047712

EDMC # 47712

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PAGE COUNT 30

ACCESSION # D1972440034

46555

0047712

ENGINEERING CHANGE NOTICE

Page 1 of 2

1. ECN 635518

Proj. ECN

2. ECN Category (mark one)	3. Originator's Name, Organization, MSIN, and Telephone No.	4. USQ Required?	5. Date
Supplemental [] Direct Revision [X] Change ECN [] Temporary [] Standby [] Supersedure [] Cancel/Void []	John H. Baldwin, Data Assessment and Interpretation, R2-12, 373-4533	[] Yes [X] No	08/05/97
	6. Project Title/No./Work Order No. Tank 241-AP-102	7. Bldg./Sys./Fac. No. 241-AP-102	8. Approval Designator N/A
	9. Document Numbers Changed by this ECN (includes sheet no. and rev.) HNF-SD-WM-ER-358, Rev. 1	10. Related ECN No(s). ECN-635422	11. Related PO No. N/A

12a. Modification Work	12b. Work Package No.	12c. Modification Work Complete	12d. Restored to Original Condition (Temp. or Standby ECN only)
[] Yes (fill out Blk. 12b) [X] No (NA Blks. 12b, 12c, 12d)	N/A	N/A Design Authority/Cog. Engineer Signature & Date	N/A Design Authority/Cog. Engineer Signature & Date

13a. Description of Change

13b. Design Baseline Document? [] Yes [X] No

This ECN was generated to include additional explanatory text in the best-basis narrative, and to update the comprehensive radionuclide inventory estimates for the tank.

14a. Justification (mark one)

Criteria Change	[]	Design Improvement	[X]	Environmental	[]	Facility Deactivation	[]
As-Found	[]	Facilitate Const	[]	Const. Error/Omission	[]	Design Error/Omission	[]

14b. Justification Details

Initial release of this document was deficient.

15. Distribution (include name, MSIN, and no. of copies)

See attached distribution.

RELEASE STAMP

DATE: STA: MANIFEST RELEASE ID: 3

AUG 25 1997

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A-7900-013-1

ENGINEERING CHANGE NOTICE

1. ECN (use no. from pg. 1): ECN-635518

16. Design Verification Required	17. Cost Impact				18. Schedule Impact (days)	
	ENGINEERING		CONSTRUCTION			
[] Yes	Additional	[] $	Additional	[] $	Improvement	[]
[X] No	Savings	[] $	Savings	[] $	Delay	[]

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

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

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

Document Number/Revision	Document Number/Revision	Document Number Revision
N/A		

21. Approvals

	Signature	Date		Signature	Date
Design Authority			Design Agent		
Cog. Eng. J.H. Baldwin	John Baldwin	8/20/97	PE		
Cog. Mgr. K.M. Hall	Kathleen M. Hall	8/20/97	QA		
QA			Safety		
Safety			Design		
Environ.			Environ.		
Other			Other		

DEPARTMENT OF ENERGY

Signature or a Control Number that tracks the Approval Signature

ADDITIONAL

Tank Characterization Report for Double-Shell Tank 241-AP-102

John H. Baldwin
Lockheed Martin Hanford, Corp., Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

EDT/ECN: ECN-635518 UC: 2070
Org Code: 74620 Charge Code: N4G3A
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Key Words: Waste Characterization, Double-Shell Tank, DST, Tank 241-AP -102, 241-AP-102, AP-102, AP Farm, Tank Characterization Report, TCR, Waste Inventory, TPA Milestone M-44

Abstract: This document summarizes the information on the historical uses, present status, and the sampling and analysis results of waste stored in Tank 241-AP-102. This report supports the requirements of the Tri-Party Agreement Milestone M-44-05.

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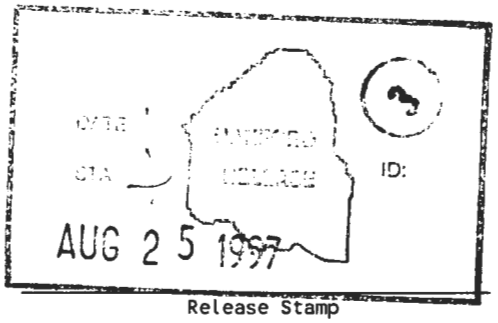
Kara J Broz 8/22/97
Release Approval Date



Release Stamp

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RECORD OF REVISION	(1) Document Number HNF-SD-WM-ER-358	Page 1

(2) Title
Tank Characterization Report for Double-Shell Tank 241-AP-102

CHANGE CONTROL RECORD

(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release (5) Cog. Engr.	(6) Cog. Mgr. Date
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A-7320-005 (08/91) WEF168

3.0 BEST-BASIS INVENTORY ESTIMATE

Information about the chemical and/or physical properties of tank wastes is used to perform safety analyses, engineering evaluations, and risk assessments associated with waste management activities, as well as to address regulatory issues. Waste management activities include overseeing tank farm operations and identifying, monitoring, and resolving safety issues associated with these operations and with the tank wastes. Disposal activities involve designing equipment, processes, and facilities for retrieving wastes and processing the wastes into a form that is suitable for long-term storage.

