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Tank Characterization Report for Double-Shell Tank 241-AN-101

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Abstract: This document summarizes the information on the historical uses, present status, and the sampling and analysis results of waste stored in Tank 241-AN-101. This report supports the requirements of Tri-Party Agreement Milestone M-44-09.

Kara J Broz 8/8/96
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Tank Characterization Report for Double-Shell Tank 241-AN-101

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EXECUTIVE SUMMARY

This tank characterization report summarizes information on the historical uses, current status, and sampling and analysis results of waste stored in double-shell underground storage tank 241-AN-101. This report supports the requirements of the *Hanford Federal Facility Agreement and Consent Order*, Milestone M-44-09 (Ecology et al. 1996).

Tank 241-AN-101 is one of seven double-shell tanks in the 200 East Area AN Tank Farm on the Hanford Site. The tank went into service in 1981, receiving PUREX low-level waste. In 1983, it began receiving saltwell liquid pumped from single-shell tanks. These transfers continued through October 1995 and have involved more than 30 single-shell tanks. Periodically the waste in tank 241-AN-101 was sent to tank 241-AW-102 for concentration in the 242-A Evaporator. Other waste types received by tank 241-AN-101 include supernatant from tanks 241-AY-102, 241-AW-105, 241-AN-103, 241-AW-102; B Plant low-level waste; and concentrated phosphate waste from the N Reactor.

A description and the status of tank 241-AN-101 are summarized in Figure ES-1 and Table ES-1. The tank has an approximate capacity of 4,390 kL (1,160 kgal) and contains 4,090 kL (1,080 kgal) of dilute noncomplexed waste, composed entirely of supernatant (Hanlon 1996). Tank 241-AN-101 is an active tank, so the waste volumes in Figure ES-1 and Table ES-1 may not represent the current tank contents.

Figure ES-1. Profile of Tank 241-AN-101.

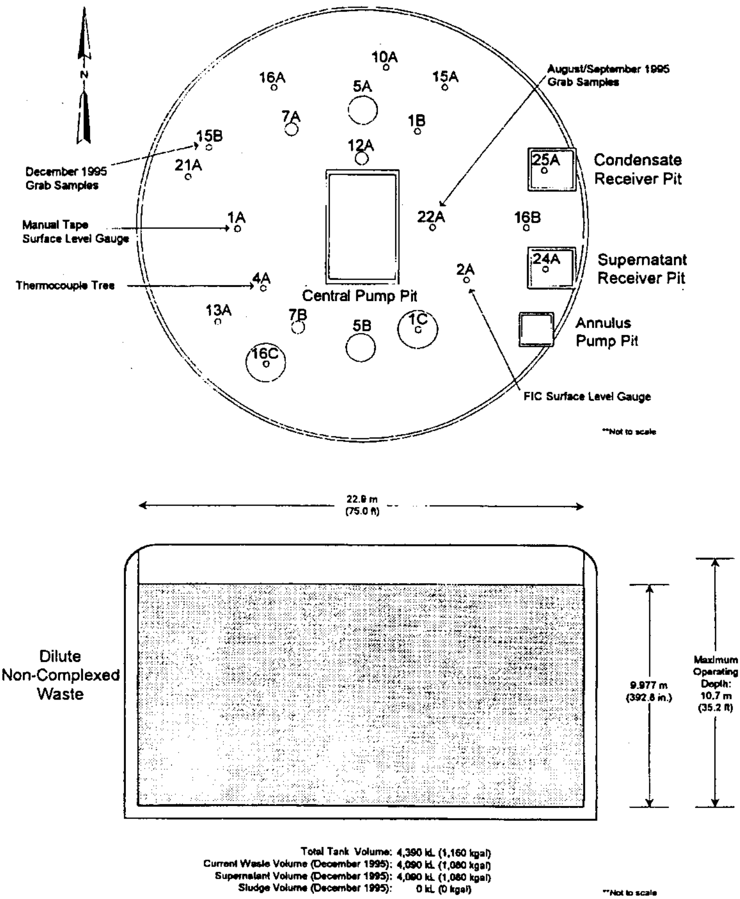

Table ES-1. Description and Status of Tank 241-AN-101.

TANK DESCRIPTION	
Type	Double-shell
Constructed	1980-81
In service	1981
Diameter	22.9 m (75.0 ft)
Maximum operating depth	10.7 m (35.2 ft)
Capacity	4,390 kL (1,160 kgal)
Bottom shape	Flat
Ventilation	Active
TANK STATUS	
Waste classification	Dilute noncomplexed
Total waste volume (December 1995)	4,090 kL (1,080 kgal)
Supernatant volume (December 1995)	4,090 kL (1,080 kgal)
Sludge volume (December 1995)	0 kL (0 kgal)
Waste surface level (March 21, 1996)	9.98 m (392.8 in.)
Temperature (July 1983 to March 1996)	32.4 to 11 °C (90.3 to 52 °F)
Integrity	Sound
Watch List	None
SAMPLING DATES	
Grab samples	August/September 1995, December 1995
SERVICE STATUS	
In service	

The characterization of tank 241-AN-101 is based on two 1995 grab sampling events, one in August/September and the other in December. The August/September sampling event was performed to satisfy the requirements of the *Data Quality Objectives for the Waste Compatibility Program* (Fowler 1995). Three grab samples were obtained from riser 22A. The sampling and analyses were performed in accordance with the *Compatibility Grab Sampling and Analysis Plan* (Jones 1995) with the following exception. Jones (1995) cites revision 0 of the waste compatibility data quality objective (DQO) as the applicable DQO. However, the samples were analyzed against Fowler (1995) because it was the most recent revision (revision 1) of the waste compatibility DQO. As required by the waste compatibility DQO, analyses for energetics, moisture content, total organic carbon (TOC), total inorganic carbon (TIC), selected metals, anions, selected radionuclides, pH, and specific gravity were performed on the grab samples, along with a visual check for the presence of an organic layer.

A decision was made later to conduct a safety screening assessment on the tank according to *Tank Safety Screening Data Quality Objective* (Dukelow et al. 1995). Because the DQO requires a vertical profile of waste from two risers, three grab samples were taken from riser 15B in December 1995. The results were to be used in conjunction with the results from the August/December 1995 sampling event, which were from a different riser.

As prescribed by the safety screening DQO, the grab samples were checked for the presence of an organic layer and analyzed for energetics, moisture content, total alpha activity, and specific gravity. The total alpha activity analyses were not required by the waste compatibility DQO, so it was necessary to perform these analyses on archived samples from the August/September 1995 sampling event. Prior to removal of the grab samples, the tank vapors were field tested using a combustible gas meter.

After the December 1995 sampling event, it was discovered that in September and October 1995, tank AN-101 received waste from saltwell liquid pumping and an unknown source. Because the tank contents changed during the time between sampling events, only the December 1995 results were used to complete the safety screening evaluation. An additional sampling event may be necessary to complete a safety screening assessment while satisfying the safety screening DQO requirement of obtaining samples from two risers.

Comparisons were made between the analytical results and the notification limits of the safety screening DQO. No exothermic reactions were observed for any samples. The average weight percent water value by thermogravimetric analysis (TGA) was 65.4 weight percent. The overall total alpha activity mean was < 0.00147 μCi/mL, which was far below the notification limit. The concentration of the tank headspace gases was 0 percent of the lower explosive limit (LEL), which more than satisfied the safety screening requirement.

Comparisons also were made between the analytical results and the safety and operational limits identified in the waste compatibility DQO. The safety issues of the DQO include energetics, criticality, flammable gas accumulation, and corrosion. All analytical results satisfied their respective safety criteria. In addition, all the operational limits evaluated were satisfied; the transuranic (TRU) content, and heat load were below levels which would cause the waste to be segregated.

The tank heat load, based on radionuclide analytical data, was 2,380 W (8,120 Btu/hr), much lower than the 20,500 W (70,000 Btu/hr) operating specification limit. The historical tank content estimate (HTCE) prediction for heat load was 102 W (349 Btu/hr) (Brevick et al. 1995a). The average tank temperature between July 1983 and March 1996 was 22.1 °C (71.8 °F), with a minimum of 11 °C (52 °F) and a maximum of 32.4 °C (90.3 °F). March 21, 1996 surveillance data show a waste level of 9.977 m (32.73 ft).

Table ES-2 provides concentration and inventory estimates for the most prevalent analytes and analytes of concern. The sample results used for this table are from the August/September 1995 sampling event. Since that time, waste transactions have occurred and the table is no longer representative of the tank contents.

Table ES-2. Major Analytes and Analytes of Concern for Tank 241-AN-101.[1] (2 sheets)

Analyte	Overall Mean Concentration	Relative Standard Deviation (Mean)	Projected Inventory
METALS	**μg/mL**	**%**	**kg**
Aluminum	20,900	3.5	85,500
Sodium	1.28E+05	3.0	5.24E+05
ANIONS	**μg/mL**	**%**	**kg**
Chloride	3,300	1.0	13,500
Hydroxide	31,400	2.5	1.28E+05
Nitrate	97,100	1.8	3.97E+05
Nitrite	48,200	2.7	1.97E+05
Phosphate	2,120	19.2	8,670
Sulfate	3,040	24.5	12,400
RADIONUCLIDES	**μCi/mL**	**%**	**Ci**
^{137}Cs	123	0.6	5.03E+05
^{90}Sr	0.378	28.3	1,550
Total alpha	< 0.00059	---	< 2.41

Table ES-2. Major Analytes and Analytes of Concern for Tank 241-AN-101.[1] (2 sheets)

Analyte	Overall Mean Concentration	Relative Standard Deviation (Mean)	Projected Inventory
CARBON	**μg/mL**	**%**	**kg**
Total inorganic carbon	2,450	2.7	10,000
Total organic carbon	2,630 (7,670)[2]	18.0	10,800
PHYSICAL PROPERTIES			
pH	13.6	2.3 %	---
Water	66.0 wt %	0.5 wt %	2.70E+06
Specific gravity	1.23	1.0 %	---

Notes:

[1]Esch (1995 and 1996)

[2]Value in parentheses is the TOC dry weight result.

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LIST OF TERMS

ANOVA	analysis of variance
Btu/hr	British thermal units per hour
Ci	curies
Ci/g	curies per gram
Ci/L	curies per liter
cm	centimeters
DBP	Dibutyl phosphate
DQO	data quality objective
DSC	differential scanning calorimetry
EDTA	Ethylenediaminetetraacetic acid
FIC	Food Instrument Corporation
ft	feet
g/gal	grams per gallon
g/L	grams per liter
g/mL	grams per milliliter
GEA	gamma energy analysis
HDW	Hanford Defined Waste
HEDTA	N-hydroxyethylenediaminetriacetic acid
HTCE	Historical Tank Content Estimate
IC	ion chromatography
ICP	inductively coupled plasma spectroscopy
ID	identification
in.	inches
J/g	joules per gram
kg	kilograms
kgal	kilogallons
kL	kiloliters
LEL	lower explosive limit
LFL	lower flammability limit
m	meters
M	moles per liter
mg	milligrams
mL	milliliters
mrad/hr	millirads per hour
ppm	parts per million
PUREX	plutonium-uranium extraction
RPD	relative percent difference
RSD	relative standard deviation
SAP	sampling and analysis plan
SpG	specific gravity
TGA	thermogravimetric analysis
TIC	total inorganic carbon

LIST OF TERMS (Continued)

TLM	Tank Layer Model
TOC	total organic carbon
TRU	transuranics
W	watts
WSTRS	Waste Status and Transaction Record Summary
wt%	weight percent
°C	degrees Celsius
°F	degrees Fahrenheit
μCi/g	microcuries per gram
μCi/mL	microcuries per milliliter
μeq/g	microequivalents per gram
μg/g	micrograms per gram
μg/mL	micrograms per milliliter
ΔH	change in enthalpy

1.0 INTRODUCTION

This tank characterization report presents an overview of double-shell tank 241-AN-101 and its waste contents. It provides estimated concentrations and inventories for the waste components based on the latest sampling and analysis activities in combination with background tank information. The characterization of tank 241-AN-101 is based on two grab sampling events which occurred in August/September and December 1995.

Tank 241-AN-101 is still in service and may continue to transfer or receive waste. Consequently, the composition of the tank waste may change depending on the waste types received. The concentration and inventory values reported in this document reflect the best estimates based on available data. This report supports the requirements of the *Hanford Federal Facility Agreement and Consent Order*, Milestone M-44-09 (Ecology et al. 1994).

1.1 PURPOSE

The purpose of this report is to summarize the information about the use and contents of tank 241-AN-101. This information will be used to assess issues associated with safety, operations, environmental, and process development activities. This report also serves as a reference point for more detailed information about tank 241-AN-101.

1.2 SCOPE

The August/September 1995 grab sampling event was performed to satisfy the requirements of the *Data Quality Objectives for the Waste Compatibility Program* (Fowler 1995). Three grab samples were taken at different depths from one riser. As required by the DQO, the following analyses were performed: differential scanning calorimetry (DSC) for energetics, thermogravimetric analysis (TGA) for moisture content, furnace oxidation for TOC and TIC, gamma energy analysis (GEA) for ^{137}Cs, beta proportional counting for ^{90}Sr, inductively coupled plasma spectroscopy (ICP) for Al, Fe, and Na, titration for OH^-, ion chromatography (IC) for Cl^-, F^-, NO_2^-, NO_3^-, PO_4^{3-}, and SO_4^{2-}, pH, alpha proportional counting for ^{241}Am and $^{239/240}Pu$, specific gravity, centrifugation for percent solids, and a visual check for an organic layer.

