AIIM

Association for Information and Image Management

1100 Wayne Avenue, Suite 1100
Silver Spring, Maryland 20910
301/587-8202

Centimeter

Inches

MANUFACTURED TO AIIM STANDARDS
BY APPLIED IMAGE, INC.

1 of 1

WHC-EP-0717

UC-721

Evaluation of 241 AN Tank Farm Flammable Gas Behavior

D. A. Reynolds

Date Published
January 1994

Prepared for the U.S. Department of Energy
Office of Environmental Restoration and
Waste Management

Westinghouse
Hanford Company P.O. Box 1970
Richland, Washington 99352

Hanford Operations and Engineering Contractor for the
U.S. Department of Energy under Contract DE-AC06-87RL10930

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

Approved for Public Release

Document Title: EVALUATION OF 241 AN TANK FARM FLAMMABLE GAS BEHAVIOR
Tank Waste Technology Applications

Prepared by: D. A. Reynolds — Date: Feb 28, 1994
D. A. Reynolds
Engineer

Reviewed by: N. E. Wilkins — Date: Feb 28, 1994
N. E. Wilkins
Engineer

Approved by: N. W. Kirch — Date: 2/28/94
N. W. Kirch
Manager

Approved by: G. D. Johnson — Date: 2/28/94
G. D. Johnson, Manager
Flammable Gas Tank Safety Program

Date Received: 11/5/93	# INFORMATION RELEASE REQUEST	Reference: WHC-CM-3-4

Complete for all Types of Release

Purpose		ID Number (include revision, volume, etc.)
[] Speech or Presentation [] Full Paper (Check only one suffix) [] Summary [] Abstract [] Visual Aid [] Speakers Bureau [] Poster Session [] Videotape	[] Reference [X] Technical Report [] Thesis or Dissertation [] Manual [] Brochure/Flier [] Software/Database [] Controlled Document [] Other	WHC-EP-0717 List attachments. Date Release Required January 31, 1994

Title EVALUATION OF 241-AN TANK FARM FLAMMABLE GAS BEHAVIOR	Unclassified Category UC-	Impact Level 4

New or novel (patentable) subject matter? [X] No [] Yes If "Yes", has disclosure been submitted by WHC or other company? [] No [] Yes Disclosure No(s).	Information received from others in confidence, such as proprietary data, trade secrets, and/or inventions? [X] No [] Yes (Identify)
Copyrights? [N] No [] Yes If "Yes", has written permission been granted? [] No [] Yes (Attach Permission)	Trademarks? [N] No [] Yes (Identify)

Complete for Speech or Presentation

Title of Conference or Meeting		Group or Society Sponsoring
Date(s) of Conference or Meeting	City/State	Will proceedings be published? [] Yes [] No Will material be handed out? [] Yes [] No
Title of Journal		

CHECKLIST FOR SIGNATORIES

Review Required per WHC-CM-3-4	Yes	No	Reviewer - Signature Indicates Approval: Name (printed)	Signature	Date
Classification/Unclassified Controlled Nuclear Information	[]	[X]			
Patent - General Counsel	[X]	[]	SW Berglin	SW Berglin	1/26/94
Legal - General Counsel	[X]	[]	SW Berglin		
Applied Technology/Export Controlled Information or International Program	[]	[X]			
WHC Program/Project	[X]	[]	GD Johnson	GD Johnson	1/24/94
Communications	[X]	[]	W.P. Whiting	WP Whiting	1-26-94
RL Program/Project	[X]	[]	R F Christensen	R F Christensen	1/28/94
Publication Services	[X]	[]	M R Turner	Marilyn R Turner	2/3/94
Other Program/Project	[]	[]			

Information conforms to all applicable requirements. The above information is certified to be correct.

	Yes	No	INFORMATION RELEASE ADMINISTRATION APPROVAL STAMP
References Available to Intended Audience	[X]	[]	Stamp is required before release. Release is contingent upon resolution of mandatory comments.
Transmit to DOE-HQ/Office of Scientific and Technical Information	[X]	[]	APPROVED FOR RELEASE — OFFICIAL DOCUMENT — Date 2/3/94
Author/Requestor (Printed/Signature): Daniel A. Reynolds	Date: 1/19/93		
Intended Audience: [] Internal [] Sponsor [X] External			
Responsible Manager (Printed/Signature): N. W. Kirch	Date: 1-21-93		Date Cancelled / Date Disapproved

CONTENTS

This page intentionally left blank.

LIST OF FIGURES

LIST OF TABLES

This page intentionally left blank.

ACRONYMS

LFL	Lower flammability limit
FIC	Food Instrument Corporation
TOC	Total organic carbon
PNL	Pacific Northwest Laboratory
TC	Total carbon
IC	Inorganic carbon
DSSF	Double-shell slurry feed
TBP	Tri-n-butylphosphate
NTA	Nitrilotriacetic acid
MAIDA	N-(Methylamine)iminodiacetic acid
MEICA	N-[2-(Methylidene)ethyl]iminocarboxyacenc acid
MICEDA	N-(Methyliminocarboxy)ethylenediamine-N-acetic acid
EPA	Environmental Protection Agency
GC-NPD	Gas chromatography with nitrogen/phosphorous detector

This page intentionally left blank.

EVALUATION OF 241 AN TANK FARM FLAMMABLE GAS BEHAVIOR

1.0 SUMMARY

The 241 AN Tank Farm tanks 241-AN-103, -104, and 105 are Flammable Gas Watch List tanks. Characteristics exhibited by these tanks (i.e., surface level drops, pressure increases, and temperature profiles) are similar to those exhibited by tank 241-SY-101, which is also a Watch List tank. Although the characteristics exhibited by tank 241-SY-101 are also present in tanks 241-AN-103, -104, and 105, they are exhibited to a lesser degree in the AN Tank Farm tanks.

The 241 AN Tank Farm tanks have only small surface level drops, and the pressure changes that occur are not sufficient to release an amount of gas that would cause the dome space to exceed the lower flammability limit (LFL) for hydrogen. Therefore, additional restrictions are probably unnecessary for working within the 241 AN Tank Farm, either within the dome space of the tanks or in the waste.

This page intentionally left blank.

2.0 INTRODUCTION

There are restrictions in place when working inside tanks on the Flammable Gas Watch List. Tanks 241-AN-103, -104, and -105 share some of the characteristics of tank 241-SY-101; a tank that exceeds the LFL for hydrogen on a periodic basis.

This evaluation compares the 241 AN Tank Farm Flammable Gas Watch List tanks and tank 241-SY-101 to determine restrictions and limitations that are appropriate when working in tanks 241-AN-103, -104, and -105.

This page intentionally left blank.

3.0 HISTORY OF THE AN TANK FARM

The 241 AN Tank Farm was constructed in 1980, and consists of seven 1.14-mgal capacity double-shell tanks which are all vented through a common ventilation system.

The 241 AN Tank Farm waste has been characterized a number of ways. One core sample has been taken from tank 241-AN-103. Other samples have been taken from tanks 241-AN-104 and -105 at various times. Details of the waste characterization of these samples are presented in Appendix A.

3.1 FILL HISTORY OF TANK 241-AN-103

Tank 241-AN-103 was initially used as a saltwell receiver tank in 1982. Transfers were made into and out of the tank over the next 4 years. Most of the transfers out of the tank were to the evaporator feed tank, which was part of the 242-A evaporator system. In February 1986, the tank was pumped to an 88.4-in. heel before receiving double-shell slurry from the 242-A evaporator (Kelly 1986). The surface level in the tank at the end of the double-shell slurry transfer was 329.1 in., of which 241 in. was double-shell slurry. The surface level immediately began increasing when the evaporator transfer was complete. This increase totaled approximately 16 in. Except for flushes of the Food Instrument Corporation (FIC) surface level gauge, the double-shell slurry transfer was the last addition to tank 241-AN-103. The current tank surface level is approximately 346 in. with fluctuations of less than 1 in.

3.2 FILL HISTORY OF TANKS 241-AN-104 AND -105

Tanks 241-AN-104 and -105 were initially used as part of the evaporator bottoms system beginning in June 1982. Both tanks received slurry from the evaporator and returned the slurry to the evaporator feed tank. The evaporator was concentrating dilute noncomplexed feed into double-shell slurry feed.

Tank 241-AN-104 was pumped to a heel of 86 in. in October 1984. It then received slurry to the 341-in. level (Gratny 1985). The surface level of the waste slowly increased to reach the 342.5-in. level by April 1985. Additional slurry was then received which increased the surface level to 386 in. (Pontious 1985).

In March 1985, tank 241-AN-105 was pumped to a 32.3-in. heel. Double-shell slurry feed was sent to the tank from the evaporator. The surface level reached the 408-in. level by April 1985.

Pontious (1985) provides details of the evaporator campaign that filled tanks 241-AN-104 and -105. These tanks have received no additional waste after the campaign.

This page intentionally left blank.

4.0 GAS RELEASE CHARACTERIZATION

The composition of gases present in the AN Tank Farm Flammable Gas Watch List Tanks has not been characterized for this evaluation. For the purpose of this evaluation, the gas composition of tanks 241-AN-103, -104, and -105 is assumed to be similar to that of tank 241-SY-101 based on similarities in behavior of the waste content of these tanks.

4.1 SURFACE LEVEL BEHAVIOR

The 241 AN Tank Farm Flammable Gas Watch List tanks have experienced surface level drops that would signal a gas release event. Figures 4-1, 4-2, and 4-3 show the surface level fluctuations.

Figure 4-1 shows steadily rising surface levels in tank 241-AN-103; however, drops in surface levels are difficult to detect. The retention of generated gases with only steady-state release was a characteristic of tank 241-SY-103 for several years. Additional liquid waste that was added to tank 241-SY-103 seems to have caused the drops that are currently seen.

Several of the surface level drops in tank 241-AN-104 seem to be associated with flushes of the FIC. Surface level drops occurring after flushing the FIC are assumed to result from the flushing and not from gas release. Surface level drops that have occurred before flushing the FIC are considered to be gas release events.

