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ENGINEERING CHANGE NOTICE

Page 1 of 2

1. ECN 657288

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 [X] Cancel/Void []	Melvin R. Adams, Data Assessment and Interpretation, R2-12, 373-6167	[] Yes [X] No	06/13/00
	6. Project Title/No./Work Order No. Tank 241-SY-101	7. Bldg./Sys./Fac. No. 241-SY-101	8. Approval Designator N/A
	9. Document Numbers Changed by this ECN (includes sheet no. and rev.) ~~HNF~~-SD-WM-ER-409, Rev. ~~1~~ 0C WHC 6-13-00	10. Related ECN No(s). ECNs: 643406, 644488, 653796	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

Document has been released and superseded by an electronic information database and data currently available via hard copy are now available at the HLAN address: http://pctwins.pnl.gov:9397/twinsproto/default.htm.

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14a. Justification (mark one)

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

14b. Justification Details

Electronic access to information and data is superseding hard copy document.

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

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ENGINEERING CHANGE NOTICE

1. ECN (use no. from pg. 1) ECN-657288

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/Specificatio n	[]
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. M. R. Adams	M R Adams	6/13/00	PE		
Cog. Mgr. J. G. Field	L M Arsenault for JG Field	6/13/00	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-SY-101

Melvin R. Adams
CH2M Hill Hanford Group, Inc., Richland, WA 99352
U.S. Department of Energy Contract 8023764-9-K001

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Abstract: N/A

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RECORD OF REVISION	(1) Document Number WHC-SD-WM-ER-409	Page 1

(2) Title
Tank Characterization Report for Double-Shell Tank 241-SY-101

CHANGE CONTROL RECORD

(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release (5) Cog. Engr.	(6) Cog. Mgr. Date
0	(7) Initially released 08/03/95 on EDT 613104.	D. L. Herting	J. G. Kristofzski
0A RS	Incorporate per ECN-643406.	M. J. Kupfer	K. M. Hodgson
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0B RS	Incorporate per ECN-644488	M.J. Kupfer	K.M. Hodgson 7/20/98
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			for J G Field

HNF-SD-WM-ER-409, Rev. 1
This report prepared especially for Archive TIR on 6/13/00

Some of the reports herein may contain data that has not been reviewed or edited. The data will have been reviewed or edited as of the date that a Tank Interpretive Report (TIR) is prepared and approved. The TIR for this tank was approved on June 7, 2000.

Tank: 241-SY-101

Sampling Events:
- 22
- 23
- 255
- 256
- 257
- 28
- 90-FIC-R8421
- 90-MT-R8423
- 90-SW-R8422
- 91-AUG-R9217
- 91-AUG-R9221
- 91-AUG-R9255
- 91-AUG-R9257
- 91-SW-R9218
- 91-SW-R9226
- 91-SW-R9256
- 91-SW-R9258
- SYNTH

Reports:
- Tank Interpretive Report

Constituent Groups:
- Anions
- Inorganics
- Metals/Nonmetals
- Organics
- PCBs
- Physical Properties
- Radionuclides

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Data Dictionary to Reports in this Document

Report	Field	Description
Tank Interpretive Report		Interprets information about the tank answering a series of seven questions covering areas such as information drivers, tank history, tank comparisons, disposal implications, data quality and quantity, and unique aspects of the tank.

Tank Interpretive Report For 241-SY-101

Tank Information Drivers

Question 1: What are the information drivers applicable to this tank? What type of information does each driver require from this tank? (Examples of drivers are Data Quality Objectives, Mid-Level Disposal Logic, RPP Operation and Utilization Plan, test plans and Letters of Instruction.) To what extent have the information and data required in the driving document been satisfied to date by the analytical and interpretive work done on this tank?

The information drivers for tank 241-SY-101 are the Flammable Gas Data Quality Objective (DQO), Tank Safety Screening DQO, Organic Solvent Safety Issue DQO, Low-Activity Waste (LAW) Feed DQO, Confirm Tank T is an Appropriate Feed Source for LAW Feed (Waste Feed Delivery) DQO, Interface Control Document-23 (ICD-23) issue, SY-101 Level Rise issue, Air Emissions DQO, and Dangerous Waste DQO. As of the date this report was prepared, March 27, 2000, the sampling events associated with this tank did not address the issues of the Air Emissions or Dangerous Waste DQOs. The issues of these two DQOs are currently being evaluated and will be applied as specified in the interface control documents with the Office of River Protection. The remaining issues are discussed below. In addition, because the Compatibility DQO was used to assess the 1998/1999 data for compatibility purposes in preparation for the December 1999 - March 2000 transfers, this DQO is also addressed.

Flammable Gas DQO: Does a possibility exist for releasing flammable gases into the headspace of the tank or releasing chemical or radioactive materials into the environment?

The requirements to support the flammable gas issue are documented in the *Data Quality Objective to Support Resolution of the Flammable Gas Safety Issue* (Bauer and Jackson 1998). The Flammable Gas DQO has been extended to apply to all tanks. Analyses and evaluations will change according to program needs until this issue is resolved. Final resolution of the Flammable Gas issue is expected to be completed by September 30, 2001 (Johnson 1997).

Retained gas samples (RGSs) from the 1998/1999 core sampling event (core 255: segments 1, 2, 3, 4, 8, 13, and 21; core 256: segments 3, 4, 10, 17, and 23; core 257: segment 5) were analyzed to address flammable gas issues. The results of RGS testing are reported in Mahoney et al. (1999), and a summary is provided below in Table 1-1.

Table 1-1. Summary of RGS Results.[1,2]

Parameter	Units	Core 255[3]	Core 256[4]
CRUST			
Average gas fraction	---	0.40 ± 0.20	0.52 ± 0.26
Gas volume in situ (wet)	m^3	245 ± 122	424 ± 212
N_2	mol%	27 ± 4.5	27 ± 4.5
H_2	mol%	34 ± 4.4	32 ± 3.9
N_2O	mol%	19 ± 2.5	19 ± 2.4
NH_3	mol%	19 ± 4.7	21 ± 5.1
CH_4	mol%	0.6 ± 0.08	0.6 ± 0.1
Other	mol%	0.6 ± 0.2	0.4 ± 0.1
MIXED SLURRY[5]			
Average gas fraction	---	0.029 ± 0.014	0.031 ± 0.015
Gas volume in situ (wet)	m^3	108 ± 54	116 ± 58
N_2	mol%	40 ± 14	32 ± 11
H_2	mol%	26 ± 8.1	31 ± 8.5
N_2O	mol%	24 ± 7.4	26 ± 7.5
NH_3	mol%	7.1 ± 2.2	7.8 ± 2.3
CH_4	mol%	1.3 ± 0.5	1.3 ± 0.4
Other	mol%	1.4 ± 0.7	1.2 ± 0.6

Notes:

[1]Mahoney et al. (1999)

[2]The values in Table 1-1 correspond to the lower-bound solubility basis.

[3]The core 255 average gas fractions were used for best-basis purposes in Question 7.

[4]Data from the lone RGS segment from core 257 were included with the core 256 results.

[5]Includes RGS samples from the convective and settled solids layers.

Tank 241-SY-101 has been fitted with a standard hydrogen monitoring system (SHMS), a gas monitoring system-1 (GMS-1), and a gas monitoring system-2 (GMS-2) to continuously monitor the tank and collect vapor-phase data to support resolution of flammable gas issues (McCain 1999). Further detail regarding these instruments is provided in McCain (1999). A summary of the vapor-phase data is provided below.