Chemical inventory information generally is derived using two approaches: 1) component inventories are estimated using the results of sample analyses; and 2) component inventories are predicted using a model based on process knowledge and historical information. The most recent model was developed by Los Alamos National Laboratory (LANL) (Agnew et al. 1997). Not surprisingly, information derived from these two different approaches is often inconsistent.

An effort is underway to provide waste inventory estimates that will serve as standard characterization information for the various waste management activities (Hodgson and LeClair 1996). Appendix D contains the complete narrative regarding the derivation of the inventory estimates presented in Tables 3-1 and 3-2.

Table 3-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-AP-102 as of October 21, 1996.

Analyte	Total inventory (kg)	Basis (S, M, or E)[1]	Comment
Al	48,500	S	
Bi	< 607	S	
Ca	334	S	
Cl	12,100	S	
CO_3	1.12E+05	S	
Cr	2,580	S	
F	< 702	S	
Fe	15.9	S	
Hg	3.98	M	
K	5,390	S	
La	7.42	M	
Mn	233	S	
Na	4.26E+05	S	

Table 3-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-AP-102 as of October 21, 1996.

Analyte	Total inventory (kg)	Basis (S, M, or E)[1]	Comment
Al	48,500	S	
Ni	111	S	
NO_2	1.59E+05	S	
NO_3	3.27E+05	S	
OH	38,200	S	
Pb	13.8	S	
PO_4	48,500	S	Some precipitate may not be included
Si	2.01	S	
SO_4	18,900	S	Some precipitate may not be included
Sr	0	M	
TOC	13,700	S	
U	19.3	S	
Zr	< 116	S	

Notes: [1]S=Sample-based, M_H=Hanford Defined Waste model-based, E=Engineering assessment-based .
[2]H=high, M=medium, L=low.

Table 3-2. Best-Basis Inventory Estimate for Radioactive Components in Tank 241-AP-102, Decayed to January 1, 1994, (Effective October 21, 1996). (2 Sheets)

Analyte	Total Inventory (Ci)	Basis (S,M or E)[1]	Comment
^{3}H	10.9	S	
^{14}C	2.09	S	
^{59}Ni	4.55	M	
^{60}Co	319	S	
^{63}Ni	447	M	
^{79}Se	0.882	S	
^{90}Sr	5,880	S	

Table 3-2. Best-Basis Inventory Estimate for Radioactive Components in Tank 241-AP-102, Decayed to January 1, 1994, (Effective October 21, 1996). (2 Sheets)

Analyte	Total Inventory (Ci)	Basis (S,M or E)[1]	Comment
^{90}Y	5,880	S	Based on ^{90}Sr
^{93m}Nb	27.6	M	
^{93}Zr	38.3	M	
^{99}Tc	358	S	
^{106}Ru	0.0169	M	
^{113m}Cd	205	M	
^{125}Sb	419	M	
^{126}Sn	11.8	M	
^{129}I	1.1	M	
^{134}Cs	14.4	M	
^{137m}Ba	881,000	S	Based on ^{137}Cs
^{137}Cs	931,000	S	
^{151}Sm	27,400	M	
^{152}Eu	9.74	M	
^{154}Eu	1,470	M	
^{155}Eu	582	M	
^{226}Ra	3.14 E-04	M	
^{227}Ac	0.00196	M	
^{228}Ra	0.581	M	
^{229}Th	0.0135	M	
^{231}Pa	0.00917	M	
^{232}Th	0.0573	M	
^{232}U	2.01	M	
^{233}U	7.71	M	
^{234}U	1.64	M	
^{235}U	0.0656	M	
^{236}U	0.0527	M	
^{237}Np	< 4.18	S	
^{238}Pu	< 0.681	S	
^{238}U	2.08	M	
$^{239/240}Pu$	< 0.313	S	
^{239}Pu	103	M	

Table 3-2. Best-Basis Inventory Estimate for Radioactive Components in Tank 241-AP-102, Decayed to January 1, 1994, (Effective October 21, 1996). (2 Sheets)

Analyte	Total Inventory (Ci)	Basis (S,M or E)[1]	Comment
^{240}Pu	17.9	M	
^{241}Am	1.75	S	
^{241}Pu	215	M	
^{242}Cm	0.00468	S	
^{242}Pu	0.00118	M	
^{243}Am	0.00506	M	
^{243}Cm	0.173	S	
^{244}Cm	< 0.266	S	

[1]S=Sample-based
M=Hanford Defined Waste model-based (Agnew et al. 1997)
E=Engineering assessment-based

APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR DOUBLE-SHELL TANK 241-AP-102

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APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR DOUBLE-SHELL TANK 241-AP-102

An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities (Kupfer et al. 1995). As part of this effort, an evaluation of available chemical information for tank 241-AP-102 was performed, and a best-basis inventory was established. This work, detailed in the following sections, follows the methodology that was established by the standard inventory task.