4.2 RELEASE EVENTS

Table 4-1 shows the surface level activity of the AN Tank Farm Flammable Gas Watch List Tanks. Of the tanks, 241-AN-103 was not very active and 241-AN-104 was the most active; tank 241-AN-105 was active but exhibited the smallest surface level drops. Tank 241-AN-104 has exhibited surface level drops in the 3- to 4-in. range in past years; however, none of the tanks show surface level drops of larger than 2 in. in recent years. Some surface level drops occurred over several days duration.

Figure 4-4 shows the latest drop in tank 241-AN-104. The surface level dropped for several days, with 1 in. being the largest drop recorded for a single day.

Table 4-2 is a summary of gas release events for tank 241-SY-101. Tank 241-SY-101 has exhibited surface level drops of greater than 5 in. In contrast, the 241 AN Tank Farm tanks have exhibited drops that mostly were less than 5 in. Table 4-2 shows that most surface level drops in tank 241-SY-101 occurred on the first date recorded. By comparison, the surface level drops recorded for tank 241-AN-103, -104, and -105 were less vigorous, with 3.6 in. being the largest drop in one day (Table 4-1).

The instances of tank 241-SY-101 hydrogen concentrations exceeding the LFL for hydrogen occurred simultaneously with surface level drops that were greater than 9 in.

Figure 4-1. Tank 241-AN-103 Surface Levels.

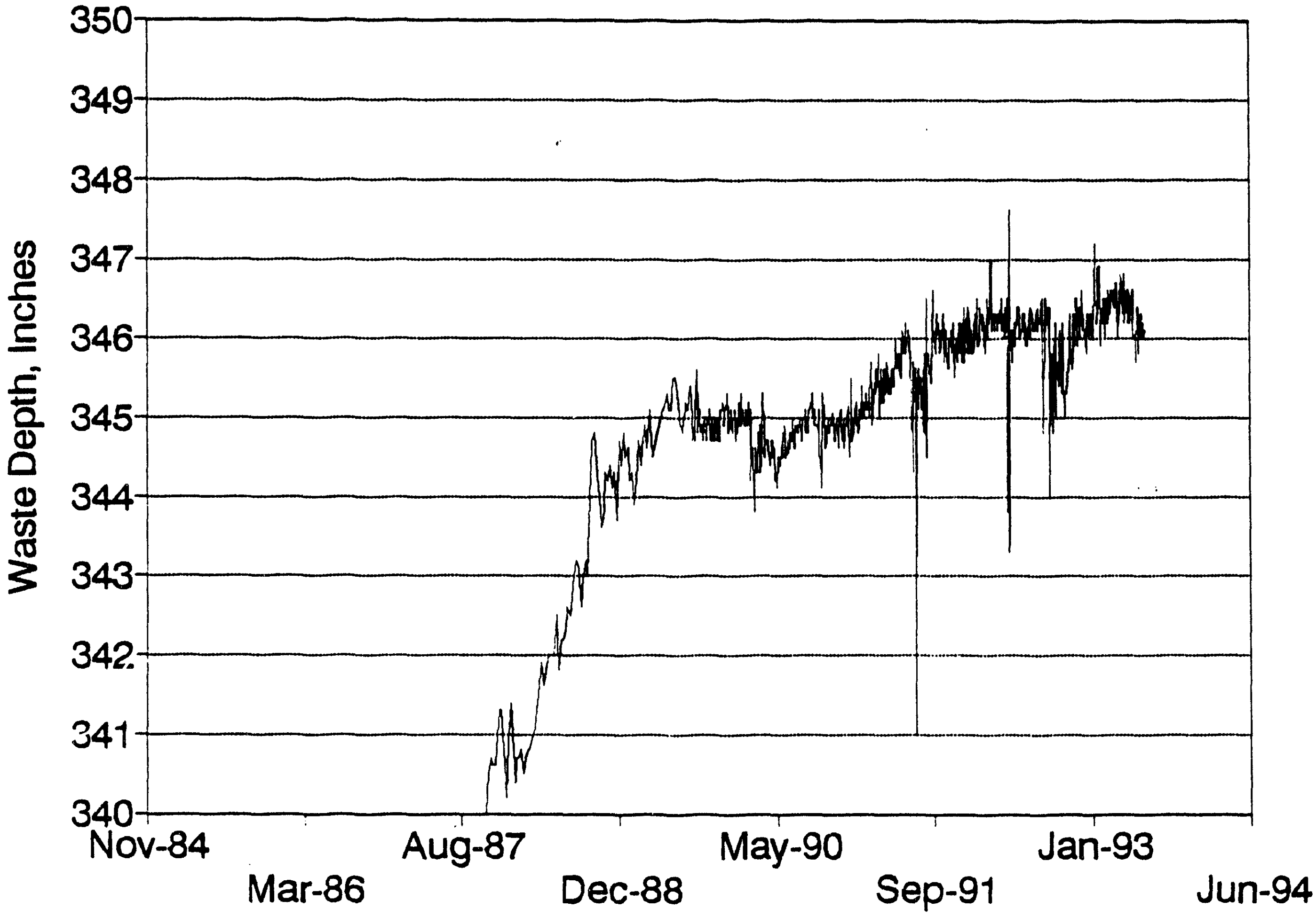


Figure 4-2. Tank 241-AN-104 Surface Levels.

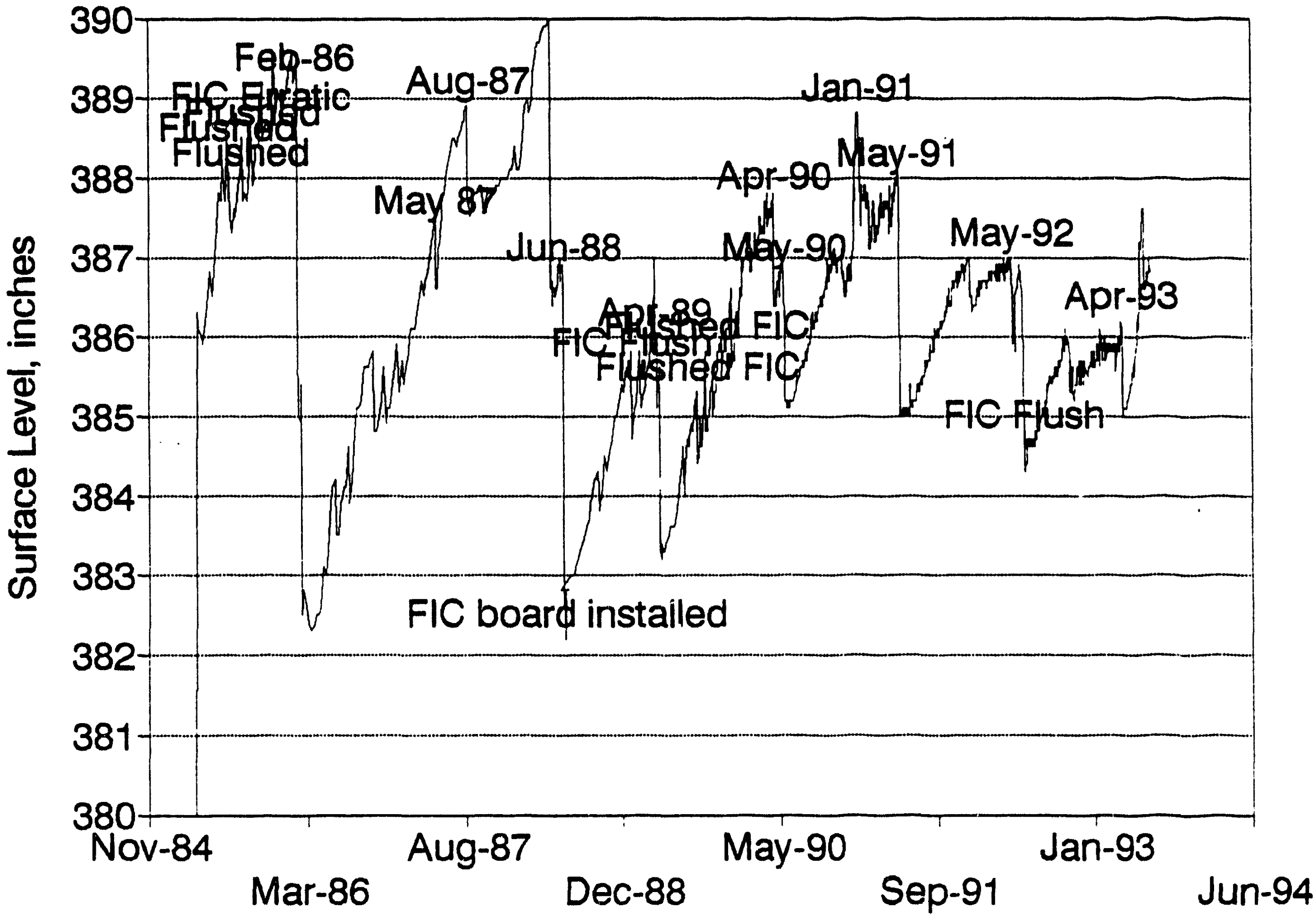


Figure 4-3. Tank 241-AN-105 Surface Levels.