Prior to installation of the mixer pump in July 1993, tank 241-SY-101 experienced large episodic gas release events (GREs). A GRE is an abrupt increase in the flammable gas concentration within the dome space of a tank, followed by a dissipation of that concentration proportional to the tank vent flow rate. Between 1990 and 1993, 11 GREs were recorded, 9 of which had hydrogen concentrations above 25 percent of the lower flammability limit (LFL) for hydrogen. Since operation of the mixer pump, the GREs have ceased, and levels of hydrogen detected in the tank headspace have stayed well below 25 percent of the LFL (which is conservatively set at 7,500 ppm for tank 241-SY-101 by LANL [2000]).

Reports covering tank 241-SY-101 waste levels, temperatures, gas releases, and mixer pump performance are generated quarterly. For the October to December 1999 quarter, hydrogen gas concentrations in the dome peaked at 590 ppm following the December 26 mixer pump run (Conner and Koreski 2000). Inspection of the weekly volume plots in Conner and Koreski (2000) reveals that the ammonia and nitrous oxide concentrations gradually decreased from 1993 until the recent transfer and back dilution activities, which caused the concentrations of these gases to trend upwards. Over the entire 3-month (12/18/99-3/15/00) transfer/back dilution campaign, the highest hydrogen, ammonia, and nitrous oxide concentrations measured were approximately 3,100 ppm, 750 ppm, and 1,450 ppm, respectively.

Following the final back dilution on March 15, 2000, most of the crust had been put back into solution, effectively removing the primary barrier to gas release. The largest measured hydrogen concentration following crust dissolution occurred immediately after the last back dilution, and measured approximately 762 ppm. The peak hydrogen concentrations during mixer pump runs after the final back dilution were below 762 ppm, and showed a steady decline. Since cessation of the mixer pump runs in early April, the hydrogen concentration has ranged between 0 and 30 ppm, the ammonia concentration has hovered around 150 ppm, and the nitrous oxide concentration has remained below 25 ppm.

Chemical, radiochemical, and physical analyses were performed on the tank waste as required by Bauer and Jackson (1998) in order to evaluate the long-term steady state and GRE conditions. The list of required analyses is available in *Tank 241-SY-101 Push Mode Core Sampling and Analysis Plan* (Conner 1999a). All required analyses were performed. No decision limits for comparison were established by Bauer and Jackson (1998).

Safety Screening DQO: Does the waste pose or contribute to any recognized potential safety problems?

Tank Safety Screening Data Quality Objective (Dukelow et al. 1995) identifies the data needed to screen the waste in tank 241-SY-101 for potential safety problems. These potential safety problems are exothermic conditions in the waste, flammable gases in the waste and/or tank headspace, and criticality conditions in the waste. The safety screening DQO was applied to cores 255, 256, and 257. Data considered suspect in Conner (2000c) were not used in the safety screening assessment.

The safety screening DQO has established a decision threshold of a change in enthalpy of 480 J/g (dry weight basis) for exothermic reactions detected during the differential scanning calorimetry (DSC) analysis. Two samples exhibited exothermic reactions greater than the decision limit. The maximum value was 582 J/g (dry weight) for the primary result on sample S99T000003 (Steen 1999). As required by the DQO, the upper limits to one-sided 95 percent confidence intervals were calculated on the sample means and compared to the 480-J/g threshold. Six more samples, in addition to the two already mentioned, had 95 percent confidence interval upper limits above the DQO threshold. The highest of these was 1,110 J/g (dry weight) for segment 6 of core 255 (S98T003283). These high results were expected based on the knowledge of the presence of a high concentration of total organic carbon (TOC) in this tank (the tank is listed by Hanlon [2000] as a concentrated complexant tank).

The safety screening DQO requires TOC analyses on samples that exceed the DSC threshold. Total organic carbon analyses were run on five out of the eight samples; none of the TOC results for these samples exceeded the 45,000-µg C/g notification limit. The highest sample mean on a dry weight basis was 19,700 µg C/g for segment 10 of core 255 (S98T003285). The highest upper limit on a 95 percent confidence interval on the mean for the TOC analysis was 23,300 µg C/g (dry weight basis) for segment 6 of core 255 (S98T003283). Because the moisture content in the segments that contained the high DSC results were higher than the criterion of 17 weight percent (between 33 and 43 weight percent water), an exothermic reaction is not expected.

The three samples with DSC results above the threshold that were not analyzed for TOC do not appear to be of concern. Two of the samples were composites, and the secondary TOC analyses were not run as they are not required for composites (Conner 1999a). Regardless, the composites had moisture contents of 41.7 and 42.7 weight percent water, well above the 17 weight percent criterion. The other sample was from segment 4 of core 257. The dry weight results were 283 J/g and 172 J/g for the primary and duplicate samples, respectively, which yielded a mean of 227 J/g. However, because of the large difference in the sample results, the upper limit to the 95-percent confidence interval on the mean (578 J/g) was above the 480-J/g limit. The variability in the sample results was attributed to sample inhomogeneity (Steen 1999). The weight percent water in this sample was approximately 36 percent. Because of the adequate moisture content and the fact that the high upper limit to a 95 percent confidence interval on the DSC mean was a function of sample inhomogeneity rather than the presence of large exotherms, exothermic reactions are not considered a concern for this sample.

The safety screening DQO limit for criticality is 33.4 µCi/g (converted from 61.5 µCi/mL using the maximum sample density of 1.84 g/mL). The total alpha activity in all of the 1998/1999 samples was well below this limit, with the maximum value being 1.12 µCi/g for core 256, segment 7. Additionally, as required by the DQO, upper limits to a one-sided 95 percent confidence interval on the mean were calculated. All upper limits were well below the criticality decision limits, with a maximum value of 1.38 µCi/g (core 256, segment 6). The data show that criticality is not a concern for this tank.

The DQO notification limit for flammable gas concentration is 25 percent of the LFL. For tank 241-SY-101, recent combustible gas meter readings taken twenty feet into the dome space were not available. Instead, the SHMS data at steady state conditions were used to derive flammable gas concentrations. Results from two periods were included for comparison. The first period was prior to the December 1999 - March 2000 transfers and back dilutions. Average hydrogen concentrations obtained by two different instruments over the month of October 1999 were both 0.19 percent of the LFL (note that steady state conditions included mixer pump runs during this time). Beginning in early April 2000, the mixer pump runs were suspended for 90 days to evaluate flammable gas behavior. Hydrogen concentration data from the SHMS during a week of this inactive period (specifically 4/11/00 through 4/17/00) for two different instruments yielded results of 0.014 and 0.019 percent of the LFL. These results can be found with other earlier headspace vapor measurements in the *IH Sniff Data* Standard Report. The SHMS data show that a rise in the flammable gas concentration occurs when waste intrusive activities take place. However, as described in the Flammable Gas DQO section, the concentrations stay well below 25 percent of the LFL.

A formal review of the sampling and analytical data for tank 241-SY-101 was performed to determine if the safety screening DQO requirements were met. This review is documented in *Evaluation of Tank Data for Safety Screening* (Reynolds et al. 1999). Reynolds et al. (1999) concluded that "the sampling and analysis performed in this tank were consistent with the requirements of the Safety Screening DQO." Therefore, tank 241-SY-101 requires no additional sampling or analysis under the safety screening DQO.

Organic Solvent Safety Issue DQO: Does an organic solvent pool exist that may cause a fire or ignition of organic solvents in entrained waste solids?

The data required to support the organic solvent screening issue are documented in the *Data Quality Objective to Support Resolution of the Organic Solvent Safety Issue* (Meacham et al. 1997). The DQO requires tank headspace samples be analyzed for total non-methane organic compounds (TNMOC). The purpose of this assessment is to ensure that an organic solvent pool fire or ignition of organic solvent cannot occur.

Tank 241-SY-101 SHMS vapor samples have not been analyzed for TNMOC to estimate the organic pool size. However, the organic program has determined that even if an organic solvent pool does exist, the consequence of a fire or ignition of organic solvents is below risk evaluation guidelines for all tanks (Brown et al. 1998). The organic solvent issue is expected to be closed for all tanks in fiscal year 2000.