A decision was made later to conduct a safety screening evaluation on the tank according to the *Tank Safety Screening Data Quality Objective* (Dukelow et al. 1995). A set of three grab samples was taken from the tank in December 1995. The following five analyses were performed on the recovered waste: DSC, TGA, total alpha activity analysis, density, and a visual check for an organic layer. As also required by the safety screening DQO, tank vapors were field tested using a combustible gas meter. The number of analyses was small because of the narrow focus of the sampling event, that is, verification of the non-Watch List status of the tank and/or identification of any unknown safety issues.

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2.0 HISTORICAL TANK INFORMATION

This section describes tank 241-AN-101 based on historical information. The first part details the current condition of the tank. This is followed by discussions of the tank's background, transfer history, and the process sources that contributed to the tank waste, including an estimate of the current contents based on the process history. Events that may be related to tank safety issues, such as potentially hazardous tank contents or off-normal operating temperatures, are included. The final part summarizes available surveillance data for the tank. Solid and liquid level data are used to determine tank integrity (leaks) and to provide clues to internal activity in the solid layers of the tank. Temperature data are provided to evaluate the heat generating characteristics of the waste.

2.1 TANK STATUS

As of December 31, 1995, tank 241-AN-101 contained an estimated 4,090 kL (1,080 kgal) of dilute noncomplexed waste (Hanlon 1996). Liquid volume was determined using a combination of a Food Instrument Corporation (FIC) automatic surface level gauge and a manual tape surface level gauge. Solids volume was determined using a sludge level measurement device. Table 2-1 shows the volume of the waste phases found in the tank.

Table 2-1. Estimated Tank Contents (December 1996).[1,2]

Waste Form	Volume	
	kL	kgal
Total waste	4,090	1,080
Supernatant liquid	4,090	1,080
Drainable interstitial liquid	0	0
Drainable liquid remaining	4,090	1,080
Pumpable liquid remaining	4,090	1,080
Sludge	0	0
Saltcake	0	0

Note:

[1]Hanlon (1996)

[2]Because tank 241-AN-101 is an active tank, the waste volumes in this table may not reflect current tank contents.

Tank 241-AN-101 is an active dilute receiver and receives noncomplexed saltwell waste. It is actively ventilated and categorized as sound. Currently, the waste is classified as dilute noncomplexed. This tank is not on any Watch Lists. All monitoring systems were in compliance with documented standards as of December 31, 1995 (Hanlon 1996).

2.2 TANK DESIGN AND BACKGROUND

The AN Tank Farm is the newest generation double-shell design tank farm. It was built between 1980 and 1981. The tank farm consists of seven type 100 series, 4,390 kL (1,160 kgal) tanks. The tanks were designed to hold concentrated supernatant with a maximum fluid temperature of 177 °C (350 °F). The AN Tank Farm does not use a cascade system between tanks. Tank 241-AN-101 has 61 risers ranging in diameter from 10 cm (4 in.) to 107 cm (42 in.) that provide surface level access to the underground tank and annulus. This tank has five risers available for sampling: three 10 cm (4 in.) risers (10A, 15B, and 21A) and two 30 cm (12 in.) risers (7B and 12A). If used as sampling ports, the risers would access a wide area of the north half of the tank and one point in the south half of the tank.

Tank 241-AN-101 entered service in September 1981. It is constructed of 0.46-m (1.5-ft) thick concrete walls and a 0.38-m (1.25-ft) thick concrete dome. The mild carbon steel liner on the bottom is 1.3 cm (0.5 in.) thick, and the lower part of the sides are 1.9 cm (0.75 in). The upper part of the sides are 1.3 cm (0.5 in.) thick, and the dome liner is 0.95-cm (0.375-in.) thick steel. The inner liner has been heat-treated and stress-relieved. The secondary liner is made of 0.95 cm (0.375 in.) mild carbon steel. The outer liner has not been heat-treated. The tank has a flat bottom and an 11.8 m (38.6 ft) liner height with a maximum operating depth of 10.7 m (35.2 ft). In addition, the tank has a grid of drain slots beneath the steel liner bottom. The grid collects any leaks that may occur and diverts them to a leak detection well. The grid also serves as an escape route for free water formed as it is released from the concrete grout during the initial heating of the tank. The bottom center elevation of tank 241-AN-101 is 186.76 m (612.74 ft). The tank is set on an insulated, reinforced concrete foundation. Coatings and sealants were used to ensure that no leaks and intrusions exist.

Table 2-2 lists tank 241-AN-101 risers and shows their size and typical use. Annulus risers are not included in this table. Figure 2-1 shows the riser configurations and locations. Figure 2-2 shows a tank cross section with the approximate waste level and a schematic of the tank equipment.

Table 2-2. Tank 241-AN-101 Risers.[1]

New Riser Number[2]	Riser Number	Diameter (inches)	Description and Comments[3]
102	1A	4	Sludge measurement port; manual tape surface level gauge
103	1B	4	Sludge measurement port
101	1C	4	Sludge measurement port with 12 in. cover and protective concrete pad
104	2A	4	FIC surface level gauge
105	3A	12	Supernatant pump, central pump pit
106	4A	4	Thermocouple tree
108	5A	42	Manhole
107	5B	42	Manhole
112	7A	12	Tank ventilation
111	7B	12	Spare
125	10A	4	Flush pit drain, spare
126	11A	42	Slurry distributor, central pump pit
127	12A	12	Observation port, spare
128	13A	4	Tank pressure
129	14A	4	Supernatant return, central pump pit
131	15A	4	High liquid level sensor
130	15B	4	Spare
134	16A	4	Sludge measurement port
132	16B	4	Sludge measurement port
133	16C	4	Sludge measurement port
155	21A	4	Spare
156	22A	4	Sludge measurement port
160	24A	6	Supernatant receiver (pit)
161	25A	8	Condensate receiver (pit)

Notes:

[1]Alstad (1992), Vitro Engineering Corporation (1987), WHC (1992)

[2]Denotes Engineering Change Notice 613266, dated January 20, 1995 made against the referenced drawings.

[3]Annulus risers are not included in this table.

Figure 2-1. Riser Configuration for Tank 241-AN-101.

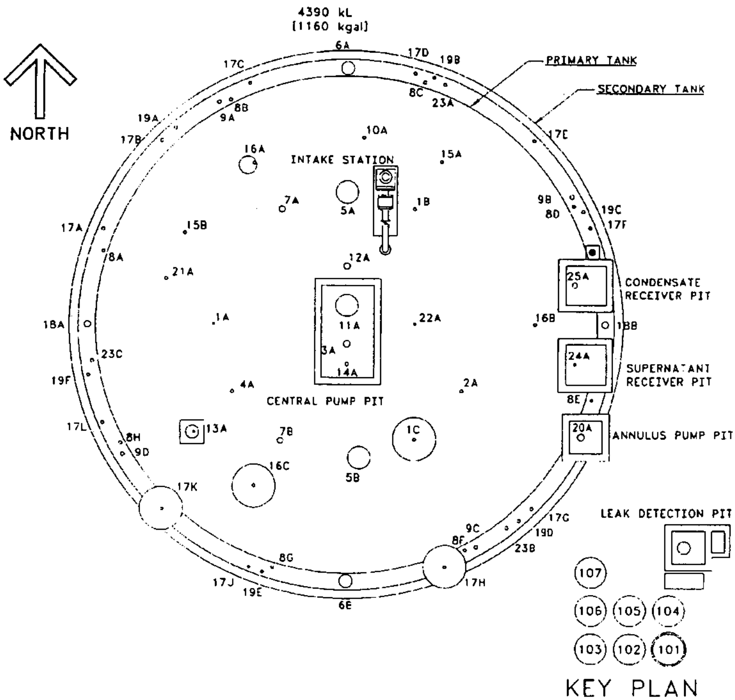
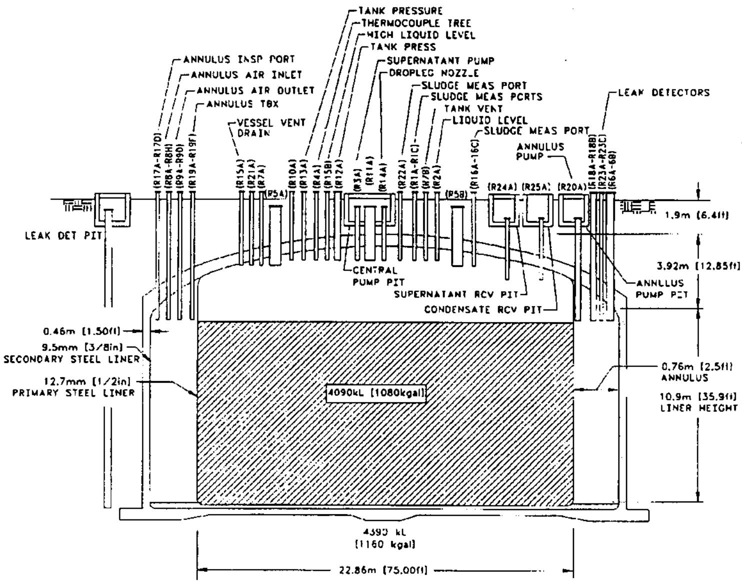


Figure 2-2. Tank 241-AN-101 Cross Section.



2.3 PROCESS KNOWLEDGE

This section presents the transfer history of tank 241-AN-101. The major waste receipts prior to 1994 are taken from the *Waste Status and Transaction Record Summary for the Southeast Quadrant of the Hanford 200 Area* (Agnew et al. 1996) (see Section 2.3.1 and Table 2-3). The post-1993 data are from a database developed for waste volume projections and have not been validated (see Section 2.3.2 and Table 2-4). Section 2.3.3 describes the historical estimate of the tank's waste contents.

2.3.1 Waste Transfer History Prior to 1994

PUREX low-level waste was transferred to tank 241-AN-101 in September 1981. Water was added to tank 241-AN-101 from the fourth quarter of 1981 until the second quarter of 1982. During the fourth quarter of 1981, an unknown waste type was transferred from tank 241-AN-101 to tank 241-AN-106.

From the third quarter of 1982 until the second quarter of 1985, tank 241-AN-101 received additional low-level waste from PUREX. From the second quarter of 1983 until the first quarter of 1992, tank 241-AN-101 received dilute, noncomplexed liquid waste pumped from saltwells in single-shell tanks in the 200 East and West Areas. Table 2-3 lists the tanks involved in the pumping and waste transfer. From the fourth quarter of 1983 until the fourth quarter of 1988, tank 241-AN-101 transferred liquid waste to tank 241-AW-102. This transfer was used for the 242-A Evaporator as a liquid feed source.

Agnew et al (1996) indicates that tank 241-AN-101 received an unknown waste type from tanks 241-AY-102, 241-AW-105, and 241-AN-103 during 1984. Tank 241-AN-101 also transferred an unknown waste type to tanks 241-AN-102, 241-AZ-102, 241-AW-101 and 241-AN-103. According to historical records, these were transfers of noncomplexed waste. Additional waste was added to tank 241-AN-101 from B Plant low-level waste operations.

Additional low-level waste from PUREX was added in the second quarter of 1985. In the third quarter of 1985, the tank received concentrated phosphate waste from N Reactor. During the second quarter of 1987, tank 241-AN-101 received waste from tank 241-AW-102.

Table 2-3. Summary of Incoming Waste Transfer History Prior to 1994.[1,2]

Transfer Source	Waste Type Received	Time Period	Estimated Waste Volume	
			kL	kgal
A Plant (PUREX)	PUREX low-level waste	1981 to 1983	1,064	281
241 tanks: A-102, AX-101, AX-102, AX-103, B-104, B-106, B-107, B-108, B-110, BX-104, BX-105, BX-107, BX-109, BX-110, BX-111, BX-112, BY-102, BY-103, BY-104, C-105, C-107, S-105, S-108, S-111, S-112, T-109, T-111, TX-113, TX-116, U-101	Saltwell liquid from listed single-shell tanks	1983 to 1992	4,652	1,229
241-AY-102	Supernatant from tank 241-AY-102	1984	659	174
241-AW-105	Supernatant from tank 241-AW-105	1984	935	247
B Plant	B Plant low level waste	1984	216	57
241-AN-103	Supernatant from tank 241-AN-103	1984	454	120
A Plant (PUREX)	PUREX low level waste	1985	541	143
N Reactor	Concentrated phosphate waste from N Reactor	1985	189	50
241-AW-102	Dilute noncomplexed waste from tank 241-AW-102	1987	1,333	352

Notes:

[1]Agnew et al. 1996

[2]Waste volumes and types are best estimates based on historical data.

2.3.2 Waste Transfer History After January 1, 1994

All transfer history information after January 1, 1994 was taken from a waste volume projection database. No discussion was provided with the transfer history data. The information should be used with caution because the data have not been validated. Table 2-4 shows the post-1993 transfer history data.

Unknown waste gains or losses in Table 2-4 may be the result of rounding calculations, clean water slowly leaking through a valve, changes in levels (expansion/contraction) because of ambient temperature changes, different measuring devices being used by tank farm operators, transfers taking place during the end of the month, tank farm activities such as miscellaneous water additions not associated with facility waste generation, or the additional water that is added to aging waste tanks and then evaporated off.

