.000
HYDROXIDE,M	7.024	7.109	7.109	.000	7.109	.000
ALUMINATE,M	.808	.818	.818	.000	.818	.000
NITRATE,M	1.289	1.305	1.305	.000	1.305	.000
NITRITE,M	1.555	1.574	1.574	.000	1.574	.000
CARBONATE,M	.009	.009	.009	.000	.009	.000
PHOSPHATE,M	.000	.000	.000	.000	.000	.000
SULFATE,M	.203	.206	.206	.000	.206	.000
FLUORIDE,M	.016	.016	.016	.000	.016	.000
ORGANIC,G/L	9.312	9.425	9.425	.000	9.425	.000

APPENDIX I

DEFT RUN RESULTS

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PRE-CAMPAIGN DEFT SAMPLING RESULTS

Table 1: Precampaign Power Curve Analysis

Analyte	Mean ¹	STD	RSD	DEFT No. Samples
Nitrite (ug/ml)	1.14E+04	1.56E+03	1.37E+01	2
Nitrate (ug/ml)	1.49E+04	1.99E+03	1.34E+01	2
Hydroxide (ug/ml)	9.03E+03	1.90E+02	2.11E+00	2
Cs-137 (uCi/ml)	4.22E+01	5.18E-01	1.29E+00	2
Sr-90 (uCi/ml)	2.09E+00	1.37E-01	6.56E+00	2
Pu-239/240 (uCi/ml)	4.02E-04	1.48E-05	3.70E+00	2
Ammonia (ug/ml)	8.27E+00	2.23E+00	2.70E+01	2
Acetone ² (ug/l)	NA	NA	NA	NA

¹The preliminary analyte concentration for Campaign 99-1 feed was determined from waste concentration in tank 102-AW and tank 108-AP (after mixing with 106-AP).

²Acetone is not included in the power curve analysis due to its unavailability.

CAMPAIGN DEFT SAMPLING VERIFICATION RESULTS

Table 2: Final Characterization Data Power Curve Analysis

Analyte	Mean ¹	STD	RSD	DEFT No. Samples
Nitrite (ug/ml)	6.87E+03	1.14E+02	1.14E+02	2
Nitrate (ug/ml)	1.75E+04	3.79E+02	3.79E+02	2
Hydroxide (ug/ml)	7.47E+03	2.50E+02	2.50E+02	2
Cs-137 (uCi/ml)	3.23E+01	0	0	2
Sr-90 (uCi/ml)	2.18E-02	6.41E-03	6.41E-03	2
Pu-239/240 (uCi/ml)	1.51E-04	3.38E-05	3.38E-05	2
Ammonia (ug/ml)	5.11E+01	2.58E+01	2.58E+01	2
Acetone (ug/l)	1.00E+03	0	0	2

¹Data is obtained from Tank 241-AW-102 Grab Samples in Support of 242-A Evaporator Campaign 99-1, Analytical Results for the Final Report, HNF-1665, Rev. 0, dated April 30, 1999.

APPENDIX J

REFERENCE LETTERS

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DON'T SAY IT — Write It!

DATE: May 11, 1999

TO: Elvis Q. LeFROM: Mark W. Bowman

S6-72

cc:

Telephone: 373-9379SUBJECT: TC MINUS TIC ANALYSIS FOR TANK 241-AW-102

The sample analyses for candidate feed tank 241-AW-102 give a Total Carbon minus Total Inorganic Carbon (TC - TIC) of 440 mg/L, which is greater than the target limit of 143 mg/L in *242-A Evaporator Waste Analysis Plan* (WAP, WHC-SD-WM-EV-060)¹. The WAP states that if the limit is exceeded, "a more detailed evaluation will be conducted to determine organic emissions out of the vessel vent." The *242-A Evaporator/LERF Data Quality Objectives* (WHC-SD-WM-DQ0-014) further says, "perform further technical evaluation (e.g., review GC data) to determine if a particular volatile or semi-volatile organic analyte is not accounted for."

The value of 143 mg/L is based on the vessel vent organic emission limit for acetone. Acetone was chosen because it is volatile and typically found in the DST waste. Most compounds are less volatile than acetone. Therefore, exceeding the limit of 143 mg/L does not mean the stack organic emissions will be exceeded.

The process for evaluating organics emissions consists of assessing organic species that are tentatively identified and determining if the species could be volatile and if existing equilibrium data could be used to calculate the species emission rate.