LAW Feed DQO: Do the samples taken from tank 241-SY-101 and the subsequent laboratory analysis meet the needs of the *Low-Activity Waste Feed Data Quality Objectives* (LAW Feed DQO) (Wiemers and Miller 1997)?

During the planning of the 1998/1999 core sampling of tank 241-SY-101, the LAW Feed DQO was one of the drivers for characterization. However, prior to analysis, the analytical requirements of the LAW Feed DQO became a lower priority for tank 241-SY-101 because of revisions to the waste retrieval schedule and because waste from the tank was to be mixed with other wastes in a series of transfers scheduled in 1999 and 2000. Consequently, the sampling and analysis plan (SAP) (Conner 1999a) for the core sampling event was modified by *Supplemental ECN-655020 against HNF-3375, Rev. 0-A, "Tank 241-SY-101 Push Mode Core Sampling and Analysis Plan"* (Conner 1999b) to delete the LAW Feed DQO analyses. The tank is tentatively scheduled for sampling in fiscal year 2002 to support the Waste Processing and Disposal program.

Waste Feed Delivery DQO: Does the waste feed meet specifications as a feed source for tank waste vitrification?

The SAP for the 1998/1999 core sampling event included the provision to make a whole tank composite for process testing to meet the requirements of *Data Quality Objectives for TWRS Privatization Phase I: Confirm Tank T is an Appropriate Feed Source for Low-Activity Waste Feed*

Batch X (Waste Feed Delivery DQO) (Certa 1998). However, because of changes in strategy and priorities, this composite was not made.

Many of the physical and rheological measurements required by the Waste Feed Delivery DQO were performed as these analyses were required by other DQOs or the information was needed to support the transfer of waste to tank 241-SY-102. However, because these analyses were not specifically performed according to the Waste Feed Delivery DQO requirements, they were not run on the waste matrix required by the DQO. A summary of the physical and rheological data is discussed in the text for Question 4.

Tank 241-SY-101 is tentatively scheduled for sampling in fiscal year 2002 to support the Waste Feed Delivery program.

ICD-23 issue: Have the required samples been provided to the Waste Treatment Plant Contractor?

Brown et al. (1998) and Adams et al. (1999) identified the ICD-23 issue as being applicable to tank 241-SY-101. However, the current revision of ICD-23 (Johnson 2000) does not include tank 241-SY-101. To date, no material from the tank has been sent to the waste treatment plant contractor, and no shipments of the currently archived material are expected to occur.

SY-101 Level Rise

Beginning in approximately mid-1996, the surface-level in tank 241-SY-101 began to increase as a result of gas retention in the crust layer. A mitigation strategy was developed that involved a sequence of waste transfers to tank 241-SY-102 and back dilutions of water into tank 241-SY-101 (Raymond et al. 1999). Various analytical studies were required to support the waste transfers, including dilution studies, viscosity testing, boildown studies, and mixing studies (Estey 1999). The core samples taken in 1998/1999 provided the material needed for these analyses. Results from these studies are presented in Person (1999) and Steen (1999). The mitigation strategy was successfully implemented in December 1999 through March 2000 through three transfers of waste to tank 241-SY-102 and subsequent back dilutions. The back dilutions added to the top of the waste greatly reduced the crust volume, stopping the crust rise and enabling a continuous release of generated gas. As of April 3, 2000, operation of the mixer pump has been suspended for 90 days to evaluate whether the tank waste will retain gas without periodic mixing. If the data indicate (as anticipated) that the waste no longer retains gas above an acceptable volume, an amendment to the authorization basis will be prepared that will, among other things, close the SY-101 Level Rise issue.

Compatibility DQO: Will safety problems be created as a result of mixing waste in interim storage? Do operations issues exist which should be addressed before waste is transferred?

Two documents are used to address compatibility concerns. Mulkey et al. (1999) includes the safety considerations and decision rules for criticality, corrosion, emissions, energetics, and flammable gas accumulation. The operational issues of heat generation of commingled waste, segregation of complexant waste, and high phosphate waste are addressed in Fowler (1995).

Three transfers of waste were made from tank 241-SY-101 to tank 241-SY-102 between December 1999 and March 2000. Before each transfer was allowed to occur, an assessment was made of the compatibility of waste in the two tanks. These assessments are documented in Fowler (1999b, 1999c, 2000a, and 2000b). All requirements for transfer were met. A summary of the findings is provided below.

For the first transfer, the flammable gas criteria (based on specific gravity) were met, as the combined tank 241-SY-101/tank 241-SY-102 waste would have a specific gravity less than 1.41. One sample in tank 241-SY-101 exceeded the energetics criterion (exotherm to endotherm ratio less than 1.0). However, when dilution water was considered, all ratios were below 1.0 (Fowler 1999c). The tank 241-SY-101 waste had the potential to be outside of corrosion prevention limits; however, tank 241-SY-102 would remain within corrosion specifications after the transfer. The heat generation rate was within specifications. Although tank 241-SY-101 waste was considered high phosphate and high salt waste, tank 241-SY-102 waste was neither high phosphate nor high salt. Therefore, mixing of the two tank wastes would be in compliance.

Tank 241-SY-101 contains concentrated complexant (CC) waste. Normally, this waste is segregated from non-CC wastes in order to minimize adverse impacts to waste volume reduction. Tank 241-SY-102 contained dilute non-complexed waste before the transfer. Mixing of these two waste types had not occurred historically. For this transfer, mixing of CC with dilute non-complexed waste was approved by the Waste Inventory Control Group to assure potential adverse effects on waste volume reduction, retrieval, or other River Protection Project (RPP) projects were evaluated. Approval for commencing the transfer operation was granted by the Office of River Protection (Sidpara 1999).

For the second and third transfers, little changed in the compatibility assessments. The estimated specific gravity for tank 241-SY-102 after the second transfer was 1.41, equal to the compatibility limit for density. This value decreased to 1.38 after the third transfer. For the combined waste after the last transfer, the projected bounding concentrations indicated that the corrosion limit for nitrate could be exceeded. The addition of water to tank 241-SY-102 would ensure that nitrate stayed within specifications. The transfers from tank 241-SY-101 caused the waste in tank 241-SY-102 to become high phosphate waste. However, previous experience indicates that the liquid portion of the waste will remain pumpable (Fowler 2000b).

Bounding Concentration Limits

Sample results from the 1998/1999 core sampling were screened against current bounding concentrations used to develop the authorization source term. These bounding concentrations are listed in Tables 4-1 and 4-2 of Section 18 of *River Protection Project Process Engineering Desk Instruction and Guidance Manual* (Adams 2000). Comparisons were made against the double-shell tank (DST) solids bounding concentrations because all of the tank 241-SY-101 waste was in solid form when extruded at the 222-S Laboratory. Results from eight ammonia, two selenium, and two sodium samples exceeded the bounding concentration limits. The ammonia results for the solids are considered suspect because the liquid sample ammonia results do not support the extremely high results for the solids, and the tremendous variability between samples is not expected based on waste

chemistry and tank status (well mixed). Therefore, these data were marked as suspect in the Tank Characterization Database (Conner 2000c). Because the selenium and sodium data represent tank waste and the data appear to have no quality assurance problems, notifications to the managers of Nuclear Safety and Licensing and Process Engineering were made (Conner 2000d) in accordance with Adams (2000).