2.3.3 Historical Estimation of Tank Contents

The following is an estimate of the contents for tank 241-AN-101 based on historical transfer data. The historical data used for the estimate is the *Waste Status and Transaction Record Summary for the Southeast Quadrant of the Hanford 200 Area* (WSTRS) (Agnew et al. 1996), *the Hanford Defined Waste: Chemical and Radionuclide Compositions* (HDW) list (Agnew 1995), and the *Tank Layer Model (TLM)* (Agnew et al. 1995) from the *Historical Tank Content Estimate for the Southeast Quadrant of the Hanford 200 Areas* (HTCE) (Brevick et al. 1995a). The WSTRS is a compilation of waste transfer and volume status data. The HDW provides the assumed typical compositions for fifty separate waste types. In most cases, the data are incomplete, reducing the reliability of the transfer data and the modeling results derived from it. The TLM takes the WSTRS data, models the waste deposition processes, and using additional data from the HDW, generates an estimate of the tank contents. Several errors are introduced as the models are added to create the estimate. Thus, these model predictions can only be considered estimates which require further evaluation using analytical data.

As of December 31, 1995, tank 241-AN-101 contained an estimated 4,090 kL (1,080 kgal) of supernatant (Hanlon 1996). Because this tank is an active receiver of dilute noncomplexed waste, the waste volume and content will continue to vary. Therefore, the TLM and inventory estimates should be used with caution. Based on the HTCE and the TLM, tank 241-AN-101 contained 2,650 kL (700 kgal) of supernatant waste as of January 1, 1994. Table 2-5 presents an estimate of the expected waste constituents and concentrations.

Table 2-4. Summary of tank 241-AN-101 Waste Transfer History after January 1, 1994.[1]

Type of Entry	From	To	Start Date	End Date	Estimated Volume	
					kL	kgal
GA	SWLIQ		1/6/94	1/8/94	61	16
LO		UNKN*	2/1/94	2/28/94	-4	-1
GA	SWLIQ		3/22/94	3/22/94	68	18
GA	SWLIQ		4/10/94	4/25/94	129	34
GA	UNKN		5/1/94	5/31/94	4	1
GA	SWLIQ		6/11/94	6/11/94	64	17
GA	SWLIQ		6/29/94	6/29/94	49	13
GA	SWLIQ		7/17/94	7/17/94	49	13
GA	UNKN		9/1/94	9/30/94	4	1
GA	SWLIQ		10/15/94	10/15/94	38	10
GA	SWLIQ		11/19/94	11/19/94	45	12
GA	SWLIQ		1/23/95	1/23/95	45	12
GA	SWLIQ		2/28/95	2/28/95	61	16
LO		UNKN	3/1/95	3/31/95	-4	-1
LO		UNKN	4/1/95	4/30/95	-4	-1
LO		UNKN	5/1/95	5/31/95	-4	-1
GA	SWLIQ		6/30/95	6/30/95	30	8
GA	SWLIQ		7/12/95	7/12/95	34	9
GA	SWLIQ		8/12/95	8/29/95	204	54
GA	SWLIQ		9/8/95	9/8/95	68	18
GA	SWLIQ		9/15/95	9/15/95	68	18
GA	UNKN		10/1/95	10/31/95	8	2
GA	SWLIQ		10/14/95	10/14/95	64	17
GA	INST[2]		10/14/95	10/14/95	11	3
GA	UNKN		7/1/96	7/31/96	4	1

Notes:

GA = volume gain
LO = volume loss
UNKN = unknown waste type
SWLIQ = waste from single-shell tank saltwell pumping

[1]The table data have not been validated and are the best estimates based on the available information.
[2]Change in instrumentation baseline (FIC failed, currently using manual tape).

Table 2-5. Double-Shell Tank 241-AN-101 Historical Inventory Estimate.[1,2] (2 sheets)

Total Inventory Estimate			
Physical Properties			
Total waste	2.69E+06 kg (700 kgal)		
Heat load	102 W (349 Btu/hr)		
Bulk density[3]	1.01 g/mL		
Water wt%[3]	97.6		
Total Organic Carbon wt% Carbon (wet)[3]	0.032		
Chemical Constituents	**M**	**ppm**	**kg[4]**
Na^{+}	0.302	6,860	18,400
Al^{3+}	0.0329	877	2,350
Fe^{3+} (total Fe)	2.97E-04	16.4	44.0
Cr^{3+}	0.00106	54.2	145
Bi^{3+}	2.32E-05	4.79	12.9
La^{3+}	1.02E-07	0.0139	0.0374
Hg^{2+}	4.41E-07	0.0872	0.234
Zr (as $ZrO(OH)_2$)	1.02E-04	9.19	24.7
Pb^{2+}	3.39E-06	0.692	1.86
Ni^{2+}	2.12E-04	12.3	33.1
Sr^{2+}	1.07E-07	0.00928	0.0249
Mn^{4+}	4.14E-04	22.4	60.3
Ca^{2+}	0.00208	82.3	221
K^{+}	0.00731	282	757
OH^{-}	0.150	2,520	6,770
NO_3^{-}	0.131	8,040	21,600
NO_2^{-}	0.0396	1,800	4,830

Table 2-5. Double-Shell Tank 241-AN-101 Historical Inventory Estimate.[1,2] (2 sheets)

Total Inventory Estimate			
Chemical Constituents (Cont'd)	**M**	**ppm**	**kg[4]**
CO_3^{2-}	0.0193	1,140	3,070
PO_4^{3-}	0.00591	554	1,490
SO_4^{2-}	0.00708	671	1,800
Si (as SiO_3^{2-})	0.00147	40.8	110
F^-	0.00857	161	431
Cl^-	0.00517	181	486
Citrate	9.41E-04	176	471
$EDTA^{4-}$	3.27E-04	93.0	250
$HEDTA^{3-}$	5.34E-04	144	388
glycolate	0.00617	457	1,230
acetate	3.85E-04	22.4	60.2
oxalate	3.83E-07	0.0333	0.0894
DBP	4.72E-04	74.9	201
butanol	4.72E-04	34.5	92.6
NH_3	0.0238	398	1,070
$Fe(CN)_6^{4-}$	0	0	0
Radiological Constituents	**Ci/L**	**μCi/g**	**Ci**
Pu	2.24E-03	0.00222	0.0991 (kg)
U	2.88E-04 (M)	67.6 (μg/g)	182 (kg)
Cs	0.00716	7.06	19,000
Sr	7.43E-04	0.734	1,970

Notes:

[1]Brevick et al. (1995a)

[2]The HTCE predictions have not been validated and should be used with caution.

[3]Volume average for density; mass average water wt% and TOC wt% C.

[4]Small differences appear to exist among the inventories in this column and the inventories calculated from the two sets of concentrations. These differences are being evaluated.

2.4 SURVEILLANCE DATA

Tank 241-AN-101 surveillance consists of surface level measurements (liquid and solid), temperature monitoring inside the tank (waste and vapor space), and leak detection well monitoring for radioactive liquids outside the primary tank. The surveillance data provide the basis for determining tank integrity.

Liquid level measurements show major leaks in or out of the tank. Solid surface level measurements indicate the physical changes and consistency of the tank's solid layers. However, because of the nature of the waste received in tank 241-AN-101, solids are either suspended or dissolved and are not a significant contributor to the waste volume. Leak detection systems within the tank annulus will detect leaks from the primary tank and prevent leaks to the soil.

2.4.1 Surface Level Readings

The tank 241-AN-101 surface level is monitored with a Food Instrument Corporation gauge and a manual tape. Because this is an active tank, the surface level is continually subject to change. The surface level on March 21, 1996 was 9.977 m (392.8 in.), which equals approximately 4,090 kL (1,080 kgal). Figure 2-3 shows a level history graph of the volume measurements.

2.4.2 Internal Tank Temperatures

Temperature data for tank 241-AN-101 are recorded by 18 thermocouples on one thermocouple tree located in riser 4A. Non-suspect temperature data from the Computer Automated Surveillance System, recorded from July 1983 to May 1986, are available for all 18 thermocouples. Non-suspect temperature data from the Surveillance Analysis Computer System recorded from January 1990 to March 1996 are available for six thermocouples. Therefore, a gap in the temperature data exists between May 1986 and January 1990. The average temperature of all temperature data from July 1983 to March 1996 was 22.1 °C (71.8 °F), the minimum temperature was 11 °C (52 °F), and the maximum temperature was 32.4 °C (90.3 °F). Figure 2-4 shows a graph of the weekly high temperature. The high tank temperatures in the second quarter of 1995 are probably caused by the waste transfers from 244-A to tank 241-AN-101 that occurred in April, May, and June. Plots of the individual thermocouple readings for tank 241-AN-101 can be found in the supporting documents for the HTCE (Brevick et al. 1995b).

2.4.3 Tank 241-AN-101 Photograph

No interior photograph is available.

Figure 2-3. Tank 241-AN-101 Level History.

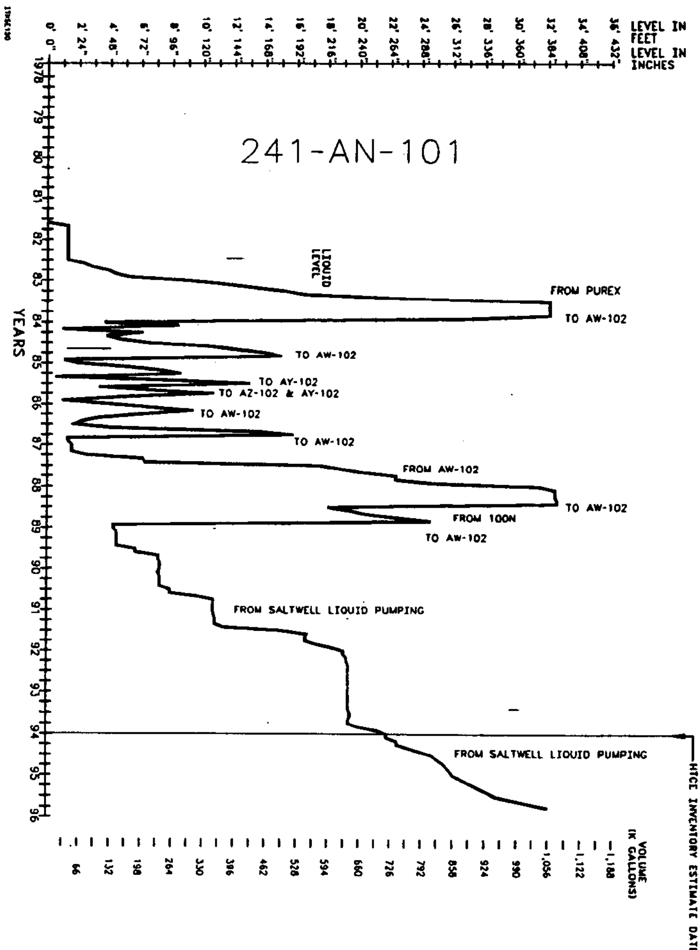
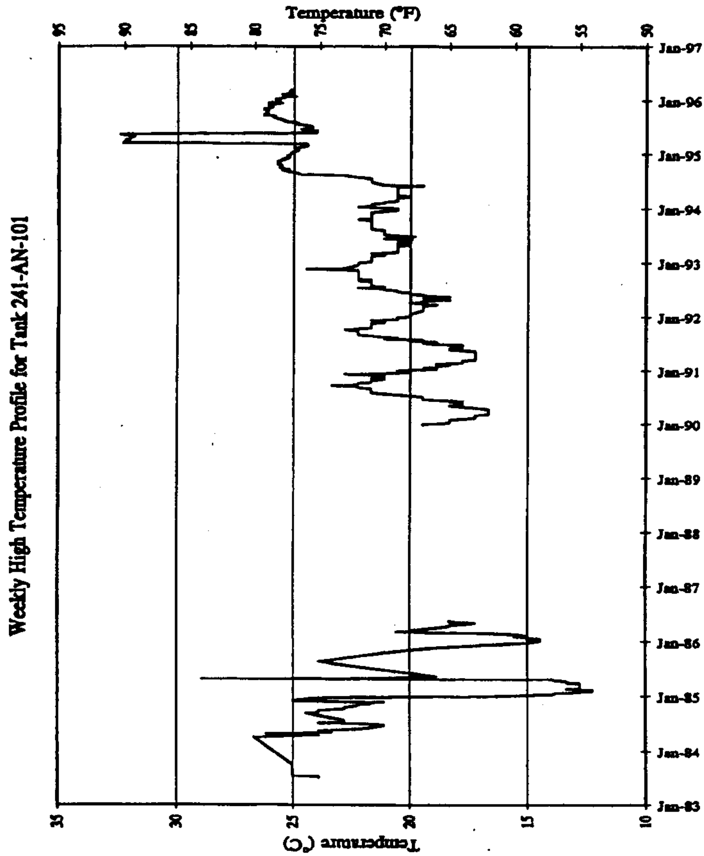


Figure 2-4. Tank 241-AN-101 Weekly High Temperature Plot.



3.0 TANK SAMPLING OVERVIEW

This section describes the August/September 1995 and the December 1995 grab sampling and analysis events for tank 241-AN-101. Grab samples 1AN-95-1, 1AN-95-2, and 1AN-95-3 were obtained in August and September 1995 to satisfy the requirements of the *Data Quality Objectives for the Waste Compatibility Program* (Fowler 1995). The sampling and analyses were performed in accordance with the *Compatibility Grab Sampling Analysis Plan* (Jones 1995). Grab samples 1AN-95-4, 1AN-95-5, and 1AN-95-6 were obtained in December 1995 to support safety screening analyses. The safety screening analyses were performed to satisfy the requirements of the *Tank Safety Screening Data Quality Objective* (Dukelow et al. 1995) and were carried out in accordance with the *Tank 241-AN-101 Grab Sampling and Analysis Plan* (Benar 1995). For further discussions of the sampling and analysis procedures, refer to the *Tank Characterization Reference Guide* (DeLorenzo et al. 1994).