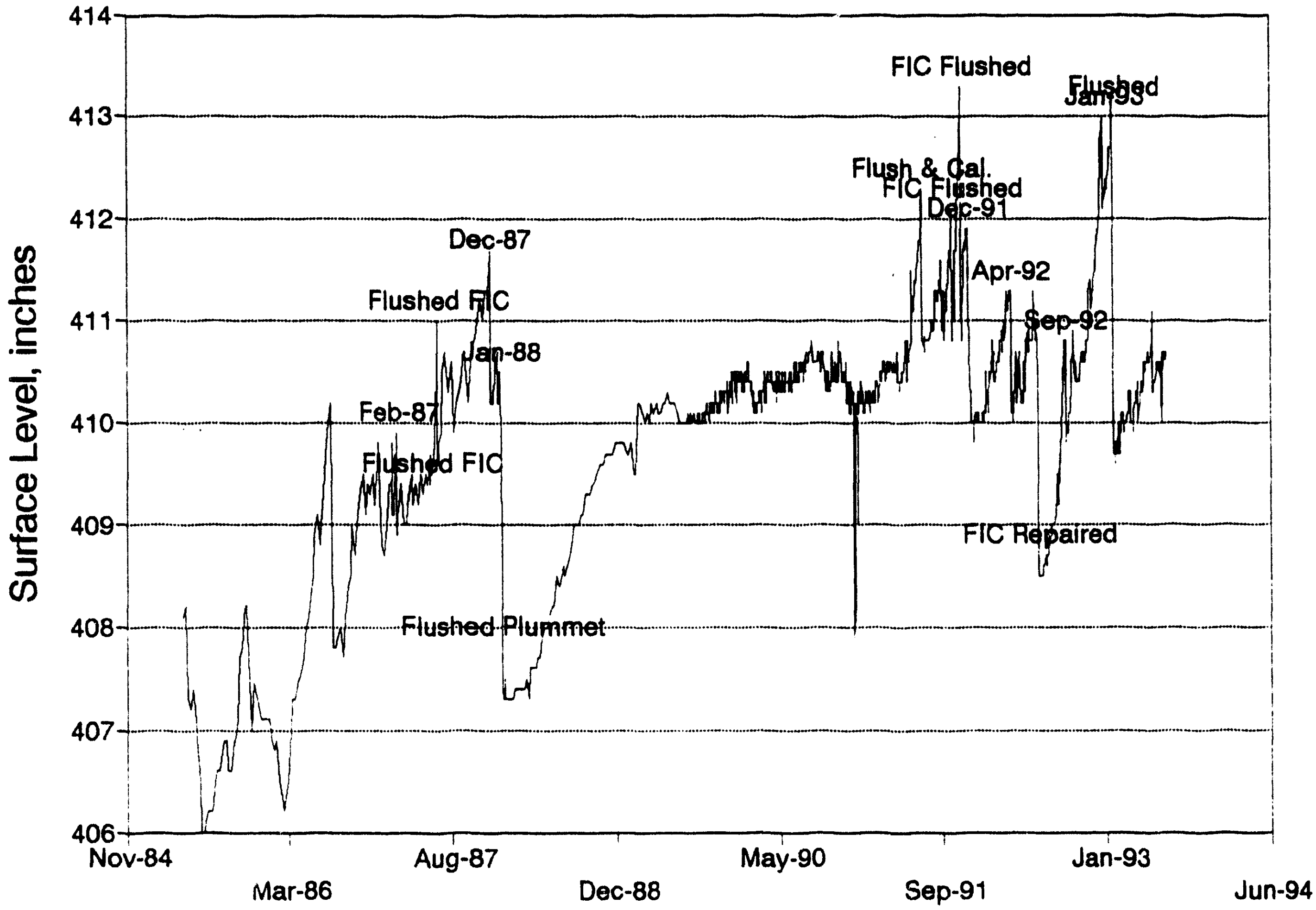


Table 4-1. Surface Level Drops in Tanks 241-AN-103, -104, and -105.

Tank	Date	Level drop (in.)	Duration (days)	Largest drop (in./day)
241-AN-103	May 1992	3.0	5	2.5
	September 1992	1.5	15	0.8
241-AN-104	February 1986	5.8	15	3.6
	May 1987	0.9	1	0.9
	August 1987	1.2	1	1.2
	June 1988	4.7	4	3.1
	April 1989	3.8	18	1.6
	April 1990	1.4	2	0.9
	May 1990	1.7	3	0.7
	January 1991	1.4	2	1
	May 1991	3.1	5	1.6
	May 1992	0.8	5	0.7
241-AN-105	February 1987	1	1	1
	December 1987	1.5	1	1.5
	January 1988	3.2	6	1.7
	December 1991	2.1	18	0.7
	April 1992	1.2	3	0.7
	September 1992	1	1	1
	January 1993	0.9	1	0.9

Figure 4-4. Surface Level Drop in Tank 241-AN-104, August 1993 Release.

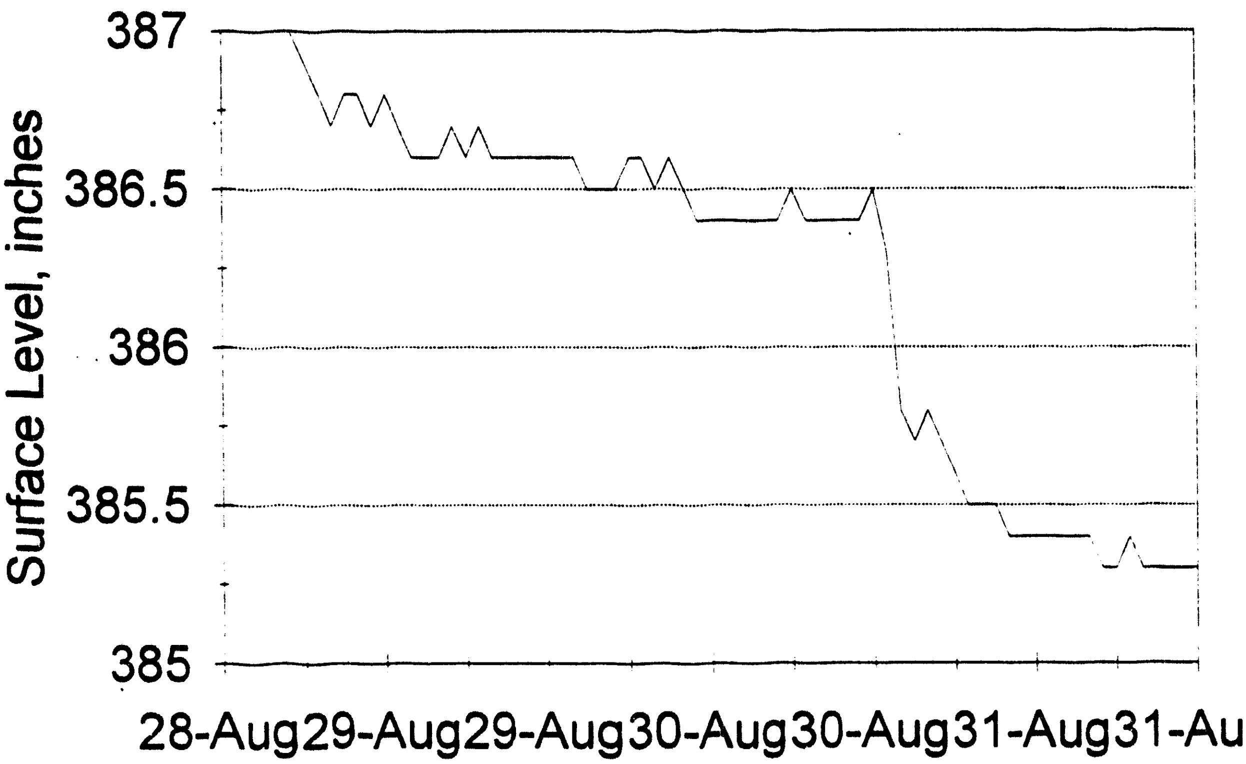


Table 4-2. Summary of Gas Release Events for Tank 241-SY-101.

Burp date	Pressure increase (in. wg)	Maximum pressure (in. wg)	Maximum H_2 concentrations (%)	Drop (in.)	Flow (cfm)
4/90	2.3	0.1	3.5	9.3	
8/90	0.25	-2	1.22	5.2	420
10/90	5.2	2.3	4.7	10	600
2/91	0.4	-2	0.6	5	480
5/91	3.34	0.24	0.5	7.2	580
8/91	0.3	-3	0.35	6	550
12/91	10	6.84	5.3	13	460
4/92	0.61	-2	1.48	7.2	500
9/92	7.7	5.37	5	9.4	500
2/93	1.1	-0.08	2.8	8.5	600
6/93	3.4	0.93	2.8	9.25	540

4.3 CRUST CHARACTER

The AN Tank Farm was last photographed in 1989. In these photographs, tanks 241-AN-103, -104, and -105 exhibit similar crust characteristics. The crust surface appears to be composed of a yellow-white foam-type substance. There were no large masses present, such as the "waste bergs" in tank 241-SY-101, and the walls of the tanks had no "bathtub ring" of waste. The internal elements of the tanks (e.g., thermocouple trees and sludge weights) appeared to be hanging straight down.

No samples of the crusts of tanks 241-AN-103, -104, and -105 have been taken for analysis or energetics. For this evaluation, it is assumed that the crust from these tanks would be no more energetic than that of tank 241-SY-101.

4.4 TEMPERATURE ANALYSIS

Tank temperatures are monitored weekly by means of thermocouple trees inside of each tank (i.e., five thermocouples in the waste and one in the vapor space). These thermocouples are designated as T/C 1, T/C 3, T/C 5, T/C 7, T/C 11, and T/C 17. Figures 4-5, 4-6, and 4-7 show averaged temperatures plotted for tanks 241-AN-103, -104, and -105. Temperatures in these tanks have increased a few degrees each year. These temperature increases indicate that the heat conduction from the tanks is decreasing. This might also indicate buildup of crust in the tanks.

An interesting feature shown in Figures 4-5, 4-6, and 4-7 is the increase in temperature the spring of 1992. Although this change seemed to affect all thermocouples, it affected the lower thermocouples to a greater extent. In May 1992, one of two blowers in the annulus ventilation system was taken out of service. This resulted in all seven of the tanks being placed on a single blower, which resulted in a drop of the annulus flow rate in the tanks.

In tank 241-SY-101, there is a distinctive temperature profile. The AN Tank Farm tanks have approximately the same profile. However, because there are fewer recorded thermocouples for the AN Tank Farm tanks, the temperature profile is not as clear. Figure 4-8 shows the temperature profiles of tanks 241-AN-103, -104, and -105. In the case of tank 241-SY-101, the temperature profile changes when a gas release event occurs; it is not clear that the same occurs in the AN Tank Farm tanks. Figures 4-9, 4-10, and 4-11 show the profiles before and after a surface level drop in tank 241-AN-104, which exhibits the largest drops. It is difficult to determine whether the observed changes result from surface level drops or from variations in the measurements.

Figure 4-6. Tank 241-AN-104 Average Temperature.

