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Page 1 of 2

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Results of Vapor Space Monitoring of Flammable Gas Watch List Tanks

Dennis J. McCain

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Abstract: This report documents the measurement of headspace gas concentrations and monitoring results from the Hanford tanks that have continuous flammable gas monitoring. The systems used to monitor the tanks are Standard Hydrogen Monitoring Systems. Further characterization of the tank off-gases was done with Gas Characterization systems and vapor grab samples. The background concentrations of all tanks are below the action level of 6250 ppm. Other information which can be derived from the measurements (such as generation rate, released rate, and ventilation rate) is also discussed.

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Results of Vapor Space Monitoring of Flammable Gas Watch List Tanks

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

CH2MHILL
Hanford Group, Inc.

Richland, Washington

Contractor for the U.S. Department of Energy
Office of River Protection under Contract DE-AC06-99RL14047

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D. J. McCain
CH2M HILL Hanford Group, Inc.

Date Published
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CH2MHILL
Hanford Group, Inc.

P. O. Box 1500
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TERMS

cfm	cubic feet per minute
DACS	Data Acquisition and Control System
DST	double-shell tank
FGWL	Flammable Gas Watch List
FTIR	Fourier transform infrared spectrometer
GC	gas chromatograph
GCS	Gas Characterization System
GMS	Gas Monitoring System
GRE	gas release event
IR	infrared
LFL	lower flammability limit
ppm	parts per million
SACS	Surveillance Analysis Computer System
SHMS	Standard Hydrogen Monitoring System
SST	single-shell tank
TBD	to be determined
TMACS	Tank Monitoring and Control System
VFR	vent flow rate

1.0 INTRODUCTION

This report documents measurements of headspace gas concentrations and monitoring results obtained using the sampling systems described in Section 2 of this report. This report has been updated annually since September 1997. This revision includes data collected from July 1999 through June 2000. The purpose of this report is to present the data, not to interpret how the data represent the safety condition of the tanks.

This report describes the methods used for monitoring or measuring tank headspace gas concentrations, summarizes the measurement results, describes actions to be taken if concentrations reach action levels, and outlines the plans for system improvements and future monitoring.

This information will be useful in developing and validating the models used to predict tank performance, supporting resolution of the Flammable Gas Safety Issue, and assisting with information needed to comply with *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1994) Milestone M-40-00, established to mitigate or resolve tank safety issues for high-priority watch list tanks.

Continuous gas monitors have been installed on the Flammable Gas Watch List (FGWL) tanks as listed in Table 1-1. Several of these monitors were placed in a standby mode or disconnected this year after extensive review of the data collected to date. This activity has been determined to be a "field optimization" and is discussed in Section 4.0. This revision (Rev. 5) continues to address the requirement for continued monitoring plus monitoring results of other tanks of concern.

Table 1-1. Flammable Gas Watch List Tanks.

Double-Shell Tanks	Single-Shell Tanks
241-AN-103, 104, 105	241-A-101
241-AW-101	241-AX-101, 103
241-SY-101, 103	241-S-102, 111, 112
	241-SX-101, 102, 103, 104, 105, 106, 109
	241-T-110
	241-U-103, 105, 107, 108, 109

1.1 PUBLIC LAW 101-510, SECTION 3137, AND THE FLAMMABLE GAS TANK WATCH LIST

In November 1990, the *National Defense Authorization Act for Fiscal Year 1991*, Public Law 101-510, Section 3137, "Safety Measures for Waste Tanks at the Hanford Nuclear Reservation," [the Wyden Amendment] was passed. It required the Secretary of Energy to identify within 90 days high-level nuclear waste tanks that could have a "serious potential for

release of high-level waste caused by uncontrolled increases in temperature or pressure.” The identified tanks contained flammable gas, ferrocyanide, organic chemicals, and high levels of radioactive decay heat.

In January 1991, Westinghouse Hanford Company formally submitted a watch list of tanks subject to the law (Harmon 1991a). In February 1991, Westinghouse Hanford Company submitted a method for selecting flammable gas tanks (Harmon 1991b). The 1991 FGWL identified 23 tanks. In 1992 and 1993, two additional tanks were added bringing the total to 25. These 6 double-shell tanks (DST) and 19 single-shell tanks (SST) are listed in Table 1-1. All the Watch List tanks have had a Standard Hydrogen Monitoring System (SHMS) installed for gas monitoring. Section 4.0 discusses those monitoring systems that have been disconnected or placed in a standby mode.

1.2 NON-WATCH LIST TANKS

Other tanks also have operating SHMS. These tanks either show evidence of gas retention or have planned activities that require flammable gas monitoring. Two of the tank farms have SHMS on a common exhaust stack. These tanks and exhaust stacks are listed in Table 1-2. The tank 241-B-111 SHMS was placed into service on May 30, 2000. Several of these SHMS have been disconnected or placed in standby mode. Refer to Section 4.0 for a discussion of SHMS removal.

Table 1-2. Non-Watch List Tanks with SHMS.

Double-Shell Tanks	Single-Shell Tanks
241-AN-101, AN-107	241-B-111
241-AY-102	241-BY-103, 105, 106, 109
241-AZ-101, 102	241-C-106
241-SY-102	241-S-101, S-106, S-107, S-109
AN FARM (Exhaust Stack)	241-U-102
AW FARM (Exhaust Stack)	

2.0 DESCRIPTION OF THE FLAMMABLE GAS MONITORING SYSTEMS

The tanks are monitored for hydrogen and other flammable gases to ensure that the tank headspace is safe and to increase the understanding of the mechanisms for gas release and dispersion. A number of different systems are in use. Depending on the information desired from a tank, different monitoring instruments are combined into a tank-specific system. These instruments, along with their measurement accuracy and ranges, are listed in Table 2-1. The following sections describe how the instruments are applied in different monitoring systems.

Table 2-1. Gas Monitoring Instruments.

Instrument	Gases Monitored	Range	Accuracy
Whittaker™ electro-chemical cell and transmitter (2 units)	Hydrogen specific	0 to 1% and 0 to 10% H ₂ by volume	±0.2% by volume absolute (resolution of 50 ppm)
Gas chromatograph reduction gas analyzer (GC-RGA)	Hydrogen specific	Low range 0 to 500 ppm H ₂ High range 500-30,000 ppm H ₂	Low range ±4 ppm <100 ppm and ±10% of reading >100 ppm High range ±10% of reading
Gas chromatograph thermal conductivity detector (GC-TCD)	Hydrogen (H ₂) Nitrous oxide (N ₂ O) Methane (CH ₄)	H ₂ : 3 to 3,000 ppm N ₂ O: 10 to 20,000 ppm CH ₄ : 10 to 4,000 ppm	H ₂ , N ₂ O, and CH ₄ ±3 ppm <30 ppm and ±10% of reading >30 ppm
Fourier transform infrared spectrometer (FTIR)	Ammonia (NH ₃) Nitrous oxide (N ₂ O) IR spectra for other species	NH ₃ : 10 to 30,000 ppm N ₂ O: 10 to 30,000 ppm Other species TBD	N ₂ O & NH ₃ ±5 ppm <100 ppm ±10% of reading >100 ppm
Infrared photo acoustic multi-gas monitor	Ammonia (NH ₃) Selected filters for other species	NH ₃ : 10 to 10,000 ppm Other species TBD	NH ₃ ±10 ppm <100 ppm ±10% of reading >100 ppm
Grab samples - mass spectrometer	Hydrogen (H ₂) Nitrous oxide (N ₂ O) Methane (CH ₄) Argon (Ar) Nitrogen (N ₂) Oxygen (O ₂)	0 to 100% by volume	±10 ppm

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2.1 STANDARD HYDROGEN MONITORING SYSTEMS

The basic SHMS monitors hydrogen continuously. Gas is vacuum pumped from the tank into a temperature-controlled cabinet that contains the monitoring instrument. For FGWL DSTs, the sample is obtained from the tank ventilation exhaust duct; for SSTs and the non-Watch List DSTs, a sample is obtained from a probe inserted deep into the tank headspace. The monitoring instrument is a hydrogen-specific Whittaker™ electrochemical cell. The cell generates an electrical signal proportional to the volume percent hydrogen concentration. The signal is processed by an analog to digital transmitter. The 4 to 20 mA output from the transmitter is sent to a digital data readout and to the data recorder. The recording channel of the data recorder is programmed to activate an alarm relay if a preset hydrogen concentration (currently 6,250 ppm) is reached. The alarm relay opens a normally closed contact that serves as the input to a programmable logic controller that controls the annunciation of a high-hydrogen alarm and initiates an automatic vapor grab sample. Data for most of the SHMS are recorded by a connection to the Tank Monitoring and Control System (TMACS); other SHMS units have an on-board chart recorder or an on-board data logger.

Each SHMS also has a grab sample station that allows two 75 cc vapor samples to be taken simultaneously from the gas stream. These "grab samples" are then isolated and transported to a laboratory for analysis. Hydrogen and other gas concentrations can be measured using these samples.

These systems are calibrated quarterly. A mixture of 100 ppm hydrogen in air is used to adjust the low end of the hydrogen sensor and a mixture of 5.0 percent hydrogen mixed with nitrogen is used to balance the high end of the sensor. A mid-range standard gas of 1,000 ppm hydrogen is used as an on-line calibration check during system operation (Schneider 1996).

The first basic SHMS unit was developed for use in continuously monitoring hydrogen concentrations in tank 241-SY-101. Three of the basic units currently are installed and operating on this tank. One system monitors the vent header concentration; the other two monitor locations within the headspace. Based on the success of these instruments, the system was upgraded for other tanks by adding the capability to automatically obtain a grab sample if a high-hydrogen reading is detected. The Whittaker™ cells were configured so that one covers a high range (0 to 10 percent by volume) and another covers a low range (0 to 1 percent by volume). This modified version is called the SHMS-B.

The SHMS-B is the most widely used SHMS instrument. It is installed on all FGWL tanks other than 241-SY-101 and 241-AN-104. Data are recorded by connection to the TMACS and by the on-board chart recorder. As specific needs have arisen, the SHMS-B has been modified to provide additional capabilities. This has resulted in several variations, including models C, D, E, and E+. Table 3-9 lists the tanks and the type of SHMS currently installed in each.

The SHMS-C is a SHMS-B modified to accommodate a data column gas chromatograph (GC) with thermal conductivity detectors. Data for the Whittaker™ cells are recorded by connection to the TMACS and/or by the on-board chart recorder. The data from the GC are recorded by a resident computer and stored on a floppy disk for off-line analysis. The SHMS-C is designed to

accurately record baseline hydrogen concentrations that are well below the range of the Whittaker™ cells.

The SHMS-D is a SHMS-B modified to accommodate an infrared (IR) photo-acoustic multi-gas monitor for measuring ammonia. Data from the Whittaker™ cells are recorded by connection to TMACS and/or by the on-board chart recorder. The data from the IR photo-acoustic multi-gas monitor are recorded by a resident computer and stored on a floppy disk for off-line analysis. The SHMS-D was developed for use in monitoring ammonia concentrations in the ventilation exhaust of DSTs.

The SHMS-E is an updated version of the SHMS-B and accommodates a dual-column GC with a thermal conductivity detector and an IR photo-acoustic multi-gas monitor. However, the detector and monitor are not installed. Data are recorded by an on-board digital data logger with data stored on a floppy disk. The upgrade in the design from the SHMS-B is in the data recording (the strip-chart is eliminated) and the programmable logic controller. The SHMS-E is intended for use in the same applications as a SHMS-B. The SHMS-E has the advantage of easily being upgraded to an E+.

The SHMS-E+ is a SHMS-E with a GC and IR monitor installed. The GC monitors hydrogen, nitrous oxide, and methane, and the IR monitor detects ammonia. An on-board digital data logger records data on a floppy disk or by connection to a host computer through the Hanford Local Area Network. The SHMS-E+ is intended for applications similar to those with the Gas Characterization System (GCS) described in Section 2.2. The SHMS-E+ provides nearly the same measurement capability as a GCS but at a significantly lower cost.

2.2 OTHER MONITORING SYSTEMS

The Gas Monitoring System-1 (GMS-1) monitors hydrogen and tank headspace pressure in tank 241-SY-101. The environmentally controlled enclosure contains one Whittaker™ electrochemical cell and a grab sample station. It also has a pressure transmitter. It initially had a mass spectrometer for multi-specie analysis that has been removed. Data from GMS-1 are recorded by the 241-SY-101 Mixer Pump Data Acquisition and Control System (DACS).