Heat Load Estimate

A factor in assessing tank safety is the heat generation and temperature of the waste. Heat is generated in the tanks from radioactive decay. The heat load estimate for tank 241-SY-101 based on the process history was 11,800 W (40,400 Btu/hr) (Agnew et al. 1997a). The heat load estimate derived from the tank radionuclide content circa 1993 was 11,700 W (40,000 Btu/hr) (Kummerer 1995). Both of these estimates do not account for the recent transfers, which would have removed some of the radionuclide inventory (especially for ^{137}Cs). The heat load estimated from the best-basis inventory is 8,270 W (28,200 Btu/hr), as shown in Table 1-2. All of these estimates are below the 14,600 W (50,000 Btu/hr) operating specification limit for the SY Tank Farm tanks (Fowler 1999a).

Table 1-2. Heat Load Estimate Based on the Best-Basis Inventory.

Radionuclide	Waste Inventory[1] (Ci)	Specific Activity (W/Ci)	Heat Load (W)
^{90}Sr	92,400	0.00669[2]	618
^{137}Cs	1.62E+06	0.00472[3]	7,650
Total			8,270

Notes:

[1]See *Best-Basis Inventory (Radionuclides)* Standard Report.
[2]Includes term for ^{90}Y.
[3]Includes term for ^{137m}Ba.

Tank History

Question 2: What is known about the history of this tank as it relates to waste behavior?

The SY Tank Farm was built between 1974 and 1976 in the 200 West area. The tank farm consists of three 4,391 kL (1,160 kgal) tanks, and is the only double-shell tank farm in the 200 West area. The SY Tank Farm does not use a cascade system between tanks. Tank 241-SY-101 was originally designed for use as a concentrated waste holding tank. It consists of a reinforced concrete shell with two (inner and outer) carbon steel liners on the bottom and sides. Twenty-four risers provide access to the tank, while 34 risers provide access to the annulus between the two tank liners. Additional tank descriptive material is contained in the *Tank Plan View, Tank Profile View,* and *Riser*

Configuration Table Standard Reports. The only risers discussed in these three reports are the 24 primary tank access risers. The following process history information was taken from Agnew et al. (1997b), Alleman et al. (1993), Babad et al. (1991), and Mahoney et al. (1999).

Tank 241-SY-101 entered service in 1977. In April 1977, the tank received double-shell slurry (DSS) from the 242-S Evaporator. Double-shell slurry is highly viscous as it has been concentrated past the sodium aluminate saturation boundary. In the fourth quarter of 1977, the tank received CC waste from tank 241-SY-102. Concentrated complexant waste is generated when dilute waste containing organic complexants is concentrated in an evaporator; however, it has not been concentrated beyond the aluminate precipitation boundary. During 1978, tank 241-SY-101 received supernatant from tanks 241-A-106, 241-SX-106, and 241-U-111. From 1977 through 1980, the tank also received supernatant from tank 241-SY-102. These additions of CC and DSS wastes nearly filled tank 241-SY-101 by 1980. The last waste transfer into the tank occurred in October 1980. Since that time, only water has been added to the tank, while pumping campaigns in late 1999 and early 2000 removed waste.

Shortly after the first waste transfer into tank 241-SY-101, the waste began to exhibit slurry growth. This phenomenon involved the generation and retention of gases within the slurry (at that time, this was the nonconvective layer in the lower portion of the tank), causing an increase in the overall waste volume. Slurry growth continued to be observed in the tank after the last waste receipts in 1980. The waste then followed a pattern of steady volume increase from the slurry growth with episodic volume decreases as large volumes of gas were released (in GREs). Release of the gas caused "roll-overs" of the tank contents, carrying liquid, gas, and solids from the nonconvective layer into the liquid layer and then into or through the crust, disrupting the crust surface. An explanation of the mechanisms of gas accumulation and release in tank 241-SY-101 can be found in Alleman et al. (1993) and Babad et al. (1991 and 1992).

From 1986 to 1989, air or water was injected into the tank waste at various times in an attempt to liberate the accumulating gas. This lancing process was discontinued in 1989 because it did not stop the cycle of slurry growth and episodic gas release.

In July 1993, a mixer pump was installed to mitigate the GREs by dispersing the nonconvective layer. While mixer pump operations prevented GREs, the absence of the periodic crust breakups provided by the GREs allowed the crust to grow. This growth was first detected in 1996 and was recognized as a potential safety issue in late 1997.

A mitigation strategy was developed that included transfers from the convective slurry and back dilutions of water. These transfers and back dilutions were done in three campaigns, which took place on 12/18/99-12/19/99, 1/25/00-1/27/00, and 2/29/00-3/2/00. Following each of the transfers, back dilutions were made to the top and bottom (at the location of the pump suction) of the waste. A total of 2,332 kL (616 kgal) were transferred, of which 1,987 kL (525 kgal) were "original" tank 241-SY-101 waste (Conner 2000a).

As of March 27, 2000, tank 241-SY-101 contains a total of 3,721 kL (983 kgal), which is categorized as CC by Hanlon (2000) and Supernatant Mixing Model waste from the 242-S evaporator (SMMS2) by Agnew et al. (1997a). This waste volume was based on the Auto ENRAF surface-level data from March 27 (CHG 2000). Based on recent temperature profiles (from

3/27/00), the tank is estimated to contain 23 kL (6 kgal) of crust, 3,176 kL (839 kgal) of convective slurry, and 522 kL (138 kgal) of settled solids. Note that these values are different than those presented in the Best-Basis Inventory (BBI) section (Question #7) because the BBI at this point only captures volume changes through 2/1/00 (this is necessary in order to maintain the global tank farm inventory). The BBI will be updated in the next quarter to reflect the current volumes.

Tank 241-SY-101 is listed as sound and is actively ventilated. It is on the Flammable Gas Watch List (Hanlon 2000). It is also scheduled as a source tank for low-activity waste for Phase I of the vitrification effort.

Tank Comparisons

Question 3: What other tanks have similar waste types and waste behaviors, and how does knowledge of the similar tanks contribute to the understanding of this tank?

Historically, the waste in tank 241-SY-101 produced and retained flammable gas. Consequently, it is on the Flammable Gas Watch List. Other double-shell tanks on the watch list include tanks 241-AN-103, 241-AN-104, 241-AN-105, 241-AW-101, and 241-SY-103. These tanks also have a history of GREs, as tank 241-SY-101 did before installation of the mixer pump.

Tank 241-SY-101 is one of seven double-shell tanks that are categorized as containing CC waste (Hanlon 2000). The other tanks that contain CC waste are tanks 241-AN-102, 241-AN-106, 241-AN-107, 241-AP-103, 241-AP-104, and 241-SY-103. Analytical data from tank 241-SY-103 were used for comparison with the tank 241-SY-101 analytical concentrations. Comparisons were made both on the nonconvective (lower solids) layer and the convective slurry layer. The data for the nonconvective layers agreed reasonably well, with approximately 50 percent of the data being similar. Most of the similarities were seen in the metals data. The convective slurry layers did not agree well, especially in the anions. The data differences between the two tanks attest to the wide variability possible in the CC waste type, and do not indicate data problems.

The entire contents of tank 241-SY-101 are categorized as SMMS2 waste from 242-S evaporator campaigns by Agnew et al. (1997a). Several single-shell tanks contain SMMS2, including tanks 241-S-101, 241-S-102, 241-S-103, and 241-SX-106, and seven tanks in the U Tank Farm. However, the tank most similar to tank 241-SY-101 is tank 241-SY-103. Characterization information from the single-shell tanks and especially tank 241-SY-103 contribute to an understanding of the waste in tank 241-SY-101. As demonstrated from the above comparison, only general information or trends can be applied to tank 241-SY-101, because substantial variability exists in the SMMS2 waste type.

Disposal Implications

Question 4: Given what is known about the waste properties and waste behaviors in this tank, what are the implications of the waste properties and behaviors to the waste retrieval/processing methodologies and equipment selection?

Tank 241-SY-101 has been selected as a Phase I source tank for vitrification. According to *Tank Farm Contractor Operation and Utilization Plan* (Kirkbride et al. 2000), the tank will provide low-activity waste feed for Envelope A.