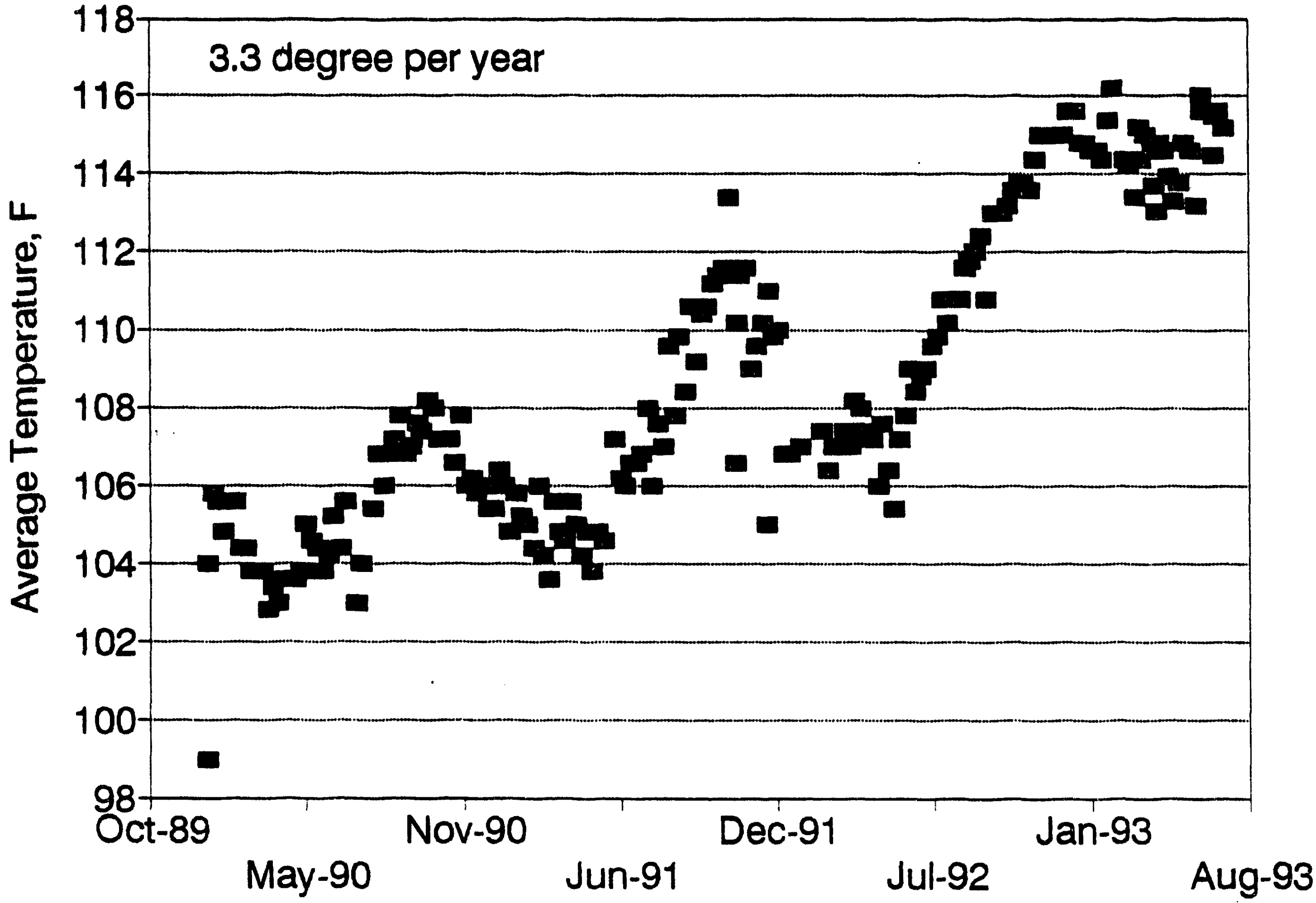


Figure 4-7. Tank 241-AN-105 Average Temperature.

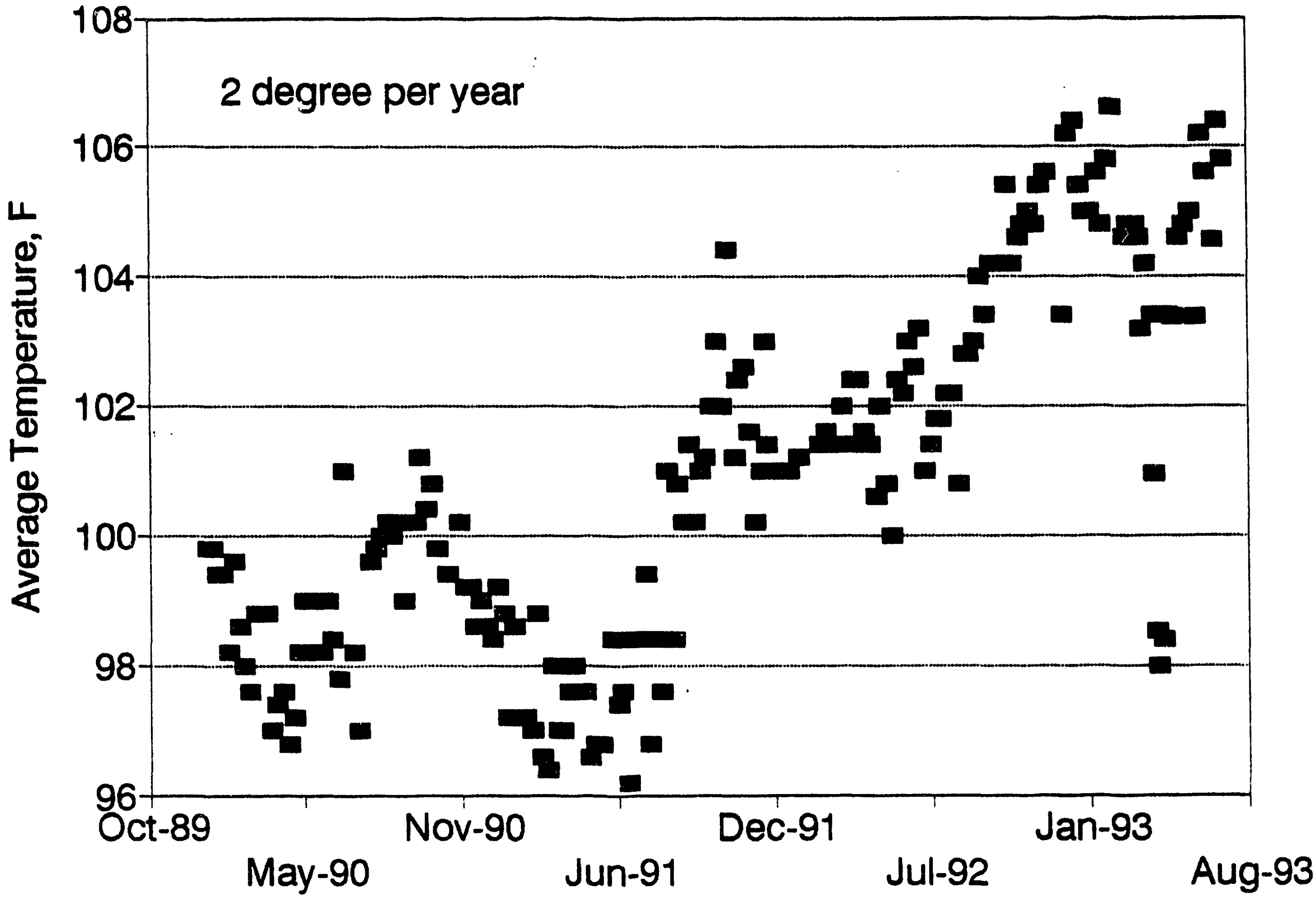


Figure 4-8. 241 AN Tank Farm Temperature Profiles.

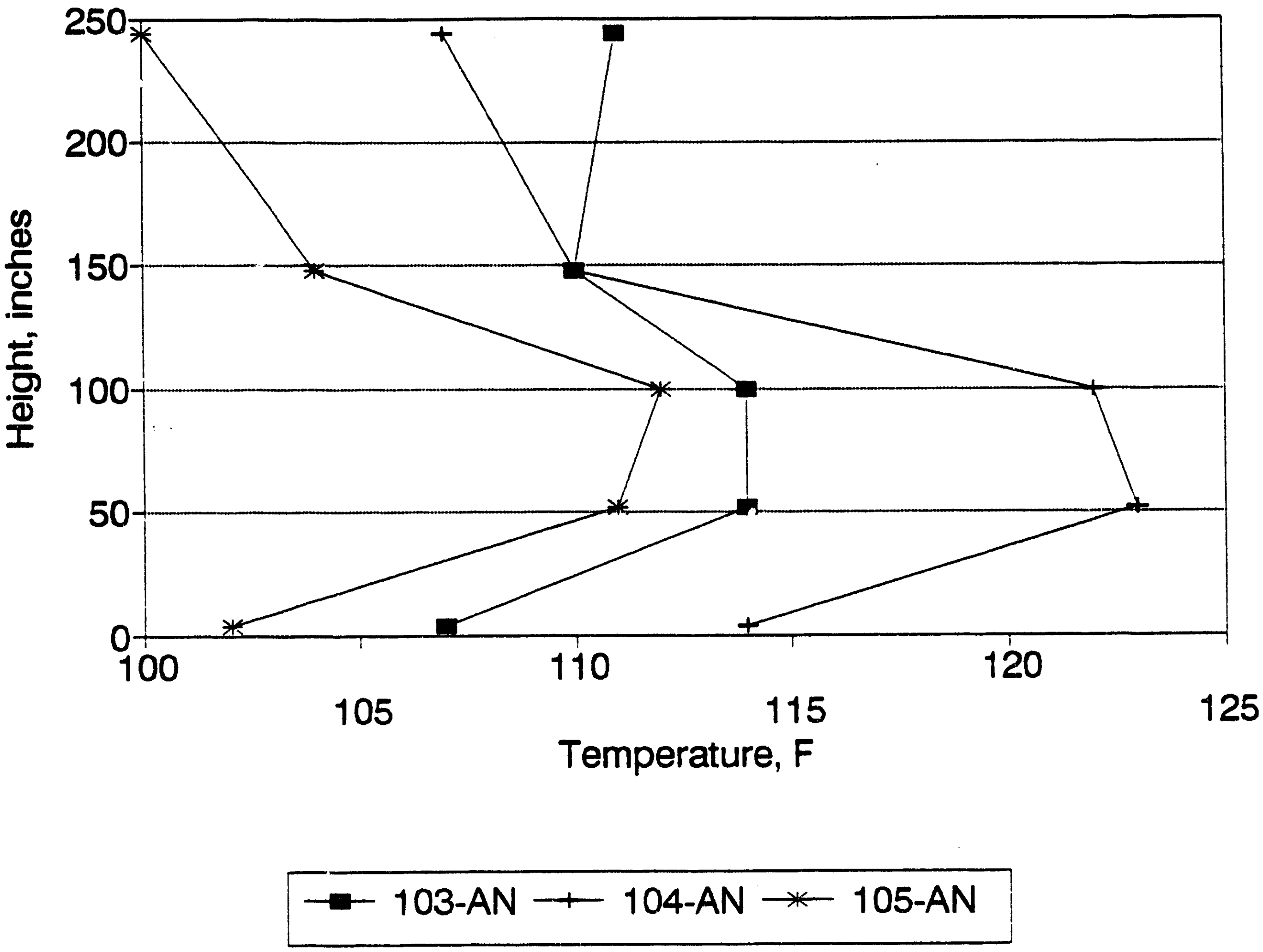


Figure 4-9. Tank 241-AN-104 April 1990
Gas Release Event Temperature Profile.