The Gas Monitoring System-2 (GMS-2) is an environmentally controlled enclosure containing a Fourier transform infrared spectrometer (FTIR), two hydrogen-specific GCs and one IR photo-acoustic monitor. GMS-2 monitors the headspace of tank 241-SY-101. The FTIR measures ammonia and nitrous oxide. One GC has a single column and monitors low concentrations of hydrogen; the other GC has a dual-column arrangement and monitors both low and high concentrations of hydrogen. The IR monitor samples the ventilation exhaust stack of the SY farm (combined exhaust from tanks 241-SY-101, -102, and -103) for ammonia. The data are recorded by the 241-SY-101 DACS. GMS-1 and GMS-2 provide the detailed concentration history necessary to support the mixer pump operation. The data from these systems have significantly contributed to the understanding of this tank.

The GCS is an environmentally controlled enclosure with an FTIR, two dual-column thermal conductivity GCs, and a grab sample station. The GCS is an upgraded version of the GMS-2. The FTIR monitors ammonia, one GC monitors hydrogen, and the other GC measures nitrous

oxide and methane. The data are recorded by the resident computer system and can be remotely accessed over the Hanford Local Area Network. The GCS is used to provide the detailed history of gas concentration over a wide range to support the decision of whether additional means are needed to mitigate the safety issue of a tank. These systems are currently installed on tanks 241-AN-105 and 241-AW-101.

3.0 GAS RELEASE EVENTS

In this document, a gas release event (GRE) is defined as an abrupt increase in tank headspace hydrogen concentration from the steady-state level, followed by a decrease back to the steady-state concentration. The hydrogen increase from steady-state to a peak concentration can take minutes or hours in a DST and days in an SST. The gas release may be accompanied by a drop in waste level, indicating the waste volume has decreased because of the release of gas. However, the tanks do not consistently show a level drop with each release. If a release occurs in one small area of the tank, the level may drop in that small area but not affect the waste near the level measurement device. The level drop also may be too small to be detected with the level instrument installed in the tank. Also, some gas may be trapped in the waste crust, causing a temporary increase in waste level. The tables in this section illustrate the wide range of variability in the change in levels.

Gas releases have several causes. Gas trapped in the waste can build up until the waste becomes buoyant. As the waste floats up, gas is released and, after the waste returns to less than neutral buoyancy, the waste resettles. Such waste movement can be monitored with thermocouples installed at different elevations in the waste. Temperatures change by several degrees within hours when warm waste rises and is replaced by the cooler supernatant liquid. This type of gas release is called “buoyant displacement” and occurs in several DSTs (Stewart et al. 1996a). Buoyant displacements (historically called “rollovers”) are not believed to occur in SSTs (Stewart et al. 1996b).

Gas releases in the SSTs have been observed to usually be associated with changes in barometric pressure. These releases have been very small compared to those seen in the DSTs. Low barometric pressure is believed to decrease the pressure on the trapped gas and allow the gas to expand and percolate to the surface of the waste.

Small gas releases also have occurred in a few cases when the waste was disturbed during work activities. Recent intrusive activities to ameliorate the crust rise in tank 241-SY-101 showed a release every time the waste was disturbed. A hydrogen concentration “spike” was evident in both tanks 241-SY-101 and 241-SY-102 during a transfer from the former to the latter in December 1999 (subsequent transfers did not result in such dramatic hydrogen responses – see Appendix A, Figure 46). Currently, hydrogen gas concentration levels are rising in correlation with saltwell pumping activity in several SSTs, particularly in the U farm. Similar increases in hydrogen gas concentrations were observed coincidental with mixer pump and airlift circulator tests in tank 241-AZ-101. Since these releases are not generated spontaneously, they are not evaluated in the same manner as GREs (Section 3.4).

3.1 241-SY-101 GAS RELEASE EVENTS

Table 3-1 lists the GREs that have been detected in tank 241-SY-101 between 1990 and July 1993, before mitigation with a mixer pump. During 9 of the 11 gas releases before July 1993, hydrogen concentrations in the headspace were above 25 percent of the lower flammability limit (LFL) for hydrogen. The LFL for hydrogen in air is about 4 percent or 40,000 ppm. Three releases increased the headspace hydrogen concentration beyond the LFL. Level drops ranging

from 12.7 to 33.5 cm accompanied the gas releases in this tank. The time between gas releases averaged 116 days $\pm$ 25. The gas releases were somewhat predictable based on the number of days between releases.

The peak hydrogen concentrations listed for GREs that occurred during 1990 were measured with a thermal conductivity analyzer, which is no longer used. The February 1991 GRE was very slow and barely registered above background levels for hydrogen on the monitoring instruments. The peak concentration listed was measured with an on-line mass spectrometer, which is no longer used. GMS-1 was installed in April 1991, and its Whittaker™ cell measured the peak concentrations listed for the May, August, and December 1991 GREs. Two SHMS and GMS-2 were installed during 1992. Further details on tank 241-SY-101 gas instrumentation before 1992 are available in Babad et al. (1992).

Table 3-1. Summary of Gas Release Events for Tank 241-SY-101,
Before Mixer Pump Mitigation.

Date	Maximum H ₂ Concentration ¹ (ppm)	Level Drop ^{2,3} (cm)	Days Since Previous GRE
04/19/90	35,000	23.6	
08/05/90	12,000	13.2	108
10/24/90	47,000	25.4	80
02/16/91	400	12.7	115
05/16/91	28,000	18.3	89
08/27/91	3800	15.2	103
12/04/91	53,000	33.0	99
04/20/92	14,800	18.3	138
09/03/92	51,200	33.5	136
02/02/93	27,400	21.6	152
06/26/93	34,000	24.8	144
Average number of days between GREs = 116			
Standard deviation (days) = 25			

Notes:

¹SHMS data

²SACS (Surveillance Analysis Computer System) data

³Level drop is measured from the pre-GRE level to the minimum level following the GRE. The waste level may not stabilize until a few days after the GRE.

Vapor data specific to tank 241-SY-101 are reported quarterly. These quarterly reports provide greater detail regarding changes in tank waste level, temperature, gas releases, and mixer pump parameters. They discuss any core or grab sampling activities for the tank and summarize waste behavior. The three reports that coincide with the time frame for this report are Conner and Koreski (1999), Conner and Koreski (2000a), and Conner and Koreski (2000b).

3.2 GAS RELEASE EVENTS FROM OTHER DOUBLE-SHELL TANKS

Tables 3-2 through 3-6 list the gas releases detected with gas monitoring in the other DSTs. Only two other DSTs, tanks 241-AW-101 and 241-AN-105, have had gas releases that have exceeded 25 percent of the LFL. None of these releases exceeded the LFL. Level drops in these tanks following gas releases are generally less than 2.5 cm. These measurements show that the GREs in these tanks are much smaller than those seen in tank 241-SY-101 before mitigation. The average number of days between gas releases is less than 100 in tanks 241-AW-101 and 241-SY-103. However, the standard deviations of these averages are almost as large as the averages. Using the time period to predict future gas releases for these tanks does not appear feasible from existing data. A gas release in a tank on one day does not guarantee another gas release will not happen the next day. During October 1995, three separate hydrogen increases occurred in tank 241-AN-104 during a 9-day period. However, the hydrogen concentration in the headspace remained low. The only tank with consistent hydrogen increases historically above 25 percent of the LFL is tank 241-AN-105. Tank 241-AN-105 had two fairly significant hydrogen releases in July and August 1999. These were the highest peak concentrations of any tanks monitored and, at 7,100 and 7,620 ppmv, respectively, the concentration appeared to exceed 25 percent of the LFL. However, using measurements of hydrogen, methane, and ammonia (available by gas chromatography), the actual flammable gas releases were determined to be 18.0 and 19.2 percent of the LFL. Based on the size of the releases seen in these tanks, events in these tanks appear to be localized and not involve the entire tank contents. The AN farm stack monitor detected several gas releases, particularly the July and August 1999 releases in tank 241-AN-105.

Table 3-2. Summary of Gas Release Events for Tank 241-SY-103.

Date	Maximum H₂ Concentration¹ (ppm)	Level Drop^{2,3} (cm)	Days Since Previous GRE
01/22/95	1,090	1.5	
03/01/95	2,230	3.0	38
05/02/95	2,940	2.2	62
08/23/95	1,260	0.9	113
09/06/95	1,890	2.5	14
12/03/95	740	0.7	88
06/06/96	1,090	1.0	186
07/14/96	2,170	1.8	38
12/20/96	5,110	6.1	159
11/27/97	2,660	5.9	130
12/07/97	2,060	4.7	140
08/15/98	1,660	2.3	251
10/23/98	1,140	1.9	69
12/25/98	3,160	4.8	63
01/10/99	690	0.36	16
03/09/99	570	0.99	58
05/30/99	950	4.8	82
10/26/99	1,020	1.40	149
11/26/99	608	0.33	31
12/03/99	570	0.51	7
01/16/00	1,100	0.91	44
02/12/00	390	1.12	27
03/13/00	1,240	1.14	30
Average number of days between GREs = 82			
Standard deviation = 64			

Notes:

¹SHMS data²SACS (Surveillance Analysis Computer System) data³Level drop is measured from the pre-GRE level to the minimum level following the GRE. The waste level may not stabilize until a few days after the GRE.

Table 3-3. Summary of Gas Release Events in Tank 241-AW-101.

Date	Maximum H₂ Concentration¹ (ppm)	Level Drop^{2,3} (cm)	Days Since Previous GRE
10/01/94	5,500	1.9	
10/04/94	8,800	Not detected	3
10/21/94	2,980	0	17
11/27/94	5,000	0	37
02/22/95	5,800	0	87
05/08/95	1,800	0	75
05/17/95	1,000	0.9	9
07/08/95	2,000	0	52
07/12/95	900	0	4
08/02/95	3,300	0	21
09/15/95	1,900	+0.2	44
09/22/95	4,660	+2.0	7
10/16/95	1,750	0.3	24
12/12/95	2,110	0.3	57
12/29/95	6,000	+0.7	17
01/13/96	1,170	Not detected	15
01/25/96	1,830	Not detected	12
02/05/96	3,200	+0.5	11
02/14/96	940	Not detected	9
05/14/96	1,455	0.2	90
06/05/96	2,500	0.2	22
04/21/98	398	0.6	685
06/24/98	450	0.2	64
07/04/98	480	0.5	10
01/16/00	210	0.6	561
04/22/00	2,092	0.7	97
Average number of days between GREs = 81			
Standard deviation = 167			

Notes:

¹SHMS data²SACS (Surveillance Analysis Computer System) data³Level drop is measured from the pre-GRE level to the minimum level following the GRE. The waste level may not stabilize until a few days after the GRE.

Table 3-4. Summary of Gas Release Events for Tanks 241-AN-103 and 241-AN-104.

Tank	Date	Maximum H₂ Concentration¹ (ppm)	Level Drop^{2,3} (cm)	Days Since Previous GRE
241-AN-103	08/22/95	3,000	0.6	
	04/11/98	960	0	963
	02/01/99	900	1.0	296
	09/04/99	1,560	0.6	215
	12/30/99	530	None	117
241-AN-104	11/06/94	3,000	5.3	
	02/16/95	2,088	0.2	102
	08/03/95	480	0	168
	10/02/95	3,200	+0.8	60
	10/05/95	1,000	0	3
	10/08/95	5,000	0.7	3
	05/03/96	6,109	1.4	208
	05/01/97	2,183	0.4	363
	08/25/98	310	None	481
	09/26/98	310	0.3	32
	12/02/98	550	0.4	67
	04/26/99	135	None	145
	06/01/99	151	None	36
	07/02/99	249	0.48	31
	08/01/99	181	0.10	30
	09/04/99	155	None	34
	05/03/00	267	None	242
	06/02/00	264	0.18	30
241-AN-103	Average number of days between GREs = 398			
	Standard deviation = 384			
241-AN-104	Average number of days between GREs = 120			
	Standard deviation = 136			

Notes:

¹SHMS data²SACS (Surveillance Analysis Computer System) data³Level drop is measured from the pre-GRE level to the minimum level following the GRE. The waste level may not stabilize until a few days after the GRE.

Table 3-5. Summary of Gas Release Events for Tanks 241-AN-105 and 241-AN-107.