3.1 DESCRIPTION OF SAMPLING EVENTS

Tank 241-AN-101 was grab sampled from riser 22A on August 31 and September 6, 1995, to obtain samples for the waste compatibility analyses. Sample 1AN-95-1 was taken on August 31, 1995 and was received by the Westinghouse Hanford Company 222-S Laboratory on September 1, 1995. Samples 1AN-95-2 and 1AN-95-3 were taken on September 6, 1995, and were received by the 222-S Laboratory the following day. The safety screening samples, designated as 1AN-95-4, 1AN-95-5, and 1AN-95-6, were taken from riser 15B on December 12, 1995, and were received by the 222-S Laboratory on December 13, 1995. A field blank, sample number 1AN-95-7, was taken with the safety screening samples.

The bottle-on-a-string sampling method was chosen for obtaining both sample sets. Prior to the December 1995 sampling, the tank headspace was sampled through riser 15B and analyzed for flammable gas as prescribed by the safety screening DQO. Table 3-1 summarizes the sampling mode, applicable DQOs, and sampling and analytical requirements for the sampling events.

Table 3-1. Integrated Data Quality Objective Requirements for Tank 241-AN-101.[1,2]

Sampling Event	Applicable DQOs	Sampling Requirements	Analytical Requirements
December 1995 grab sampling	Safety screening (Dukelow et al. 1995)	Vertical profiles from two widely spaced risers	▸ Energetics ▸ Moisture content ▸ Total alpha activity ▸ Density ▸ Visual check for presence of organic layer ▸ Headspace gas flammability
August/September 1995 grab sampling	Waste compatibility (Fowler 1995)	Grab samples from different depths	▸ Energetics ▸ Moisture content ▸ Metals by ICP ▸ Anions by IC ▸ Radionuclides ▸ Total carbon ▸ Hydroxide ▸ Density ▸ pH ▸ Percent solids ▸ Visual check for presence of organic layer

Notes:

[1]Jones (1995)

[2]Benar (1995)

3.2 SAMPLE HANDLING

The grab samples were shipped to the 222-S Laboratory for subsampling and analysis. Samples 1AN-95-1, 1AN-95-2, and 1AN-95-3 were assigned labcore numbers S95T002405, S95T002406, and S95T002407, respectively; they were subsampled on September 20, 1995. Samples 1AN-95-4, 1AN-95-5, and 1AN-95-6 were subsampled on December 15, 1995, and were assigned labcore numbers S95T003909, S95T003910, S95T003911, and S95T003912 (field blank), respectively. All samples were subjected to visual inspection for color, clarity, and solids content; over-the-top radiation measurements were taken. All samples were a clear, yellow liquid (except for the field blank which was colorless) with no visible solids and no organic layer. The samples were then subsampled into portions for the different analyses and for archiving. Table 3-2 provides a description of the samples.

Table 3-2. Grab Sample Descriptions.[1]

Riser	Customer ID	Laboratory ID (Labcore Number)	Sample Elevation[2]	Sample Volume	Over-the-Top Radiation
			m (in.)	mL	mrad/hr
22A	1AN-95-1	S95T002405	8.76 (345)	125	3,500
	1AN-95-2	S95T002406	4.32 (170)	125	4,500
	1AN-95-3	S95T002407	0.254 (10)	125	4,500
15B	1AN-95-4	S95T003909	8.76 (345)	125	7,000
	1AN-95-5	S95T003910	4.32 (170)	125	7,500
	1AN-95-6	S95T003911	0.254 (10)	125	5,000
	1AN-95-7 (Field blank)	S95T003912	11.0 (432)	125	< 0.5

Notes:

ID = identification
mrad/hr = millirads per hour

[1]Esch (1996)

[2]Sample elevation is the distance from the mouth of the sample bottle to the tank bottom. Note that the sample elevation of the field blank is above the waste surface.

3.3 SAMPLE ANALYSIS

Samples 1AN-95-1, 1AN-95-2, and 1AN-95-3 were assessed for waste compatibility. Analytes required for the waste compatibility evaluation include the following: energetics by DSC, weight percent water by TGA, TOC, GEA, ^{90}Sr, ICP, OH^-, IC, pH, TIC, $^{239/240}$Pu, ^{241}Am, density, percent solids, and a visual check for the presence of an organic layer. Waste compatibility analyses are used in controlling corrosion, evaluating waste rheology, avoiding mixing TRU and non-TRU waste, and preventing criticality.

Samples 1-AN-95-4, 1-AN-95-5, and 1AN-95-6 were subjected to a safety screening evaluation. Safety screening analyses include: total alpha activity to determine the criticality potential; DSC to evaluate the fuel content; TGA to obtain the total moisture content; and density. The analysis of tank headspace gases for flammability is also required by the safety screening DQO. A combustible gas meter was used for the analyses. Table 3-1 summarizes the sampling and analytical requirements from the applicable DQOs.

The total alpha analyses were performed on archived samples from the August/September 1995 sampling event; however, the results were not used during the safety screening evaluation.

A brief discussion of the sample analyses, including a listing of the quality control measures used in the analyses follows. Table 3-3 summarizes the analyses performed on specific samples. The quality control tests for the safety screening analyses were performed and evaluated in accordance with Benar (1995); and tests for the waste compatibility analyses were performed in accordance with Jones (1995). Results of the quality control tests and the implications for data quality are discussed in Section 5.1.2.

3.3.1 Thermal Analysis - Thermogravimetric Analysis and Differential Scanning Calorimetry

Thermogravimetric analysis measures the rate of mass loss from the sample at a constant rate of temperature increase. The TGA scans are used to interpret thermal decomposition temperatures, water content, and reaction temperatures. Differential scanning calorimetry measures the heat released or absorbed by a sample while the temperature of the sample is increased at a constant rate. The DSC analyses are used to measure thermal decomposition temperatures, heats of reaction, reaction temperatures, melting points, and solid-solid transition temperatures.

Both TGA and DSC analyses were performed on samples whose mass ranged from 9.718 mg to 28.00 mg. Quality control tests included duplicates and standards.

3.3.2 Total Alpha Activity Analysis

Analyses for total alpha activity, which indicate the potential of a substance to achieve criticality, were performed on all grab samples directly using an alpha proportional counter. Quality control tests included duplicates, blanks, standards, and spikes.

Table 3-3. Tank 241-AN-101 Sample Analysis Summary.

Customer ID	Laboratory ID (Labcore Number)	Subsample Labcore Number	Analysis
1AN-95-1	S95T002405	S95T002408	DSC, TGA, TOC, TIC, ICP (Al, Fe, Na), IC (anions), pH, OH^-, SpG
		S95T002411	GEA (^{137}Cs), $^{239/240}Pu$, ^{90}Sr, ^{241}Am
		S95T003903	Total alpha
		S95T003904	Archive
1AN-95-2	S95T002406	S95T002409	DSC, TGA, TOC, TIC, ICP (Al, Fe, Na), IC (anions), pH, OH^-, SpG
		S95T002412	GEA (^{137}Cs), $^{239/240}Pu$, ^{90}Sr, ^{241}Am
		S95T003905	Total alpha
		S95T003907	Archive
1AN-95-3	S95T002407	S95T002410	DSC, TGA, TOC, TIC, ICP (Al, Fe, Na), IC (anions), pH, OH^-, SpG
		S95T002413	GEA (^{137}Cs), $^{239/240}Pu$, ^{90}Sr, ^{241}Am
		S95T003906	Total alpha
		S95T003908	Archive
1AN-95-4	S95T003909	S95T003913	DSC, TGA, SpG, total alpha, archive
1AN-95-5	S95T003910	S95T003914	DSC, TGA, SpG, total alpha, archive
1AN-95-6	S95T003911	S95T003915	DSC, TGA, SpG, total alpha, archive
1AN-95-7 (Field blank)	S95T003912	S95T003916	DSC, TGA, SpG, total alpha, archive

Note:

SpG = specific gravity

3.3.3 Specific Gravity

Specific gravity measurements, used to convert the safety screening DQO total alpha activity notification limit from g/L to µCi/mL and to evaluate the physical condition of the waste, were performed on all grab samples. Quality control tests included duplicate analyses and standards.

3.3.4 Gamma Energy Analysis

Gamma energy analyses, specifically required by the waste compatibility DQO for ^{137}Cs, were performed directly on the waste compatibility samples (see Section 3.3). Results for ^{60}Co and ^{134}Cs were also recorded. Quality control tests included standards, blanks, and duplicate samples.

3.3.5 Inductively Coupled Plasma/Atomic Emission Spectroscopy

Inductively coupled plasma/atomic emission spectroscopy analyses were performed following acid dilution on the waste compatibility samples. These analyses were performed for Al, Na, and Fe to assess waste type and for criticality analyses as described by the waste compatibility DQO. Quality control tests included standards, blanks, duplicate samples, and spike recoveries.

3.3.6 Ion Chromatography

Ion chromatography analyses were performed following acid dilution on the waste compatibility samples. These analyses were performed for Cl^-, F^-, NO_2^-, NO_3^-, PO_4^-, and SO_4^- to determine corrosion and leakage potential, as described by the waste compatibility DQO. Quality control tests included standards, blanks, duplicate samples, and spike recoveries.

3.3.7 pH Analyses

Analyses for pH were performed on the waste compatibility samples. Because the results were at or above the top of the accurate range for the pH measurement (by electrode), they should be considered estimates (Esch 1995). Quality control tests included standards and duplicate measurements.

3.3.8 Hydroxide Ion Titration

Analyses by potentiometric titration were performed directly on the waste compatibility samples, as a backup for the pH measurement. These analyses were performed to determine corrosion and leakage potential as described in the waste compatibility DQO. Quality control tests included standards, blanks, and duplicate measurements.

3.3.9 Separation and Counting

Chemical separation, followed by alpha or beta counting as appropriate, were performed directly on the waste compatibility samples. These methods were used to measure the $^{239/240}Pu$, ^{241}Am, and ^{90}Sr activity of the waste. Quality control tests included standards, blanks, and duplicate measurements.

3.3.10 Total Carbon

Total carbon analyses by furnace oxidation were performed directly on the waste compatibility samples. Results for TIC and TOC were reported. Quality control tests included standards, blanks, duplicate measurements, and spikes (TIC only).

3.3.11 Visual Check and Over-the-Top Radiation Measurements

All samples were subjected to a visual check for suspended solids, clarity, and an organic layer. All samples were clear, yellow in color, and exhibited no organic layer. The over-the-top radiation measurements were as noted in Table 3-2. No formal quality control tests were performed.

3.3.12 Percent Solids

No measurements, either by filtering or by centrifugation, were made of the total solids because of the lack of solid material in the samples.

Table 3-4 summarizes the analytical procedure titles, instruments, and preparation methods used in the analysis of the tank 241-AN-101 samples.

Table 3-4. Analytical Procedures.[1]

Analysis	Instrument	Preparation Procedure	Procedure Number
Energetics by DSC	Differential scanning calorimeter	All analyses were performed directly on the liquid samples.[2]	LA-514-113, Rev. C-0 LA-514-114, Rev. C-1
Percent water by TGA	Thermal gravimetric analyzer		LA-560-112, Rev. B-1 LA-514-114, Rev. C-1
Total alpha activity	Alpha proportional counter		LA-508-101, Rev. D-2
Specific gravity	Not applicable		LA-510-112, Rev. C-3
Total metals	Inductively coupled plasma/atomic emission spectrometer		LA-505-161, Rev. B-0
Anions	Ion chromatograph		LA-533-105, Rev.D-1
^{137}Cs, ^{134}Cs, ^{60}Co	Gamma energy analyzer		LA-548-121, Rev. D-1
^{90}Sr	Beta proportional counter		LA-220-101, Rev. D-1
OH^-	Potentiometric titration		LA-211-102, Rev. C-0
H^+	pH electrode		LA-212-106, Rev. A-0
TOC, TIC	Coulometric titration		LA-622-102, Rev. C-0
$^{239/240}Pu$	Alpha proportional counter		LA-943-127, Rev. B-0
^{241}Am	Alpha proportional counter		LA-953-103, Rev. A-4

Notes:

Rev. = revision

[1]Esch (1996)

[2]Samples for ICP measurement were diluted in acid prior to analysis.

3.4 HISTORICAL SAMPLING EVENTS

Tank 241-AN-101 was sampled several times prior to the 1995 sampling events. Because of the active process history of the tank, historical sample results no longer represent the current tank contents. Sample results from a 1993 sampling event have been included in this characterization report for informational purposes. A comparison between the 1993 results and the 1995 results was not made, however, the raw laboratory data can be found in Appendix B.

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4.0 ANALYTICAL RESULTS

This section presents the analytical results associated with the August/September and December 1995 samplings of tank 241-AN-101. The August/September 1995 event was performed to evaluate waste compatibility as defined in the waste compatibility DQO (Fowler 1995). The sampling and analysis parameters governing this event were integrated and described in the waste compatibility sampling and analysis plan (SAP) (Jones 1995). The December 1995 event was performed to evaluate safety screening criteria as defined in the safety screening DQO (Dukelow et al. 1995). The sampling and analysis parameters governing the December sampling event were integrated and described in the safety screening SAP (Benar 1995). Sample analysis was performed at the Westinghouse Hanford Company 222-S Laboratory.

Table 4-1 shows the data locations for this characterization report. Appendix A has information on the complete analytical data set. Except for TGA and DSC data, this section has information on analyte overall means only.

Table 4-1. Analytical Data Presentation Tables.