Volatile Organic Analysis (VOA) of 102-AW

Acetone and 1-butanol were detected in the VOA performed on 102-AW. Only one tentatively identified compounds, 2-heptanone, was detected in one of three samples (2AW-99-2A-S). The 2-heptanone concentration was estimated to be at the quantitation limit of 1.0 mg/L. 2-heptanone has been identified in VOA analysis from earlier campaigns. Triethylamine was also detected in the samples; however, this result was rejected because it was detected at similar concentrations in the laboratory blanks.

2-heptanone can be treated as pentanone for estimating organic emissions. This is conservative because the volatility for 2-heptanone is lower than pentanone due to its higher molecular weight. From the THOMES database, the volatility of 2-butanone is 35.4 mm Hg and the volatility of 2-heptanone is 1.6 mm Hg. The partition factor for pentanone is 16.5 (from *Organic Emissions Calculations for the 242-A Evaporator Vessel Vent System*, WHC-SD-WM-ES-380), giving an emission rate for 2-heptanone of $(16.5)(1.0)(1.0E-3) = 1.7E-2$ kg/hr.

Semi-Volatile Organic Analysis (SVOA)

No organic species exceeded their practical quantitation limits by semi-VOA analysis. One unknown tentatively identified organic compound was detected at 6.7 mg/L in sample 2AW-99-4B-T. No information is given about what type of organic species this is (i.e., alcohol, ketone, phthalate, etc.). Conservatively assuming this compound has a high partition factor, such as 36.2 for methyl isobutyl

¹This limit is based on 174.4 mg/L multiplied by (R-1)/R, assuming R = 5.56 for Campaign 99-1.

ketone, the emission from this species is $(36.2)(6.7)(1.0E-3) = 0.24$ kg/hr. The emission rate for all organics during Campaign 99-1 is estimated to be 0.41 kg/hr (see attachment).

Discussion

The question remains what constituents make up the 440 mg/L in the TC-TIC analysis in 102-AW. Tank transfer information indicates that 102-AW is made up of waste from multiple sources:

Source	Percent of 102-AW Volume	Type of Waste Material
Heel	8 %	Evaporator Campaign 97-2 heel
B Plant	3 %	B Plant cleanout
242-A	4 %	Evaporator cold run
102-AY	42 %	Condensate from aging waste tanks
108-AP	43 %	B Plant cleanout, Evaporator slurry

The heel consists of waste material from Campaign 97-2. This contained a variety of nonvolatile organics and organic acids: citrate, EDTA, HEDTA, glycolate, acetate, and oxalate. The material from the 242-A Evaporator cold run is essentially water. The waste in 102-AY is condensate from aging waste tanks. The waste in 108-AP consisted of material from 108-AP and 106-AP which were mixed together before transfer to 102-AW. The material in 106-AP was received from B Plant during terminal cleanout. The material in 108-AP was waste from 106-AN that was previously processed through 242-A Evaporator. So the primary waste materials added were from B Plant terminal cleanout and condensate from aging waste tanks.

The most likely type of nonvolatile organic in double-shell tank waste are salts of organic acids such as EDTA, citric acid, and oxalic acid. The TC analysis consists of burning the sample in a furnace, converting all carbon compounds into carbon dioxide which is absorbed and measured. TIC consist of acidifying the sample, converting inorganic carbonate compounds into carbon dioxide which is absorbed and measured. Thus TC-TIC represents carbon-based materials (i.e., organic) which are not converted into carbonates. Based on sample analysis obtained from Tank Waste Information Network System (TWINS), the most likely source of such compounds is sodium oxalate.

Oxalate sample analysis from the tanks which make up the waste in 102-AW are:

- 106-AP: average oxalate concentration = 350 mg/L
- 108-AP: average oxalate concentration = 1220 mg/L
- 102-AY: average oxalate concentration = 56 mg/L.

The weighted average oxalate concentration is 410 mg/L in 102-AW. This closely matches the TC-TIC value of 440mg/L.

In conclusion, the waste to be processed in Campaign 99-1 includes trace amounts of volatile and semi-volatile organics, with an emission rate of 0.41kg/hr. This is less than the regulatory limit of 1.4 kg/hr in 40 CFR 264, Subpart AA. The waste also includes nonvolatile oxalate which accounts for the TC-TIC results.