Tank	Date	Maximum H₂ Concentration¹ (ppm)	Level Drop^{2,3} (cm)	Days Since Previous GRE
241-AN-105	08/21/95	17,000	3.8	
	05/30/96	14,500	2.5	283
	04/05/97	6,980	0.8	310
	09/25/97	950	None	173
	11/22/97	1,030	None	58
	12/31/97	3,940	None	39
	09/01/98	2,280	0.4	244
	03/07/99	760	None	187
	05/02/99	182	None	56
	07/28/99	7,100	1.45	87
	08/02/99	7,620	1.37	5
	10/27/99	180	None	86
	01/01/00	186	None	66
241-AN-107	04/30/00	290	None	
241-AN-105	Average number of days between GREs = 133			
	Standard Deviation = 103			

Notes:

¹SHMS data²SACS (Surveillance Analysis Computer System) data³Level drop is measured from the pre-GRE level to the minimum level following the GRE. The waste level may not stabilize until a few days after the GRE.

Table 3-6. Summary of Gas Release Events for Tanks 241-AY-102 and 241-AZ-102.

Tank	Date	Maximum H₂ Concentration¹ (ppm)	Level Drop^{2,3} (cm)	Days Since Previous GRE
241-AY-102	01/05/00	260	0.51	
241-AZ-102	09/27/99	450	None	
	01/16/00	700	None	111
	02/09/00	440	None	24
241-AZ-102	Average number of days between GREs = 68			
	Standard deviation = 62			

Notes:

¹SHMS data²SACS (Surveillance Analysis Computer System) data³Level drop is measured from the pre-GRE level to the minimum level following the GRE. The waste level may not stabilize until a few days after the GRE.

3.3 GAS RELEASE EVENTS FROM SINGLE-SHELL TANKS

SSTs appear to have small, localized GREs that are most likely caused by changes in barometric pressure. No surface level drops have been associated with these events and the hydrogen concentrations following the events all have been below 1,500 ppm.

The hydrogen signature of a gas release shows a fairly sharp rise from a steady-state concentration followed by a steady decrease back to the steady-state concentration. A two-step process calculates the volume of gas released.

First, the vent flow rate (VFR) during the GRE is determined by

$$VFR = (V_d)/(t_p - t_s) \times [\ln(H_p) - \ln(H_s)]$$

where

- H_p = peak hydrogen concentration
- H_s = steady-state concentration (post release)
- t_p = time of peak concentration
- t_s = time when release returns to steady-state concentration
- V_d = headspace volume of the tank.

Then, the actual release is calculated by integrating the area beneath the curve that describes the release event (in terms of time versus concentration), from event initiation through return to steady-state. The units for this integrated value are adjusted with the appropriate conversion

factors to allow multiplication by the derived vent flow rate. The result is the total volume of gas released in the GRE.

The dates of gas releases as well as their duration, peak concentrations, and amount of gas released are listed in Table 3-7. Only 10 SSTs had gas releases this measurement period. Each of these 10 tanks has had a previous gas release. None of the 19 remaining SST monitors detected GREs.

The results of hydrogen release volume calculations, seen in Table 3-7, indicate what can be expected from these tanks. The estimation of hydrogen gas release volumes is sensitive to the selected starting point of the release, the SHMS baseline offset and calibration, the magnitude of the SHMS concentration peak, and any drift that may occur in the SHMS data over the period of several months. This results in uncertainties of 2 to 3 times the calculated value in Table 3-7. Nevertheless, these releases are relatively small and are spread over long periods of time. Longer term shifts in hydrogen concentration, as were found with the saltwell pumping of tank 241-U-105, are not considered the same as a GRE, although a sharp increase in hydrogen concentration occurred followed by a sustained higher steady-state concentration. Steady-state-to-peak differences of less than or equal to 100 ppm were not recorded on Table 3-7.

Table 3-7. Amount of Gas Released from GREs in Single-Shell Tanks. (10 sheets)

Tank	GRE Start Date	GRE End Date	Peak Date	Event Length (days)	Time to Peak (days)	Peak GRE H ₂ (ppm)	Steady-State H ₂ (ppm)	H ₂ Released (m ³)
241-A-101	02/03/98	02/03/98	02/03/98	0.5	0.5	700	350	0.81
	02/14/98	02/14/98	02/14/98	0.5	0.5	705	250	0.48
	02/20/98	02/20/98	02/20/98	0.5	0.5	627	288	0.59
	04/10/98	04/12/98	04/11/98	2.0	1.0	300	40	0.76
	04/21/98	04/22/98	04/24/98	3.0	1.5	380	0	1.01
	05/11/98	05/13/98	05/12/98	2.0	1.0	700	297	0.73
	06/09/98	06/10/98	06/09/98	1.0	0.5	458	325	0.25
	06/22/98	06/25/98	06/23/98	3.0	1.0	476	312	0.64
	07/07/98	07/12/98	07/10/98	5.0	2.4	446	250	0.65
	07/22/98	07/25/98	07/23/98	2.3	0.8	510	380	0.98
	07/28/98	08/01/98	07/30/98	2.9	1.8	660	430	1.1
	09/16/98	09/18/98	09/17/98	2.2	1.1	540	420	0.34
	09/24/98	09/27/98	09/25/98	2.3	0.8	600	390	0.75
	10/01/98	10/03/98	10/01/98	1.9	0.5	570	340	0.35
	10/23/98	10/26/98	10/24/98	2.6	1.0	470	260	0.45
	10/27/98	10/29/98	10/27/98	2.4	0.4	530	310	0.43
	11/07/98	11/09/98	11/08/98	2.2	0.7	485	328	0.05
	11/14/98	11/16/98	11/15/98	1.9	0.3	403	238	0.05
	11/20/98	11/23/98	11/21/98	2.8	0.5	697	242	0.31
	12/25/98	12/27/98	12/26/98	1.8	0.3	530	170	0.44
	12/27/98	12/31/98	12/28/98	4.3	0.5	800	170	0.42
	01/10/99	01/14/99	01/11/99	3.6	1.2	437	236	0.11

Table 3-7. Amount of Gas Released from GREs in Single-Shell Tanks. (10 sheets)

Tank	GRE Start Date	GRE End Date	Peak Date	Event Length (days)	Time to Peak (days)	Peak GRE H ₂ (ppm)	Steady-State H ₂ (ppm)	H ₂ Released (m ³)
241-A-101 (Cont'd)	01/16/99	01/17/99	01/16/99	1.9	0.5	592	339	0.11
	01/20/99	01/22/99	01/21/99	1.5	0.6	472	340	0.09
	02/03/99	02/06/99	02/04/99	2.5	0.6	424	184	0.09
	2/06/99	02/09/99	02/07/99	3.5	0.7	837	299	0.34
	03/02/99	03/07/99	03/03/99	4.4	0.4	388	194	0.09
	03/23/99	03/26/99	03/25/99	3.0	1.7	383	282	0.04
	04/07/99	04/10/99	04/08/99	2.7	0.6	374	222	0.06
	04/24/99	04/29/99	04/25/99	4.9	1.2	420	211	0.10
	04/30/99	05/07/99	05/03/99	6.6	2.7	755	212	0.61
	05/23/99	05/26/99	05/25/99	2.7	1.2	305	196	0.05
	05/31/99	06/08/99	06/02/99	7.6	1.5	310	159	0.08
	06/14/99	06/20/99	06/15/99	5.5	1.2	460	196	0.13
	06/23/99	06/26/99	06/25/99	2.4	1.2	350	176	0.13
	07/12/99	07/18/99	07/14/99	6.0	1.5	364	164	0.08
	07/26/99	07/30/99	07/28/99	4.3	1.5	290	157	0.07
	08/05/99	08/09/99	08/07/99	4.4	1.6	348	218	0.05
	08/09/99	08/13/99	08/11/99	4.0	1.3	365	217	0.05
	08/23/99	08/26/99	08/24/99	3.4	1.4	300	178	0.03
	09/15/99	09/21/99	09/16/99	6.1	1.2	321	204	0.02
	10/04/99	10/08/99	10/05/99	3.5	0.7	318	204	0.05
	10/22/99	10/25/99	10/23/99	2.8	1.2	306	187	0.05
	10/27/99	10/31/99	10/28/99	3.6	0.8	681	170	0.32

Table 3-7. Amount of Gas Released from GREs in Single-Shell Tanks. (10 sheets)

Tank	GRE Start Date	GRE End Date	Peak Date	Event Length (days)	Time to Peak (days)	Peak GRE H ₂ (ppm)	Steady-State H ₂ (ppm)	H ₂ Released (m ³)
241-A-101 (Cont'd)	11/6/99	11/13/99	11/08/99	6.5	1.7	395	175	0.09
	11/16/99	11/19/99	11/17/99	3.2	0.6	374	188	0.08
	11/24/99	11/29/99	11/26/99	5.3	1.7	358	151	0.12
	12/02/99	12/04/99	12/02/99	2.2	0.5	368	201	0.06
	12/12/99	12/15/99	12/13/99	3.3	1.0	380	230	0.06
	12/17/99	12/19/99	12/18/99	2.0	0.5	243	130	0.04
	12/31/99	01/05/00	01/02/00	4.5	1.4	502	206	0.22
	01/10/00	01/12/00	01/11/00	2.2	0.7	447	294	0.07
	02/14/00	02/15/00	02/14/00	1.2	0.7	610	416	0.30
	03/04/00	03/11/00	03/06/00	6.8	2.2	335	186	0.08
	03/22/00	03/27/00	03/23/00	4.7	0.9	248	142	0.03
	04/10/00	04/22/00	04/14/00	12.3	4.0	539	280	0.30
	06/17/00	06/20/00	06/18/00	3.0	0.9	270	114	0.09
241-AX-101	12/03/96	12/07/96	12/04/96	5	2	430	300	0.25
	12/08/96	12/12/96	12/10/96	3.5	1.5	540	300	0.46
	12/19/96	12/22/96	12/20/96	3.5	2.5	360	270	0.17
	12/25/96	12/28/96	12/27/96	3	1.5	390	250	0.27
	12/31/96	01/03/97	01/01/97	3	0.5	420	240	0.35
	01/24/97	01/27/97	01/25/97	2.5	1	320	250	0.13
	02/11/97	02/14/97	02/12/97	3	1	340	250	0.17
	02/15/97	02/18/97	02/16/97	2.5	1	360	250	0.21
	02/26/97	02/28/97	02/26/97	2.5	0.5	370	200	0.33

Table 3-7. Amount of Gas Released from GREs in Single-Shell Tanks. (10 sheets)

Tank	GRE Start Date	GRE End Date	Peak Date	Event Length (days)	Time to Peak (days)	Peak GRE H ₂ (ppm)	Steady-State H ₂ (ppm)	H ₂ Released (m ³)
241-BY-103	12/26/96	01/04/97	12/19/96	9.0	3.0	200	50	0.38
	01/19/98	01/19/98	01/19/98	1.0	0.5	490	10	1.20
	08/15/98	08/19/98	08/17/98	4.0	2.0	300	20	0.75
	10/26/99	10/31/00	10/27/00	5.0	1.0	170	70	0.12
241-BY-105	01/19/99	01/25/99	01/20/99	6.0	0.7	310	63	0.44
241-BY-106	06/01/96	06/05/96	06/03/96	4	2	300	0	0.43
	12/03/97	12/03/98	12/03/98	1	.5	430	80	0.61
	12/23/97	12/26/97	12/24/97	3	1	580	340	0.34
	08/13/98	08/16/98	08/14/98	3.0	1.0	780	480	1.18
241-BY-109	02/24/96	03/10/96	03/02/96	15.5	7.5	280	0	0.77
	01/12/98	01/12/98	01/12/98	0.5	0.5	320	0	0.87
	08/30/99	09/09/99	09/01/99	10.0	2.0	1,390	350	1.95
241-C-106 ¹	03/07/99	03/08/99	03/07/99	0.9	0.2	196	27	0.31
	04/30/99	05/02/99	04/30/99	1.6	0.4	303	22	0.48
	05/24/99	05/25/99	05/24/99	1.1	0.2	310	17	0.90
	09/10/99	09/11/99	09/10/99	1.3	0.2	433	21	1.10
	09/14/99	09/15/99	09/14/99	1.3	0.2	403	24	0.85
	09/16/99	09/17/99	09/16/99	1.2	0.3	319	22	0.73
	09/21/99	09/22/99	09/21/99	0.9	0.2	226	24	0.52
241-S-101	09/16/98	09/19/98	09/17/98	3.0	1.0	700	580	0.36
241-S-111	11/07/95	11/24/95	11/09/95	17	2.2	750	500	0.48
	11/24/95	12/11/95	12/4/95	17.2	9.6	710	470	0.46