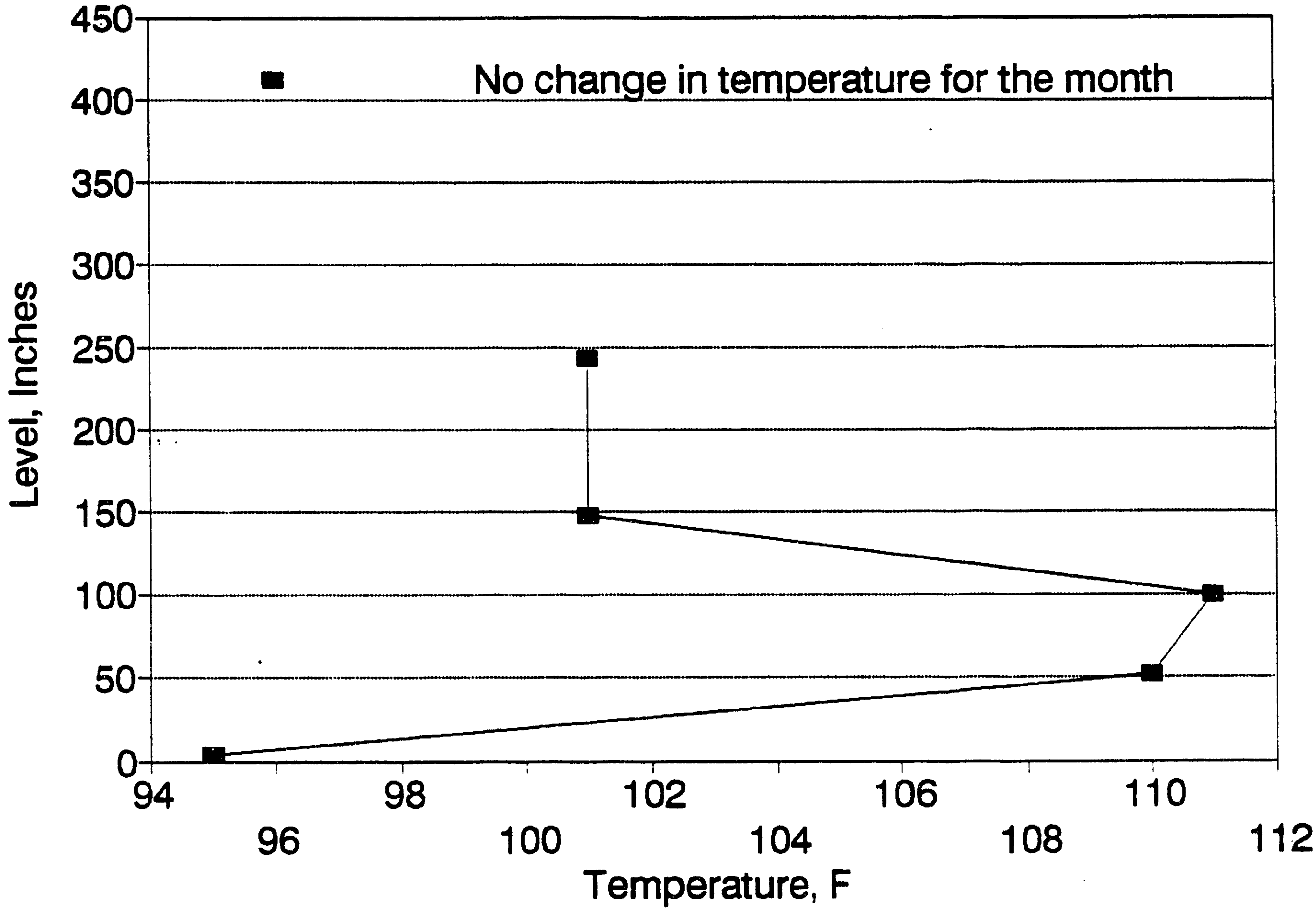


Figure 4-10. Tank 241-AN-104 June 12, 1992
Gas Release Event Temperature Profile.

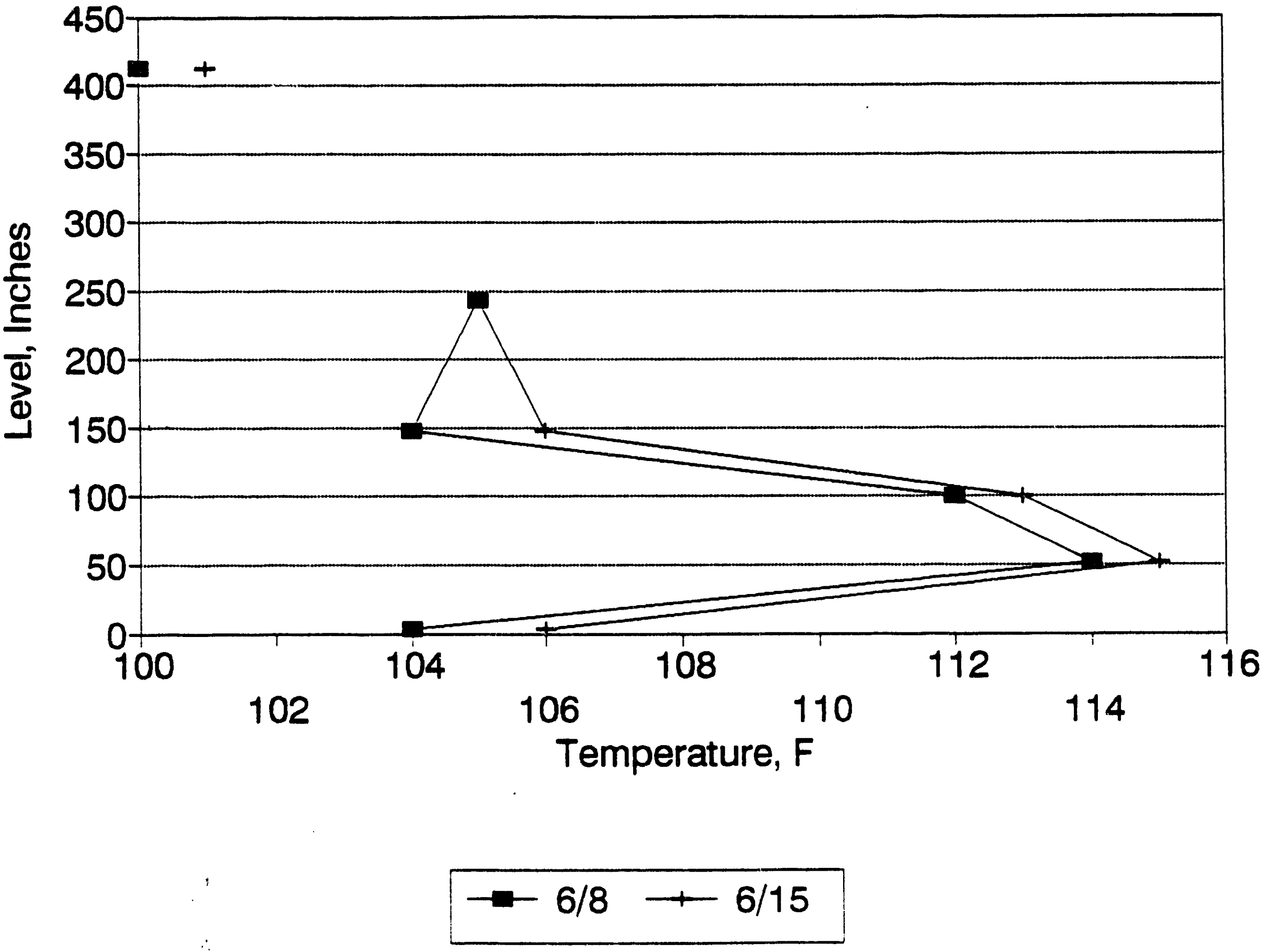
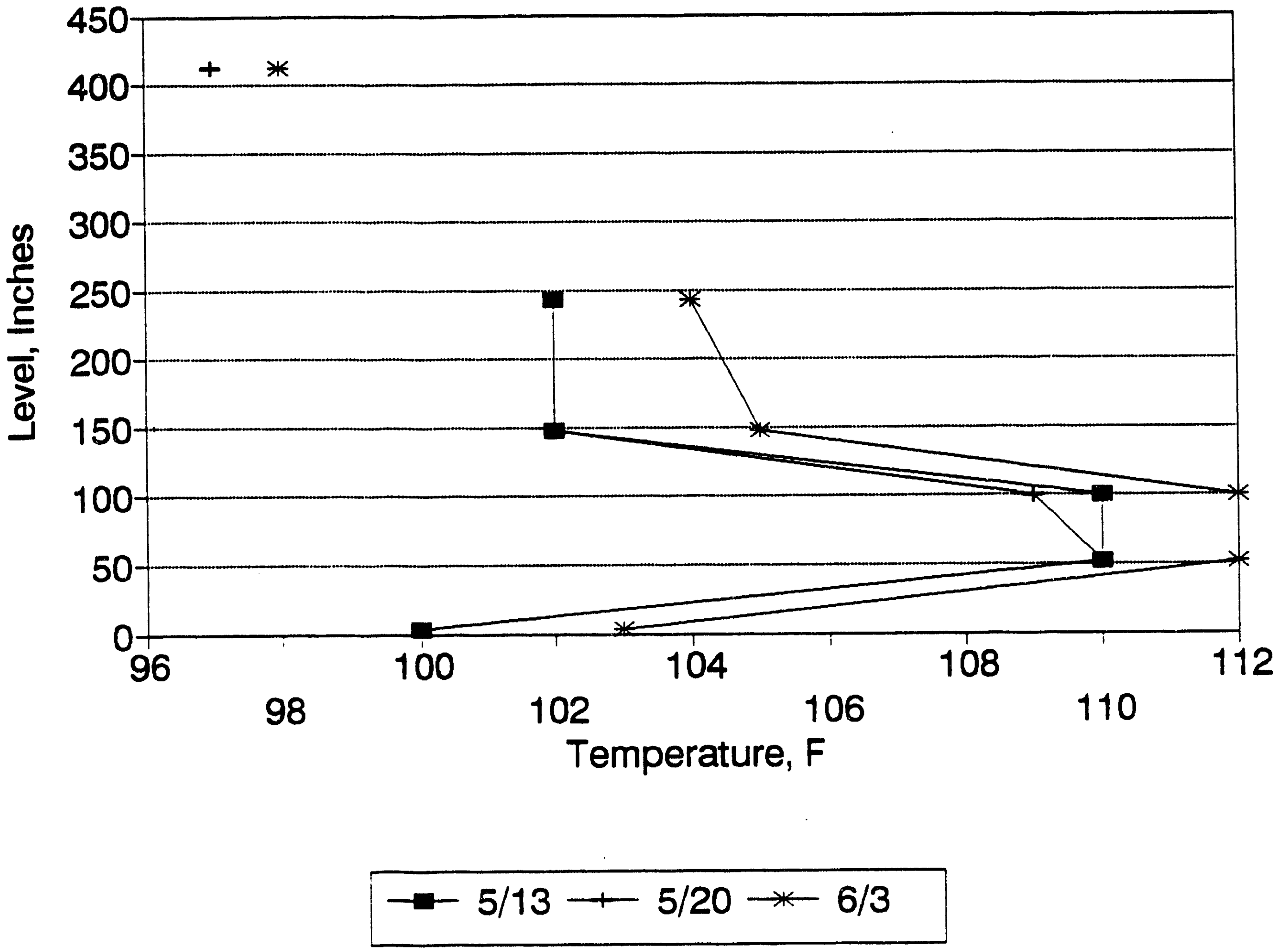