Mark Bowman

Mark Bowman

242-A EVAPORATOR VESSEL VENT ORGANIC EMISSIONS FOR CAMPAIGN 99-1 (PAGE 1 OF 3)

FEED CONCENTRATIONS

(reference: laboratory sample data)

FEED TANK: Volume Fraction:	102-AW 100%	XXX-NN 0%	XXX-NN 0%	XXX-NN 0%	XXX-NN 0%
Organic Constituent:	Feed Conc. (mg/L)*	Feed Conc. (mg/L)	Feed Conc. (mg/L)	Feed Conc. (mg/L)	Feed Conc. (mg/L)
Acetone	1.1	0	0	0	0
1-Butanol	3.8	0	0	0	0
2-Butoxyethanol	20.0	0	0	0	0
2-Butanone	1.0	0	0	0	0
Tri-Butyl Phosphate	20.0	0	0	0	0
Other1**	1.0	0	0	0	0
Other2**	6.7	0	0	0	0

*The values for 2-butoxyethanol and tri-butyl phosphate are detection limit values.

**Other organics compounds (see DSI)

Estimated Campaign Operating Time (hours) = 264

(based on volume to be processed)

242-A EVAPORATOR VESSEL VENT ORGANIC EMISSIONS FOR CAMPAIGN 97-2 (PAGE 2 OF 3)

ORGANIC EMISSIONS

(reference: WHC-SD-WM-ES-380)

FEED TANK:	102-AW	XXX-NN	XXX-NN	XXX-NN	XXX-NN
Organic Constituent:	Emission Rate (kg/hr)	Emission Rate (kg/hr)	Emission Rate (kg/hr)	Emission Rate (kg/hr)	Emission Rate (kg/hr)
Acetone	7.5E-03				
1-Butanol	9.9E-03				
2-Butoxyethanol	1.2E-01				
2-Butanone	1.0E-02				
Tri-Butyl Phosphate	1.2E-03				
Other1	1.7E-02				
Other2	2.4E-01				
TOTAL (kg/hr):	4.1E-01	0	0	0	0
WEIGHTED TOTAL (kg/hr):	4.1E-01	0	0	0	0

WEIGHTED AVERAGE: 0.41 kg/hr
 0.91 lb/hr

ESTIMATED TOTAL EMISSION: 109 kg Limit: < 2800 kg per year
 240 lb < 6200 lb per year

MAXIMUM EMISSION RATE: 0.41 kg/hr Limit: < 1.4 kg/hr
 0.91 lb/hr < 3.0 lb/hr

Prepared by: Mark W. Beroman Date 5-11-99

Checked by: ELVIS LE Date 5-11-99

HMF-4431 Rev. 0

242-A EVAPORATOR VESSEL VENT ORGANIC EMISSIONS FOR CAMPAIGN 97-2 (PAGE 3 OF 3)

ASSUMPTIONS

(reference: WHC-SD-WM-ES-380)

1. Vacuum condenser system emissions are trivial compared to Tank C-100 emissions.
2. Pressure in tank C-100 = 750 mmHg.
3. Temperature of the off-gas from tank C-100 = 75°C.
4. Flowrate of off-gas from tank C-100 = 150 cfm.
5. Molar flowrate of tank C-100 off-gas (based on assumptions #1, 2, 3) is 8,810 moles/hour.
6. The molar concentration of organics is low compared to the molar concentration of water.
7. All the organic species in the feed go into the process condensate.
8. The value of R in $(R - 1)/R$ is 2. For Campaign 99-1, $R = 5.56$, which is more conservative.
9. The values for partition factors are given in WHC-SD-WM-ES-380.

Partition Factors:

Acetone	6.74
1-Butanol	2.62
2-Butoxyethanol	6.23
2-Butanone	10.2
TBP	0.0582
2-Hexanone	14.1
2-Pentanone	16.5
MIBK	36.2
Tetrahydrofuran	41.1
Butanal	31.1

The partition factor converts gm/L
in the feed to kg/hr in the off-gas

HNF - 4431 R.W. 0

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NHC
Numatec
Hanford Corporation
 An SGN/Cogema, Inc. Company

Internal
Memo

From: Process Chemistry
 Phone: 373-2182/T6-07
 Date: April 28, 1999
 Subject: AW-102 Evaporator Campaign 99-1 Boildown Report

82100-99-013

To: E. Q. Le S6-72

cc: K. E. Bell T6-12
 R. R. Bloom S6-71
 D. L. Flyckt S6-72
 D. L. Herting T6-07
 M. D. Guthrie S6-72
 J. R. Jewett T6-07
 L.L. Lockrem S3-90
 S. G. McKinney R2-12
 D. K. Smith S6-71
 W.I. Winters T6-50
 MAB File/LB T6-07