Given what is known about the waste types and behaviors in tank 241-SY-101, and drawing from the success of the recent transfers, there should be little difficulty in retrieving the waste in the tank. However, several items should be considered in regard to waste retrieval. Tank 241-SY-101 is on the Flammable Gas Watch List and has been known to contain high levels of hydrogen and ammonia. In addition, the bulk temperature of the waste is approximately 35 °C (95 °F).

Waste disturbing activities, such as those performed during retrieval, have the potential to release gas retained in the waste matrix. Tank 241-SY-101 is currently being evaluated to determine if the waste still retains appreciable amounts of gas. Data gathered during the recent transfer campaigns indicated that as long as a barrier to gas release (e.g., a crust, or a slurry with a high specific gravity) is not present in tank 241-SY-101, waste disturbing activities during retrieval would not be expected to release levels of hydrogen greater than 25 percent of the LFL. The largest hydrogen concentration measured over the three-month transfer period was 3,100 ppm, which is just over 10 percent of the LFL.

Hydrogen concentrations in the tank that will receive tank 241-SY-101 waste during retrieval are also a potential concern. However, data gathered during the recent transfers into tank 241-SY-102 prove that hydrogen concentrations in the receiver tank should stay below 25 percent of the LFL. The hydrogen concentrations in tank 241-SY-102 did rise during the transfers, but they remained below 200 ppm (less than 1 percent of the LFL).

Ammonia may also be of concern from an industrial health standpoint, especially in the receiver tank. Ammonia concentrations during the transfers peaked at 450 ppm in tank 241-SY-101. However, in tank 241-SY-102, the ammonia concentration peaked at 6,600 ppm. During the transfer to tank 241-SY-102, a siphon break was used, which likely entrained air into the waste stream as it entered tank 241-SY-102. As the entrained air bubbled to the surface of the tank 241-SY-102 waste, it brought along ammonia that had been retained in the waste. In both cases, the ammonia concentration exceeded the National Institute for Occupational Safety and Health (NIOSH) immediately dangerous to life or health concentration of 300 ppm (NIOSH 2000). Note that these were measurements of the concentrations in the tank dome space, and do not directly correlate to the concentrations that would be in a worker's breathing zone. Monitoring in the worker's breathing zone during the transfers yielded a maximum ammonia result of 3 ppm, well below the NIOSH recommended exposure limit of 25 ppm (NIOSH 2000).

The pumpability of the waste should be evaluated before retrieval commences. Before the recent transfers and back dilutions, the potential for solids to precipitate out in the transfer lines during pumping was a concern. At that time, temperatures in the nonconvective and convective slurry layers generally ranged between 51.7 and 46.1 °C (125 and 115 °F). Cooling of this waste produced precipitates, as evidenced by laboratory observations of the 1998/1999 core samples. Upon extrusion at the laboratory, all of the segments were solid, including those from the convective slurry layer.

Prior to the transfers, a dilution study was performed to measure the effects of temperature and dilution on the tank 241-SY-101 waste. The dilution study was performed on a composite of segments 5 through 22 of core 255, which made it representative of the convective slurry and settled solids layers. The tests showed that both the centrifuged solids and the true (dry) solids decrease with dilution and with increasing temperature (Person 1999). The viscosity was observed to decrease with increasing temperature and with increasing dilution. For the centrifuged liquid from the undiluted tank 241-SY-101 waste, the average viscosity was 25.5 cP at 26 °C and 10.5 cP at 47 °C. The viscosity for the centrifuged liquid after 100 percent dilution was 4.7 cP at 27 °C and 3.2 cP at 47 °C (Person 1999). Note that the dilution study results are preliminary; no final report was issued as a result of funding issues. However, the preliminary results provided the critical information required for the transfers.

Since the transfers and back dilutions, pumpability concerns have decreased. The waste in tank 241-SY-101 has been nearly diluted to a 1:1 ratio between original tank waste and water. In addition, tank temperatures have dropped to approximately 35 °C (95 °F). The lower waste temperatures mean that less cooling will occur during pumping, and therefore the chance that precipitates will form during pumping is decreased.

Additional physical property data were gathered during the last sampling and analytical event. Shear strength, viscosity, and particle size distribution tests were to be run on segments 2 and 7 of core 257. (These segments were selected in order to obtain data from the crust [segment 2] and the convective slurry [segment 7]). However, because of different analytical problems, only the particle size distribution was performed on both segments; shear strength was only performed on segment 2, while viscosity was only performed on segment 7. The particle size distribution data are available in the *Analytical Results* Standard Reports, while the shear strength results are presented in the *241-SY-101 Rheology Report* Standard Report. Viscosity data are reported in Steen (1999).

A mixer pump has been utilized in tank 241-SY-101 since 1993. In the future, other tanks may be required to operate mixer pumps to support the vitrification effort. The operating experience and lessons learned during the use of the tank 241-SY-101 mixer pump may be applied to the design of these other mixer pumps and their implementation.

Scientists Assessment of Data Quality and Quantity

Question 5: Given the current state of understanding of the waste in this tank on the one hand and the information drivers on the other; should additional tank data be sought via sampling/analysis from a strictly technical point-of-view? Can the waste behavior in this tank be adequately understood by other means (eg. archive samples, tank grouping studies, modeling) without additional sampling and analysis? If so, what characteristics of the tank waste lend themselves to a non-sample alternative? Is the quality of the data from this tank adequate from a field sampling and analytical laboratory point-of-view? Are there any clarifications or explanations needed for the data tables and figures?

Sampling and Analysis

The following DQOs and waste issues have been addressed for this tank and accepted by the RPP: Flammable Gas, Safety Screening, Organic Solvent Safety Issue, Compatibility, and the tank 241-SY-101 Level Rise Issue. No additional sampling or analyses are necessary to satisfy current safety issue requirements for this tank. Further action may be identified to address the LAW Feed DQO (the one in effect at the time of the 1998/1999 core sampling has been superseded by the LAW/HLW Feed DQO (Patello et al. 1999), Waste Feed Delivery DQO (Nguyen 1999 has superseded Certa 1998), ICD-23 issue, Air Emissions DQO, and Dangerous Waste DQO.

The current long-range plans call for tank 241-SY-101 to stage Envelope A waste. As of March 2000, the short-term plans for the tank are undetermined. Different options are being investigated, including eventually returning the tank to active service.

From a field sampling perspective, the quality of data obtained during the 1998/1999 sampling event was excellent. At least a 90 percent recovery was obtained for the vast majority of segments. Very few problems were encountered during the sampling. Segment 7 of core 255 was expected to be an RGS sample; however, it was empty and therefore abandoned. Also, the SAP (Conner 1999a) requirement that segments be transported to the laboratory within three calendar days of removal from the tank was not met (Steen 1999). However, this should not impact the quality or usability of the data.

Data Quality

Samples obtained in the 1998/1999 core sampling event were collected and analyzed with approved and recognized sampling and laboratory procedures and in accordance with Conner (1999a). The laboratory procedures for the core sample analysis can be found in the *Analytical Methods and Procedures* Standard Report. Quality control (QC) parameters assessed in conjunction with the core samples included standard recoveries, spike recoveries, duplicate analyses, and blanks. Appropriate QC footnotes were applied to data outside the QC parameter limits as shown in the *Analytical Results* Standard Report. Analytical results and data quality are discussed in the analytical data package (Steen 1999).

The vast majority of QC results were within the boundaries specified in the SAP (Conner 1999a). Small discrepancies noted in the data package (Steen 1999) and footnoted in the *Analytical Results* Standard Report should not impact the data validity or use. A brief discussion of these small discrepancies is presented below.