Table 3-7. Amount of Gas Released from GREs in Single-Shell Tanks. (10 sheets)

Tank	GRE Start Date	GRE End Date	Peak Date	Event Length (days)	Time to Peak (days)	Peak GRE H ₂ (ppm)	Steady-State H ₂ (ppm)	H ₂ Released (m ³)
241-S-111 (Cont'd)	12/11/95	12/31/95	12/14/95	19.2	2.5	1,270	470	1.55
	04/18/96	04/19/96	04/19/96	1.6	1.0	Undetermined	200	1.86
	11/19/96	11/30/96	11/20/96	11.2	1	700	400	0.58
	12/09/96	12/25/96	12/11/96	15.9	2	690	300	0.76
	12/30/96	01/28/97	01/02/97	28.9	3.1	320	0	0.62
	02/26/97	03/13/97	03/03/97	14.8	4.7	320	30	0.56
	12/31/97	01/01/98	12/31/97	1.0	0.5	770	210	1.06
	02/03/98	02/06/98	02/04/98	3.0	1.0	760	400	0.70
	07/15/98	07/16/98	07/15/98	2.7	2.0	990	120	0.83
	05/02/99	05/16/99	05/04/99	13.5	1.5	460	180	0.22
	01/09/00	01/21/00	01/12/00	11.5	3.1	380	140	0.18
241-SX-103	10/22/95	10/28/95	10/25/95	6.3	3.5	210	50	0.38
	11/06/95	11/10/95	11/08/95	4.4	2.2	160	60	0.24
	11/30/95	12/07/95	12/03/95	6.8	3.3	170	60	0.26
	12/08/95	12/17/95	12/12/95	9.2	3.9	640	50	1.41
	01/25/96	02/07/96	02/01/96	12.9	6.8	180	30	0.36
	02/07/96	02/08/96	02/08/96	0.88	0.87	360	40	0.77
	12/05/96	12/12/96	12/10/96	7	5	170	70	0.24
	12/27/96	01/05/97	12/31/96	9.1	4.5	230	60	0.41
	04/30/98	04/30/98	04/30/98	1.0	0.5	165	15	0.31
	05/07/98	05/12/98	05/08/98	4.3	1.0	451	28	1.54
241-SX-104	12/11/95	12/15/95	12/12/95	3.9	0.7	80	0	0.21

Table 3-7. Amount of Gas Released from GREs in Single-Shell Tanks. (10 sheets)

Tank	GRE Start Date	GRE End Date	Peak Date	Event Length (days)	Time to Peak (days)	Peak GRE H ₂ (ppm)	Steady-State H ₂ (ppm)	H ₂ Released (m ³)
241-SX-104 (Cont'd)	01/25/96	02/07/96	02/01/96	12.9	6.9	200	0	0.52
	11/22/96	11/27/96	11/26/96	4.8	3.5	110	60	0.13
241-SX-105	12/10/95	12/13/95	12/12/95	3.7	2.5	320	0	0.75
	01/25/96	02/07/96	01/31/96	12.4	5.4	120	0	0.28
	12/26/96	01/08/97	12/28/96	13.3	1.4	710	200	1.2
	05/15/98	05/16/98	05/15/98	1.4	0.5	450	150	1.18
241-SX-106	10/24/95	10/28/95	10/25/95	3.4	1.3	130	0	0.37
	12/12/95	12/15/95	12/12/95	3	0.6	330	0	0.93
	11/18/96	11/22/96	11/19/96	3.8	0.7	210	0	0.59
	12/09/96	12/12/96	12/10/96	2.7	0.3	200	0	0.56
	03/15/97	03/17/97	03/16/97	3.1	0.6	160	0	0.45
	12/31/97	01/01/98	12/31/97	1.0	0.5	150	0	0.31
241-SX-109	12/11/95	12/19/95	12/12/95	7.7	0.8	110	0	0.43
241-U-102	08/28/98	08/31/98	08/29/98	3.2	1.0	360	10	1.47
	05/02/99	05/06/99	05/03/99	3.5	1.1	760	540	0.09
241-U-103	12/9/95	12/24/95	12/12/95	14.3	3	1,080	200	1.27
	02/12/96	03/05/96	02/20/96	22.4	8	990	0	1.43
	12/07/96	12/17/96	12/10/96	9.6	2.5	690	400	0.42
	02/16/97	02/23/97	02/17/97	7.6	1	630	300	0.48
	02/25/97	03/09/97	02/27/97	11.9	2	670	320	0.51
	03/14/97	03/21/97	03/16/97	6.3	1.7	750	320	0.62

Table 3-7. Amount of Gas Released from GREs in Single-Shell Tanks. (10 sheets)

Tank	GRE Start Date	GRE End Date	Peak Date	Event Length (days)	Time to Peak (days)	Peak GRE H ₂ (ppm)	Steady-State H ₂ (ppm)	H ₂ Released (m ³)
241-U-103 (Cont'd)	12/31/97	01/01/98	12/31/97	1.0	0.5	1,000	400	0.87
	02/02/98	02/04/98	02/03/98	2.0	1.0	1,000	570	0.62
	02/13/98	02/15/98	02/14/98	2.0	1.0	950	620	0.48
	02/20/98	02/22/98	02/21/98	2.0	1.0	940	770	0.25
	04/10/98	04/11/98	04/11/98	1.0	0.5	850	650	0.28
	04/23/98	04/24/98	04/25/98	2.0	1.0	940	650	0.42
	05/11/98	05/18/98	05/13/98	6.5	1.5	1,210	890	0.70
	05/01/99	05/08/99	05/04/99	6.8	2.7	930	450	0.30
	06/28/99	07/06/99	06/30/99	6.1	2.0	1,260	890	4.44
	09/23/99	09/24/99	09/23/99	1.2	0.4	1,120	700	0.18
241-U-105	09/28/99	10/04/99	09/30/99	5.6	2.0	1,670	760	0.81
	12/10/95	12/26/95	12/12/95	15.7	2	740	170	0.92
	01/31/96	02/09/96	02/07/96	8.6	6.4	540	0	0.87
	02/18/96	02/29/96	02/20/96	11	1.8	450	80	0.60
	11/14/96	12/01/96	11/20/96	16.9	6	1,440	800	1.04
	12/03/96	12/17/96	12/10/96	14	7	1,050	570	0.78
	01/08/97	01/11/97	01/10/97	3.3	2	850	590	0.42
	02/25/97	03/10/97	02/27/97	12.4	1.5	540	160	0.62
	03/15/97	03/23/97	03/16/97	7.8	0.9	550	130	0.68
	10/28/97	10/30/97	10/28/97	2.0	0.5	400	50	1.68
	11/19/97	11/19/97	11/19/97	1.0	0.5	300	100	0.31

Table 3-7. Amount of Gas Released from GREs in Single-Shell Tanks. (10 sheets)

Tank	GRE Start Date	GRE End Date	Peak Date	Event Length (days)	Time to Peak (days)	Peak GRE H ₂ (ppm)	Steady-State H ₂ (ppm)	H ₂ Released (m ³)
241-U-105 (Cont'd)	12/06/97	12/10/97	12/07/97	4.0	1.0	1,140	100	1.65
	02/02/98	02/04/98	02/03/97	2.0	1.0	450	70	0.62
	02/13/98	02/15/98	02/14/98	2.0	1.0	440	120	0.50
	02/20/98	02/21/98	02/20/98	1.0	0.5	400	270	0.20
	05/01/99	05/07/99	05/03/99	5.7	1.6	920	680	0.08
	07/13/99	07/19/99	07/13/99	6.1	0.3	473	363	0.03
	08/09/99	08/14/99	08/10/99	4.8	1.1	625	520	0.02
	10/04/99	10/08/99	10/05/99	4.0	0.9	740	627	0.02
	11/25/99	12/02/99	11/26/99	6.7	0.8	430	266	0.04
	12/11/95	12/24/95	12/11/95	11.6	0.6	640	50	1.00
241-U-107	02/18/96	03/02/96	02/21/96	12.5	2.7	400	0	0.68
	09/11/96	09/18/96	09/14/96	6.8	3.4	480	300	0.30
	10/22/96	11/14/96	10/27/96	22.5	4.4	680	400	0.47
	11/14/96	11/27/96	11/19/96	13	5.4	810	430	0.64
	12/04/96	12/18/96	12/10/96	14	5.6	770	600	0.29
	12/28/96	01/16/97	12/28/96	19.3	0.4	1,900	470	2.42
	04/02/97	04/09/97	04/05/97	6.7	2.5	1,230	230	1.69
	04/12/97	04/20/97	04/15/97	8.2	2.8	1,220	220	1.69
	12/31/97	01/01/98	12/31/97	1.0	0.5	1,130	870	0.45
	04/10/98	04/13/97	04/11/97	3.0	1.0	600	550	0.08
	04/23/98	04/25/98	04/24/98	2.0	1.0	550	450	0.17

Table 3-7. Amount of Gas Released from GREs in Single-Shell Tanks. (10 sheets)

Tank	GRE Start Date	GRE End Date	Peak Date	Event Length (days)	Time to Peak (days)	Peak GRE H ₂ (ppm)	Steady-State H ₂ (ppm)	H ₂ Released (m ³)
	12/01/99	12/14/99	12/01/99	13.2	0.6	790	400	0.13
	02/14/00	02/19/00	02/15/00	4.6	1.1	510	120	0.45
241-U-108	08/31/95	09/21/95	09/16/95	21.7	15.8	680	280	0.58
	09/24/95	09/30/95	09/27/95	6.3	2.8	620	340	0.41
	12/11/95	12/27/95	12/12/95	15.3	0.8	1,000	300	1.02
	09/25/96	10/13/96	09/30/96	18	5.1	850	500	0.51
	10/17/96	11/06/96	10/26/96	19.8	8.6	1,220	500	1.05
	11/11/96	11/28/96	11/20/96	16.2	9.3	1,530	530	1.46
	12/08/96	12/26/96	12/10/96	18.2	2.5	1,290	820	0.68
	02/15/97	02/24/97	02/21/97	9.1	5.6	790	490	0.44
	12/31/97	01/01/98	12/31/97	1.0	0.5	820	280	0.78
	02/03/98	02/04/98	02/03/98	2.0	1.0	600	400	0.28
	05/01/99	05/13/99	05/03/99	11.7	1.7	1,080	590	0.16
	05/17/99	05/25/99	05/17/99	7.5	0.4	890	580	0.08
	10/27/99	11/14/99	10/29/99	17.3	1.8	1,280	640	0.20
	02/14/00	02/20/00	02/15/00	6.3	1.5	770 (adjusted)	230 (adjusted)	0.38
241-U-109	12/11/95	12/25/95	12/13/95	13.8	1.4	2,190	1,480	1.05
	01/02/96	01/08/96	01/06/96	5.8	3.8	1,510	1,170	0.50
	01/09/96	01/12/96	01/10/96	2.8	0.3	1,850	1,030	1.21
	01/15/96	01/23/96	01/19/96	7.5	3.9	1,300	980	0.47
	02/08/96	02/14/96	02/10/96	6.3	2.2	850	680	0.25
	02/18/96	02/23/96	02/22/96	4.7	4	1,110	660	0.66

Table 3-7. Amount of Gas Released from GREs in Single-Shell Tanks. (10 sheets)

Tank	GRE Start Date	GRE End Date	Peak Date	Event Length (days)	Time to Peak (days)	Peak GRE H ₂ (ppm)	Steady-State H ₂ (ppm)	H ₂ Released (m ³)
241-U-109 (Cont'd)	02/28/96	03/04/96	03/11/96	5.6	2.3	1,390	780	0.90
	01/10/97	01/18/97	01/12/97	8.1	2.5	630	210	0.62
	01/26/97	01/28/97	01/27/97	1.9	0.7	540	280	0.38
	12/31/97	01/01/98	12/31/97	1.0	0.5	1,320	820	0.73
	01/13/98	01/14/98	01/13/98	1.0	0.5	1,790	1,000	>1.15
	05/02/99	05/12/99	05/04/99	10.4	1.6	810	420	0.17
	10/27/99	10/31/99	10/29/99	4.0	1.3	1,290	1020	0.08
	02/11/00	02/26/00	02/14/00	15.0	4.0	530	270	0.14

Note:

¹Tank 241-C-106 peaks are coincidental with tank sluicing activity in fiscal year 1999

3.4 SALTWELL PUMPING EFFECTS ON HYDROGEN CONCENTRATION

Last year's report (McCain 1999a) described a "phenomenon" involving hydrogen concentration increases associated with saltwell pumping activities. First noted in tank 241-S-106, it was apparent that the dynamics of liquid removal from several SSTs resulted in an elevation of gas concentrations in rough synchrony with the pumping efficiency. Similar behavior has now been observed in tanks 241-S-102, 241-S-106, 241-SX-104, 241-U-102, 241-U-103, 241-U-105, and 241-U-109. A study was conducted (McCain 2000) to evaluate this behavior as it might relate to simplifying regulations affecting saltwell pumping. Sections 3.4.1 and 3.4.2 describe the results of this study.