- References:(1) R.R. Bloom, "Letter of Instruction 02-242-A Evaporator Campaign 99-1 Boildown Studies", Internal Memo 74B50-99-011, March 30, 1999.
- (2) LT-519-183 "Determination of Temperature and Pressure versus %WVR (Boildown)", Laboratory Technology Procedure.
- (3) M. A. Beck, Controlled Laboratory Notebook, WHC-N-1305 1.
- (4) Perry's Chemical Engineer's Handbook, 50th Edition, D. W. Green, J. O. Maloney, eds. McGraw Hill, New York, pg 3-45.
- (5) M. A. Beck to C. J. Benar, "SX-104 Solids Solubility vs. Temperature Test Results", Internal Memo 8C510-97-022, July 16, 1997.
- (6) K. D. Fowler, "Data Quality Objectives for Tank Farms Compatibility Program", WHC-SD-WM-DQO-001, Rev 1, Section 4.2.1, April 25, 1995.

INTRODUCTION

This letter reports the results of a boildown of Evaporator feed from Tank AW-102, as requested in Reference 1. A boildown is a distillation at customer-specified pressures to a customer-specified degree of volume reduction (called %Waste Volume Reduction or %WVR).

EXPERIMENTAL

Calibration

The temperature readout was a NIST-traceable thermocouple reader. The values were checked against a NIST-traceable thermometer, and found to be within accuracy specifications for the range 25 °C- 60 °C (± 1 °C).

The pressure was calibrated by noting the boiling temperature and pressure, and comparing those values to published values (Reference 4).

The boildown composite solution was made by pouring equal portions (70 mL each) of samples 2AW-99-2D-T, 2AW-99-3D-T, and 2AW-4D-T together. Observations were made during the composite preparation.

The "boildowns" (distillations) were done per Reference 2 as directed by Reference 1. Essentially this meant that the temperatures and pressures were measured at 80, 60 and 50 torr every 10% WVR. Visual observations were recorded as changes occurred. The boildown was stopped before the endpoint goal of Reference 1, since the material seemed nearly dried out.

RESULTS

Mixing Study:

No changes were seen when the samples were mixed together to make the composite. The samples were visually identical. No visible density differences or other hindrances to mixing

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were noted as each sample was poured into the composite jar. A 10 mL aliquot of composite was placed in Jar # 15805, Customer ID "Preboil" Labcore Sample # S99T000706.

Boildown Study:

The observations recorded in the laboratory notebook (Reference 3) are reported in the table below. The boildown was started with 200 mL of clear, light yellow liquid in the pot.

Distillate Collected mL	%WVR	Temperature °C	Corrected Pressure torr	Comments
0	0	48.6	80	Ambient = 29.6 C, 744 torr, 23.928g-13.370g / 10mL volumetric flask = 1.056g/mL Heat ON 10:05 4/12/99 Light yellow solution, Condenser 4 °C,
0	0	43	60	Some foaming, light bubbles (the degree of foaming may be due to volume or height of solution, i.e. a "geyser" effect)
0	0	40.4	53	4/12/99
20	10	48.7	80	
20	10	43.8	61	
20	10	41.5	52	10:45
40	20	48.8	80	
40	20	42.9	60	bumping on pressure reduction
40	20	40	52	11:15 dumped 40 mL condensate
60	30	48.8	80	
60	30	42.9	60	
60	30	40.1	52	11:45
80	40	49.3	81	40mL + 40mL previously dumped condensate
80	40	43.6	61	
80	40	40	52	12:02
100	50	49.7	81	
100	50	44.1	62	
100	50	40.6	52	12:35 60 mL condensate dumped
120	60	50.3	81	
120	60	44.9	62	
120	60	41.2	53	13:00 slightly cloudy
140	70	51.5	80	40 mL in condensate receiver
140	70	45.5	60	
140	70	42.5	53	no major cloudiness change
160	80	56	81	at 157 mL too cloudy to see stirr-bar
160	80	50.9	61	
160	80	47.6	52	
163	81.5	57.8	81	solids on side of flask, small particles splashed up
165	82.5	58.5	81	Declared endpoint, bubbling indicating insufficient water, nearly at point of drying out.

A graph of the data above is shown below.

Note that even at the start (0%WVR), the solution has a higher boiling point than pure water and therefore has some concentration of salts. There is a sharp increase in boiling point after 70 %WVR, which corroborates the visual observation of an increase in amount of solids after 70%WVR. Despite the increase in solids, there was no distinct "nucleation" point, but rather a range existed over which the solution became cloudier.