D1.0 CHEMICAL INFORMATION SOURCES

Available composition information for the waste in tank 242-AP-102 is as follows:

- De Lorenzo et al. (1995) provides characterization results from the 1993 "bottle-on-a-string" sampling event and summarizes the results of the statistical analysis of data from the sample event.

- The characterization and test plan for the grouting of the waste in 241-AP-102 (Hendrickson et al. 1993) provides data on the waste heel in that tank before the receipt of waste from tank 241-AN-106.

- Characterization results for the waste existing in tank 241-AN-106 before being transferred to tank 241-AP-102 (Welsh 1991) was used to compare with the characterization results from the latest sampling event for tank 241-AP-102.

- 242A Evaporator Post Run Documents provide information about the waste before it was sent to tank 241-AN-106 (Certa 1983, Gratny 1984a, 1984b).

- The HDW model document (Agnew et al. 1996) provides tank content estimates derived from the LANL model, in terms of component concentrations and inventories. A complete list of data sources used in this evaluation is provided at the end of this section.

D2.0 COMPARISON OF COMPONENT INVENTORY VALUES

Sample-based inventories derived from analytical concentration data, and HDW model inventories generated by the HDW model (Agnew et al. 1996), are compared in Tables D2-1 and D2-2. (The chemical species are reported without charge designation per the best-basis inventory convention). A tank volume of 4,150 m^3 (1,097 kgal) is used by both sources. The density used to calculate the sample-based inventory is 1.20 g/mL, which is slightly lower than the HDW model prediction of 1.28 g/mL.

The HDW model estimates are higher for all major components with the exception of ^{137}Cs and potassium. Some components like sodium, phosphate, and nitrate agree very well, while others, particularly iron and chromium, two components that are derived primarily from suspect corrosion estimates made by Agnew et al. (1996), show poor agreement. The largest disparity is found with silicon; the HDW model estimate is over three orders of magnitude larger than the sample-based silicon inventory.

Table D2-1. Sampling and Hanford Defined Waste Model Inventory Estimates for Nonradioactive Components in Double-Shell Tank 241-AP-102. (2 sheets)

Analyte	Sampling Inventory Estimate[1] (MT)	HDW Inventory Estimate[2] (MT)	Analyte	Sampling Inventory Estimate[1] (MT)	HDW Inventory Estimate[2] (MT)
Al	48.5	87.4	NO_3	327	622
As	3.71E-04	NR	Ni	0.111	0.960
Ba	0.00119	NR	Pb	0.0138	0.475
Be	6.10E-04	NR	Se	0.00153	NR
B	0.00251	NR	Si	0.00201	4.35
Cd	0.00614	NR	Ti	0.0147	NR
Ca	0.334	NR	U	0.0193	5.41
Ce	NR	NR	Zn	< 0.0395	NR
Cr	2.58	6.49	Zr	< 0.116	0.14
Cu	< 0.0157	NR	NH_3	1.14	1.76
Fe	0.0159	1.07	CO_3	112	59.6
K	5.39	4.60	Cl	12.1	15.0
Mg	0.0110	NR	NO_2	159	216
Mn	0.233	0.463	PO_4	48.5	53.3
Na	426	572	SO_4	18.9	51.2

Table D2-1. Sampling and Hanford Defined Waste Model Inventory Estimates for Nonradioactive Components in Double-Shell Tank 241-AP-102. (2 sheets)

Analyte	Sampling Inventory Estimate[1] (MT)	HDW Inventory Estimate[2] (MT)	Analyte	Sampling Inventory Estimate[1] (MT)	HDW Inventory Estimate[2] (MT)
CN	0.103	NR	TOC	13.7	35.0
F	< 0.702	2.82	OH	38.2	243

Notes:

NR = not reported
MT = metric tons
[1]De Lorenzo et al. (1994)
[2]Agnew et al. (1996)

Table D2-2. Sampling and Hanford Defined Waste Model Inventory Estimates for Radioactive Components in Double-Shell Tank 241-AP-102. (Decayed to January 1, 1994)

Analyte	Sampling inventory estimate[1] (Ci)	HDW inventory estimate[2] (Ci)	Analyte	Sampling inventory estimate[1] (Ci)	HDW inventory estimate[2] (Ci)
^{241}Am	1.75	134	$^{239/240}Pu$	<0.313	121
^{14}C	2.09	77.1	^{79}Se	0.882	7.79
^{137}Cs	9.31E+05	6.04E+05	$^{89/90}Sr$	5,880	2.45E+05
^{60}Co	319	93.1	^{99}Tc	358	571
^{242}Cm	0.00468	0.349	^{3}H	10.9	516
^{243}Cm	0.173	0.0329			

Notes:

[1]De Lorenzo et al. (1994)
[2]Agnew et al. (1997)

D2.1 REVIEW AND EVALUATION OF COMPONENT INVENTORIES

The following evaluation of tank contents is performed in order to identify potential errors and/or missing information that would influence the sampling-based and HDW model component inventories.