Data Type	Table Location
Chemical data summary	Table 4-2
Thermogravimetric analysis results	Table 4-3
Differential scanning calorimetry results	Table 4-4
Headspace flammability screening results	Table 4-5
1995 comprehensive analytical data	Appendix A

4.1 DATA PRESENTATION

Section 4.1 summarizes the analytical results from the two 1995 sampling events involving tank 241-AN-101. Data from the August/September 1995 analysis are reported in the *60-Day Waste Compatibility Safety Issue and Final Results for Tank 241-AN-101 Grab Samples 1AN-95-1, 1-AN-95-2, and 1-AN-95-3* (Esch 1995). Data from the December 1995 analysis were reported in the *Revised Final Report for Tank 241-AN-101 Grab Samples 1AN-95-1 Through 1AN-95-7* (Esch 1996). Section 4.1.1 summarizes the chemical data, Section 4.1.2 summarizes the physical data, and Section 4.1.3 summarizes the headspace flammability results.

4.1.1 Chemical Data Summary

Data from the three grab samples taken from riser 15B were combined to derive an overall mean for the three safety screening analytes: weight percent, specific gravity, and total alpha activity. Mean values for each grab sample were calculated by averaging the sample/duplicate results of each analyte, which were then used to calculate overall means. The DSC results do not require the calculation of a mean. The overall means can be found in the Appendix A tables. These values are no longer representative of the current tank contents.

Data from the three grab samples taken from riser 22A were combined to derive an overall mean for the waste compatibility analytes. The same general procedure as described above was followed. When results for 50 percent or more of the grab samples had detected results, the overall mean was reported as a detected value. Conversely, when results for more than half of the grab samples were nondetected, the overall mean was reported as a nondetected value. The overall means can be found in the Appendix A tables and are used to complete Table 4-2. The overall means and the projected inventory values are no longer representative of the tank contents.

The first two columns of Table 4-2 show the analyte and overall mean. The third column shows the relative standard deviation (RSD) of the mean, defined as the standard deviation (of the mean) divided by the mean, multiplied by 100. The RSDs were determined using analysis of variance (ANOVA) techniques. They were computed for analytes that had 50 percent or more of their values above the detection limit. For these analytes, the value of the detection limit was used in the computations. The projected inventories listed in the last column are derived by multiplying the overall mean in μg/mL or μCi/mL by the estimated waste volume of 4,090 kL (1,080 kgal).

Table 4-2. Chemical Data Summary for Tank 241-AN-101.[1] (2 sheets)

Analyte	Overall Mean	Relative Standard Deviation (Mean)	Projected Inventory
METALS	**μg/mL**	**%**	**kg**
Aluminum	20,900	3.5	85,500
Iron	< 20.1	---	< 82.2
Sodium	1.28E+05	3.0	5.24E+05
ANIONS	**μg/mL**	**%**	**kg**
Chloride	3,300	1.0	13,500
Fluoride	475	8.7	1,940
Hydroxide	31,400	2.5	1.28E+05

Table 4-2. Chemical Data Summary for Tank 241-AN-101.[1] (2 sheets)

Analyte	Overall Mean	Relative Standard Deviation (Mean)	Projected Inventory
ANIONS (Cont'd)	**μg/mL**	**%**	**kg**
Nitrate	97,100	1.8	3.97E+05
Nitrite	48,200	2.7	1.97E+05
Phosphate	2,120	19.2	8,670
Sulfate	3,040	24.5	12,400
RADIONUCLIDES	**μCi/mL**	**%**	**Ci**
^{241}Am	5.15E-05	32.7	0.211
^{134}Cs	0.00996	45	40.7
^{137}Cs	123	0.6	5.03E+05
^{60}Co	< 0.00413	---	< 16.9
$^{239/240}$Pu	5.98E-05	18.6	0.245
^{90}Sr	0.378	28.3	1,550
Total alpha	< 0.00059	---	< 2.41
CARBON	**μg/mL**	**%**	**kg**
Total inorganic carbon	2,450	2.7	10,000
Total organic carbon	2,630 (7,670)[2]	18.0	10,800
PHYSICAL PROPERTIES			
pH	13.6	2.3 %	---
Water	66.0 wt %	0.21 wt %	2.70E+06 kg
Specific gravity	1.24	0.58 %	---

Notes:

[1]Esch (1995 and 1996)

[2]Value in parentheses is the TOC dry weight result.

4.1.2 Physical Data Summary

Thermal analyses and density tests were performed on the tank 241-AN-101 grab samples to satisfy the requirements of the safety screening DQO (Dukelow et al. 1995) and the waste compatibility DQO (Fowler 1995). In addition, pH measurements were performed on the three waste compatibility (riser 22A) samples.

4.1.2.1 Thermogravimetric Analysis. During TGA, the mass of a sample is measured while its temperature is increased at a constant rate. A gas, such as nitrogen or air, is passed over the sample during heating to remove any released gases. Any decrease in the weight of a sample represents a loss of gaseous matter from the sample through evaporation or through a reaction that forms gas phase products. The moisture content is estimated by assuming that all TGA sample weight loss up to a certain temperature (typically 150 to 200 °C) is caused by water evaporation. Weight percent water by TGA was performed by the 222-S Laboratory under a nitrogen purge using procedures LA-514-114, Rev. C-1 (Perkin-Elmer[1]), and LA-560-112, Rev. B-1 (Mettler[2]).

Table 4-3 shows the TGA results for tank 241-AN-101. All samples exhibited a large weight loss between the ambient temperature and 240 °C. Again, this weight loss is attributed to the evaporation of water. The overall percent water value for the tank from the December 1995 sampling event was 65.4 weight percent.

4.1.2.2 Differential Scanning Calorimetry. During DSC, heat absorbed or emitted by a substance is measured while the substance is exposed to a linear increase in temperature. While the substance is being heated, a gas such as nitrogen is passed over the waste material to remove any gases being released. The onset temperature for an endothermic (characterized by or causing the absorption of heat) or an exothermic (characterized by or causing the release of heat) event is determined graphically. Analyses by DSC were performed by the 222-S Laboratory under a nitrogen atmosphere using procedure LA-514-114, Rev. C-1 (Perkin-Elmer™), and procedure LA-514-113, Rev.C-1 (Mettler™).

Table 4-4 shows the DSC results. All reactions were endothermic; therefore, none of the samples exceeded the safety screening action limit of -480 J/g. The peak temperature for the endothermic reactions and the magnitude of the enthalpy changes are provided for each transition. The first transition represents the endothermic reaction associated with the evaporation of free and interstitial water. For this tank, the second and third transitions probably represent the energy (heat) required to remove bound water from hydrated compounds such as aluminum hydroxide or to melt salts such as sodium nitrate. The results in Table 4-4 are on a wet weight basis. Since there were no exothermic reactions, the calculation of a 95 percent confidence interval as required by the safety screening DQO (Dukelow et al. 1995) was not necessary.

4.1.2.3 Specific Gravity. Specific gravity measurements were performed on all six grab samples using procedure LA-510-112, Rev. C-3. The analysis was performed in duplicate on direct samples (see Table A-22 for results). The overall tank specific gravity from the December 1995 sampling event was 1.22.

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[1]Perkin-Elmer is a registered trademark of Perkins Research and Manufacturing Company, Inc., Canoga Park, California.

[2]Mettler is a registered trademark of Mettler Electronics, Anaheim, California.

Table 4-3. Thermogravimetric Analysis Results for Tank 241-AN-101.[1]

Sample Number	Sample Location		Temp. Range[2]	Result	Duplicate	Mean
	Riser	Segment Number	°C	% H_2O	% H_2O	% H_2O
2408[3]	22A	1AN-95-1	30-210 (30-215)	66.28	66.11	66.19
2409[3]		1AN-95-2	30-215 (30-215)	66.27	65.72	66.00
2410[3]		1AN-95-3	30-205 (30-205)	65.96	65.81	65.88
3913[4]	15B	1AN-95-4	35-230 (35-240)	65.51	64.93	65.22
39414[4]		1AN-95-5	35-230 (35-235)	64.80	65.11	64.95
3915[3]		1AN-95-6	35-215 (35-210)	65.95	66.03	65.99
Sample Weight % Loss Mean (% Water)[5] = 65.4 %						
Relative Standard Deviation of the Mean = 0.5 %						

Notes:

Temp. = temperature

[1]Esch (1995 and 1996).

[2]The first temperature range is for the sample result, and the range in parentheses is for the duplicate result.

[3]Analysis performed with Mettler™ equipment.

[4]Analysis performed with Perkin-Elmer™ equipment.

[5]Calculated with the December 1995 (15B) sample results.

4.1.2.4 pH Measurements. Measurements for pH were performed on the three grab samples removed from riser 22A using procedure LA-212-106, Rev. A-0. The analysis was performed in duplicate (see Table A-20 for results). The overall tank pH was 13.6. Because the results were at or above the top of the accurate range for the pH measurement (by electrode), they should be considered estimates (Esch 1995).

4.1.3 Headspace Flammability Screening Results

As requested in the safety screening SAP (Benar 1995), tank 241-AN-101 headspace was sampled and analyzed for the presence of flammable gases prior to grab sampling. Although the SAP indicated that the results were to be reported as a percent of the lower flammability limit (LFL), the instrumentation used to collect the data reported the results as a percent of the lower explosive limit (LEL). The Industrial Hygiene engineer responsible for testing stated that the two values were equivalent (Esch 1996). The reported LEL of 0 percent was well below the safety screening limit. In addition, the concentrations of oxygen, ammonia, and TOC vapor were determined. See Table 4-5 for the results of the combustible gas monitoring inside riser 15B.

Table 4-4. Differential Scanning Calorimetry Results for Tank 241-AN-101.[1]

Sample Number	Sample Location		Run	Sample Weight	Transition 1		Transition 2		Transition 3	
	Riser	Number		mg	Peak Temp. (°C)	ΔH (J/g)	Peak Temp. (°C)	ΔH (J/g)	Peak Temp. (°C)	ΔH (J/g)
2408[2]	22A	1AN-95-1	1	13.49	116	1,265	---	---	---	---
			2	11.39	119	1,516	---	---	---	---
2409[2]		1AN-95-2	1	12.90	116	1,606	---	---	---	---
			2	15.16	122	1,891	---	---	---	---
2410[2]		1AN-95-3	1	16.28	115	1,303	243	6.0	---	---
			2	17.39	113	1,255	243	6.5	---	---
3913[3]	15B	1AN-95-4	1	16.00	116	1,555	182	10.1	245	7.2
			2	21.21	122	1,657	238	6.8	---	---
3914[3]		1AN-95-5	1	23.53	127	1,728	441	21.0	---	---
			2	21.27	123	1,581	474	13.1	---	---
3915[2]		1AN-95-6	1	14.95	126	2,005	242	29.4	---	---
			2	28.00	140	1,130	---	---	---	---

Notes:

ΔH = change in enthalpy (negative sign denotes exothermic reaction).

[1]Esch (1995 and 1996)

[2]Analysis performed on Mettler™ equipment.

[3]Analysis performed on Perkin-Elmer™ equipment.

Table 4-5. Headspace Flammability Screening for Tank 241-AN-101.[1]

Vapor Characteristic Measured	Results
Flammability vapor concentration as percent of the LEL	0 %
Volume percent oxygen gas	20.9 %
Concentration of ammonia gas	40 ppm
Concentration of total organic carbon vapor	1.5 ppm

Note:

[1]Esch (1996)

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5.0 INTERPRETATION OF CHARACTERIZATION RESULTS

The purpose of this section is to discuss the overall quality and consistency of the current sampling results for tank 241-AN-101 and to assess and compare these results against historical information and program requirements.

5.1 ASSESSMENT OF SAMPLING AND ANALYTICAL RESULTS

This section evaluates sampling and analysis factors that may impact interpretation of the data. These factors are used to assess the overall data quality and consistency and to identify limitations in data use.

5.1.1 Field Observations

The safety screening DQO (Dukelow et al. 1995) requirement to sample at least two widely spaced risers was not fulfilled. An additional sampling event may be necessary to complete a safety screening assessment while satisfying the safety screening DQO requirement of obtaining samples from two risers. No problems were noted during the sampling operations. All seven samples (including the field blank) achieved 100 percent recovery.

5.1.2 Quality Control Assessment

The usual quality control assessment includes an evaluation of the appropriate standard recoveries, spike recoveries, duplicate analyses, and blanks that are performed in conjunction with the chemical analyses. All pertinent quality control tests were conducted on the 1995 analyses, allowing a full assessment regarding the accuracy and precision of the data. The SAPs (Benar 1995 and Jones 1995) established the specific criteria for all quality control checks. Sample and duplicate pairs exhibiting one or more quality control results outside the SAP target levels are identified (by footnoting) in Appendix A data tables.

The standard and spike recovery results provide an estimate of analysis accuracy. If a standard or spike recovery is above or below the given criterion, then the analytical results may be biased high or low, respectively. All standard recoveries were within the defined criterion. The single spikes conducted for chloride and fluoride were below the target level of 80 to 120 percent recovery. The laboratory chemist noted an interference on the chromatogram in the region in which chloride and fluoride elute. This was most likely responsible for the poor spike recoveries. The precision (estimated by the relative percent difference, which is defined as the absolute value of the difference between the primary and duplicate samples, divided by their mean, times one hundred) between all sample pairs for all analytes was within the limits. Finally, none of the samples exceeded the criterion for preparation blanks; therefore, contamination was not a problem.

In summary, nearly all quality control results were within the boundaries specified in the SAPs. The spike recovery difficulties with chloride and fluoride should not impact data validity or use.

5.1.3 Data Consistency Checks

Comparing different analytical methods can help to assess data consistency and quality. The quantity of data made it possible to compare total alpha activity to the sum of specific alpha emitters and to calculate mass and charge balances.

5.1.3.1 Comparison of Results from Different Analytical Methods. The following data consistency check compares the results from two different analytical methods. A close correlation between the two methods strengthens the credibility of both results, whereas a poor correlation brings the reliability of the data into question.