Settling Study:

The slurry generated by the boildown was allowed to sit without stirring, with the heat maintained near the final boildown temperature. The pressure was allowed to rise, to prevent the mixing that accompanies boiling. The slurry was then allowed to cool down overnight, and observed the next day, when aliquots requested by Reference 1 were taken.

Time	Temperature °C	Comments, Observations
4/12/99		
13:55	63 C	Homogeneous thin slurry Settling started (heat, stirrer, vacuum OFF)
14:16	51.9	25 mL total volume 15-18 settling solids
14:27	50	Thin (5 mL?) Clear liquid layer
14:40	65.1	No change in solids volume, liquid layer cloudier
14:53	58.1	Condensate return seen on video
15:00	54.1	An attempt to restart stirr-bar (with stirrer) failed
15:15	43.4	No change from 14:40
4/13/99	~28 C	
14:05		An attempt to restart stirr-bar (with stirrer) failed
14:08		Tried to move stirr-bar with small magnet - no movement
Vigorous scraping resulted in the removal most material from walls and floor of flask. Some material on floor of flask was quite solid and firmly affixed to the floor of the flask.		
14:25		shook slurry
14:40		~5-10 ml solids have settled, liquid slightly cloudy
14:45		shook up flask, got pretty good suspension (except for a few large [1cm long dimension] clods
decanted slurry/suspension to post boil sample jars 15787 ---- S99T000708 post boil, 15785 ---- S99T000707 post boil-TC		

Laboratory analytical results:

Sample ID#s	SpG	TC	TIC
Jar # 15805 Labcore Sample # S99T000706 Customer ID "Preboil"	1.056 g/mL (Hot cell method)	2570 µg/mL	2110 µg/mL
Jar #15787 Labcore#S99T000708 Customer ID# "post boil"	1.49 g/mL	Not requested	Not requested
Jar #15785 Labcore #S99T000707 Customer ID# "post boil-TC"	Not requested	10800 µg/mL	8370 µg/mL

Due to the sampling problems with the "post-boil" samples (see the settling test table above), the values in the table above are approximate. No specific gravity was taken in the hot cell, because the author was not sure if the limited amount of sample could be recovered from the volumetric flask used in the hot cell determination of specific gravity. The "post-boil" samples are essentially duplicate samples of slurry, but were requested as two aliquots per Reference 1.

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Since the slurry had significant amounts of settle-able solids the specific gravity measurement reported above may only include the supernate.

During the washing of the boildown pot and apparatus, it was noted that the solids that precipitated from the solution during the boildown, readily (quickly) dissolve on redilution with water.

DISCUSSION

The results indicate waste was not "complexed" (as defined in the Compatibility DQO, Reference 6). Observations supporting this statement are: 1) no gelation (or other severe viscosity increase) occurred on either heating or cooling, 2) the slurry had crystalline (as opposed to amorphous) solids at the endpoint and 3) the temperature-%WVR curve shows no **sharp** increases in temperature. The increase in temperature seen is expected for a low solids starting material. The final temperature is lower than that seen in some previous boildowns.

CONCLUSION

This material does not appear to be "complexed" waste by the definition of Reference 1 (which is taken from the "Compatibility DQO", Reference 6).

This material should not cause any foaming, early precipitation or other problems for the Evaporator.

If you have any questions about this report, please feel free to call me at 373-2182.

Mark A. Beck
Chemist
Process Chemistry

mab

Attachment:
VHS Video with E.Q. Le's copy.

Approval Date : 5/7/99**WASTE STREAM PROFILE SHEET**

Follow attached instructions when filling out this waste stream profile sheet.

I. WASTE SHIPPER INFORMATION

1. DST customer (waste shipper/generator): 242-A Evaporator
2. Contact: R. R. Bloom
3. Phone: 373-4574
4. Mail stop: S6-71

II. GENERAL WASTE INFORMATION

1. DST customer: 242-A Evaporator
2. Waste stream name: Campaign 99-1 Evaporator Slurry
3. Process generating waste: Waste from tank 102-AW will be concentrated and sent to tanks 102-AW and 106-AW
4. Anticipated volume including any flush water: 228,000 gallons
5. Anticipated transfer frequency: continuous during the campaign
6. Method of transfer (railcar, truck, pipeline): pipeline
7. Were analytical data used to fill out this profile sheet?