D2.1.1 Evaluation of Historical Data

Tank 241-AP-102 was last sampled in April 1993. Approximately 88 volume percent of the waste in tank 241-AP-102, or 3,679 m^3 (972 kgal) was transferred from tank 241-AN-106 in 1992. Samples were taken of this waste at both locations; tank 241-AN-106 was sampled in 1989 and tank 241-AP-102 in 1993. A comparison of inventory estimates, using composite concentrations reported from both sampling events and taking into consideration the dilute phosphate heel in tank 241-AP-102 that mixed with the incoming waste from tank 241-AN-106, shows that the historic concentration estimates developed from the data for tank 241-AN-106 and data for the heel are usually 70 percent to 80 percent of the concentrations in the TCR for tank 241-AP-102 as indicated in Table D2-3.

Table D2-3. Estimated and Analytical Composition for Waste in Tank 241-AP-102.

Analyte	Historical estimate (μg/L)	Reported analytical composite[1] (μg/L)	Historic/ analytical
Al	8.17E+06	1.16E+07	0.70
Cr	4.96E+05	6.18E+05	0.80
K	9.50E+05	1.29E+06	0.74
Na	8.10E+07	1.02E+08	0.79
U	3,520	4,620	0.76
NH_3	1.08E+05	2.73E+05	0.40
CO_3	1.74E+07	2.68E+07	0.65
Cl	2.16E+06	2.90E+06	0.74
OH	7.09E+06	9.15E+06	0.77
NO_3	6.03E+07	7.82E+07	0.77
NO_2	2.60E+07	3.80E+07	0.68
PO_4	1.80E+07	1.16E+07	1.55
SO_4	2.06E+06	4.51E+06	0.46
^{137}Cs (μCi/L)	1.77E+05	1.94E+05	0.79
$^{89/90}Sr$ (μCi/L)	1,910	1,410	1.35

Note:
[1]De Lorenzo et al. (1994)

Prior to being transferred to tank 241-AP-102, the phosphate-rich waste had stratified into two layers, the result of pouring two batches of phosphate waste with markedly different specific gravities into the tank. After transfer to tank 241-AP-102, this waste, with the addition of the more-dilute phosphate heel, had been mixed for 53 days prior to sampling to homogenize the waste and to ensure that the resulting temperature increase from the heat of mixing had dissolved most of the salt crystals. Both sampling events used bottles attached to strings to collect multiple samples from the entire depth of the waste.

Provisions were made in the sampling plan for the characterization of tank 241-AN-106 to obtain samples that did not over-represent any one layer. An objective of the characterization effort was to locate the interface between these layers. A statistical analysis of the data could not determine with confidence the location of the interface; furthermore, the analysis concluded that equal volumes of each sample would represent the contents of the tank (Welsh 1991), the inference being that the interface was in the mid-level of the waste. This assumption does not hold up under scrutiny. Data from the samples of concentrated phosphate (CP) waste taken from tank 241-AN-106 are shown in Table D2-4, supposedly in increasing depth from the bottom of the tank. Sample 10, labeled by the sampling crew as having been taken 533 cm (210 in.) from the bottom, has concentrations very much like samples from the bottom rather than the top, which may indicate that the sample's location was misidentified. Alternatively, it may be that sample 10 is labeled correctly and samples 7 and 11 between sample 10 and the bottom of the tank are out of place and belong above sample 10.

The latter explanation is more likely the truth. The density for sample 7 corresponds with the upper layer. The concentrations in sample 11 appear to reflect the interface region because they lie between the concentrations found in the upper and lower regions. Additionally, a study of the 242A Evaporator records indicates that 508 cm (200 in) of CP waste with a density of 1.35 g/cm^3, and constituent concentrations similar to samples taken from the bottom of tank 241-AN-106, were transferred to tank 241-AN-106 after Campaign 83-5 (Certa 1983). A comparison of Table D2-4 with Table D2-5 shows that the composition of the product from the 83-5 evaporator campaign compares very well with samples taken from the lower layer tank 241-AN-106 represented by samples 3, 4, 8, 10 and 12.

Following evaporator campaigns 84-1 and 84-2, two additional batches totaling 394 cm (155 in.) were transferred from the 242A Evaporator to tank 241-AN-106. This waste had a lower average specific gravity than the first batch and the average concentrations for these batches are not unlike the concentrations of the upper layer in tank 241-AN-106. The Evaporator data for the 84-1 and 84-2 campaigns are shown in Table D2-5. The higher concentrations in the upper layer of the tank 241-AN-106 data (Table D2-4) are likely due to diffusion of waste from the bottom layer to the region of lower concentration.