For ammonia, nine subsamples had standard recoveries outside of the 90-110% required range. Although these standard recoveries were outside the required range listed in the SAP, they were within the laboratory control limits of 78-130%, so no reanalysis was requested. A small percentage of samples analyzed for potassium, sodium, and zinc had standard recoveries outside of the 80-120% SAP range. In addition, standard failures were noted for approximately 50% of the samples analyzed for silicon. These standard failures occurred on the acid digestion portion of the subsamples. The standard failures for sodium and silicon may have been because of leaching from the glassware during the digestion process or contamination from sample handling. No reanalysis was performed, because it is difficult to avoid contamination from these processes.

Spike recoveries outside of the required range (75-125%) were reported for two ammonia subsamples. Although these spike recoveries were outside of the required range listed in the SAP, they were within the laboratory control limits and no reanalysis was requested. A small percentage of samples analyzed for formate had spike recoveries outside of the required 75-125% range. The spike failures were attributed to matrix interferences from metals. No reanalyses were requested.

Two TOC subsamples had spike recoveries outside of the 75-125% SAP range. These spike failures were a result of sample inhomogeneity and the high concentration of the analyte with respect to the amount of spike standard added. No reanalysis was performed.

Matrix spike recoveries outside of the 75-125% SAP limits were reported for a small percentage of samples analyzed for chromium, potassium, nickel, and silicon. In addition, spike failures were

noted for approximately 50% of the samples analyzed for aluminum and sodium. The spike failures were attributed to the high concentration of these analytes in the samples with respect to the amount of spike standard added. A post-digestion spike analysis was performed as an additional instrument performance check. The post-digestion spike recoveries were within the required limits.

Typically, with high concentrations of analytes, it is difficult to add sufficient spike to perform a meaningful analysis. Therefore, an assessment of the accuracy of the measurements for these analytes was also made by performing a serial dilution of the sample and comparing these results with the sample results. The serial dilution was performed by preparing and analyzing an additional five-fold dilution of the sample. The result obtained from this analysis should be within ± 10% of the undiluted sample result. The results of the comparison revealed the accuracy of the analysis was acceptable for all but six samples. The undiluted results for these samples were already near the detection limit and an additional five-fold dilution decreased the precision of the analysis even further.

Nine of the 47 subsamples analyzed by DSC had relative percent differences (RPDs) between duplicate samples greater than the required 30-% limit. The chemist noted the high RPDs were a result of sample inhomogeneity and no reanalyses were performed. However, two samples had triplicate analyses performed. High RPDs (greater than 10%) were reported for two hydroxide subsamples. The results for these subsamples were near the detection limit, which decreased the precision of the analysis and made it difficult to obtain the precision requirement. The hydroxide concentrations were consistent with the other solids samples, so no reanalysis was requested. One of the 29 ammonia subsamples had an RPD outside of the 10% limit. However, because the results were near the detection limit, no reanalysis was requested.

High RPDs (greater than 20%) were reported for a small percentage of samples analyzed for chloride, fluoride, formate, nitrite, nitrate, oxalate, phosphate, and sulfate by ion chromatography (IC). Selected samples were reanalyzed with some improvement in the RPDs. The high RPDs were attributed to sample inhomogeneity and no further reanalyses were requested. The raw data from the initial analyses were not used.

A small percentage of samples analyzed by inductively coupled plasma spectroscopy (ICP) reported RPDs greater than the 20% SAP limit. Most of the failures occurred on the acid digested subsamples. In certain matrices, some metals may not have been completely or uniformly dissolved by the acid digestion process. However, the concentration of many of the ICP analytes was less than ten times the detection limit, so the precision of the analysis was decreased. No repreparation or reanalysis was requested. RPDs greater than 20% were reported for approximately half of the samples analyzed for boron, nickel, and silicon. These analytes in particular had high RPDs due to non-uniform leaching from the digestion vessels used for the sample and duplicate aliquots. Since this leaching could not be avoided, no reanalyses were requested.

One ICP/mass spectroscopy (MS) sample and one TOC sample exceeded the 20% RPD threshold. These high RPDs were attributed to sample inhomogeneity. A triplicate analysis was performed on the TOC sample. Improvement in the RPD was obtained, as the results from the triplicate analysis supported the duplicate result and were similar to the TOC results from other samples. Twelve of 47 total alpha subsamples exceeded the 20% RPD limit. The results were near the detection limit, which decreased the precision of the analysis. Because of the low total alpha activity, no reanalyses

were requested. One ^{241}Am subsample slightly exceeded the 20% RPD threshold. The sample was reanalyzed with no improvement in the RPD. Because the sample results were near the detection limit, the precision was decreased; no further analysis was requested.

A small amount of contamination was found in the gamma energy analysis preparation blank. However, the levels of contamination are insignificant when compared to the sample results, and do not affect the usability of the data.

Using internal QC standards, a computer algorithm flagged data that were potentially suspect. The flagged data were reviewed to determine if the data were compromised, and if so, the anomalous values were removed from the *Analytical Results* Standard Report. Of the analytes flagged, only eight total alpha results, nineteen silicon fusion results, and thirty nickel fusion results were removed from the *Analytical Results* Standard Report. The total alpha results were considered suspect because they were not supported by the ^{241}Am and $^{239/240}$Pu results (the prime contributors to the total alpha activity), and because large concentration differences should not be present due to thorough mixing from the mixer pump. The silicon fusion data displayed wide variability, which was not supported by the silicon acid digestion results or the well-mixed waste conditions. The nickel fusion results were biased high as a nickel crucible was used during the fusion preparation. The remaining flagged results were considered usable (Conner 2000c).

As discussed in Question #1, eight solids ammonia results were marked as suspect in the Tank Characterization Database. These extremely high results were not supported by the liquid ammonia data and were not expected based on waste chemistry and the well-mixed nature of the tank. Consequently, these results were considered suspect (Conner 2000c).

Clarification and Explanation of Data Tables and Figures

Description of Tank Standard Report: The volumes reported in this table do not match those used in the best-basis inventory (Question #7). This is because the best-basis inventory volumes are only updated through February 1, 2000, in order to maintain the global inventory (i.e., all tanks with transfers were updated to a common date so that the overall tank farm inventory remains internally consistent). The volumes in the *Description of Tank* Standard Report are the volumes as of the date of preparation of this Tank Interpretive Report (TIR) (March 27, 2000).

The volumes in the current Hanlon report (February 2000) as of the preparation date of this TIR do not match the volumes in the *Description of Tank* Standard Report. This is a result of the recent transfers. The February 2000 Hanlon report does not include the transfers and back dilutions in March 2000, while the volumes in the *Description of Tank* Standard Report have been adjusted for them.

In addition, the volumes in the *Description of Tank* Standard Report do not match the surface level shown in the "Surface Level as of Status Date" row in the Standard Report. All volumes displayed in the Standard Report are based on the AutoENRAF surface level reading from March 27, 2000, as indicated by the status date. However, the surface level presented in the "Surface Level as of Status Date" row is presently programmed to be an average of surface level data over the month most

recently covered in the Hanlon Report. The correct surface level on March 27, 2000, based on the AutoENRAF, was 907.8 cm (357.4 in.).

Subsampling Scheme and Sample Description Standard Report: Between the 1991 and 1998/1999 sampling events, the tank 241-SY-101 riser numbers changed (see the *Riser Configuration* Standard Report). In order to maintain consistency with the data packages, the riser number used at the time of sampling was retained in the tank characterization database and, therefore, the *Subsampling Scheme and Sample Description* Standard Report. Consequently, a combination of new and old riser numbers appear in this report.