A comparison was made between the total alpha activity mean and the sum of the means of the individual alpha emitters in Table 5-1. The sum of the activities of the individual alpha emitters was determined by adding the ^{241}Am and $^{239/240}$Pu mean activities.

The analytical result of total alpha activity for all tank 241-AN-101 samples was below the detection limit. The sum of the alpha emitters compared well with the total alpha activity mean which is less than 0.00059 μCi/mL.

Table 5-1. Comparison of the Total Alpha Activity with the Sum of the Individual Activities.

Analyte	Overall Mean[1] μCi/mL
^{241}Am	5.15E-05
$^{239/240}$Pu	5.98E-05
Sum of alpha emitter means	1.11E-04
Total alpha activity mean	< 5.90E-04

Note:

[1]Calculated using sample results from the August/September 1995 sampling event.

5.1.3.2 Mass and Charge Balances. The principle objective in performing mass and charge balances is to determine whether the measurements are consistent. In calculating the balances, only analytes listed in Table 4-2, which were detected at a concentration of 1,000 μg/g (0.1 weight percent) or greater, were considered. All analytical results presented in this section were converted from μg/mL to μg/g (using the specific gravity mean of 1.24) before being used in the tables.

Sodium was the only cationic species present in detectable quantities in tank 241-AN-101 waste. However, only three metals were analyzed, which could create a low bias in the overall mass balance if an unmeasured metal were present in large quantities. This is unlikely because tank 241-AN-101 waste is entirely liquid, and most metals exist in tank waste as partially soluble or insoluble hydroxides or oxides. No solids are known to exist in tank 241-AN-101, thereby decreasing the likelihood that such metals are present.

Aluminum was assumed to be present as the aluminate anion. The acetate and carbonate values were derived from the TOC and TIC analyses, respectively. The other anionic analytes listed in Table 5-3 were assumed to be present as sodium salts and were expected to balance the positive charge exhibited by the cation. Sulfur is considered to be present as the sulfate ion, and phosphorus as the phosphate ion. Both species are assumed to be completely water soluble and appear only in the anion mass and charge calculations. The concentrations of sodium shown in Table 5-2, the anionic species shown in Table 5-3, and the percent water were ultimately used to calculate the mass balance. The uncertainty estimates (RSDs) associated with each analyte are shown in the tables. The uncertainty estimates for the cation and anion totals and the overall uncertainty shown in Table 5-4 were computed by a statistical technique known as the propagation of errors (Nuclear Regulatory Commission 1988).

The mass balance was calculated from the formula below. The 0.0001 value is the conversion factor from μg/g to weight percent.

$$\text{Mass balance} = \text{\% Water} + 0.0001 \times \{\text{Total Analyte Concentration}\}$$
$$= \text{\% Water} + 0.0001 \times \{Na^{+} + AlO_2^{-} + C_2H_3O_2^{-} + CO_3^{-2} + Cl^{-} + OH^{-} + NO_3^{-} + NO_2^{-} + PO_4^{-3} + SO_4^{-2}\}$$

The total analyte concentrations calculated from the above equation is 307,000 μg/g. The mean weight percent water obtained from thermogravimetric analysis reported in Table 4-2 is 66.0 percent, or 660,000 μg/g. The mass balance resulting from adding the percent water to the total analyte concentration is 96.4 percent (see Table 5-4).

The following equations demonstrate the derivation of total cations and total anions, and the charge balance is the ratio of these two values. To derive the results as shown in the equations, all concentrations must first be converted to a μg/g basis.

Total cations (microequivalents) = $[Na^{+}]/23.0$ = 4,480 microequivalents

Total anions (microequivalents) = $[AlO_2^-]/59.0 + [C_2H_3O_2^-]/59.0 + [CO_3^{-2}]/30.0 + [Cl^-]/35.5 + [OH^-]/17.0 + [NO_3^-]/62.0 + [NO_2^-]/46.0 + [PO_4^{-3}]/31.7 + [SO_4^{-2}]/48.1$ = 4,821 microequivalents.

The charge balance obtained by dividing the sum of the positive charge by the sum of the negative charge was 0.929.

In summary, the above calculations yield reasonable mass and charge balance values (close to 1.00 for charge balance and 100% for mass balance) indicating that the analytical results are generally consistent.

Table 5-2. Cation Mass and Charge Data.

Analyte	Concentration µg/g	Assumed Species	Concentration of Assumed Species µg/g	RSD (Mean) %	Charge µeq/g
Sodium	103,000	Na^+	103,000	3.0	4,480
Total			103,000	3.0	4,480

Table 5-3. Anion Mass and Charge Data.

Analyte	Concentration µg/g	Assumed Species	Concentration of Assumed Species µg/g	RSD (Mean) %	Charge µeq/g
Aluminum	16,900	AlO_2^-	37,000	3.5	627
TOC	2,120	$C_2H_3O_2^-$	5,210	18.0	88
TIC	1,980	CO_3^{2-}	9,900	2.7	330
Chloride	2,660	Cl^-	2,660	1.0	75
Hydroxide	25,300	OH^-	25,300	2.5	1,490
Nitrate	78,300	NO_3^-	78,300	1.8	1,260
Nitrite	38,900	NO_2^-	38,900	2.7	846
Phosphate	1,710	PO_4^{3-}	1,710	19.2	54
Sulfate	2,450	SO_4^{2-}	2,450	24.5	51
Total			201,000	1.3	4,821

Table 5-4. Mass Balance Totals.

Totals	Concentrations µg/g	RSD (Mean) %
Total from Table 5-2	103,000	3.0
Total from Table 5-3	201,000	1.3
Water %	660,000	0.21
Grand Total	964,000	0.5

5.2 TANK WASTE PROFILE

Six grab samples were taken during the August/September and December 1995 sampling events from risers 22A and 15B. Three samples were collected from each riser at sample elevations identified in Table 3-2. Because three different elevations were selected in each riser, a statistical assessment of the vertical distribution of the tank waste for most analytes was possible. An assessment of the horizontal distribution of the waste for percent water and specific gravity was performed; however, the results are of limited value because the tank contents changed between sampling events.

Information on the vertical disposition of the tank contents was also available from the TLM, which indicated the waste consists entirely of supernatant. The visual descriptions of the samples from both risers were the same (clear and yellow), which, taken together with the TLM prediction, strongly implies that the tank contents were expected to be vertically homogeneous.

Waste samples were taken from three depths and from two risers. Consequently, ANOVA models with riser and/or depth terms were fit to the analytical data. The results from these models can be used to test whether or not analyte concentrations are significantly different according to the horizontal and/or vertical location.

A two-way (riser and depth) nested random effects ANOVA model was fit to the percent water and specific gravity data. For other analytes, data were available from only one riser and a one-way (depth) random effects model was fit to the results. These models ere used only for analytes with 50 percent or more of the measurements above the detection limit.

The results from the ANOVA models are used to test the significance of the riser and/or depth effect. The p-value associated with a statistical test is compared with a standard level of significance ($\alpha = 0.05$). If the p-value is less than 0.05, there is sufficient evidence to conclude that analyte means are significantly different from each other. If the p-value is greater than 0.05, there is not sufficient evidence to conclude that analyte means are different from each other. In the following paragraph, the p-values are in parentheses.

The results from the ANOVA models indicated that there was no significant difference between risers (horizontal variability) for percent water (0.120), but there were significant differences for specific gravity (0.042). There were no significant differences between depths (vertical variability) for five analytes: chloride (0.918), fluoride (0.900), hydroxide (0.120), ^{137}Cs (0.303), and specific gravity (0.280). There were significant differences between depths for the other 13 analytes: aluminum (0.009), sodium (0.010), nitrate (0.003), nitrite (0.026), phosphate (0.001), sulfate (0.001), ^{241}Am (0.002), ^{239,240}Pu (<0.001), ^{89,90}Sr (<0.001), TIC (0.014), TOC (<0.001), pH (<0.001), and percent water (0.045). For these 13 analytes, the mean concentrations (as a function of depth, both increased and decreased.

In summary, only two analytes had horizontal information. This is insufficient to draw conclusions regarding horizontal variability. Thirteen of three 18 analytes showed significant concentration changes as a function of depth (vertical variability). However for these 13, the mean concentrations increased and decreased.

5.3 EVALUATION OF PROGRAM REQUIREMENTS

The three grab samples retrieved from tank 241-AN-101 in August and September 1995 were analyzed to meet the requirements of the waste compatibility DQO (Fowler 1995). The three December 1995 grab samples were analyzed in accordance with the safety screening DQO (Dukelow et al. 1995) and were to be used in conjunction with the August/September 1995 sample results to complete a safety screening assessment of tank 241-AN-101. The requirements of the waste compatibility DQO included all the safety screening analyses except total alpha. The total alpha analyses were later performed on the August/September archived samples.

It was discovered that waste was added to tank 241-AN-101 during September and October 1995, so a safety screening evaluation was performed with only the December 1995 sample results. Section 5.0 discusses the specific requirements of the two DQOs and a comparison of the analytical data to define concentration limits. Section 5.3.1 details the safety evaluations required by both DQOs, and Section 5.3.2 discusses the pertinent operations decision rules specified in the waste compatibility DQO.

5.3.1 Safety Evaluation

Data criteria identified in the safety screening DQO are used to assure that appropriate safety issues have been identified. The waste compatibility DQO establishes criteria to assess waste compatibility for transfers into and within the double-shell tank system problems. Both DQOs investigate the same safety issues: energetics, criticality, and flammable gas accumulation. In addition, the waste compatibility DQO examines corrosion and leakage concerns. Because the safety issues of the DQOs were similar, the set of primary safety analyses required by them was also similar.

Both DQOs requested analyses for energetics (by DSC) to evaluate the fuel content and total alpha activity to determine the criticality potential, although the specific limits set by the DQOs differed. The safety screening DQO requires the determination of the percent of the LFL of the gases in the tank headspace, while the waste compatibility DQO used specific gravity to evaluate the potential for flammable gas accumulation within the waste. In addition, the waste compatibility DQO imposes waste composition limits on the tank contents to control corrosion. For each required analysis, a notification threshold was established which, if exceeded, could warrant further investigation to assure the safety of the tank. Tables 5-5 and 5-6 list the applicable safety issues, decision variables, and thresholds for the safety screening and waste compatibility DQOs and the mean analytical results from the 1995 grab sampling events.

For a proper safety assessment, the safety screening DQO requires vertical profiles of the waste from at least two widely-spaced risers. This requirement was not met.

The safety screening DQO has a notification limit of 480 J/g (dry weight) for the DSC analyses (Dukelow et al. 1995). The waste compatibility DQO mandated that the value of the exotherm/endotherm ratio must be $\leq$ 1.0 for any transfer to be allowed. Because no exothermic reactions were noted in any sample, neither DQO limit was exceeded, and the calculation of a 95 percent upper confidence limit (per the safety screening DQO) was unnecessary.

The potential for criticality can be assessed from the total alpha activity data. The safety screening notification limit is 1 g/L (Dukelow et al. 1995). Because the laboratory reported total alpha activity in units of μCi/mL, the 1 g/L threshold was converted to 61.5 μCi/mL using the formula in footnote 1, Table 5-5. The calculated overall mean, based on the nondetected results, was < 0.00147 μCi/mL, well below the 61.5 μCi/mL safety screening DQO limit. Because total alpha activity was not detected in any sample, the statistical calculation of a 95 percent upper confidence limit was unnecessary. The waste compatibility DQO limit for total alpha activity was $\leq$ 0.05 g/gal. This converts to 0.812 μCi/mL (using the ^{239}Pu specific activity of 0.0615 Ci/g), which was almost a factor of three above the estimated analytical result (see Table 5-6).

The flammability of the gas in the tank headspace is the final safety screening DQO consideration. According to the DQO, any flammable gas present must be $\leq$ 25 percent of the LFL. The analytical result was 0 percent of the LEL, which is equivalent to 0 percent of the LFL (see Section 4.1.3). The waste compatibility DQO flammable gas decision rule requires that the specific gravity of the waste be < 1.3 before any transfer is allowed. The analytical result of 1.24 was below this limit.

The waste compatibility DQO also specifies several waste composition limits to control corrosion; these are listed in Table 5-6. The analytical results from the 1995 grab samples for hydroxide, nitrate, and nitrite all met the criteria listed.

Table 5-5. Decision Variables and Criteria for the Safety Screening Data Quality Objective.

Safety Issue	Primary Decision Variable	Decision Criteria Threshold	Mean Analytical Result[1]
Ferrocyanide/Organics	Total fuel content	480 J/g	No exotherms
Criticality	Total alpha activity	1 g/L[2] (61.5 μCi/mL)	< 0.00147 μCi/mL
Flammable gas	Flammable gas	25% of the LFL	0 percent LEL

Notes:

[1]December 1995 sampling event.

[2]Although the actual decision criterion listed in the DQO was 1 g/L, total alpha was measured in μCi/mL rather than g/L. To convert the notification limit for total alpha into the same units as the laboratory, it was assumed that all alpha decay originated from ^{239}Pu. Using the specific activity of ^{239}Pu (0.0615 Ci/g), the decision criterion may be converted to 61.5 μCi/mL as shown:

$$\left(\frac{1\ g}{L}\right)\left(\frac{1\ L}{10^3\ mL}\right)\left(\frac{0.0615\ Ci}{1\ g}\right)\left(\frac{10^6\ \mu Ci}{1\ Ci}\right) = 61.5\ \frac{\mu Ci}{mL}$$

Table 5-6. Decision Variables and Criteria for the Waste Compatibility Data Quality Objective.