Figure 4-11. Tank 241-AN-104 May 19, 1991
Gas Release Event Temperature Profile.



4.5 GAS QUANTITY

The amount of gas release resulting from an AN Tank Farm surface level drop has been estimated. The temperature profiles indicate that all tanks have a nonconvective layer, about 150 in. deep, which traps gas. Estimated hydrogen gas concentrations in tanks 241-AN-103, -104, and -105 are shown in Appendix B. The average location of the gas within this layer is at the 75-in. level. The hydrostatic head is different for each tank as is the surface level and density.

The estimated amount of gas for each tank is shown in Table 4-3. Table 4-3 also shows that each tank has a different volume headspace. Using an estimated hydrogen concentration high of 43 percent in the vent gas, Table 4-3 shows an estimated maximum concentration in the dome space of each tank for the greatest daily surface level drop recorded. The hydrogen concentrations shown in Table 4-3 do not exceed the LFL, even when the most severe drops occur.

Table 4-3. Gas Volume and Concentrations.

Tank	Maximum drop (in.)	Dome volume (ft^3)	Gas release (ft^3)	Hydrogen concentra-tion[a] (%)	Release drop (ft^3/in)	Hydrogen concentra-tion[b] (%)
241-AN-103	2.50	61,100	1,933	1.36	773	.89
241-AN-104	3.60	46,010	2,848	2.66	791	1.73
241-AN-105	1.50	37,350	1,234	1.64	823	.93

[a]Assuming gas is 43 percent hydrogen (maximum likely).
[b]Assuming gas is 28 percent Hydrogen (most likely).

Table 4-4 shows the growth rate of the AN Tank Farm Flammable Gas Watch List tanks. Note that these tanks have a growth rate approximately one-tenth as fast as the growth rate of tank 241-SY-101.

Table 4-4. Growth Rate of Tanks 241-AN-103, -104, and -105.

Tank	Growth rate (in./day)
241-AN-103	0.0059
241-AN-104	0.011
241-AN-105	0.012

4.6 TANK PRESSURE

Table 4-2 shows that tank 241-SY-101 usually had large increases in pressure. It is common to see tank 241-SY-101 go to positive pressure during gas release events. Table 4-2 shows that hydrogen concentrations exceeded the LFL only when pressure went positive.

A slight increase in pressure can be seen on some of the surface level drops in the AN Tank Farm tanks. However, there is no history of any AN Tank Farm tank being positively pressurized while experiencing a drop in surface level.

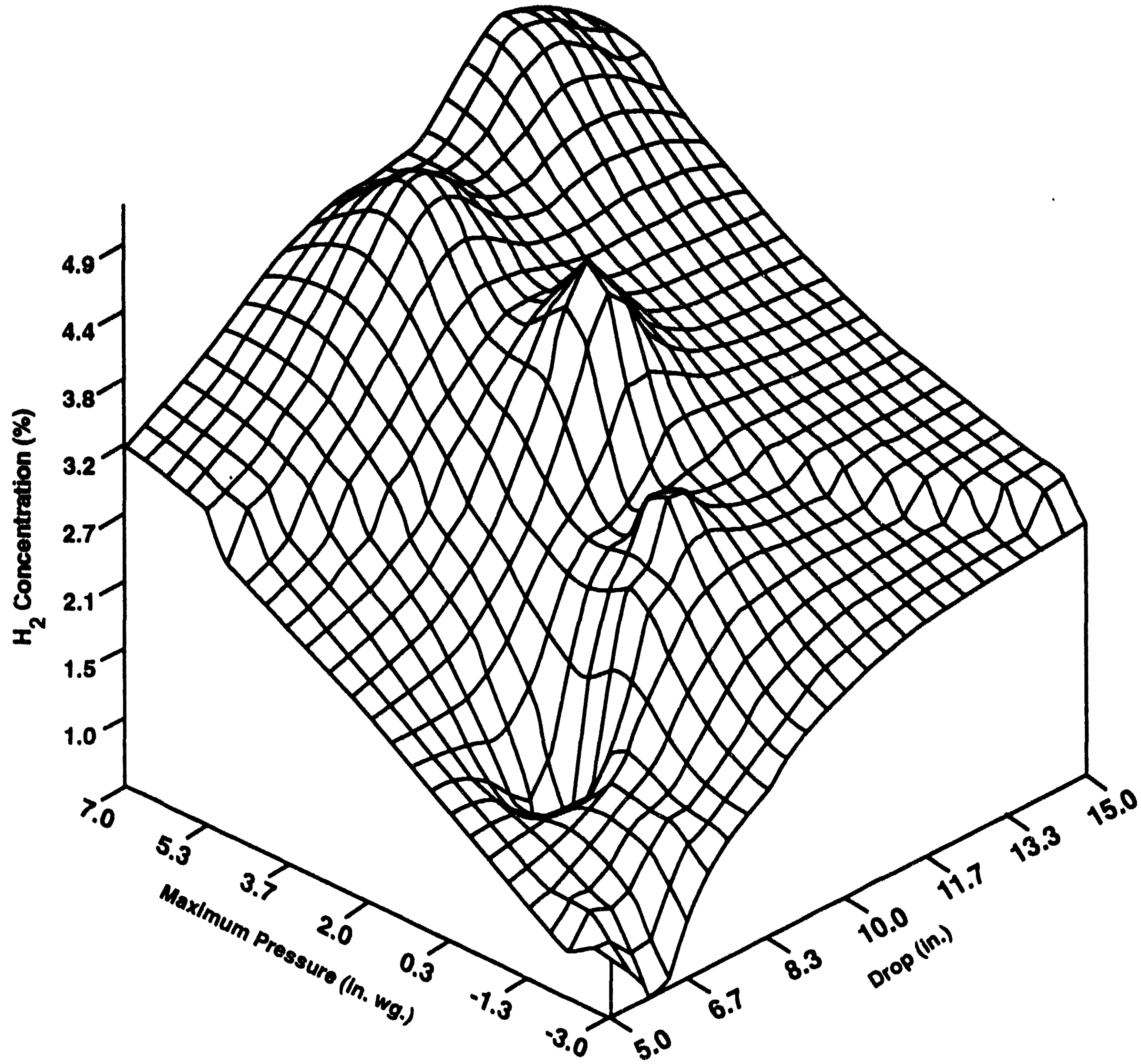
4.7 HYDROGEN, PRESSURE, AND SURFACE LEVEL DROP RELATIONSHIP

Table 4-2 shows a correlation in hydrogen concentration, maximum pressure, and drop size. When combined, the maximum pressure and drop size can account for 80 percent of the hydrogen concentration. This correlation is illustrated in Figure 4-12.

A large drop will release a large amount of gas. In a confined space, the large amount of gas will increase the pressure and raise the hydrogen concentration. If the drop is small and slow, then the ventilation system has a chance to remove the gas so the pressure and concentration will not be as large.

If the correlation is extrapolated to the AN Tank Farm range (-3 to 0 in. wg maximum pressure, 0- to 5-in. drop), the predicted hydrogen concentration is less than 25 percent of the LFL of hydrogen. The AN Tank Farm range cannot be plotted on Figure 4-12, but would be represented off the low end of the range represented by Figure 4-12. This would indicate that the hydrogen concentration in the AN Tank Farm tanks does not pose the same degree of risk as the hydrogen concentration of tank 241-SY-101.

Figure 4-12. Hydrogen Concentration, Maximum Pressure, and Drop Size.



5.0 CONCLUSIONS

Considering the small drops and low pressures exhibited in the AN Tank Farm tanks, additional restrictions do not appear necessary for working inside of these tanks. Those restrictions imposed on all unreviewed safety question tanks are probably adequate.