3.4.1 Hydrogen Gas Behavior in Response to Saltwell Pumping Activity

Saltwell pump running times were reviewed in correlation to hydrogen gas concentrations for the last two years. Thirty-two identifiable pumping termination events in eight SSTs were used as reference points for hydrogen concentration increases or decreases. Of the 32 events, the hydrogen concentration decreased 27 times and increased only five times. These observations support the hypothesis that rising hydrogen concentrations can be controlled merely by stopping pumping operations. A study of the five events that produced increased hydrogen concentrations determined that the maximum observed rate of concentration increase was 0.07 volume percent per day with a maximum observed duration of 17 days. These data suggest that a tank's hydrogen concentration might climb by 1.2 volume percent even after pumping is terminated. This rise in flammable gas concentration, added to the steady-state concentration observed in SSTs, is still well below the control point of 25 percent of the LFL.

3.4.2 Pump Pit Monitor Redundancy to SHMS Instrumentation

Section 1 of this document states that one of the principal reasons SHMS instrumentation is installed on a tank is to monitor flammable gas behavior during waste movement. Interim stabilization activities involve moving pumpable waste liquids. Tanks that have been identified as having significant quantities of pumpable waste generally are equipped with SHMS. Supplemental monitoring equipment has been used to measure the flammable gas concentration in the space directly over the tank (the pump pit). These pits house the pumping mechanism and are interconnected with the dome headspace. McCain (2000) compared the data from the two measurement systems and found that they tend to produce readings congruent with each other; i.e., the concentrations rise and fall in the same time intervals. Vapor grab samples were taken from the pump pits of tanks 241-U-102, 241-U-103, and 241-U-105 during pumping operations and analyzed through mass spectrometry. The results (see Table 3-8) demonstrate that the SHMS are quite accurate in determining hydrogen concentration in the pump pits, even though the sample heads are extended down into the dome space of the tank. Identifying this redundancy is a potential cost saving discovery.

Table 3-8. Comparison of Monitoring Results with Pump Pit Vapor Samples.

TANK	Pump Pit Hydrogen from Grab Sample (ppm)	Dome Space Hydrogen from SHMS (ppm)
241-U-102	2,880	3,060
241-U-103	3,000	2,940
241-U-105	1,600	1,411

3.5 VAPOR GRAB SAMPLING

In previous years, vapor grab samples were taken periodically to confirm SHMS hydrogen readings and to obtain additional information about other gases in the tanks. This year's engineering task plan (McCain 1999b) has no such sampling requirement. Five years of grab sampling have verified that SHMS instrumentation accurately determines flammable gas concentrations. The three grab samples detailed in Table 3-8 were similar to those taken in previous years. They were taken to determine flammable gas concentrations in the pump pit of three tanks being saltwell pumped. All grab sample results since 1994 are detailed in Appendix B. Except for tanks 241-AX-103 and 241-C-106, all tanks with SHMS were vapor grab sampled since July 1, 1998. Tank 241-U-105 had the highest percentage of the LFL at 3.8 percent. The next highest was tank 241-U-107 at 1.7 percent of the LFL. Previous measurements of all passively ventilated tanks showed flammable gas concentrations above 1 percent of the LFL for 27 tanks.

3.6 SUMMARY OF SHMS MONITORING

As discussed previously, continuous monitoring of a tank's hydrogen concentration is performed using SHMS. Most of the tanks being continuously monitored have a SHMS-B, which has two Whittaker™ electrochemical cells. Tank 241-AN-104 has a SHMS-C, which adds a GC. Tanks 241-C-106 and 241-AY-102 also have SHMS-C cabinets with GCs. A SHMS-D has been installed on the exhaust vents of AN and AW tank farms. Note that tanks 241-BY-106 and 241-BY-109 have SHMS-D cabinets but lack ammonia monitors. The SHMS-D can measure both hydrogen and ammonia. The ammonia results are shown in Appendix D. The various monitoring systems are described fully in Section 2.0. Table 3-9 lists the tank, the type of SHMS, the date the original SHMS was installed, and the maximum hydrogen reading the SHMS has measured. When a SHMS type has been modified, the installation date for the latest configuration is listed in the second column. Most of the maximum readings occurred during GREs. Tanks 241-SX-101, 241-SX-102, and 241-T-110 have not exhibited any GRE behavior to date, and the maximums listed are maximum steady-state readings. Appendix A contains plots of data from the SHMS.

Table 3-9. Maximum SHMS Readings. (2 sheets)

Tank	SHMS Type	Date Original SHMS Installed	Maximum H₂ Reading (ppm)	Date of Maximum Reading
241-A-101	SHMS-E+ (11/97)	March 1995	837	02/07/99
241-AN-101	SHMS-E+	June 1997	330	05/11/98
241-AN-103	SHMS-B	October 1994	3,000	08/22/95
241-AN-104	SHMS-C	October 1994	5,900	05/03/96
241-AN-105 ¹	SHMS-B	October 1994	17,000	08/21/95
241-AN-107	SHMS-B	February 1998	290	04/30/00
AN Farm Stack	SHMS-D	June 1996	1,040	07/28/99
241-AW-101 ¹	SHMS-B	September 1994	8,800	10/04/94
AW Farm Stack	SHMS-D	June 1996	490	07/20/99
241-AX-101	SHMS-B	March 1995	540	12/10/96
241-AX-103	SHMS-B	March 1995	380	11/22/96
241-AY-102	SHMS-C	March 1997	320	06/27/98
241-AZ-101	SHMS-E ¹	February 1998	750	04/18/98
241-AZ-102	SHMS-E ¹	February 1998	1,500	12/09/99
241-B-111	SHMS-E+	May 2000	150	06/21/00
241-BY-103	SHMS-B	July 1995	770	11/27/96
241-BY-105	SHMS-E+	March 1998	310	01/20/99
241-BY-106	SHMS-D (w/o ammonia monitor)	July 1995	880	01/05/96
241-BY-109	SHMS-D (w/o ammonia monitor)	July 1995	1,770	02/03/00
241-C-106	SHMS-C	March 1997	756	05/16/97
241-S-101	SHMS-E	March 1998	1,120	07/23/99
241-S-102	SHMS-B	March 1995	3,780	05/20/96
241-S-106	SHMS-E+	March 1998	2,585	05/20/99
241-S-107	SHMS-B	March 1998	370	11/22/98
241-S-109	SHMS-E+	March 1998	185	06/13/98
241-S-111	SHMS-B	March 1995	1,270	12/14/95
241-S-112	SHMS-B	March 1995	490	08/22/95
241-SX-101	SHMS-B	March 1995	400	08/22/95
241-SX-102	SHMS-B	March 1995	740	11/12/96
241-SX-103	SHMS-E+ (3/98)	March 1995	640	02/12/95

Table 3-9. Maximum SHMS Readings. (2 sheets)

Tank	SHMS Type	Date Original SHMS Installed	Maximum H₂ Reading (ppm)	Date of Maximum Reading
241-SX-104	SHMS-B	March 1995	580	08/22/95
241-SX-105	SHMS-B	March 1995	710	12/28/96
241-SX-106	SHMS-B	March 1995	560	08/17/97
241-SX-109	SHMS-B	March 1995	890	12/15/99
241-SY-101 ²	SHMS (3 units)	March 1992	50,000	09/03/92
241-SY-102	SHMS-E+	March 1998	238	12/18/99
241-SY-103	SHMS-B	May 1992	5,720	05/08/98
241-T-110	SHMS-B	March 1995	500	08/31/99
241-U-102	SHMS-B	May 1998	3,280	02/24/00
241-U-103	SHMS-B	March 1995	4,870	11/02/99
241-U-105	SHMS-E+ (5/98)	March 1995	3,680	10/24/96
241-U-107	SHMS-B	March 1995	1,900	12/28/96
241-U-108	SHMS-B	March 1995	3,280	02/25/96
241-U-109	SHMS-B	March 1995	4,930	03/23/00

Notes:

¹GCS installed (April 1996)²GMS-1 and GMS-2 also installed (November 1992)

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4.0 SHMS CABINET REMOVAL

The Tri-Party Agreement (Ecology et al. 1994) Milestone M-40-00 required design, procurement, and fabrication of SHMS for all FGWL tanks. The current number of FGWL tanks is 25. Subsequent studies provided justification for installing SHMS on non-FGWL tanks. These include the following:

- Tanks with the calculated potential to exceed 100 percent of the LFL in the head space caused by gas retention and an episodic release
- Tanks scheduled for saltwell pumping
- DSTs that receive supernatant from saltwell pumping with the potential for gas retention and episodic release
- Project tanks (e.g., W-320) with the potential for gas retention and episodic release
- Aging waste tanks with high radiolytic gas generation rates.

Starting with tank 241-SY-101 in May 1992, SHMS were installed on 41 tanks and on exhausters vents for the AN and AW tank farms. Improvements and enhancements in data retrieval and management were implemented, resulting in an extensive network providing hundreds of thousands of recorded data points available for review every month. Continual monitoring combined with monthly, quarterly, and annual reports provides flammable gas concentration information formatted to allow data trending and comparisons.

Two documents were developed to deal with the operation of the SHMS. First, a technical basis report (Estey 1998) was issued that provides the basis for the alarm limit of 6,250 ppm for 25 percent of the LFL as a conservative monitoring value for hydrogen; this paper also discusses the role of other species on the LFL. The Engineering Test Plan (McCain 1999b) gives the guidelines for organizational responsibilities for the operation and maintenance of the SHMS. Although the technical basis document provides guidelines for removing a SHMS from a tank, the collection of data and operational history since the document was issued provided an opportunity to reevaluate the need to monitor selected tanks.

The reevaluation of SHMS needs was presented to the U.S. Department of Energy, Office of River Protection in December 1999 (LMHC 1999) as an implementation of field optimization. The proposal was to place 10 SHMS in a standby mode and remove 11 other SHMS completely. The standby mode option was selected for those tanks that may require flammable gas monitoring in the future because of waste movement activities such as transfers and saltwell pumping. The Office of River Protection responded in January 2000 with Performance Initiative ORP3.2.3 (DOE 2000). This initiative directed that SHMS on seven tanks be placed in a standby mode: 241-AZ-102, 241-S-101, 241-S-107, 241-S-109, 241-S-111, 241-S-112 and 241-SX-102. Seven additional units are to be removed from the following tanks: 241-AX-103, 241-BY-109, 241-C-106, 241-SX-104, 241-SX-109, 241-T-110, and the AW stack monitor SHMS. The SHMS unit on tank 241-SX-106 was to remain in service until interim stabilization is declared. Table 4-1 shows the status of the SHMS equipment for these tanks, along with the date the last

hydrogen data was available. The charts in Appendix A also indicate the date each SHMS cabinet was isolated.

Table 4-1. SHMS Removal/Standby Status as of June 30, 2000.

Tank	SHMS Disposition	Last Data Date
241-AX-103	Removed	08/01/97
AW Stack Monitor	Removed	02/14/00
241-AZ-102	Standby	02/13/00
241-BY-109	Removed	02/14/00
241-C-106	Removed	06/30/00
241-S-101	Standby	02/14/00
241-S-107	Standby	02/14/00
241-S-109	Standby	02/15/00
241-S-111	Standby	02/16/00
241-S-112	Standby	02/16/00
241-SX-102	Standby	02/16/00
241-SX-104	Removed	06/08/00
241-SX-106	Removed	06/06/00
241-SX-109	Removed	02/16/00
241-T-110	Removed	02/13/00

5.0 SUMMARY OF MONITORING BY OTHER SYSTEMS

Some tanks are monitored using other systems in addition to the Whittaker™ cells in the SHMS.