Table D2-4. Mean Sample Data from 1989 Sampling of Tank 241-AN-106. (Welsh 1991)

Sample Number	Sample Depth[1] (cm)	Na (mg/L)	Al (mg/L)	P (mg/L)	K (mg/L)	NO_3 (mg/L)	Cr (mg/L)	CO_3 (M)
9	930	38,400	1,410	9,600	288	16,200	106	0.18
1	841	39,500	1,460	10,300	294	17,900	105	0.14
5	742	40,200	1,480	9,910	292	16,400	106	0.15
6	569	42,700	2,520	8,060	401	22,300	169	0.18
2	559	40,700	1,460	9,720	323	18,300	104	0.14
10	533	1.04E+05	13,800	3,680	1,250	95,800	831	0.44
7	348	37,200	1,420	9,150	308	15,000	101	0.13
11	290	88,100	10,300	5,870	1,040	76,900	649	0.35
3	254	1.65E+05	20,700	1,410	2,010	1.62E+05	1,150	0.61
8	124	1.55E+05	20,400	1,360	1,940	1.66E+05	1,170	0.55
4	51	1.64E+05	19,700	4,700	2,010	1.55E+05	1,160	0.62
12	41	1.57E+05	20,400	1,420	2,090	1.36E+05	1,180	0.72
Sample Number	**Sample Depth (cm)**	**OH (M)**	**NO_2 (M)**	**SO_4 (mg/L)**	**^{137}Cs (μCi/L)**	**Ca (mg/L)**	**Cl (mg/L)**	**Density (g/cm^3)**
9	930	0.25	0.14	893	38,250	24	646	1.12
1	841	0.09	0.14	2,820	38,250	11	1,160	1.11
5	742	0.09	0.10	499	37,660	11	595	1.12
6	569	0.14	0.18	840	56,540	18	939	1.13
2	559	0.09	0.14	2,710	39,330	11	1,060	1.11
10	533	0.51	0.84	3,120	2.60E+05	124	3,290	1.41
7	348	0.07	0.10	534	36,925	10	685	1.09
11	290	0.40	0.67	2,420	1.92E+05	97	2,700	1.41

Table D2-4. Mean Sample Data from 1989 Sampling of Tank 241-AN-106. (Welsh 1991)

Sample Number	Sample Depth (cm)	OH (M)	NO_2 (M)	SO_4 (mg/L)	^{137}Cs (μCi/L)	Ca (mg/L)	Cl (mg/L)	Density (g/cm^3)
3	254	1.11	1.23	4,430	3.91E+05	160	5,430	1.37
8	124	1.12	1.26	4,570	3.98E+05	145	4,800	1.36
4	51	0.78	1.18	3,650	3.83E+05	155	4,020	1.60
12	41	1.16	1.23	4,380	3.90E+05	162	4,850	1.35

Note:

[1]Depth from bottom of the tank.

Table D2-5. Evaporator Pre-Run Data.

Analyte	Campaign 83-5 Analytical Mean (mg/L)	Campaign 84-1 and 84-2 Analytical Mean (mg/L)
Al	23,500	213
OH	21,300	635
NO_2	67,200	1,495
NO_3	1.77E+05	3,418
PO_4	4,460	21,130
SO_4	23,100	439
CO_3	38,400	969
TOC	6,600	800
^{137}Cs (μCi/L)	4.56E+05	21,600
^{90}Sr (μCi/L)	7,770	1.67
Density (g/cm^3)	1.35	1.053 (Post-run)

It is evident from these observations that the interface for the two layers in tank 241-AN-106 should have been at about 508 cm (200 in.). A new historic estimate recognizing the correct location of the interface could be done at this point; however, there are other considerations that may have contributed to the differences between the tank 241-AN-106 samples and those samples taken from tank 241-AP-102. These factors are discussed below.

First of all, the volume in tank 241-AN-106 decreased about 95 m^3 (25 kgal), or about 3 percent, during the period after it was sampled and before the transfer to tank 241-AP-102 (Koreski 1994). Transfer records label these losses as unknowns, but the loss is likely due to in-tank evaporation over the three-year period.

Secondly, the TCR for tank 241-AN-106 indicates that about 64 m^3 (17 kgal) of solids formed in that tank before its contents were sent to tank 241-AP-102. This may mean that solids also precipitated from the samples while they were in holding at the laboratory. Precipitated solids in sampling containers were not always included in laboratory characterization work at that time. Welsh does not mention whether or not solids were detected in the samples. Furthermore, it is not unlikely that a significant fraction of the solids in tank 241-AN-106 were transferred to tank 241-AP-102, given that the tank was pumped from the bottom. These solids would likely have been redissolved in tank 241-AP-102 during homogenization (mixing), especially considering that the heat of mixing increased the temperature above 27 °C

(81 °F)--the temperature at which Na_3PO_4, the predominant species in the solid phase of wastes of this type are observed to dissolve.