Safety Issue	Primary Decision Variable	Decision Criteria Threshold	Mean Analytical Result[1]
Energetics	Total fuel content	Exotherm/endotherm ratio < 1.0	No exotherms
Criticality	Total alpha activity	0.05 g/gal (0.812 μCi/mL)	< 0.00147 μCi/mL
Flammable gas accumulation	Waste-specific gravity	< 1.3	1.24
Corrosion	Concentration of hydroxide, nitrate, and nitrite	1.0 M < $[NO_3^-]$ ≤ 3.0 M; 0.1 x $[NO_3^-]$ ≤ $[OH^-]$ < 10.0 M; $[OH^-]$ + $[NO_2^-]$ ≥ 0.4 x $[NO_3^-]$	$[NO_3^-]$ = 1.57 M $[OH^-]$ = 1.85 M $[NO_2^-]$ = 1.05 M

Note:

[1]August/September 1995 sampling event.

Another factor in assessing tank safety is the heat generation and temperature of the waste. Heat is generated in tanks from radioactive decay; therefore the tank heat load can be calculated from radionuclide data. An estimate of 2,380 W (8,120 Btu/hr) was derived (see Table 5-7). For comparison, the HTCE estimate of heat load was 102 W (349 Btu/hr). The HTCE prediction is low because the ^{137}Cs was underestimated. Both heat load values are well below the 70,000 Btu/hr operating specification limit (Harris 1994).

Because an upper temperature limit has been exhibited (see Section 2.4.2), it may be concluded that any heat generated from radioactive sources throughout the year is dissipated.

Table 5-7. Tank 241-AN-101 Projected Heat Load.

Radionuclide	μCi/mL	Ci	W
^{241}Am	5.15E-05	0.211	0.00692
^{134}Cs	0.00996	40.7	0.415
^{137}Cs	123	5.03E+05	2,370
^{60}Co	< 0.00413	< 16.9	< 0.260
$^{239/240}Pu$	5.98E-05	0.245	0.00747
$^{89/90}Sr$	0.378	1,550	10.4
Total		5.05E+05	2,380

5.3.2 Operations Decision Rules Evaluation

The waste compatibility program requires a formal operations analysis of nonroutine transfers before they are approved. Several criteria are applicable when evaluating the feasibility of a waste transfer between tanks (see Table 5-8). The criteria address three operations issues: segregating waste, avoiding excess heat generation, and ensuring that the source waste can be pumped to the receiving tank (Fowler 1995).

The TRU waste segregation rule is addressed by determining the TRU concentration of the source waste. If the source waste has a TRU concentration $\geq$0.1 μCi/g, the waste is transferred to a TRU storage tank; otherwise, it is sent to a non-TRU tank, or a technical evaluation is prepared demonstrating that TRU segregation will not be jeopardized. The tank 241-AN-101 TRU concentration of 9.05E-05 μCi/g was derived by summing the measured ^{241}Am and $^{239/240}Pu$ activity means. This value is well below the TRU threshold.

The complexant waste segregation rule is addressed by determining the TOC of the source waste at the double-shell slurry feed composition. This is done by running several parameters, including the source waste TOC, into a computer program that simulates concentrating the waste to double-shell slurry feed composition. When the desired concentration has been reached, the TOC is compared to 10 g/L. If the TOC exceeds this limit, the waste is segregated with complexed waste. If the TOC is less than 10 g/L, the waste may be segregated with noncomplexed waste. The tank 241-AN-101 TOC analytical result is 2,630 μg/mL.

The heat generation threshold depends on the operating specification document limit for a given tank. The heat generation limit for tank 241-AN-101 is 20,500 W (70,000 Btu/hr) (Harris 1994). The heat load was calculated at 2,380 W (8,120 Btu/hr), far below the limit.

Table 5-8. Waste Compatibility Operations Decision Rules.

Operations Issue	Primary Decision Variable	Decision Criteria Threshold	Mean Analytical Result of Source Waste
Transuranics	TRU elements	[TRU] $\leq$ 0.1 μCi/g	9.05E-05 μCi/g
Heat load	Heat generation rate of source waste plus that of waste in the receiving tank.	20,500 W (70,000 Btu/hr)	2,380 W (8,120 Btu/hr)
Pipe plugging and waste viscosity			not applicable to this document
Organics	TOC of the double-shell slurry feed	10,000 μg/mL[1]	2,630 μg/mL

Note:

[1]Comparison made on a wet weight basis per the DQO (Fowler 1995).

6.0 CONCLUSIONS AND RECOMMENDATIONS

Tank 241-AN-101 was grab sampled in August/September and December 1995. The August/September sampling event was performed to evaluate the waste for compatibility issues in accordance with *Data Quality Objectives for the Waste Compatibility Program* (Fowler 1995). The December sampling event was performed to provide sample results from a second riser as required by the *Tank Safety Screening Data Quality Objective* (Dukelow et al. 1995) so that a safety screening assessment of the tank could be completed. The sampling and analysis of the December grab samples were performed as mandated in the safety screening DQO. Because the total alpha analyses were not required for the August/September sampling event, they were later performed on the archived August/September 1995 samples.

A safety screening evaluation for tank 241-AN-101 was performed with only the December 1995 sample results, which were from one riser. It was discovered that tank AN-101 received waste from saltwell liquid pumping and an unknown source in September and October 1995. Because the tank contents changed during the time between sampling events, the sample results from riser 22A (August/September 1995 sampling event) were not used. An additional sampling may be necessary to complete a safety screening assessment of tank 241-AN-101 while fulfilling the requirement of obtaining samples from two risers.

Comparisons were made between the analytical results and the decision criteria of the safety screening and waste compatibility DQOs. All analytical results satisfied the DQO criteria. No exothermic reactions were observed in any samples. The total alpha activity mean of < 0.00147 μCi/mL was well below the safety screening limit of 61.5 μCi/mL and the 0.05 g/gal waste compatibility safety limit, and the TRU content of 9.05E-05 μCi/g was below the waste compatibility operations limit of 0.1 μCi/g. The flammable gas concentration in the tank headspace was found to be 0 percent of the LEL, and the waste specific gravity was 1.24, below the waste compatibility safety limit of 1.3 for the flammable gas accumulation issue.

The requirements for the remaining waste compatibility issues, corrosion, and heat load also were satisfied. The concentrations of NO_3^-, OH^-, and NO_2^- were within their prescribed boundaries. The tank heat load calculated from radionuclide data was 2,380 W (8,120 Btu/hr), less than the operating specification limit of 20,500 W (70,000 Btu/hr).

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APPENDIX A

ANALYTICAL RESULTS FROM 1995 GRAB SAMPLING EVENTS

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A.0 ANALYTICAL RESULTS FROM 1995 GRAB SAMPLING EVENTS

A.1 INTRODUCTION

Appendix A presents the tank 241-AN-101 chemical, radiochemical, and physical data in table form and in terms of the specific concentrations of metals, ions, radionuclides, and physical properties.

Each data table lists the following: Labcore sample identification, sample origin (riser and grab sample numbers), an original and duplicate result for each sample, a sample mean, a mean for the tank in which all grab samples are weighted equally, an RSD of the mean, and a projected tank inventory for the particular analyte using the overall mean and the estimated waste volume (4,090 kL). The projected tank inventory column is not applicable for the pH, percent water, or specific gravity data. The data are listed in standard notation for values greater than 0.001 and less than 100,000. Values outside these limits are listed in scientific notation.

The tables are numbered A-1 through A-22. A description of the units and symbols used in the analyte tables and the references used in compiling the analytical data (Esch 1995 and 1996) are found in the List of Terms and Section 7.0, respectively. For information on sampling rationale, locations, and descriptions of sampling events, see Section 3.0.

A.2 ANALYTE TABLE DESCRIPTION

The "Labcore Sample Number" column lists the laboratory sample for which the analyte was measured. Only the last four digits of each sample number are included in the tables because the first six digits are repetitive for all samples (S95T00____). Column two lists the riser from which the sample was obtained, and column three specifies the particular grab sample.

The "Result" and "Duplicate" columns are self-explanatory. The "Mean" column is the average of the result and duplicate values. All values, including those below the detection level (indicated by a less-than symbol, <), were averaged in calculating the sample means. If the result and duplicate values were both nondetected, the mean is expressed as a nondetected value. If one of the two values is nondetected, and one or both are detected, then the sample mean is reported as a detected value. The result and duplicate values and the result/duplicate means, are reported in the tables exactly as found in the original laboratory data package. The means may appear to have been rounded up in some cases and rounded down in others. This is because the analytical results in the tables may have fewer significant figures than originally reported, not because the means were incorrectly calculated.

The overall (or analyte concentration) means for the waste in tank 241-AN-101 were calculated as follows:

Grab sample mean: The arithmetic mean within a grab sample was calculated by averaging the result and duplicate values.

Riser mean (applicable only to the total alpha activity, percent water, and specific gravity data): For each of the two risers, the riser mean was calculated by averaging the three grab sample means.

Overall mean: The overall mean was calculated by averaging the two riser means for total alpha activity, percent water, and specific gravity. For other analytes, the overall mean was derived by averaging the three result/duplicate means.

The RSD of the mean (in percent) is 100 times the standard deviation of the mean divided by the overall tank mean. Relative standard deviations of the mean were not computed for analytes that had greater than 50 percent nondetected values. The standard deviation of the mean was estimated using standard ANOVA statistical techniques and used all data available for a given analyte.

The projected inventory is the product of the overall mean and the estimated volume of tank waste (4,090 kL) and the appropriate conversion factors.

The four quality control parameters assessed on the tank 241-AN-101 samples were standards, spikes, duplicates, and blanks. The quality control results were summarized in Section 5.1.2. The only quality control parameters outside their target level were the low spike results for chloride and fluoride. The sample and duplicate pairs for these two analytes are footnoted in their respective tables.

Table A-1. Tank 241-AN-101 Analytical Results: Aluminum.

Labcore Sample Number	Riser Number	Grab Sample Number	Result	Duplicate	Mean	Overall Mean	RSD (Mean)	Projected Inventory
			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
2408	22A	1AN-95-1	22,200	21,900	22,000	20,900	3.5	85,500
2409	22A	1AN-95-2	19,600	19,500	19,500			
2410	22A	1AN-95-3	20,800	21,500	21,200			

Table A-2. Tank 241-AN-101 Analytical Results: Iron.

Labcore Sample Number	Riser Number	Grab Sample Number	Result	Duplicate	Mean	Overall Mean	RSD (Mean)	Projected Inventory
			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
2408	22A	1AN-95-1	< 20.05	< 20.05	< 20.05	< 20.1	---	< 82.2
2409	22A	1AN-95-2	< 20.05	< 20.05	< 20.05			
2410	22A	1AN-95-3	< 20.05	< 20.05	< 20.05			

Table A-3. Tank 241-AN-101 Analytical Results: Sodium.

Sample Number	Riser Number	Grab Sample Number	Result	Duplicate	Mean	Overall Mean	RSD (Mean)	Projected Inventory
			μg/mL	μg/mL	μg/mL	μg/mL	%	kg
2408	22A	1AN-95-1	1.24E+05	1.23E+05	1.23E+05	1.28E+05	3.0	5.24E+05
2409	22A	1AN-95-2	1.26E+05	1.25E+05	1.25E+05			
2410	22A	1AN-95-3	1.34E+05	1.38E+05	1.36E+05			

Table A-4. Tank 241-AN-101 Analytical Results: Chloride.

Labcore Sample Number	Riser Number	Grab Sample Number	Result	Duplicate	Mean	Overall Mean	RSD (Mean)	Projected Inventory
			μg/mL	μg/mL	μg/mL	μg/mL	%	kg
2408	22A	1AN-95-1	3,300	3,260	3,280[1]	3,300	2.7	13,500
2409	22A	1AN-95-2	3,300	3,230	3,260			
2410	22A	1AN-95-3	3,040	3,700	3,370			

Note:

[1]The spike recovery was below the 80 to 120 percent recovery range defined in the SAP.

Table A-5. Tank 241-AN-101 Analytical Results: Fluoride.

Labcore Sample Number	Riser Number	Grab Sample Number	Result	Duplicate	Mean	Overall Mean	RSD (Mean)	Projected Inventory
			μg/mL	μg/mL	μg/mL	μg/mL	%	kg
2408	22A	1AN-95-1	< 68.9	817.0	443.0[1]	475	21.2	1,940
2409	22A	1AN-95-2	604.0	510.0	557.0			
2410	22A	1AN-95-3	425.0	423.0	424.0			

Note:

[1]The spike recovery was below the 80 to 120 recovery range specified in the SAP.

Table A-6. Tank 241-AN-101 Analytical Results: Hydroxide.

Labcore Sample Number	Riser Number	Grab Sample Number	Result	Duplicate	Mean	Overall Mean	RSD (Mean)	Projected Inventory
			μg/mL	μg/mL	μg/mL	μg/mL	%	kg
2408	22A	1AN-95-1	30,800	30,000	30,400	31,400	2.5	1.28E+05
2409	22A	1AN-95-2	32,200	33,700	33,000			
2410	22A	1AN-95-3	30,100	31,500	30,800			

Table A-7. Tank 241-AN-101 Analytical Results: Nitrate.

Labcore Sample Number	Riser Number	Grab Sample Number	Result	Duplicate	Mean	Overall Mean	RSD (Mean)	Projected Inventory
			μg/mL	μg/mL	μg/mL	μg/mL	%	kg
2408	22A	1AN-95-1	96,500	97,700	97,100	97,100	1.8	3.97E+05
2409	22A	1AN-95-2	1.00E+05	1.00E+05	1.00E+05			
2410	22A	1AN-95-3	94,200	94,000	94,100			

Table A-8. Tank 241-AN-101 Analytical Results: Nitrite.