5.1 GAS MONITORING SYSTEM-2

The GMS-2 has been sampling from the vent header (riser 7A) of tank 241-SY-101 since November 1992. This system is a combination of an FTIR, two hydrogen-specific reduction gas analysis GCs, and one photoacoustic IR analyzer. The FTIR measures NH_3 and N_2O , one GC measures low concentrations of hydrogen, the other GC has a dual column and can measure both low and high concentrations of hydrogen, and the IR analyzer monitors the SY farm exhaust stack for ammonia. The GCs, FTIR, and IR analyzer are used to support mixer pump administrative controls. The data are sent to the tank 241-SY-101 DACS.

Steady-state concentrations before mixer pump operation were measured using this system (Wilkins 1993). Table 5-1 lists monthly averages leading up to the last major GRE and the peak concentrations during the last major GRE in this tank. Mixer pump operations began in July 1993. Gas concentration monthly averages during selected months after July 1993 also are listed in Table 5-1. Significant quantities of waste were transferred out of tank 241-SY-101 in December 1999 and in January and February 2000. The volumes transferred out in these months were 84 kgal, 241 kgal, and 154 kgal, respectively. The bottom two rows of Table 5-1 show pretransfer and post-transfer gas concentrations for these mitigation activities. The complete database of tank 241-SY-101 gas data is archived regularly. A quarterly report is issued containing much more detail than this document provides. Please refer to Conner and Koreski 1999, 2000a, and 2000b.

5.2 GAS CHARACTERIZATION SYSTEM

GCSs are installed and operating on tanks 241-AW-101 and 241-AN-105 in addition to SHMSs. The headspaces of these tanks have had hydrogen concentrations greater than 6,250 ppm, the action level for hydrogen grab sampling. These high hydrogen concentrations occurred during GREs. To learn more about the gases emitted from these tanks, GCSs were installed; they began recording data in April 1996. A GCS has a GC to measure hydrogen, another GC to measure nitrous oxide and methane, and an FTIR to measure ammonia. Appendix A has charts that depict the steady-state gas measurements from the system. The GCS readings are consistent with the results from the grab samples. The difference between continuous hydrogen measurements measured with a SHMS and the GCS is usually less than 150 ppm. Table 5-2 lists the peak concentrations measured with the GCS during the GREs that have occurred since the systems were installed on the tanks. Hydrogen, nitrous oxide, and methane tend to peak together, but ammonia tends to peak about 3 hours later.

Table 5-1. Tank 241-SY-101 Gas Monitoring.

Tank Condition	Date	H₂ (ppm)	N₂O (ppm)	NH₃ (ppm)
Steady-state	2/93	26	28	34
Steady-state	3/93	16	15	34
Steady-state	4/93	20	22	36
Steady-state	5/93	21	24	49
Steady-state	6/93	16	17	64
GRE	6/26/93	31,200	32,500	13,000
Steady-state	7/93	24	27	68
Steady-state	1/94	30	31	38
Steady-state	1/95	36	52	32
Steady-state	1/96	35	46	28
Steady-state	9/96	40	49	39
Steady-state	1/97	34	44	28
Steady-state	5/97	42	38	30
Steady-state	11/10/97	21	35	31
Steady-state	3/29/98	11	12	29
Steady-state	12/9/98	20	17	44
Steady-state	6/22/99	18	15	66
Steady-state	12/1/99	38	20	54
Steady-state	3/15/00	261	161	72

Table 5-2. GCS Results during GREs (ppm)

Tank	GRE Date	Peak Hydrogen (ppm)	Peak Nitrous Oxide (ppm)	Peak Methane (ppm)	Peak Ammonia (ppm)
241-AN-105	05/30/96	14,500	2,850	150	610
	04/05/97	6,980	1,496	0	119
	09/25/97	950	124	11	27
	11/22/97	1,030	170	12	78
	12/31/97	3,940	763	53	113
	09/01/98	1,870	564	37	481
	03/07/99	760	Not available	Not available	565
	05/02/99	182	51	0	579
	07/28/99	7,100	1,958	94	69
	08/02/99	7,620	977	64	60
	10/27/99	180	63	20	65
	01/01/00	186	52	21	29
241-AW-101	05/14/96	1,455	33	0	15
	05/06/96	2,500	86	2	19
	04/21/98	398	58	10	260
	06/24/98	450	145	5	330
	07/04/98	Non-GCS system used to announce peak. Not confirmed by GCS.			
	01/16/00	210	18	0	15
	04/22/00	2,092	19	0	8

5.3 GAS CHROMATOGRAPH RESULTS

The following tanks have gas chromatographs installed in conjunction with the SHMS cabinets: 241-A-101, 241-AN-101, 241-AN-104, 241-AY-102, 241-B-111, 241-BY-105, 241-C-106, 241-S-106, 241-S-109, 241-SX-103, 241-SY-102, and 241-U-105. The GC has a much higher sensitivity and accuracy than the SHMS at low hydrogen concentrations. The system has been very reliable. Consequently, the GC data are used to provide GRE data for this report. Data for all these tanks are found in Appendix A.

5.4 AMMONIA MONITORING OF TANK FARM EXHAUST VENTS AND INDIVIDUAL TANKS

Ammonia and hydrogen are monitored at the exhaust vents of the AW and AN tank farms, while ammonia is monitored with photoacoustic IR multi-gas monitors on tanks 241-A-101, 241-AN-101, 241-BY-105, 241-S-106, 241-S-109, 241-SX-103, 241-SY-102, and 241-U-105. The data for these tanks are found in Appendix A. The highest ammonia concentration in 2000 was detected in tank 241-SY-102 on March 1, with a concentration of 7,390 ppm, well below the flammable concentration of about 150,000 ppm. This concentration was associated with a transfer of waste from tank 241-SY-101 to tank 241-SY-102. When the transfer stopped, the ammonia level immediately decreased.

6.0 HYDROGEN GENERATION RATE

Previous revisions of this document contained a lengthy section on hydrogen generation. A recently released document (Hu 2000) presents the empirical rate equation model and rate calculations of hydrogen generation. The empirical rate equations were derived to estimate hydrogen generation based on chemical reaction, radiolysis of water and organic compounds, and corrosion processes.

Key components of the model include the discovery that both the thermal and radiolysis rates of hydrogen generation are temperature dependent and follow Arrhenius behavior. The thermal rate also is proportional to the total organic carbon and aluminate concentrations. The radiolysis rate is the product of the radiation dose rate and the hydrogen "G-value." This G-value divides the radiolysis contribution to hydrogen generation into water and organic radiolyses, which are affected by waste with a high nitrate or nitrite concentration or total organic carbon concentration, respectively. The G-value also is a function of temperature. The contribution of liner corrosion is a product of the liner corrosion rate and the wetted area inside the tank.

The final test of the model compared the hydrogen generation rate with field observed data for 28 tanks, both single- and double-shelled. For most of these tanks, the calculated generation rate is within a factor of three.

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7.0 FLAMMABLE GAS ACTION LEVELS FOR HANFORD WASTE TANKS

The following sections define the flammable gas action level for Hanford Site waste tanks, the planned response if the action level is exceeded, and a summary of the occurrences in which the action level has been exceeded.

7.1 DESCRIPTION OF ACTION LEVEL

Tank Farm Operations is required by DOE Order 5480.4, *Environmental Protection, Safety, and Health Protection Standards*, to follow the guidelines provided within NFPA 69, *Explosion Prevention Systems*. This guideline requires systems that contain flammable gas and have the potential for an ignition source to be maintained at concentrations below 25 percent of the LFL of the gas or gas mixture. The exception to this limit is when automatic instrumentation with safety interlocks is provided, the combustible concentration shall be permitted to be maintained at or below 60 percent of the LFL.

Each Hanford Site tank generates a different composition of flammable gas. The fuel gases produced by the tanks are composed primarily of hydrogen, but they also can contain significant quantities of ammonia and methane. In addition to the fuel gases, the tanks also can produce nitrous oxide, which under certain conditions can enhance the flammability of the mixture. Monitoring for all the gases that can contribute to the flammable gas issue is cumbersome and expensive. For this reason, hydrogen — by far the dominant flammable gas of concern — was selected as the gas species to be monitored as the indicator when additional action is required.

To account for the effect of the other gases that may be present, the hydrogen concentration at which action is taken is adjusted (Estey 1998). The action level is set at 6,250 ppm of hydrogen. This concentration of hydrogen is equivalent to 25 percent of the LFL for the expected worst case gas mixture from a Hanford Site tank. This is the level at which additional characterization of the headspace gas and other mitigation measures would be considered. A recent study of flammability of Hanford Site waste gases (Mahoney et al. 2000) is currently being evaluated with the intention of raising this conservative action level closer to the actual 25 percent of LFL value (10,000 ppm).

7.2 ACTION-LEVEL RESPONSE

If a hydrogen vapor reading in a tank headspace exceeds 6,250 ppm, an engineering evaluation is to be performed (Estey 1998). The purpose of this evaluation is to determine whether the tank presents a serious safety issue and if mitigating the tank condition is necessary. This approach in deciding the need for mitigation is used because implementing the mitigation methods, such as installing and operating a mixer pump, is expensive and installing this type of equipment presents a substantial safety risk to the tank farm workers.

A typical example of the recommendations resulting from the engineering evaluation of a gas release event is found in WHC-SD-WM-ER-524, *Waste Tank 241-AN-105 Gas Release Response Recommendation* (Minteer 1996). Note that this action plan is for an actively ventilated DST and portions of this plan would likely be different for a passively ventilated SST:

1. Improve tank monitoring and characterization capabilities to obtain the data necessary to lower uncertainties in the gas composition, gas release volume, and waste gas inventory determinations.
 - Install a GCS
 - Install a hydrogen/ammonia monitor in the ventilation system
 - Obtain characterization data from void fraction meter, viscometer, and retained gas sampler tests
 - Install an air flow meter
 - Increase frequency of tank waste level measurements.
2. Optimize tank ventilation flows to ensure that dilution air flow is adequate to minimize the time required to reduce the flammable gas concentration following a release.
 - Determine optimum tank air flow balance, considering any necessary dilution at the existing fan
 - Provide air flow control capability for every tank in the farm and set flow rates to the optimum values
 - For the interim, ensure FGWL tank air flows are maintained at or above 2.8 m³/min (100 ft³/min) (based on engineering judgement).
3. Ensure a low risk of igniting a flammable gas mixture to prevent ignition of the released gas if the LFL is exceeded.
 - Evaluate need to deenergize or replace ventilation system heaters, and other options
 - Evaluate need to replace ventilation fan with “sparkless” model, and other options
 - Evaluate need to deenergize or replace any other potential ignition sources.
4. Determine the need for additional actions after subsequent gas release event data are obtained and evaluated.

7.3 SUMMARY OF GAS RELEASE EVENTS EXCEEDING THE ACTION LEVEL

Other than the major gas release events recorded in tank 241-SY-101, three events in which the tank headspace flammable gas concentration exceeded the action level have been observed since the installation of SHMS units. Two events were observed in tank 241-AN-105 (both exceeded 14,000 ppm hydrogen) and one in tank 241-AW-101 (approximately 8,800 ppm hydrogen). The flammable gas headspace concentration has not exceeded the action level in tank 241-SY-101 since installation of the mixer pump in July 1993.

Tanks 241-AN-105 and 241-AW-101 have undergone additional characterization as a result of these events. This characterization includes installing a GCS, sampling with the retained gas sampler, and taking measurements with the void fraction instrument and ball rheometer.

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8.0 MAINTENANCE ISSUES AND ACTIONS PLANS FOR CONTINUED MONITORING

Continued monitoring of the Watch List tanks and other tanks with a serious potential to exceed 25 percent of the LFL in the headspace will be accomplished using either the currently installed SHMS units, the GCSs, or portable systems that can be installed temporarily. Improvements to the existing systems are planned to correct operational problems encountered to date. The basis for tank monitoring and the duration of monitoring required is addressed in Estey (1998) and was still in effect for fiscal year 2000.