Another reason that may account for some of the variance between the historical estimate and the sample data from tank 241-AP-102 is that the waste in tank 241-AN-106 was not mixed before transfer. Because the lower layer of waste was pumped out first, the liquid heel that was left on top of the accumulated solids consisted mostly of the upper waste layer. If the volume of waste transferred to tank 241-AP-102 was 3,679 m^3 (972 kgal) (De Lorenzo et al. 1994) out of a total volume of 3,929 m^3 (1,038 kgal) (Douglas et al. 1996), then the residual heel in tank 241-AN-106 was 250 m^3 (66 kgal) of which 185 m^3 (49 kgal) were liquids.

D2.1.2 Predicted Waste Inventories

A new historical estimate, based on information in the previous discussion, was established and compared to the results of the 1993 sampling event. The following assumptions and observations were used to generate the historical estimate:

- The location of the interface between the waste layers in tank 241-AN-106 before transfer was located at 508 cm (200 in.) from the bottom of the tank.
- Samples 7 and 11 from the 1989 sampling of tank 241-AN-106 are assumed to have come from the upper layer of the tank.
- The volume in tank 241-AN-106 decreased 3 percent from evaporation before the transfer to tank 241-AP-102. The total volume at the time of transfer was 3,929 m^3 (1,038 kgal).
- 64.4 m^3 (17 kgal) of solids precipitated in tank 241-AN-106 before the transfer of liquids to tank 241-AP-102. No assumptions were made about the amount of solids transferred with the liquid to tank 241-AP-102 or its composition.
- 185 m^3 (49 kgal) of liquid composed of waste from the upper layer of tank 241-AN-106 was left in tank 241-AN-106 after the transfer to tank 241-AP-102.
- No radiolysis of nitrate to nitrite and no addition of nitrite to the waste for corrosion purposes are factored into this assessment.
- 88 percent of the waste volume in tank 241-AP-102 is from the waste transferred from tank 241-AN-106; the remainder is the dilute phosphate heel from previous waste additions.

Average concentrations for both the upper and lower waste layers were calculated from the data in Table D2-4. Bottom-layer concentrations (< 508 cm [200 in.] from the bottom) were multiplied by 2,082 m^3 (508 cm [200 in.] of waste) and the results were added to the top-layer concentrations (> 508 cm [200 in.] from the bottom) multiplied by the remaining volume of 1,749 m^3 (427 cm [168 in.] of waste). This volume was calculated by subtracting both the volume of the 508-cm (200-in.) bottom layer and the volume of the top layer assumed to have been left in tank 241-AN-106 after the transfer, from the total waste volume in tank 241-AN-106 at the time it was sampled. To finally arrive at the corrected concentrations, the resulting inventories were divided by the waste volume in tank 241-AN-106 at the time when it was transferred to tank 241-AP-102. It should be noted that this volume was 3 percent lower than the volume recorded four years earlier at the time of the sampling event.

The corrected concentration estimates for wastes sent from tank 241-AN-106 were combined with data for the 12 volume percent heel in tank 241-AP-102 (Winters 1988) by adding 88 percent of the values from the transferred waste to 12 percent of the values from the heel. The resulting historical estimate of the composition of the waste in tank 241-AP-102 are compared in Table D2-6 to the results of the 1993 sampling event for tank 241-AP-102.

Table D2-6. Comparison of Historical Estimate and Analytical Estimates of the Composition of Waste in Tank 241-AP-102.

Analyte	Historical Estimate (μg/L)	Reported Analytical Composite[1] (μg/L)	Historical/ Analytical
Al	1.11E+07	1.16E+07	0.96
Cr	6.45E+05	6.18E+05	1.04
K	1.16E+06	1.29E+06	0.90
Na	9.72E+07	1.02E+08	0.95
U[2]	3,520	4,620	0.76
NH_3[2]	1.08E+05	2.73E+05	0.40
CO_3	2.60E+07	2.68E+07	0.97
Cl	2.79E+06	2.90E+06	0.96
OH	9.99E+06	9.15E+06	1.09
NO_3	8.67E+07	7.82E+07	1.11
NO_2	3.15E+07	3.80E+07	0.83
PO_4	1.68E+07	1.16E+07	1.45
SO_4	2.97E+06	4.51E+06	0.66
^{137}Cs[3] (μCi/L)	1.40E+05	2.23E+05	0.63

Table D2-6. Comparison of Historical Estimate and Analytical Estimates of the Composition of Waste in Tank 241-AP-102.

Analyte	Historical Estimate (μg/L)	Reported Analytical Composite[1] (μg/L)	Historical/ Analytical
$^{89/90}Sr^{2,3}$ (μCi/L)	1,510	1,410	1.07

Notes:
[1]De Lorenzo et al. (1994)
[2]Constituent concentrations reported for the heel only.
[3]Decayed to January 1, 1994.