Labcore Sample Number	Riser Number	Grab Sample Number	Result	Duplicate	Mean	Overall Mean	RSD (Mean)	Projected Inventory
			μg/mL	μg/mL	μg/mL	μg/mL	%	kg
2408	22A	1AN-95-1	48,400	49,300	48,800	48,200	2.7	1.97E+05
2409	22A	1AN-95-2	51,000	49,300	50,200			
2410	22A	1AN-95-3	46,000	45,400	45,700			

Table A-9. Tank 241-AN-101 Analytical Results: Phosphate.

Labcore Sample Number	Riser Number	Grab Sample Number	Result	Duplicate	Mean	Overall Mean	RSD (Mean)	Projected Inventory
			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
2408	22A	1AN-95-1	1,390	1,400	1,400	2,120	19.2	8,670
2409	22A	1AN-95-2	2,880	2,720	2,800			
2410	22A	1AN-95-3	2,170	2,170	2,170			

Table A-10. Tank 241-AN-101 Analytical Results: Sulfate.

Labcore Sample Number	Riser Number	Grab Sample Number	Result	Duplicate	Mean	Overall Mean	RSD (Mean)	Projected Inventory
			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
2408	22A	1AN-95-1	1,580	1,610	1,600	3,040	24.5	12,400
2409	22A	1AN-95-2	4,250	3,910	4,080			
2410	22A	1AN-95-3	3,460	3,430	3,440			

Table A-11. Tank 241-AN-101 Analytical Results: Americium-241.

Labcore Sample Number	Riser Number	Grab Sample Number	Result	Duplicate	Mean	Overall Mean	RSD (Mean)	Projected Inventory
			µCi/mL	µCi/mL	µCi/mL	µCi/mL	%	Ci
2411	22A	1AN-95-1	< 1.31E-05	2.28E-05	1.80E-05	5.15E-05	32.7	0.211
2412	22A	1AN-95-2	6.90E-05	7.28E-05	7.09E-05			
2413	22A	1AN-95-3	6.52E-05	6.59E-05	6.55E-05			

Table A-12. Tank 241-AN-101 Analytical Results: Cesium-134.

Labcore Sample Number	Riser Number	Grab Sample Number	Result	Duplicate	Mean	Overall Mean	RSD (Mean)	Projected Inventory
			µCi/mL	µCi/mL	µCi/mL	µCi/mL	%	Ci
2411	22A	1AN-95-1	0.00525	---	0.00525	0.00996	45	40.7
2412	22A	1AN-95-2	0.00574	---	0.00574			
2413	22A	1AN-95-3	0.0189	---	0.0189			

Table A-13. Tank 241-AN-101 Analytical Results: Cesium-137.

Labcore Sample Number	Riser Number	Grab Sample Number	Result	Duplicate	Mean	Overall Mean	RSD (Mean)	Projected Inventory
			µCi/mL	µCi/mL	µCi/mL	µCi/mL	%	Ci
2411	22A	1AN-95-1	121.5	121.2	121.3	123	0.6	5.03E+05
2412	22A	1AN-95-2	123.0	123.9	123.5			
2413	22A	1AN-95-3	122.0	125.0	123.5			

Table A-14. Tank 241-AN-101 Analytical Results: Cobalt-60.

Labcore Sample Number	Riser Number	Grab Sample Number	Result	Duplicate	Mean	Overall Mean	RSD (Mean)	Projected Inventory
			µCi/mL	µCi/mL	µCi/mL	µCi/mL	%	Ci
2411	22A	1AN-95-1	< 0.00410	< 0.00374	< 0.00392	< 0.00413	---	< 16.9
2412	22A	1AN-95-2	< 0.00418	< 0.00431	< 0.00425			
2413	22A	1AN-95-3	< 0.00386	< 0.00456	< 0.00421			

Table A-15. Tank 241-AN-101 Analytical Results: Plutonium-239/240.

Labcore Sample Number	Riser Number	Grab Sample Number	Result	Duplicate	Mean	Overall Mean	RSD (Mean)	Projected Inventory
			µCi/mL	µCi/mL	µCi/mL	µCi/mL	%	Ci
2411	22A	1AN-95-1	8.16E-05	8.25E-05	8.21E-05	5.98E-05	18.6	0.245
2412	22A	1AN-95-2	4.96E-05	4.80E-05	4.88E-05			
2413	22A	1AN-95-3	4.86E-05	4.82E-05	4.84E-05			

Table A-16. Tank 241-AN-101 Analytical Results: Strontium-89/90.

Labcore Sample Number	Riser Number	Grab Sample Number	Result	Duplicate	Mean	Overall Mean	RSD (Mean)	Projected Inventory
			μCi/mL	μCi/mL	μCi/mL	μCi/mL	%	Ci
2411	22A	1AN-95-1	0.590	0.593	0.591	0.378	28.3	1,550
2412	22A	1AN-95-2	0.268	0.259	0.264			
2413	22A	1AN-95-3	0.289	0.268	0.278			

Table A-17. Tank 241-AN-101 Analytical Results: Total Alpha.

Labcore Sample Number	Riser Number	Grab Sample Number	Result	Duplicate	Mean	Overall Mean	RSD (Mean)	Projected Inventory
			μCi/mL	μCi/mL	μCi/mL	μCi/mL	%	Ci
3903	22A	1AN-95-1	< 4.43E-04	< 5.95E-04	< 5.19E-04	< 0.00059	---	< 2.41
3905		1AN-95-2	< 5.43E-04	< 3.92E-04	< 4.68E-04			
3906		1AN-95-3	< 7.40E-04	< 8.37E-04	< 7.89E-04			
3913	15B	1AN-95-4	< 1.01E-03	< 1.35E-03	< 1.18E-03	< 0.00147		< 6.01
3914		1AN-95-5	< 1.01E-03	< 1.86E-03	< 1.44E-03			
3915		1AN-95-6	< 2.20E-03	< 1.35E-03	< 1.78E-03			

Table A-18. Tank 241-AN-101 Analytical Results: Total Inorganic Carbon.

Labcore Sample Number	Riser Number	Grab Sample Number	Result	Duplicate	Mean	Overall Mean	RSD (Mean)	Projected Inventory
			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
2408	22A	1AN-95-1	2,540	2,610	2,580	2,450	2.7	10,000
2409	22A	1AN-95-2	2,410	2,390	2,400			
2410	22A	1AN-95-3	2,380	2,350	2,360			

Table A-19. Tank 241-AN-101 Analytical Results: Total Organic Carbon.

Labcore Sample Number	Riser Number	Grab Sample Number	Result	Duplicate	Mean	Overall Mean	RSD (Mean)	Projected Inventory
			µg/mL	µg/mL	µg/mL	µg/mL	%	kg
2408	22A	1AN-95-1	3,670	3,500	3,580	2,630	18.0	10,800
2409	22A	1AN-95-2	2,150	2,180	2,160			
2410	22A	1AN-95-3	2,150	2,170	2,160			

Table A-20. Tank 241-AN-101 Analytical Results: pH.

Labcore Sample Number	Riser Number	Grab Sample Number	Result	Duplicate	Mean	Overall Mean	RSD (Mean) %
2408	22A	1AN-95-1	12.95	12.96	12.96	13.6	2.3
2409	22A	1AN-95-2	13.95	13.94	13.95		
2410	22A	1AN-95-3	13.88	13.87	13.88		

Table A-21. Tank 241-AN-101 Analytical Results: Percent Water.

Labcore Sample Number	Riser Number	Grab Sample Number	Result	Duplicate	Mean	Overall Mean	RSD (Mean) %
2408	22A	1AN-95-1	66.28	66.11	66.19	66.0	0.21
2409		1AN-95-2	66.27	65.72	66.00		
2410		1AN-95-3	65.96	65.81	65.88		
3913	15B	1AN-95-4	65.51	64.93	65.22	65.4	0.33
3914		1AN-95-5	64.80	65.11	64.95		
3915		1AN-95-6	65.95	66.03	65.99		

Table A-22. Tank 241-AN-101 Analytical Results: Specific Gravity.

Labcore Sample Number	Riser Number	Grab Sample Number	Result	Duplicate	Mean	Overall Mean	RSD (Mean) %
2408	22A	1AN-95-1	1.230	1.240	1.235	1.24	0.58
2409		1AN-95-2	1.270	1.250	1.260		
2410		1AN-95-3	1.220	1.250	1.235		
3913	15B	1AN-95-4	1.226	1.214	1.220	1.22	0.19
3914		1AN-95-5	1.214	1.216	1.215		
3915		1AN-95-6	1.223	1.217	1.220		

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APPENDIX B

HISTORICAL SAMPLING RESULTS

B.0 HISTORICAL SAMPLING RESULTS

Table B-1 shows the results of a grab sampling from April 19, 1993. Three 100 mL supernate samples were retrieved from tank 241-AN-101 using the bottle-on-a-string sampling method (Sutey 1993). The sample locations and identifications are listed below:

Sample	**Lab Identification**
Top sample	R3715
Middle sample	R3716
Bottom sample	R3717

Table B-1. 1993 Sampling Results.[1] (2 sheets)

Analyte	Sample R 3715	Sample R 3716	Sample R 3717	Overall Mean
Metals	**µg/mL**	**µg/mL**	**µg/mL**	**µg/mL**
Aluminum	15,700	15,400	12,600	14,600
Barium	0.119	0.0840	---	0.102
Boron	10.0	10.0	6.67	8.89
Calcium	5.90	5.21	8.00	6.37
Chromium	213	211	140	188
Copper	0.312	0.368	0.964	0.548
Iron	3.07	2.95	2.27	2.76
Lead	15.2	15.0	11.3	13.8
Molybdenum	31.7	31.0	20.8	27.8
Nickel	3.06	3.10	2.35	2.84
Phosphorus	896	896	595	796
Potassium	3,270	3,250	2,530	3,020
Silicon	8.46	8.02	5.14	7.21
Sodium	1.15E+05	1.13E+05	84,600	1.04E+05
Sulfur	948	942	581	824
Tungsten	63.3	63.2	42.8	56.4
Zinc	2.11	2.64	1.22	1.99
Zirconium	0.291	0.407	0.304	0.334

Table B-1. 1993 Sampling Results.[1] (2 sheets)

Analyte	Sample R 3715	Sample R 3716	Sample R 3717	Overall Mean
Anions	**μg/mL**	**μg/mL**	**μg/mL**	**μg/mL**
Hydroxide	28,100	26,600	17,400	24,000
Nitrate	93,600	89,200	58,600	80,500
Nitrite	46,400	44,400	30,400	40,400
Phosphate	2,200	2,280	1,480	1,990
Sulfate	3,070	3,030	2,110	2,740
Chloride	2,660	2,490	2,320	2,490
Ammonium	86.0	< 80.0	87.4	84.5
Cyanide	19.4	19.1	11.0	16.5
Radionuclides	**μCi/mL**	**μCi/mL**	**μCi/mL**	**μCi/mL**
Total beta	174	187	137	166
Total alpha	0.114	0.121	0.0911	0.109
^{241}Am	5.76E-04	8.29E-04	2.23E-04	5.43E-04
^{137}Cs	120	123	93.3	112
^{237}Np	< 5.95E-05	< 1.08E-04	< 1.08E-04	9.18E-05
$^{239/240}$Pu	3.27E-05	3.62E-05	1.56E-05	2.82E-05
^{90}Sr	0.0852	0.0819	0.100	0.0890
Carbon	**μg/mL**	**μg/mL**	**μg/mL**	**μg/mL**
TIC	2,150	2,150	3,510	2,600
TOC	2,570	2,140	1,460	2,060
Physical Properties				
SPG (g/mL)	1.28	1.23	1.18	1.23
% Solids (wt)	27.1	26.9	20.5	24.8
DSC	No exothermic reactions	No exothermic reactions	No exothermic reactions	---
TGA (% H_2O)	71.8	71.7	81.0	74.8
pH	13.8	13.7	13.6	13.7

Note:

[1]Sutey (1993)

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DISTRIBUTION SHEET

To	From	Page 3 of 4
Distribution	Data Assessment and Interpretation	Date 07/22/96
Project Title/Work Order		EDT No. EDT-617505
Tank Characterization Report for Double-Shell Tank 241-AN-101, WHC-SD-WM-ER-578, Rev. 0		ECN No. N/A

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
ONSITE					
Department of Energy - Richland Operations					
J. F. Thompson	S7-54	X			
W. S. Liou	S7-54	X			
N. W. Willis	S7-54	X			
ICF-Kaiser Hanford Company					
R. L. Newell	S3-09	X			
Pacific Northwest Laboratory					
N. G. Colton	K3-75	X			
J. R. Gormsen	K7-28				X
S. A. Hartley	K5-12	X			
J. G. Hill	K7-94	X			
G. J. Lumetta	P7-25	X			
A. F. Noonan	K9-81	X			
Westinghouse Hanford Company					
H. Babad	S7-14	X			
D. A. Barnes	R1-80	X			
C. J. Benar	R2-12	X			
G. R. Bloom	H5-61	X			
W. L. Cowley	A3-37	X			
L. A. Diaz	T6-06	X			
G. L. Dunford	S7-81	X			
E. J. Eberlein	R2-12				X
D. B. Engelman	R1-49	X			
J. S. Garfield	H5-49	X			
J. D. Guberski	R1-51				X
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<u>Los Alamos Laboratory</u> CST-14 MS-J586 P. O. Box 1663 Los Alamos, NM 87545					
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<u>CH2M Hill</u> P. O. Box 91500 Bellevue, WA 98009-2050					
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D. Powers		X			
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J. L. Kovach		X			
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