IH Sniff Data Standard Report: The standard IH sniff data displayed in this standard report are the pre-check measurements made 20 feet into the tank dome space. In the case of tank 241-SY-101, no recent measurements at this level in the tank are available. Instead, the SHMS data are used for IH purposes when determining the dome space flammable gas concentration. Therefore, these data appear in the *IH Sniff Data* Standard Report. The IH data table with a survey date of 10/31/99 contains averages of the SHMS data over the month of October 1999. The table with a survey date of 4/11/00 contains average SHMS data over the week from 4/11/00 to 4/17/00.

241-SY-101 HTCE Surface Levels and *241-SY-101 Average Monthly Tank Surface Level* Standard Reports: The surface levels depicted in these two figures clearly show the slurry growth and gas release events that led to transfers of waste from the tank in order to mitigate these phenomena. The *241-SY-101 HTCE Surface Levels* figure shows a sawtooth pattern in the waste surface level that disappears after July 1993 when the mixer pump was installed in the tank. The *241-SY-101 Average Monthly Tank Surface Level* figure shows a rising surface level indicative of crust growth in the tank beginning about mid 1996. As waste was pumped from the tank in the last quarter of 1999, the surface level dropped. In the *241-SY-101 Average Monthly Tank Surface Level* figure, the difference between the ENRAF level and the neutron level was caused by the thick crust that existed on the surface of the waste. As back-dilution water was added to the waste and the crust began to dissolve, the ENRAF and neutron levels became nearly identical.

Unique Aspects of the Tank

Question 6: What are unique chemical, physical, historical, operational or other characteristics of this tank or its contents?

Tank 241-SY-101 is likely the most unique tank on the Hanford Site. For the past ten years, the tank has been one of the most scrutinized because of the large GREs in the early 1990's and the dramatic rise in surface level in the late 1990's. The gas generation and retention phenomena within the tank waste has been studied extensively. Various resources that address this matter include *Assessment of Gas Accumulation and Retention – Tank 241-SY-101* (Alleman et al. 1993), *Understanding of Cyclic Venting Phenomena in Hanford Site High-Level Waste Tanks: The Evaluation of Tank 241-SY-101* (Babad et al. 1992), *Evaluation of the Generation and Release of Flammable Gases in Tank 241-SY-101* (Babad et al. 1991), and *A Discussion of SY-101 Crust Gas Retention and Release Mechanisms* (Rassat et al. 1999).

Tank 241-SY-101 is the only tank that ran its mixer pump on a regular basis. In the future, tanks that stage vitrification feed may need mixer pumps in order to ensure adequate mixing has occurred before transfer to the waste treatment plant contractor. Although the design of these mixer pumps may be different than the one in tank 241-SY-101, the operating experience and lessons learned from tank 241-SY-101 can be applied to them.

Best-Basis Inventory Derivation

Question 8: What is the source data used to derive this tank's Best-Basis inventories by mass (kg) and activity (Ci) for the standard list of 25 chemicals and 46 radionuclides?

The Best-Basis Inventory (BBI) effort involves developing and maintaining waste tank inventories comprising 25 chemical and 46 radionuclide components in the 177 Hanford Site underground storage tanks. These best-basis inventories provide waste composition data necessary as part of the RPP process flowsheet modeling work, safety analyses, risk assessments, and system design for waste retrieval, treatment, and disposal operations.

Development and maintenance of the BBI is an on-going effort. Since new sample data were recently made available for tank 241-SY-101, and recent transfers have occurred, a re-evaluation of the best-basis inventories was performed and is documented in the following text. The following information was used in this evaluation:

- Statistical means from analysis of the segment data from the 1998/1999 core samples (see *Means and Confidence Intervals* Standard Report).
- Statistical means from analysis of the composite data from the 1998/1999 core samples (see *Means and Confidence Intervals* Standard Report).
- Data from analyses of core composites from the December 1991 Window E core (Herting et al. 1992).
- BBI templates for Supernatant Mixing Model waste from the 242-S Evaporator (SMMS2). The templates are based on sample data supplemented with Hanford Defined Waste (HDW) model data (Agnew et al. 1997a) where sample data are not available.

Table 7-1 represents how the available information was used to derive best-basis inventories for tank 241-SY-101.

Table 7-1. Tank 241-SY-101 Best-Basis Inventory Source Data.

Waste Phase	Waste Type	Applicable Concentration Data	Density	Volume
Supernatant	Retained gas	N/A	N/A	91 kL (24 kgal)
	Convective slurry (SMMS2)[1]	Calculated convective slurry concentrations 2-1-00[2]	1.55[3]	3,020 kL (798 kgal)
		S2 salt slurry liquid template	1.83	

Table 7-1. Tank 241-SY-101 Best-Basis Inventory Source Data.

Waste Phase	Waste Type	Applicable Concentration Data	Density	Volume
Saltcake	Retained gas	N/A	N/A	8 kL (2 kgal)
	Settled solids (SMMS2)[1]	1998/1999 core settled solids segment means	1.62	307 kL (81 kgal)
		1998/1999 core settled solids composite means	1.58	
		1991 Window E means from core composite 3 and 4	1.70[4]	
		S2 salt slurry solids template	1.59	
Total tank	Overall tank volume			3,425 kL (905 kgal)[5]

Notes:

[1]Hanlon (2000) characterizes the waste as concentrated complexant waste.
[2]Most of the results in this vector are based on a weighted average of the supernatant and crust means from the 1998/1999 sampling event. Several radionuclide values were taken from the 1991 slurry core composite data. All data were adjusted for dilutions that occurred following the December 1999 and January 2000 pumping campaigns.
[3]Density value is a weighted mean of the supernatant and crust means from the 1998/1999 sampling event.
[4]Density value is a mean of data from both the May 1991 and December 1991 cores from tank 241-SY-101 (Reynolds 1993).
[5]Total volume as of 2/1/00.

For BBI purposes, as of February 1, 2000, only a supernatant layer and a saltcake layer existed in tank 241-SY-101, as the former crust layer had been put into solution through back dilutions of water. As described later in greater detail, the inventory that was in the crust layer is now included in the supernatant inventory. The waste types listed in Table 7-1 were taken from process knowledge and the HDW model (Agnew et al. 1997a). The waste in tank 241-SY-101 is also characterized as concentrated complexant waste by Hanlon (2000).

The BBI overall tank volume, 3,425 kL (905 kgal), was derived from the riser 1A manual ENRAF surface-level reading on 2/1/00. From the waste temperature profile, the interface between the saltcake layer and the convective slurry layer was known to occur at approximately 30 inches from the tank bottom. Thirty inches is equivalent to 314 kL (83 kgal) of waste. Selected segments during the 1998/1999 sampling event were taken with a retained gas sampler (RGS), which enabled analysts to determine the amount of retained gas in the waste. At tank conditions prior to the 12/99 and 1/00 transfers, Mahoney et al. (1999) estimated an average in situ gas volume of 2.9 percent for the "mixed slurry layer", which included the saltcake region along with the convective slurry layer. This same gas volume was assumed to apply to the saltcake after the transfers. Therefore, of the 314 kL (83 kgal), 8 kL (2 kgal) is retained gas. No inventory was attributed to the retained gas. By subtraction, the settled solids portion of the saltcake layer is 307 kL (81 kgal).

Because very little drainable liquid was present with the solids during laboratory extrusions of the samples, a separate drainable interstitial liquid inventory was not determined for the saltcake phase; it was assumed that the sample analyzed represented both solids and drainable interstitial liquids in the saltcake. As described later, lower laboratory temperatures account for the differences between laboratory observations and in-tank conditions. Assuming an average in-tank saltcake drainable porosity of 0.25 (Field and Vladimiroff 1999), the volume of drainable interstitial liquid present in the saltcake phase would be 75.7 kL (20 kgal).

The volume of the convective slurry layer was calculated by subtracting the saltcake volume from the total volume. The 2.9 percent average in situ gas volume was also applied to this layer, yielding a retained gas volume of 91 kL (24 kgal). This volume was removed from the total layer volume, yielding a convective slurry volume of 3,020 kL (798 kgal).