All indications suggest that the vapor space will not exceed 25 percent of the LFL of hydrogen, even during a drop. The volume of gas that might be released during a surface level drop are shown in Table 4-3 (about 2,000 ft^3). These volumes are below the volume of gas permitted in tank 241-SY-101. Safety assessments for tank 241-SY-101 are based on keeping the volume of gas below 8,700 ft^3 of gas with a maximum of 3,700 ft^3 of hydrogen (Los Alamos 1983). The amounts of gas released by the AN Tank Farms remains well below the limits set in the safety assessments for tank 241-SY-101 (LASL 1993).

It would be prudent to minimize work activity within tanks 241-AN-103, -104, and -105 until hydrogen monitors have been operational in these tanks for some time. Activities in these tanks should be well planned and rapidly executed to minimize risk to personnel.

This page intentionally left blank.

6.0 REFERENCES

Fow, C. L., 1987, *Characterization of Waste From Double-Shell Tank 103-AN*, Letter Report 7W21-87-14, Pacific Northwest Laboratory, Richland, Washington.

Gratny, E. G., 1985, *242-A Evaporator/Crystallizer FY '84 Campaign 84-5 Post Run Document*, SD-WM-PE-022, Rockwell Hanford Operations, Richland, Washington.

Kelly, M. G., 1986, *242-A Evaporator/Crystallizer FY 1986 Campaign Run 86-2 Post Run Document*, SD-WM-PE-028, Rockwell Hanford Operations, Richland, Washington.

LASL, 1993, *A Safety Assessment for Proposed Pump Mixing Operations to Mitigate Episodic Gas Releases in Tank 241-SY-101: Hanford Site, Richland, Washington*, Los Alamos Scientific Laboratory, Los Alamos, New Mexico.

Pontious, N. L., 1985, *242-A Evaporator/Crystallizer FY 1985 Campaign 85-3 Post Run Document*, SD-WM-PE-023, Rockwell Hanford Operations, Richland, Washington.

Toste, A. P. 1987, Internal Memorandum to W. G. Richmond, Pacific Northwest Laboratory, Richland, Washington.

WHC, 1986, *Process Aids*, WHC-IP-0711, Volume 18, Westinghouse Hanford Company, Richland, Washington.

This page intentionally left blank.

APPENDIX A. WASTE CHEMISTRY

This page intentionally left blank.

WASTE CHEMISTRY

The waste chemistry of the 241 AN Tank Farm tanks is fairly well known. A core sample has been taken from tank 241-AN-103, and other samples have been taken from all of the AN Tank Farm tanks.

Tank 241-AN-103 was pumped down to an 88-in. heel before the addition of double-shell slurry to the tank. A sample was taken of the sludge in the heel as shown in Table A-1 (WHC 1986).

Table A-1. Composition of Sludge Sample R-8190, Taken from Tank 241-AN-103.

Component	Liquid phase (M)	Solid phase (wt%)
Al	0.59	
OH	1.05	
NO_2	1.53	11
NO_3	2.38	31
CO_3	0.15	49
PO_4	0.016	3
SO_4	0.031	3
F	0.051	1
Cl	.24	
K	.26	
Na	10.47	
TOC (g/l)	3.406	1
^{137}Cs (μCi/l)	7.17E+05	
Pm (μCi/l)	372	
^{239}Pu/^{240}Pu (g/l)	3.8E-06	
^{89}Sr/^{90}Sr (μCi/l)	89.4	
Specific gravity	1.48	1.47
H_2O (%)	48.8	39
pH	13.2	
Filtered solids[a] (%) = 58.5		
TOC = Total organic carbon		

[a]The solids were primarily sodium nitrate, sodium nitrite, and sodium carbonate.

Several slurry samples were taken at the evaporator while the double-shell slurry run was made (WHC 1986). These samples represent waste transfers into tank 241-AN-103, which was the only tank to receive this slurry. Table A-2 shows the overall composition of the various slurry samples.

Table A-2. Composition of Slurry Samples Taken During the Double-Shell Slurry Run.

Component	Date Sampled				Average (M)
	2/10/86 (M)	2/11/86 (M)	2/13/86 (M)	2/14/86 (M)	
Al	2.87	2.67	2.48	2.5	2.63
OH	5.50	5.75	4.91	5.5	5.42
NO_2	3.2	3.56	3.21	2.85	3.2
NO_3	2.54	4.08	3.20	2.81	3.16
CO_3	.3	.27	.16	.14	.22
PO_4	.025	.025	.023	.02	.023
F	.07	.105	.1	.11	.096
Cl	.29	.99	.22	.28	.45
K	.31	.4	.47	.49	.42
Na	16.25	14.1	15.28	15.3	15.23
TOC (g/l)	4.7	6.15	4.33	4.29	4.9
^{137}Cs (μCi/l)	9.25E+05	8.50E+05	6.9E+05	7.65E+05	8.08E+05
Pm (μCi/l)	95.5				
$^{239}Pu/^{240}Pu$ (g/l)	8.35E-06	4.1E-06	7.2E-06	3.58E-06	5.8E-06
$^{89}Sr/^{90}Sr$ (μCi/l)	1310	1230	715	530	946
Specific gravity		1.79	1.51	1.54	1.61
H_2O (%)	45.1	37.4	45.5	47	43.8
pH	13.3	13.3	13.3	13.3	13.3
Filtered Solids (%) = 58.5					

The slurry samples were separated in three cases and the solid and liquid portions were analyzed for the major components as shown in Tables A-3 and A-4.

Table A-3. Liquid Portion of Double-Shell Slurry Samples.

Component	Date sampled			Average
	2/11/86 (M)	2/13/86 (M)	2/14/86 (M)	
Al	2.05	2.61	2.49	2.83
OH	6.9	4.94	5.36	5.73
NO_2	2.95	1.07	2.96	2.33
NO_3	2.24	2.34	2.46	2.35
CO_3	.077	.13	.095	.1
PO_4	.025	.023	.018	.02
F	.14	.1	.11	.12
Cl	.035	.23	.24	.17
TOC (g/l)	6.6	5.63	5.51	5.91
Specific Gravity	1.56	1.535	1.54	1.54
H_2O (%)	45.9	45.8	46.5	46.1

Table A-4. Solid Portion of Double-Shell Slurry Samples.

Component	Date sampled		
	2/11/86 (wt%)	2/13/86 (wt%)	2/14/86 (wt%)
Al	16		3
NO_2	20	6	5
NO_3	49	88	83
CO_3	7	5	8
Cl	1		
TOC (g/l)	7		
Specific Gravity	1.79	1.39	1.54
H_2O (%)	21.9	14.7	18

Table A-4 shows that sodium nitrate makes up the bulk of the solids. Sodium nitrite and sodium carbonate also are important. The aluminate was probably supersaturated and would increase once the slurry is in the tank.

The measured viscosity of the slurry was between 12 and 36 centipoise.

Tank 241-AN-103 was core sampled during December 1986. The surface level was about 334.5 in. during December 1986. Normal paraffin hydrocarbon was used as a hydrostatic fluid during core sampling. Eighteen segments were recovered. Segment 1 contained only 4 in. of waste. Segment 18 (at the bottom of the tank) contained 14.25 in. of waste as expected. A hard layer was encountered at the segment 12 level (approximately 110 in.). Segments 2 through 10 and the upper portion of segment 11 contained a less dense slurry. A slurry of greater density was encountered at segments 12 through 18 and the lower portion of segment 11. The midpoint of segment 11 should be at 138 in.

A composite of the core sample was sent to Pacific Northwest Laboratory (PNL) for chemical composition (Toste 1987). The main constituents are shown in Table A-5. This table represents the weighted averages of the values given in Tables A-1 to A-4.

The radionuclide measurements for the core composite are found in Table A-6.

Organic analysis was done for the core composite. Only about 33 percent of the TOC was identified. Oxalic acid was the most prevalent organic. The organic analysis is in Table A-7.

Three segments of the core sample (i.e., segments 9, 12, and 16) were sent to PNL for physical property measurements (Fow 1987). These segments represented waste from the top, middle, and bottom of the tank. Segments 9 and 12 slumped slightly when extruded, but segment 16 held its shape.

The physical properties of the segments are summarized in Table A-8.

Tanks 241-AN-104 and -105 have not been core sampled. Individual samples from these tanks have not been taken. Both tanks were filled during a common evaporator run (Pontious 1985). These slurry samples are reported in Table A-9. The slurry samples were reported to be 40 to 50 percent light colored settled solids.

The viscosity of the last slurry was reported as less than 20 cp.

Table A-5. Inorganic Analyses of Tank 241-AN-103 Core Composite.

Ion	(μmole/g)	(μg/g)
Al	1,670	45,000
Ca	2.38	95
Cd	0.090	10
Cr	11.7	610
Cu	0.080	5
Fe	1.38	77
K	231	9,000
Mg	1.04	25
Mn	0.450	25
Mo	0.520	<50
Na	10,300	236,000
Ni	0.340	<20
Pb	0.390	80
Si	10.4	290
Sn	0.840	<100
Ti	0.210	<10
U	0.220	53
V	1.96	<100
W	0.870	160
Zr	0.220	<20
Zn	0.770	50
Hg[a]	0.10	20 ± 1.35
NH_3	12.9	220
CO_3^{2-},[b]	92.8	5,570
CN^-,[c]	0.850	22
Cl-	151	5,300
F-	11.05	210
$SO4^{2-}$	18.8	1,800
NO3-	1,180	73,000
NO2-	1,630	75,000
$PO4^{3-}$	9.48	900
OH-	5.6	

[a]Analyzed in replicate.
[b]Computed by difference from carbon analyses: total carbon (TC) minus TOC equals inorganic carbon (IC) or, at highly basic pH, CO3- concentration.
[c]Total CN- in water soluble portion of waste; free CN- in same fraction was 2.5 μg/g (0.100 μmole/g).

Table A-6. Radiochemical Analyses of Tank 241-AN-103.