8.1 RELIABILITY OF SHMS INSTRUMENTATION

Table 8-1 displays the accessibility of SHMS data from the various instrument systems from July 1, 1999, through June 30, 2000. To ensure the accuracy of the chart, the following steps were taken. For WhittakerTM Cell reliability, the operator round sheets were consulted for each week. If a reading was in either the high or low range cells, and the airflow was within the required ranges, the cell was considered operational for the day. The WhittakerTM Cell entries are defined as "SHMS" with a designation of the specific SHMS configuration (e.g., E+). All GCs or other measurement systems were evaluated in terms of days where data were available. Sometimes data may be missing for some days because the measurement system was shut down for calibration. This may appear to not be an accurate statement of reliability. However, when such a calibration activity precludes collection and availability of gas concentration data, the results are the same. Table 8-2 provides a summary for each instrument type.

Table 8-1. SHMS Data System Reliability. (3 sheets)

Tank System	Days Available*	Days Unavailable	Percent Available
A-101 SHMS-E	356	10	97.3
GC	330	36	90.2
PHOTO	132	234	36.1
AN-101 SHMS-E+	366	0	100.0
GC	286	80	78.1
PHOTO	157	209	42.9
AN-103 SHMS-B	366	0	100.0
AN-104 SHMS-C	366	0	100.0
GC	356	10	97.3

Table 8-1. SHMS Data System Reliability. (3 sheets)

Tank System	Days Available*	Days Unavailable	Percent Available
AN-105 SHMS-B	366	0	100.0
GCS1 / GC-1	355	11	97.0
GCS1 / GC-2	343	23	93.7
FTIR	337	29	92.1
AN-107 SHMS-B	212	154	57.9
AN Stck SHMS-D	363	3	99.2
AW-101 SHMS-B	359	7	98.1
GCS2/ GC-1	327	39	89.3
GCS2 / GC-2	338	28	92.3
GCS2 / FTIR	354	12	96.7
AW Stck SHMS-D	229	0	100.0
AX-101 SHMS-B	365	1	99.7
AX-103 SHMS-B	0	229	0.0
AY-102 SHMS-C	349	17	95.4
GC	322	44	88.0
AZ-101 SHMS-E	274	92	74.9
AZ-102 SHMS-E	207	21	90.8
BY-103 SHMS-B	366	0	100.0
BY-105 SHMS-E+	366	0	100.0
GC	346	20	94.5
PHOTO	213	153	58.2
BY-106 SHMS-B	366	0	100.0
BY-109 SHMS-B	229	0	100.0
C-106 SHMS-C	319	47	87.2
GC	284	82	77.6
S-101 SHMS-E	177	52	77.3
S-102 SHMS-B	280	86	76.5
S-106 SHMS-E+	358	8	97.8
GC	335	31	91.5
PHOTO	243	123	66.4
S-107 SHMS-B	150	79	65.5

Table 8-1. SHMS Data System Reliability. (3 sheets)

Tank System	Days Available*	Days Unavailable	Percent Available
S-109 SHMS-E+	229	0	100.0
GC	215	14	94.3
PHOTO	139	90	60.7
S-111 SHMS-B	229	0	100.0
S-112 SHMS-B	229	0	100.0
SX-101 SHMS-B	175	191	47.8
SX-102 SHMS-B	139	90	60.7
SX-103 SHMS-E+	366	0	100.0
GC	341	25	93.2
PHOTO	169	197	46.2
SX-104 SHMS-B	332	12	96.5
SX-105 SHMS-B	366	0	100.0
SX-106 SHMS-B	342	0	100.0
SX-109 SHMS-B	229	0	100.0
SY-101 SHMS	360	6	98.4
SY241 SHMS	362	4	98.9
SY01A-SHMS	354	12	96.7
SY-102 SHMS-E+	340	26	92.9
GC	330	36	90.2
PHOTO	277	89	75.7
SY-103 SHMS-B	352	14	96.2
T-110 SHMS-B	227	2	99.1
U-102 SHMS-B	326	40	89.1
U-103 SHMS-B	365	1	99.7
U-105 SHMS-E+	344	22	94.0
GC	331	35	90.4
PHOTO	280	86	76.5
U-107 SHMS-B	366	0	100.0
U-108 SHMS-B	282	84	77.0
U-109 SHMS-B	366	0	100.0

*Because of isolation of several SHMS cabinets this year, not all units were available for 366 days (see Table 4-1).

Table 8-2. Summary of SHMS Data System Reliability

Tank System	Days Available	Days Unavailable	Percent Available
PHOTO	1,610	1,181	57.7
GC	3,476	412	89.4
GCS	1,363	101	93.1
FTIR	691	41	94.4
Whittaker™ Cells	13,782	1,592	89.6

8.2 CURRENT SYSTEM ISSUES AND CORRECTIVE ACTIONS

Several issues affecting the operations of the SHMS units and the quality of the data obtained have been encountered during the years of operation. The major issues include plugging of the sample line filter with condensed water, failure of the system to record data, and plugging of the sample line with ammonium nitrate. The efficiency of operations during the time period July 1, 1999, through June 30, 2000, has been generally excellent, but a few issues required resolution this year.

8.2.1 Description of System Issues

Plugging of Sample Line Filter with Condensed Water — The waste tank headspace temperature is typically warmer than the ambient temperature. Because one of the major components of the waste is water, the moisture content in the headspace is expected to be above the saturation level for the ambient conditions. The SHMS design includes provisions to minimize the effects of moisture by heat tracing the sample lines and controlling the temperature of the instrumentation cabinet. This is intended to prevent moisture from condensing in the sample piping. Moisture becomes an issue in the system when the volume of collected water becomes so great that the sample line filter becomes plugged. Last year, this issue accounted for 36 percent of the down time. This year the issue became critical only in the SHMS operations on tank 241-SY-102. This tank has received significant new waste from tank 241-SY-101 and the U farm salt-well pumped tanks. How this change in tank chemistry led to increased moisture in the sample lines, resulting in filling the condensate bowl and subsequent shutdown of the SHMS is still uncertain.

Plugging of Sample Lines with Ammonium Nitrate — This problem has been encountered only with the system installed on tank 241-AX-103. The loss of this one SHMS unit accounts for 23 percent of the lost data days this year. In this case the sample line does not plug with water but with a substance composed of ammonium nitrate contaminated with plutonium-uranium extraction solvent and solvent degradation products. This material is known to have plugged Hanford Site waste tank ventilation systems on other occasions (Borsheim and Kirch 1991).

Proper precautions must be taken when working on the portions of the system that may contain this material. The SHMS cabinet on this tank has been removed from service.

Extended “Down Time” for Photoacoustic Ammonia Monitors — Table 8-2 clearly shows that the Bruel and Kjaer ammonia monitors are not providing data in an efficient manner. Physical failure of the measurement systems occurs in four major areas: chopper belt failure, carousel belt failure, infrared source filament burnout, and sample pump failure. This instrument requires offsite vendor repair for all but the chopper belt replacement. In previous years, the vendor repair shop was located in Prosser, Washington — a fairly easily accessible site. This year, the nearest shop for this instrument service is in California. Service procurement, shipping, receiving inspection, and other issues associated with offsite support have contributed to the significant delays in system operation.

8.2.2 Issue Resolution

Plugging of Sample Line Filters with Condensed Water — For SHMS on tanks with a history or potential of high headspace moisture, gas sample conditioners have been installed. These systems consist of a condenser coil and a chilled annulus that separates moisture from the sample stream. These systems are intended to prevent moisture from clogging the SHMS sample lines and filters. These systems have been installed on tanks 241-A-101, 241-AX-101, 241-AY-102, 241-C-106, 241-S-102, 241-SX-102. A similar system is being requested for tank 241-SY-102.

Extended “Down Time” for Photoacoustic Ammonia Monitors — Replacement parts for the chopper belt have been kept available, and maintenance notification systems have been expedited, but the transportation and specialized shop issues are still unresolved.

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9.0 CONCLUSIONS

SHMS units were designed, procured, fabricated, and installed on all 25 FGWL tanks. Additional SHMS units were installed on high priority tanks. The headspaces of the tanks have been observed for long enough to demonstrate that steady-state release of gas into the tank headspace of passively and actively ventilated tanks does not result in gas concentrations exceeding the action level. As a result, SHMS units were removed from eight tanks and placed in a standby mode on seven other tanks. The standby mode allows a SHMS cabinet to be available for future gas monitoring during transfer/pumping activities without having to maintain high maintenance and engineering costs until that activity occurs.

Monitoring to date has shown the following:

1. SSTs do not appear to be subject to large, rapid gas releases. The peak hydrogen concentrations during GREs in the SSTs have been below 25 percent of the LFL. GREs in the SSTs require days to increase from steady-state concentrations to peak concentrations. Interim stabilization activities and other waste-disturbing activities like mixer pump tests and transfers appear to have an effect on the steady-state hydrogen concentration of most tanks monitored during the last year.
2. SHMS reliably detect GREs. Redundant systems (e.g., GCS) have been placed on the systems that generate the most flammable gases; these systems have verified WhittakerTM Cell data.
3. Grab samples taken in the pump pit area immediately above the tanks demonstrate that the SHMS samplers in the dome space can accurately measure pump pit flammable gas concentrations.

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APPENDIX A

**FLAMMABLE GAS CONCENTRATIONS FOR SHMS TANKS
JULY 1999 THROUGH JUNE 2000**

Note: In those cases where two analytical systems measure the same analyte in the same tank, the most accurate system data are posted in this appendix. In some cases, the less accurate system is used to fill in the “data gap” created by down time on the more accurate system.

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Figure 1. Tank 241-A-101 Ammonia Concentration (Photoacoustic).

Figure 2. Tank 241-A-101 Gases (GC).

Figure 3. Tank 241-AN-101 Hydrogen Concentration (GC).

Figure 4. Tank 241-AN-101 Methane Concentration (GC).

Figure 5. Tank 241-AN-101 Nitrous Oxide Concentration (GC).

Figure 6. Tank 241-AN-101 Ammonia Concentration (Photoacoustic).

Figure 7. Tank 241-AN-103 Hydrogen Concentration (Whittaker Cells).

Figure 8. Tank 241-AN-104 Hydrogen Concentration (GC).

Figure 9. Tank 241-AN-105 Hydrogen Concentration (GCS).

Figure 10. Tank 241-AN-105 Methane and Nitrous Oxide Concentrations (GCS).

Figure 11. Tank 241-AN-105 Ammonia Concentration (FTIR).

Figure 12. Tank 241-AN-107 Hydrogen Concentration (Whittaker Cells).

Figure 13. AN Farm Stack Monitor Hydrogen Concentration (Whittaker Cells).

Figure 14. Tank 241-AW-101 Hydrogen Concentration (GCS).

Figure 15. Tank 241-AW-101 Nitrous Oxide Concentration (GCS).

Figure 16. Tank 241-AW-101 Ammonia Concentration (FTIR).

Figure 17. AW Farm Stack Monitor Hydrogen Concentration (Whittaker Cells).

Figure 18. Tank 241-AX-101 Hydrogen Concentration (Whittaker Cells).

Figure 19. Tank 241-A-Y-102 Hydrogen Concentration (GC).

Figure 20. Tank 241-A Y-102 Hydrogen Concentration (Whittaker Rounds).

Figure 21. Tank 241-AZ-101 Hydrogen Concentrations (Whittaker Cells).

Figure 22. Tank 241-AZ-102 Hydrogen Concentration (Whittaker Rounds).

Figure 23. Tank 241-BY-103 Hydrogen Concentration (Whittaker Cells).

Figure 24. Tank 241-BY-105 Ammonia Concentration (Photoacoustic).

Figure 25. Tank 241-BY-105 Gases (GC).

Figure 26. Tank 241-BY-106 Hydrogen (Whittaker Cells).

Figure 27. Tank 241-BY-109 Hydrogen Concentration (Whittaker Rounds).

Figure 28. Tank 241-C-106 Hydrogen Concentration (GC - Hi Range Cell).

Figure 29. Tank 241-S-101 Hydrogen Concentration (Whittaker Cells)

Figure 30. Tank 241-S-102 Hydrogen Concentration (Whittaker Cells).

Figure 31. Tank 241-S-106 Ammonia Concentration (Photoacoustic).

Figure 32. Tank 241-S-106 Gas Concentrations (GC).

Figure 33. Tank 241-S-107 Hydrogen Concentration (Whittaker Rounds).

Figure 34. Tank 241-S-109 Ammonia Concentration (Photoacoustic).

Figure 35. Tank 241-S-109 Gases (GC).