☒ Yes ☐ No

If yes, cite document used as the basis for sampling and analysis (i.e., waste analysis plan and/or sampling analysis plan) and attach a complete copy of the latest results.

Tank 241-AW-102 Grab Samples in Support of 242-A Evaporator Campaign 99-1, Analytical Results for the Final Report HNF-1665, Rev. 0.

J-15

8. Does the waste stream contain waste that was not generated as part of Hanford's Cleanup?
☐ Yes ☒ No
9. Is the waste subject to the Toxic Substance Control Act? ☐ Yes ☒ No
10. Is the waste subject to any disposal requirements other than those mandated under the Resource Conservation and Recovery Act? ☐ Yes ☒ No
 If yes, identify those requirements _____
11. At the point of origination, does the waste contain 10% or more organics?
☐ Yes ☒ No
12. Does the waste qualify for the exemption for mixed waste listed in 40 C.F.R. 264.1080 (b)(6)? ☒ Yes ☐ No
13. Does waste contain any material that was generated by a spill? ☐ Yes ☒ No

III.

WASTE STREAM COMPOSITION

List all constituents that are greater than 1,000 mg/kg.

1. Component	2. Concentration range (units)	3. Average % (sum of average % of waste stream components must total 100)	4. Basis for composition
Water	50% to 95%	82%	Analysis/PK
Organics, Radionuclides, And inorganics	5% to 50%	18%	Analysis/PK
	to		

IV. PHYSICAL PROPERTIES

1. Physical state at 70°F (identify all applicable)

Liquid ☒
Slurry ☐Semisolid ☐
Sludge ☐Solid ☐
Gas ☐

2. Viscosity at 70°F(degree)
- ☒
- < 0.01 kg/m*s
- ☐
- > 0.01 kg/m*s

3. Is waste multi-layered?
- ☐
- Yes
- ☒
- No

If yes, describe and quantify each layer:

a. (Top) ----- %

b. ----- %

c. (Bottom) ----- %

d. Suspended solids: ☐ < 1% ☒ between 1% and 10% ☐ > 10%e. Flash point: ☒ > 200 °F ☐ between 100 and 200 °F ☐ < 100 °Ff. Color: Clear to Yellow

4. Does the waste contain polychlorinated biphenyls (PCB)
- ☐
- Yes
- ☒
- No

If so what is the concentration range Maximum Minimum

5. Does the waste contain organics
- ☒
- Yes
- ☐
- No

If yes what is the range of the organics 4.0 Maximum 0.58 Minimum. (Units g/L TOC)

V. SPECIFIC ANALYSIS OF WASTE

Fill in the following chart giving maximum, minimum, or averages for each specific analyte. Also state whether this information is based on process knowledge or actual analytical data.

Parameter	Minimum	Maximum	Average	Basis
Ammonia (grams/liter)	0	0.07	0.056	Analysis/PK
Chloride (only for waste going to 204-AR) (moles/liter)	N/A	N/A	N/A	N/A
Energetics (net exotherm or no net exotherm)	No net exotherm	No net exotherm	No net exotherm	Analysis/PK
Hydroxide (moles/liter)	0.4	2.6	2.44	Analysis/PK
Moisture (volume % water)	60%	95%	70%	Analysis/PK
Nitrate (moles/liter)	0.28	1.7	1.58	Analysis/PK
Nitrite (moles/liter)	0.23	1.4	1.31	Analysis/PK
Organics, separable (visible or not visible)	No visible layer	No visible layer	No visible layer	Analysis
pH (pH units)	12	14	13.1	Analysis/PK
Sodium (grams/liter)	27	200	135	Analysis/PK
Sodium Hydroxide (grams/liter)	17	100	88	PK
Solids (volume %)	0	5	2.4	Analysis/PK
Specific gravity	1.05	1.4	1.30	Analysis/PK
Total Organic Carbon (grams/liter)	0.58	4	3.23	Analysis/PK
Americium-241 (curies/liter)	1.83E-8	1.20E-7	1.02E-7	Analysis/PK
Cesium-137 (curies/liter)	3.31E-2	2.00E-1	1.84E-1	Analysis/PK
^{239/240} Pu (curies/liter)	1.44E-7	9.00E-7	8.00E-7	Analysis/PK
Strontium 90 (curies/liter)	2.34E-5	2.00E-4	1.30E-4	Analysis/PK
^{233/235} Uranium (grams/liter)*	2.79E-5	1.60E-4	1.40E-4	PK
Yttrium-90 (curies/liter)	2.34E-5	2.00E-4	1.30E-4	PK
Neutron Absorbers (required if Pu equivalent $\geq 0.001\text{g/L}$) Absorbers = chromium, iron, manganese, nickel, aluminum, and zirconium	N/A Pu < 0.001g/l	N/A Pu < 0.001g/l	N/A Pu < 0.001g/l	Analysis/PK