Radionuclide	Sample concentration (Ci/L)[b] (DSSF-1)	Detection limit required
3H	(8.08±19.5)E-6	4.0E-2
^{14}C	(4.00±4.10)E-6	8.0E-3
^{60}Co	(3.71±1.04)E-5	7.0E-1
^{79}Se	(4.34±3.31)E-5	
^{90}Sr	(2.44±0.05)E-2	4.0E-5
^{94}Nb	(1.94±1.25)E-6	2.0E-4
^{99}Tc	(1.08±0.10)E-4	3.0E-3
^{106}Ru	(6.83±8.56)E-5	
^{129}I	(-1.42±1.01)E-7	8.0E-5
^{134}Cs	(2.17±0.14)E-4	
^{137}Cs	(7.55±0.09)E-1	1.0E-3
^{234}U	(3.65±0.41)E-8	
^{235}U	(7.11±5.81)E-10	
^{238}U	(1.35±0.38)E-8	
^{237}Np	(2.55±1.68)E-8	
^{238}Pu	(5.67±0.48)E-7	
$^{239/240}Pu$	(1.24±0.07)E-6	
^{241}Am	(3.34+0.02)E-6	
^{244}Cm	(3.85±0.34)E-7	3.0E-2
Total Alpha	(7.21±11.92)E-6	1.5E-4
Total Beta	(7.89±0.09)E-1	4.0E-5
DSSF = Double-shell slurry feed		

[a]Activity as of August 1987
[b]Numbers in parentheses are error limits; e.g., (5.49±1.57) E-6 in full is 5.49±1.57 x 10^{-6}. If the number in parenthesis exceeds the preceding number, the actual value is zero within experimental error.

Table A-7. Organics Identified in Tank 241-AN-103 Core Sample.

Compound	Concentration[a]	
	μg/g	μgC/g
Semivolatile[b]		
Tri-n-butylphosphate (TBP)	Trace	
Carboxylic acids[c]		
Ethanedioic Acid (Oxalic Acid)	2644 ± 183	705
Butanedioic Acid (Succinic Acid)	256 ± 19	104
Pentanedioic Acid (Glutamic Acid)	44 ± 2	20
Hexanedioic Acid	40 ± 2	21
Hexanoic Acid	27 ± 1	18
Heptanedioic Acid	17 ± 1	9
Octanedioic Acid	Trace	
Nonanedioic Acid	Trace	
Undecanedioic Acid	Trace	
Unknowns(2)[d]	Trace	
Chelating/Complexing Agents[c]		
Nitrilotriacetic Acid (NTA)	Trace	
Citric Acid	Trace	
Chelator/Complexor Fragments[c]		
N-(Methylamine)iminodiacetic Acid (MAIDA)	357 ± 29	181
N-[2-(Methylidene)ethyl]iminocarboxyacenc Acid (MEICA)	Trace	
N-(Methyliminocarboxy)ethylenediamine-N-acetic Acid (MICEDA)	19 ± 1	7
TOC	3,220	
TOC Identified[f] (%)	33.1	
GC-NPD = Gas chromatography with nitrogen/phosphorous detector		

[a]Exact contributions of unknown organics to waste TOC content cannot be determined unequivocally.
[b]Also referred to as basic/neutral and acidic, solvent-extractable organics in EPA Methods 625 and 8,270.
[c]Methylated (BF3/methanol), acids identified as methyl esters.
[d]Two nitrogen- and/or phosphorous-containing compounds, on the basis of GC-NPD analysis; weak mass spectra precluded any further characterization.
[e]TOC analyses performed by persulfate oxidation followed by nondispersive infrared analysis.
[f]Reflects only organic analyses completed to date; analysis of semivolatile organics currently underway.

Table A-8. Physical Properties of Tank 241-AN-103 Core Segments.

Property	Segment 9	Segment 12	Segment 16
Density (g/ml)	1.5	1.8	1.8
Centrifuged Solids (vol%)	18	90.2	85
Settled Solids (Vol%)	32 (after 4 days)		91 (after 5 days)
Total Solids (wt%)	59.3	74.7	73.8
Viscosity	19.4 cp at 44.5 °C		89 to 93 cp at 38 °C
Shear Strength			25,300 dynes/cm^2

Table A-9. Samples of Slurry Received in Tanks 241-AN-104 and -105.

Component	Slurry Sample R-4680 (M unless otherwise stated)	Slurry Sample (R-4687)	
		Filtrate	Solids (wt%)
Al	1.7	1.73	3
OH	3.05	3.38	
NO_2	2.42	3.13	5
NO_3	4.18	3.05	61
CO_3	.07	.25	25
PO_4	.03	.02	
Cl	.28	.2	
TOC	4.1	2.23	3
EDTA	2.46E-4		
Na	11.45	13.08	
K	.14	.15	
^{137}Cs (μCi/l)	6.13E+05		
Sr (μCi/l)	3950		
pH	13.5		
DSC	Slight Exotherm		
% H_2O	40.1	50	14.8
Specific Gravity	1.53	1.51	1.41
NH_3		.02	

APPENDIX B. HYDROGEN GAS CONCENTRATIONS

This page intentionally left blank.

HYDROGEN GAS CONCENTRATIONS

Tanks 241-AN-103, -104, and -105 have similar profiles that indicate a nonconvective layer about 150 in. deep. Assuming that the gas is stored in this layer, the average height of the gas is 75 in.

$Gas\_height := 75\ in$

$H\_103\_AN := 346\ in$

$H\_104\_AN := 387\ in$

$H\_105\_AN := 410.5\ in$

Densities:

$D\_103\_AN := 1.65\ \frac{gm}{mL}$ $\quad D\_104\_AN := 1.5\ \frac{gm}{mL}$ $\quad D\_105\_AN := 1.5\ \frac{gm}{mL}$

Pressure

$P\_103\_AN := (H\_103\_AN - Gas\_height) \cdot D\_103\_AN \cdot g + 14.7\ psi$

$P\_104\_AN := (H\_104\_AN - Gas\_height) \cdot D\_104\_AN \cdot g + 14.7\ psi$

$P\_105\_AN := (H\_105\_AN - Gas\_height) \cdot D\_105\_AN \cdot g + 14.7\ psi$

$P\_103\_AN = 2.1 \cdot atm$

$P\_104\_AN = 2.151 \cdot atm$

$P\_105\_AN = 2.237 \cdot atm$

Volume of Gas Represented by 1 inch drop

$Tank\_inch := 368\ \frac{ft^3}{in}$

$Vol\_103\_AN := Tank\_inch \left(\frac{P\_103\_AN}{1\ atm}\right)$ $\qquad Vol\_103\_AN = 772.62 \cdot \frac{ft^3}{in}$

$Vol\_104\_AN := Tank\_inch \left(\frac{P\_104\_AN}{1\ atm}\right)$ $\qquad Vol\_104\_AN = 791.483 \cdot \frac{ft^3}{in}$

$Vol\_105\_AN := Tank\_inch \left(\frac{P\_105\_AN}{1\ atm}\right)$ $\qquad Vol\_105\_AN = 823.372 \cdot \frac{ft^3}{in}$

Vapor Space in Tank

$Vol_{dome} := 3.301 \cdot 10^4\ ft^3$

$VS\_103\_AN := Vol_{dome} + (422.31\ in - H\_103\_AN) \cdot \pi \cdot (37.5\ ft)^2$

$VS\_104\_AN := Vol_{dome} + (422.31\ in - H\_104\_AN) \cdot \pi \cdot (37.5\ ft)^2$

$VS\_105\_AN := Vol_{dome} + (422.31\ in - H\_105\_AN) \cdot \pi \cdot (37.5\ ft)^2$

$VS\_103\_AN = 6.11 \cdot 10^4 \cdot ft^3$

$VS\_104\_AN = 4.601 \cdot 10^4 \cdot ft^3$

$VS\_105\_AN = 3.736 \cdot 10^4 \cdot ft^3$

Maximum drop per day for each tank

Max_drop_103 := 2.5·in

Max_drop_104 := 3.6·in

Max_drop_105 := 1.5·in

H2% := 43 **Maximum likely H2 concentration**

Maximum hydrogen concentration in the dome

$$\text{Max\_H2\_103} := \frac{\text{Max\_drop\_103}\cdot\text{Vol\_103\_AN}\cdot\text{H2\%}}{\text{VS\_103\_AN}}$$

$$\text{Max\_H2\_104} := \frac{\text{Max\_drop\_104}\cdot\text{Vol\_104\_AN}\cdot\text{H2\%}}{\text{VS\_104\_AN}}$$

$$\text{Max\_H2\_105} := \frac{\text{Max\_drop\_105}\cdot\text{Vol\_105\_AN}\cdot\text{H2\%}}{\text{VS\_105\_AN}}$$

Max_H2_103 = 1.359·%

Max_H2_104 = 2.663·%

Max_H2_105 = 1.422·%

H2% := 28 **More likely H2 concentration**

Maximum hydrogen concentration in the dome

$$\text{Max\_H2\_103} := \frac{\text{Max\_drop\_103}\cdot\text{Vol\_103\_AN}\cdot\text{H2\%}}{\text{VS\_103\_AN}}$$

$$\text{Max\_H2\_104} := \frac{\text{Max\_drop\_104}\cdot\text{Vol\_104\_AN}\cdot\text{H2\%}}{\text{VS\_104\_AN}}$$

$$\text{Max\_H2\_105} := \frac{\text{Max\_drop\_105}\cdot\text{Vol\_105\_AN}\cdot\text{H2\%}}{\text{VS\_105\_AN}}$$

Max_H2_103 = 0.885·%

Max_H2_104 = 1.734·%

Max_H2_105 = 0.926·%

DISTRIBUTION

Number of copies		
OFFSITE		
2	**Los Alamos National Laboratory** PO Box 1663 Los Alamos, NM 87545	
	SW Eisenhawer	
	LH Sullivan	
ONSITE		
3	**U. S. Department of Energy-Richland Operations Office**	
	RF Christensen	R3-72
	GW Rosenwald	R3-72
	Reading Room	A1-65
3	**Pacific Northwest Laboratory**	
	JW Brothers	K5-22
	CW Stewart	K7-15
	Hanford Technical Library	P8-55
25	**Westinghouse Hanford Company**	
	RA Dodd	R1-51
	JC Fulton	R2-31
	GD Johnson	R2-78
	NW Kirch	R2-11
	WL Knecht	H0-34
	NG McDuffie	R2-78
	RW Reed	R1-51
	DA Reynolds (10)	R2-11
	NE Wilkins	R2-11
	Central Files (2)	L8-04
	Document Processing and Distribution (2)	L8-15
	Information Release Administration (3)	R1-08