During the 1998/1999 event, three cores were taken from different locations in the tank. Core 255 contained a total of 22 segments, of which segments 1, 2, 3, 4, 8, 13, and 21 were taken with an RGS. Core 256 consisted of 23 segments, with segments 3, 4, 10, 17, and 23 taken using an RGS. Although this core contained 23 segments, the offset from the other cores of 22 segments was truly only 6 inches, because segment 15 was intentionally pushed only 6 inches. Twenty-two segments were taken for core 257. Only segment 5 was obtained using an RGS.

Analyses were performed on each of the non-RGS segments, and means were calculated from the resulting data. Separate means were calculated for the three layers (crust, convective slurry, and settled solids) that existed in tank 241-SY-101 before the 12/99 and 1/00 transfers and subsequent back dilutions. The crust means were based on data from the first four segments of each core. The settled solids means were based on data from the bottom three segments, i.e., segments 20 through 22 for cores 255 and 257 and segments 21 through 23 for core 256 (note that segment 21 of core 255 and segment 23 of core 256 were not included because they were taken with an RGS). The remaining segments comprised the convective slurry.

Composites were made for each of the cores according to the strata within the tank. The composite data for a particular stratum were averaged to derive a single mean for that stratum.

Upon extrusion at the laboratory, all segments consisted primarily of solids, including the convective slurry segments. The waste in these convective slurry segments solidified upon removal from the tank as a result of cooling. Temperatures in the convective slurry prior to the 12/99 and 1/00 transfers ranged between 48.9 and 51.7 °C (120 and 125 °F). Very little drainable liquid was observed; any drainable liquid recovered was added back to the solids. Therefore, no manipulation of the solids data (i.e., reconstitution of the supernatant from solids and liquid portions) was needed to characterize the convective slurry.

Although no drainable liquid was recovered in the saltcake layer segments, it is believed that in situ the material in this region does contain liquid. Due to the lack of analytical data for this liquid, an alternative method was required for characterization. Because of the similarity between the convective slurry data and the settled solids data, the convective slurry data were selected to represent the saltcake liquid.

Data were also available from two core sampling events in 1991, one in May and a second in December. None of the data from the May 1991 sampling event were used in this BBI because all of the BBI-relevant analytes measured in that event were also measured on the 1998/1999 core samples. Data from the December 1991 sampling event for nine radionuclides were used in the development of this BBI. As described in Herting et al. (1992), four core composites were made from the tank material. Composites 1 and 2 were representative of the convective slurry, while composites 3 and 4 were representative of the settled solids. The composite data within a layer were averaged to obtain an overall layer mean. All measurements were made on bulk samples except the analyses for ^{99}Tc and ^{129}I in the convective slurry, which were done on centrifuged fractions. Centrifuged fraction data for these two analytes were combined according to weighting factors based on the liquid and solid weight percents in the bulk sample.

Analytical data were modified to reflect changes that occurred in tank 241-SY-101 between the time it was sampled and 2/1/00. During the pumping campaigns in 12/99 and 1/00, transfers of waste were made from the tank, while back dilutions of water entered the tank. Waste transfers from the tank did not impact analyte concentrations (inventory change only). However, the back dilutions caused changes in analyte concentrations due to dilution. In addition to diluting the waste, the back dilutions also caused a phase change for the crust layer. These changes were accounted for using multipliers.

Table 7-2 shows the waste transfers and back dilutions that occurred in 12/99 (Campaign #1) and 1/00 (Campaign #2) (Conner 2000b). Based on the information in the table, the multipliers used to account for the back dilutions were 0.749 for the crust and 0.947 for the convective slurry. These multipliers were applied to the appropriate data from the 1998/1999 sampling event. Because no transfers had occurred from 1991 to 1999, and any flush water additions during that time were minimal, application of the 0.947 convective slurry multiplier was the only adjustment required for the 1991 slurry composite data. Note that changes as a result of the transfers and back dilutions in February and March will be captured in next quarter's BBI update.

Table 7-2. Tank 241-SY-101 Transfer and Dilution Volumes for Campaigns #1 and #2 (Through 2/1/00).[1]

	Amount of SY-101 Waste Transferred	Top Back Dilution[2]	Bottom Back Dilution[3]	Total Back Dilution
	Gallons	Gallons	Gallons	Gallons
Campaign #1	89,500	26,000	36,000	62,000
Campaign #2[4]	240,500	78,500	N/A	78,500
Cumulative	330,000	104,500	36,000	140,500

Notes:

[1]Conner (2000b)

[2]Top back dilution water was added to the top of the waste.

[3]Bottom back dilution water was added to the convective slurry layer near the transfer pump suction.

[4]At 2/1/00, Campaign #2 was still in progress.

As of 2/1/00, the former crust layer in tank 241-SY-101 had been dissolved as a result of the top back dilutions following the 12/99 and 1/00 transfers. In order to correctly represent the waste as it existed in the tank, the crust and convective slurry means were combined into a single mean. The combination was done based on volume percent fractions. The crust volume was 48.5 percent of the combined crust/convective slurry volume, with the convective slurry comprising the remaining 51.5 percent. Therefore, the crust means were multiplied by 0.485, while the convective slurry means were multiplied by 0.515. The products from these calculations were then summed to determine the combined mean. The combined means were treated as a process knowledge vector.

Where possible, data from the 1998/1999 core sampling event were used to characterize the convective slurry and settled solids layers. Segment data were preferred over composite data. The 1991 composite data were only used for nine radionuclides that did not have results from the 1998/1999 sampling event. For analytes without sampling data, or analytes that had large less-than sample-based values, means from the S2 salt slurry templates were used. Templates are based on sampling data from tanks that contain the same waste type as tank 241-SY-101, supplemented with HDW model data. A multiplier was used to scale the template vectors to the sample data using sample weight percent water results and densities. Based on the calculated weight percent water of 42.4 percent and density of 1.55 g/mL, the multiplier applied to the S2 salt slurry liquid template was 0.720. The multiplier for the S2 salt slurry solids template was 0.940, as determined from the measured weight percent water (39 percent) and density (1.62 g/mL). A more detailed description of template data is found in Tran (1999).

The densities listed in Table 7-1 for the sampling data were determined analytically. The convective slurry densities are weighted means of the supernatant and crust means from the 1998/1999 sampling event, adjusted for the water additions during the pumping campaigns. The density applied to the December 1991 core composites was taken from Reynolds (1993) and is actually a mean of data from the settled solids region from both the May 1991 (Window C) and December 1991 sampling events. Template densities were obtained from the templates themselves.

All inventory calculations were performed using the Best-Basis Inventory Maintenance (BBIM) Tool. The updated best-basis inventory values for tank 241-SY-101 can be found in the *Best-Basis Inventory (Non-Radionuclides)* and *Best Basis Inventory (Radionuclides)* Standard Reports. Unique data treatments are discussed below by analyte.

Mercury. The best-basis mercury value was assumed to be zero because no mercury-bearing waste was transferred to the tank (Simpson 1998).

Alpha-emitting isotopes. Data from analysis of the total alpha activity and uranium were used to derive inventories for the various alpha-emitting isotopes. Initially, the total alpha activity and uranium results were input into a spreadsheet that calculated the contributions from ^{239}Pu and ^{241}Am. Results for these two radionuclides were entered into the vectors as sample data. The BBIM tool used the ^{239}Pu and ^{241}Am results to do a distribution for the remaining alpha-emitting isotopes. This was done on each waste phase separately.

Hydroxide. Once the best-basis inventories were determined, the hydroxide inventory was calculated by performing a charge balance with the valences of other analytes. This charge balance approach is consistent with that used by Agnew et al. (1997a).

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