The two estimates are in agreement with each other for most components. Phosphate, sulfate, and ammonia appear to have the largest discrepancies. The phosphate and sulfate differences are probably due to solids formation; these and other discrepancies are discussed below.

Because of the agreement between the sampling events, and the extensive sampling preparations for the 1993 sampling of tank 241-AP-102 (such as mixing for 53 days, temperature controls, the sample-based data is a better basis than the HDW model although the HDW estimates for several major components like sodium and phosphate are reasonably close to the sample estimates.

D3.0 COMPONENT INVENTORY EVALUATION

D3.1 PHOSPHATE

The PO_4 inventory predicted by the historical data is 45 percent higher than the tank 241-AP-102 sample result. Sodium phosphate salts have been observed to crystallize from CP waste on many occasions. During evaporator operations, sodium phosphate solids were found plated on the walls of the evaporator receipt tank; sodium phosphate solids were also found in samples taken from tank 241-AN-106 and 241-AP-102. The lower phosphate concentrations in the sample result likely reflect the formation of sodium phosphate salts in tank 241-AN-106 before the transfer. Salts that may have precipitated in tank 241-AP-102 should have been redissolved when the temperature was elevated above 80 degrees Fahrenheit although it's conceivable that smaller patches of solid material remained plated to the walls of the tank. It's more likely that phosphate salts continued to form in tank 241-AN-106 before the waste was transferred. This explanation does account for the lower phosphate concentrations in the tank 241-AP-102 samples. The HDW model value agrees very well with the sample; it is 10 percent higher. The sample value is assumed to be correct.

D3.2 SULFATE

The sulfate inventory predicted by the corrected historical estimate is only 2/3 of the sample value. The sulfate concentrations in samples taken from tank 241-AN-106 (Table 11.2-4) indicate a sporadic distribution that is suspect. Sulfate concentrations increased after heating the samples. The increase was attributed to salts that may have been present in solids obtained from the samples, or to the fact that sulfate was a ligand of a complex ion that could have dissociated after heating. While it is part of a complex ion, sulfate cannot be detected by chromatography. If a complex ion containing sulfate were present during the 1989 sampling of tank 241-AN-106 then it would not have been detected. Because measures were taken in 1993 to ensure the entire sample was analyzed, the sample value is assumed to be correct.

D3.3 ALUMINUM

The aluminum in tank 241-AP-102 did not come from the CP waste in significant quantities; rather, it was part of the waste heels in the evaporator feed and receipt tanks that were mixed with the CP waste before processing in the 242A evaporator. This mixing is reflected in the higher cation concentrations in the lower layer of the waste when it was in tank 241-AN-106; this layer contained about 14 volume percent of waste from other processes (Certa 1983). The HDW model is in agreement in assuming no significant quantities of aluminum in the CP waste, but the HDW model prediction for aluminum is 80 percent higher than the sample-based value. The aluminum inventory predicted by this engineering assessment and the sample-based inventory are statistically identical and for that reason the sample-based value is considered to be the best basis.

D3.4 SODIUM

The sodium inventory predicted by the corrected historical estimate is only 5 percent lower than the TCR results, lending more credence to the assumption that the sample-based estimates are the better basis. The HDW model estimate for sodium is 34 percent higher than the TCR results, which is respectable agreement. In the HDW model, about 93 percent of the sodium came from sources other than CP waste. In defining the liquid phase composition for these source terms, the HDW model overpredicts the solubility of most components. This accounts for much of the higher concentrations being observed in this and other waste tanks.

D4.0 DEFINE THE BEST-BASIS AND ESTABLISH COMPONENT INVENTORIES

The results from this evaluation support using the sample results as the basis for the best estimate inventory to tank 241-AP-102 for the following reasons:

1. Data from samples of essentially the same waste taken at two different times in two different tanks show excellent agreement.

2. The contents of tank 241-AP-102 were well mixed before sampling and the elevated temperature that resulted from this mixing should have dissolved precipitated salts.

Best-basis inventory estimates for tank 241-AP-102 are presented in Tables D4-1 and D4-2.. HDW model values are used where sample values were not available. Radionuclide values are decayed to January 1, 1994.

The inventory values reported in Tables D4-1 and D4-2 are subject to change. Refer to the Tank Characterization Database (TCD) for the most current inventory values.