VI. REACTIVITY AND STABILITY

1. What are the Reactivity Group¹ number(s) for this waste?

10 and 106

2. Is this material stable? ☒ Yes ☐ No

If no, explain: -----

3. Is this material shock sensitive? ☐ Yes ☒ No

If yes, explain: -----

1. From EPA, 1984, Design and Development of Hazardous Waste Reactivity Testing Protocol, EPA-600/2-84-057, U. S. Environmental Protection Agency, Washington D.C. Alternatively the categories specified in 40 CFR 265 appendix V may be specified.

VII. DANGEROUS WASTE INFORMATION

1. Is this waste a dangerous waste as defined by WAC 173-303?

☒ Yes ☐ No

2. If it is a dangerous waste, list the applicable Hazardous and/or Dangerous Waste number(s) and explain the basis for the number. For example if you assign D001, the reason for selection is that the flash point is less than 140 °F.

Hazardous/Dangerous Waste number	Reason for selection
See attached Table 1	

3. Is waste a mixed waste? ☒ Yes ☐ No

4. List any reportable quantities listed in 40 CFR 302.4 that are applicable to the waste.

Constituent	Reportable quantity
See attached Table 1	

1. WAC 173-303, 1994, "Dangerous Waste Regulations," Washington Administrative Code

VIII. LAND DISPOSAL RESTRICTION INFORMATION

Fill in the following information pertaining to all applicable Land Disposal Restrictions (LDR) (See 40 CFR 268.40¹ and WAC 173-303-140²). For certain waste designated as D001, D002, and/or D0012-D043, also indicate any underlying hazardous constituents which do not meet LDR requirements (see 40 CFR 268.7¹).

Washington and/or EPA Dangerous (Hazardous) Waste Number	Waste Constituent for which the DST system must monitor Place an * before the entry if this is for an underlying hazardous constituent.	Treatability Group (wastewater or nonwastewater)	Treatment Standard
See attached Table 2			

- 40 CFR 268, "Land Disposal Restrictions," Code of Federal Regulations, as amended.
- WAC 173-303, "Dangerous Waste Regulations," Washington Administrative Code, as amended.

IX. SUPPLEMENTAL INFORMATION AND ACCOUNTABILITY STATEMENT

1. Is there an attachment containing additional information?

☒ Yes ☐ No (list below)

2. I hereby certify that to the best of my knowledge all information submitted in this and all attached documents contain true and accurate descriptions of this waste. Any sample that was analyzed or submitted was representative as defined in 40 CFR 261 Appendix I¹ or by using an equivalent method. All relevant information regarding known or suspected hazards in the possession of the DST customer and generator has been disclosed.

Authorized signature

Elvis Q. Le, Process Engineer
Name and title

5/5/99
Date

Authorized signature

Don L. Flyckt, ECO
Name and title

5/7/99
Date

Table 1 Waste Designation & Reportable Quantities		
Constituent	Reason for Selection	Reportable Quantity (lbs)
D001	Receipt of waste with this code	100
D002	Receipt of waste with this code	100
D003	Receipt of waste with this code	100
D004	Receipt of waste with this code	1
D005	Receipt of waste with this code	1000
D006	Receipt of waste with this code	10
D007	Receipt of waste with this code	10
D008	Receipt of waste with this code	10
D009	Receipt of waste with this code	1
D010	Receipt of waste with this code	10
D011	Receipt of waste with this code	1
D018	Receipt of waste with this code	10
D019	Receipt of waste with this code	10
D022	Receipt of waste with this code	10
D028	Receipt of waste with this code	100
D029	Receipt of waste with this code	100
D030	Receipt of waste with this code	10
D033	Receipt of waste with this code	1
D034	Receipt of waste with this code	100
D035	Receipt of waste with this code	5000
D036	Receipt of waste with this code	1000
D038	Receipt of waste with this code	1000
D039	Receipt of waste with this code	100
D041	Receipt of waste with this code	10
D043	Receipt of waste with this code	1
WT01	Receipt of waste with this code	NA
WT02	Receipt of waste with this code	NA
WP01	Receipt of waste with this code	NA
F001	Receipt of waste with this code	10
F002	Receipt of waste with this code	10
F003	Receipt of waste with this code	100
F004	Receipt of waste with this code	100
F005	Receipt of waste with this code	100