Best-basis tank inventory values are derived for 46 key radionuclides (as defined in Section 3.1 of Kupfer et al. 1997), all decayed to a common report date of January 1, 1994. Often, waste sample analyses have only reported ^{90}Sr, ^{137}Cs, $^{239/240}Pu$, and total uranium, or (total beta and total alpha) while other key radionuclides such as ^{60}Co, ^{99}Tc, ^{129}I, ^{154}Eu, ^{155}Eu, and ^{241}Am, etc., have been infrequently reported. For this reason it has been necessary to derive most of the 46 key radionuclides by computer models. These models estimate radionuclide activity in batches of reactor fuel, account for the split of radionuclides to various separations plant waste streams, and track their movement with tank waste transactions. (These computer models are described in Kupfer et al. 1997, Section 6.1 and in Watrous and Wootan 1997.) Model generated values for radionuclides in any of 177 tanks are reported in the Hanford Defined Waste Rev. 4 model results (Agnew et al. 1997a). The best-basis value for any one analyte may be either a model result or a sample or engineering assessment-based result if available. (No attempt has been made to ratio or normalize model results for all 46 radionuclides when values for measured radionuclides disagree with the model.) For a discussion of typical error between model derived values and sample derived values, see Kupfer et al. 1997, Section 6.1.10.

Best-basis tables for chemicals and only four radionuclides (^{90}Sr, ^{137}Cs, Pu and U) were being generated in 1996, using values derived from an earlier version (Rev. 3) of the Hanford Defined Waste model. When values for all 46 radionuclides became available in Rev 4 of the HDW model, they were merged with draft best-basis chemical inventory documents. Defined scope of work in FY 1997 did not permit Rev. 3 chemical values to be updated to Rev. 4 chemical values.

Table D4-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-AP-102 as of October 21, 1996.

Analyte	Total inventory (kg)	Basis (S, M, or E)[1]	Comment
Al	48,500	S	
Bi	< 607	S	
Ca	334	S	
Cl	12,100	S	
CO_3	1.12E+05	S	
Cr	2,580	S	
F	< 702	S	
Fe	15.9	S	
Hg	3.98	M	
K	5,390	S	
La	7.42	M	
Mn	233	S	
Na	4.26E+05	S	
Ni	111	S	
NO_2	1.59E+05	S	
NO_3	3.27E+05	S	
OH	38,200	S	
Pb	13.8	S	
PO_4	48,500	S	Some precipitate may not be included
Si	2.01	S	
SO_4	18,900	S	Some precipitate may not be included
Sr	0	M	
TOC	13,700	S	
U	19.3	S	
Zr	< 116	S	

Notes: [1]S=Sample-based, M_H=Hanford Defined Waste model-based, E=Engineering assessment-based .
[2]H=high, M=medium, L=low.

Table D4-2. Best-Basis Inventory Estimate for Radioactive Components in Tank 241-AP-102, Decayed to January 1, 1994, (Effective October 21, 1996). (2 Sheets)

Analyte	Total Inventory (Ci)	Basis (S,M or E)[1]	Comment
^{3}H	10.9	S	
^{14}C	2.09	S	
^{59}Ni	4.55	M	
^{60}Co	319	S	
^{63}Ni	447	M	
^{79}Se	0.882	S	
^{90}Sr	5,880	S	
^{90}Y	5,880	S	Based on ^{90}Sr
^{93m}Nb	27.6	M	
^{93}Zr	38.3	M	
^{99}Tc	358	S	
^{106}Ru	0.0169	M	
^{113m}Cd	205	M	
^{125}Sb	419	M	
^{126}Sn	11.8	M	
^{129}I	1.1	M	
^{134}Cs	14.4	M	
^{137m}Ba	881,000	S	Based on ^{137}Cs
^{137}Cs	931,000	S	
^{151}Sm	27,400	M	
^{152}Eu	9.74	M	
^{154}Eu	1,470	M	
^{155}Eu	582	M	
^{226}Ra	3.14 E-04	M	
^{227}Ac	0.00196	M	
^{228}Ra	0.581	M	
^{229}Th	0.0135	M	
^{231}Pa	0.00917	M	
^{232}Th	0.0573	M	
^{232}U	2.01	M	
^{233}U	7.71	M	
^{234}U	1.64	M	

Table D4-2. Best-Basis Inventory Estimate for Radioactive Components in Tank 241-AP-102, Decayed to January 1, 1994, (Effective October 21, 1996). (2 Sheets)

Analyte	Total Inventory (Ci)	Basis (S,M or E)[1]	Comment
^{235}U	0.0656	M	
^{236}U	0.0527	M	
^{237}Np	< 4.18	S	
^{238}Pu	< 0.681	S	
^{238}U	2.08	M	
$^{239/240}Pu$	< 0.313	S	
^{239}Pu	103	M	
^{240}Pu	17.9	M	
^{241}Am	1.75	S	
^{241}Pu	215	M	
^{242}Cm	0.00468	S	
^{242}Pu	0.00118	M	
^{243}Am	0.00506	M	
^{243}Cm	0.173	S	
^{244}Cm	< 0.266	S	

[1]S=Sample-based
M=Hanford Defined Waste model-based (Agnew et al. 1997)
E=Engineering assessment-based

D5.0 APPENDIX D REFERENCES

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