Table 2 Land Disposal Information			
Washington and/or EPA Dangerous (Hazardous) Waste Number	Waste constituent	Treatability Group	Treatment Standard "mg/L"
D001	Ignitability	Nonwastewater	DEACT & 268.48
D002	Corrosivity	Nonwastewater	DEACT & 268.48
D003	Reactivity	Nonwastewater	DEACT
D004	Arsenic	Nonwastewater	5.0
D005	Barium	Nonwastewater	100
D006	Cadmium	Nonwastewater	1.0
D007	Chromium	Nonwastewater	5.0
D008	Lead	Nonwastewater	5.0
D009	Mercury	Nonwastewater	0.20
D010	Selenium	Nonwastewater	5.7
D011	Silver	Nonwastewater	5.0
D018	Benzene	Nonwastewater	10 & 268.48
D019	Carbon Tetrachloride	Nonwastewater	6.0 & 268.48
D022	Chloroform	Nonwastewater	6.0 & 268.48
D028	1,2-Dichloroethane	Nonwastewater	6.0 & 268.48
D029	1,1-Dichloroethylene	Nonwastewater	6.0 & 268.48
D030	2,4-Dinitrotoluene	Nonwastewater	140 & 268.48
D033	Hexachloroethane	Nonwastewater	30 & 268.48
D035	Methyl Ethyl Ketone	Nonwastewater	36 & 268.48
D036	Nitrobenzene	Nonwastewater	14 & 268.48
D038	Pyridine	Nonwastewater	16 & 268.48
D039	Tetrachloroethylene	Nonwastewater	6.0 & 268.48
D040	Trichloroethylene	Nonwastewater	6.0 & 268.48
D041	2,4,5-Trichlorophenol	Nonwastewater	7.4 & 268.48
D043	Vinyl chloride	Nonwastewater	6.0 & 268.48
WT01	State only extremely toxic hazardous waste	Nonwastewater	None
WT02	State only extremely toxic hazardous waste	Nonwastewater	None
WP01	Halogenated hydrocarbons	Nonwastewater	None
WP02	Halogenated hydrocarbons	Nonwastewater	None
F001	1,1,1-Trichloroethane	Nonwastewater	6.0
F002	Acetone		160
F003	Methylene Chloride		30
F004	Methyl Isobutyl		33
F005	Ketone		36
	o-Cresol & p-Cresol		5.6

Parameters For Operational Decisions

Fill in the following chart giving maximum, minimum, or averages for each specific analyte. Also state whether this information is based on process knowledge or actual analytical data. This information supplements the information on the Waste Stream Profile Sheet which is required by the DST Waste Analysis Plan.

PARAMETER (moles/liter)	MINIMUM (specify units)	MAXIMUM (specify units)	AVERAGE (specify units)	BASIS (Process Knowledge or Analysis)
Aluminum	0.05 M	0.4 M	0.28	Both
Americium 241	1.83E-8 Ci/L	1.20E-7 Ci/L	1.02E-7 Ci/L	Both
Carbonate	0.15 M	1.0 M	0.88 M	Both
Cesium 137	3.31E-2 Ci/L	2.00E-1 Ci/L	1.84E-1 Ci/L	Both
Cyanide	0.0 ug/ml	<1000 ug/ml	NA ¹	PK
Flouride	0.07 M	0.6 M	0.44 M	Both
Phosphate	0.008 M	0.06 M	0.046 M	Both
Plutonium 239/240	1.44E-7 Ci/L	9.0E-7 Ci/L	8.0E-7 Ci/L	Both
Sodium	1.2 M	7 M	6.83 M	Both
Total Dissolved Solids, %	5%	30%	18%	Both
Strontium 90	2.3E-5 Ci/L	2.0E-4 Ci/L	1.3E-4 Ci/L	Both
Sulphate	1.2E-2 M	8.0E-2 M	7.1E-2 M	Both
Temperature	20 C	56 C	50 C	Both
Total alpha	9.7E-7 Ci/L	6.0E-6 Ci/L	5.4E-6 Ci/L	Both
Total Fuel content	0 J/g	0 J/g	0 J/g	Analysis
Organic Carbon	0.5 g/L	4 g/L	3.23 g/L	Both

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