Figure 36. Tank 241-S-111 Hydrogen Concentration (Whittaker Cells).

Figure 37. Tank 241-S-112 Hydrogen Concentration (Whittaker Cells).

Figure 38. Tank 241-SX-101 Hydrogen Concentration (Whittaker Cells).

Figure 39. Tank 241-SX-102 Hydrogen Concentration (Whittaker Cells).

Figure 40. Tank 241-SX-103 Gas Concentration (GC).

Figure 41. Tank 241-SX-103 Ammonia Concentration (Photoacoustic).

Figure 42. Tank 241-SX-104 Hydrogen Concentration (Whittaker Cells).

Figure 43. Tank 241-SX-105 Hydrogen Concentration (Whittaker Cells).

Figure 44. Tank 241-SX-106 Hydrogen Concentration (Whittaker Cells).

Figure 45. Tank 241-SX-109 Hydrogen Concentration (Whittaker Cells).

Figure 46. Tank 241-SY-101 Hydrogen Concentration (Whittaker Cells).

Figure 47. Tank 241-SY-102 Hydrogen Concentration (GC).

Figure 48. Tank 241-SY-102 Methane Concentration (GC).

Figure 49. 241-SY-102 Nitrous Oxide.

Figure 50. Tank 241-SY-102 Ammonia Concentration (Photoacoustic).

Figure 51. Tank 241-SY-103 Hydrogen Concentration (Whittaker Cells).

Figure 52. Tank 241-T-110 Hydrogen Concentration (Whittaker Cells).

Figure 53. Tank 241-U-102 Hydrogen Concentration (Whittaker Cells).

Figure 54. Tank 241-U-103 Hydrogen Concentration (Whittaker Cells).

Figure 55. Tank 241-U-105 Gases (GC).

Figure 56. Tank 241-U-105 Ammonia Concentration (B&K).

Figure 57. Tank 241-U-107 Hydrogen Concentration (Whittaker Cells).

Figure 58. Tank 241-U-108 Hydrogen Concentration.

Figure 59. Tank 241-U-109 Hydrogen Concentration (Whittaker Cells).

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APPENDIX B

**VAPOR GRAB SAMPLE RESULTS
(BOTH SINGLE- AND DOUBLE-SHELL TANKS)**

Note: For calculations in Appendix B, it was necessary to factor in values such as <10 ppm. This was accomplished by establishing the nominal "less than" value as the number to be used in the calculations. Double-shell tank and stack monitor data have been placed at the end of this appendix in the format used in previous years; i.e., no averages or ratios.

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Table B-1. Tank A-101 Vapor Grab Sample Results.

Sample Date	H2 (ppm)	CH4 (ppm)	N2O (ppm)
5-18-95	1,260	7	220
6-8-95	743	<12	217
6-8-95	746	<12	219
6-8-95	786	<12	218
7-25-95	1,180	8	210
7-27-95	1,460	8	210
8-3-95	360	6	55
8-4-95	390	5	53
8-7-95	1,540	14	250
8-8-95	1,370	13	220
8-10-95	1,350	13	230
8-11-95	1,420	12	230
8-15-95	950	10	160
3-19-98	250	5	110
5-18-98	190	6	75
8-21-98	330	<10	150
[H₂]_{Range}	190 - 1,540 ppm		
[H₂]_{Average}	895 ppm		
[H₂]/[N₂O]_{Range}	2 - 7		

Table B-2. Tank A-101 SUMMATM Canister Samples.

Sample Identification	Hydrogen (ppm)	Methane (ppm)	Nitrous Oxide (ppm)	Helium (ppm)
V0001-A01.011	170	3	69	4
V0001-A02.057	170	3	66	4
V0001-B01.149	190	3	64	580
V0001-B02.223	190	3	74	580
V0001-C01.069	160	2	74	72
V0001-C02.071	180	<2	73	79

These six samples were taken on July 29, 1997, during ventilation rate measurements using helium as a tracer gas. The valves on canisters 011 and 069 were found to be leaking slightly.

Table B-3. Tank AX-101 Vapor Grab Sample Results.

Sample Date	H₂ (ppm)	CH₄ (ppm)	N₂O (ppm)
6-15-95	103	<12	<13
6-15-95	102	<12	<13
7-25-95	59	2	6
7-27-95	67	2	8
7-28-95	50	1	5
7-31-95	43	2	5
8-3-95	57	2	6
8-7-95	17	2	13
8-8-95	56	2	5
8-9-95	44	2	5
8-10-95	100	3	9
8-11-95	62	3	8
8-15-95	78	2	7
10-3-96	65	<10	<10
10-3-96	63	<10	<10
12-19-96	28	<10	<10
12-19-96	40	<10	<10
1-29-97	18	<10	<10
3-12-97	26	<10	<10
3-12-97	18	<10	<10
2-12-99	18	<10	<10
[H₂] Range 17 - 103 ppm			
[H₂] Average 53 ppm			
[H₂]/[N₂O] Range 1 - 11			

Table B-4. Tank AX-103 Vapor Grab Sample Results.

Sample Date	H₂ (ppm)	CH₄ (ppm)	N₂O (ppm)
6-21-95	<98	<12	24
6-21-95	<98	<12	24
6-21-95	<98	<12	23
7-25-95	27	2	21
7-27-95	33	2	24
7-28-95	28	1	24
7-31-95	27	2	22
8-3-95	24	2	24
8-4-95	26	3	25
8-7-95	17	2	13
10-3-96	36	<10	40
10-3-96	20	<10	20
[H₂]_{Range} 17 - <98 ppm			
[H₂]_{Average} 26 ppm			
[H₂]/[N₂O]_{Range} 0.9 - 1.4			

Table B-5. Tank BY-103 Vapor Sample Results.

Sample Date	H ₂ (ppm)	CH ₄ (ppm)	N ₂ O (ppm)
5-5-94	21	n/r	49
5-5-94	22	n/r	49
5-5-94	21	n/r	49
9-22-95	230	4	70
10-2-95	130	3	22
10-9-95	200	3	25
10-13-95	150	2	19
3-27-96	66	<10	20
3-27-96	69	<10	20
8-22-97	10	1	9
11-19-97	<10	1	<10
2-18-98	<10	2	<10
4-24-98	<10	2	13
7-15-98	<10	<10	<10
3-23-99	12	<50	14
[H ₂] _{Range} <10 - 230 ppm			
[H ₂] _{Average} 65 ppm			
[H ₂]/[N ₂ O] _{Range} 0.43 - 8			

Note:

n/r = not reported

Table B-6. Tank BY-105 Vapor Sample Results.

Sample Date	H₂ (ppm)	CH₄ (ppm)	N₂O (ppm)
6-11-98	55	<10	65
9-14-98	20	<10	20
[H₂]_{Range}	55 - 20 ppm		
[H₂]_{Average}	38 ppm		
[H₂]/[N₂O]_{Range}	.85 - 1.00		

Table B-7. Tank BY-106 Vapor Sample Results.

Sample Date	H ₂ (ppm)	CH ₄ (ppm)	N ₂ O (ppm)
5-4-94	48	<61	92
5-4-94	43	<61	91
5-4-94	46	<61	96
7-8-94	104	3.6	70
7-8-94	47	4	71
7-8-94	40	4	71
9-22-95	1,110	20	1,140
10-2-95	520	12	410
10-9-95	210	5	17
10-13-95	140	2	45
3-27-96	51	<10	41
3-27-96	50	<10	34
8-22-97	43	2	32
11-19-97	50	1	36
2-18-98	40	5	160
4-24-98	50	2	70
7-15-98	40	<10	40
3-23-99	58	<50	70
[H₂]_{Range} 40 - 1,110 ppm			
[H₂]_{Average} 149 ppm			
[H₂]/[N₂O]_{Range} 0.25 - 12			

Table B-8. Tank BY-109 Vapor Sample Results.

Sample Date	H₂ (ppm)	CH₄ (ppm)	N₂O (ppm)
9-22-95	154	2	40
10-2-95	90	4	9
10-9-95	100	4	7
10-13-95	80	2	6
3-27-96	10	<10	<5
3-27-96	15	<10	<5
8-22-97	39	3	<10
11-19-97	10	<5	<10
2-18-98	11	1	<10
4-24-98	12	1	<10
7-15-98	22	<10	<10
10-26-98	<10	<10	<10
[H₂]_{Range} <10 - 154 ppm			
[H₂]_{Average} 46 ppm			
[H₂]/[N₂O]_{Range} 2 - 14 (division by <10 is undefined)			

Table B-9. Tank C-106 Vapor Sample Results.

Sample Date	H ₂ (ppm)	CH ₄ (ppm)	N ₂ O (ppm)
3-17-97	4	4	<10
3-17-97	4.4	5	<10
3-18-97	5	4	<10
3-18-97	4.2	4	<10
3-19-97	5	5	<10
3-19-97	4.4	5	<10
3-20-97	6.5	4	<10
3-20-97	1.8	5	<10
3-21-97	8.7	5	<10
3-21-97	6.6	4	<10
3-27-97	5.8	3	<10
3-27-97	4.5	4	<10
6-4-97 (1445)	4.2	2	<10
6-4-97 (1445)	4.3	2	<10
6-4-97 (2146)	22	1	11
6-4-97 (2146)	20	1	11
6-5-97 (0509)	38	1	18
6-5-97 (0509)	38	2	20
6-5-97 (1440)	69	2	32
6-5-97 (1440)	67	2	31
6-5-97 (2152)	68	2	32
6-5-97 (2152)	14	2	8
6-6-97 (0530)	100	2	55
6-6-97 (0530)	49	2	25
6-9-98 (1140)	<10	<10	<10
[H ₂] _{Range} 1.8 - 100 ppm			
[H ₂] _{Average} 23 ppm			
[H ₂]/[N ₂ O] _{Range} 1.8 - 2.2			

Table B-10. Tank S-101 Vapor Sample Results.

Sample Date	H ₂ (ppm)	CH ₄ (ppm)	N ₂ O (ppm)
6-5-98	425	<10	275
9-14-98	280	<10	75
12-7-98	425	<10	240
[H ₂] _{Range} 280 - 425 ppm			
[H ₂] _{Average} 377 ppm			
[H ₂]/[N ₂ O] _{Range} 1.5 - 1.8			

Table B-11. Tank S-102 Vapor Sample Results.

Sample Date	H ₂ (ppm)	CH ₄ (ppm)	N ₂ O (ppm)
3-14-95	669	<12	491
3-14-95	670	<12	550
3-14-95	668	<12	487
5-5-95	300	4	210
8-4-95	600	4	410
8-7-95	280	4	210
8-7-95	410	5	280
8-8-95	750	7	560
8-8-95	720	8	510
8-9-95	700	9	490
8-10-95	750	10	530
8-10-95	760	9	540
8-11-95	750	10	530
1-21-99	400	17	440
[H ₂] _{Range} 280 - 760 ppm			
[H ₂] _{Average} 602 ppm			
[H ₂]/[N ₂ O] _{Range} 0.91 - 1.5			

Table B-12. Tank S-106 Vapor Sample Results.

Sample Date	H ₂ (ppm)	CH ₄ (ppm)	N ₂ O (ppm)
6-5-98	20	<10	<10
9-14-98	30	<10	<10
11-12-98	14	<10	<10
[H ₂] _{Range} 14 - 30 ppm			
[H ₂] _{Average} 21 ppm			
[H ₂]/[N ₂ O] _{Range} Undetermined			

Table B-13. Tank S-107 Vapor Sample Results.

Sample Date	H ₂ (ppm)	CH ₄ (ppm)	N ₂ O (ppm)
6-5-98	180	<10	90
9-14-98	165	<10	80
12-7-98	150	<10	65
[H ₂] _{Range} 150 - 180 ppm			
[H ₂] _{Average} 165 ppm			
[H ₂]/[N ₂ O] _{Range} 2.0 - 2.3			

Table B-14. Tank S-109 Vapor Sample Results.

Sample Date	H ₂ (ppm)	CH ₄ (ppm)	N ₂ O (ppm)
6-5-98	27	<10	<10
9-14-98	62	<10	<10
[H ₂] _{Range} 27 - 62 ppm			
[H ₂] _{Average} 45 ppm			
[H ₂]/[N ₂ O] _{Range} Undetermined			

Table B-15. Tank S-111 Vapor Sample Results.

Sample Date	H₂ (ppm)	CH₄ (ppm)	N₂O (ppm)
7-11-95	53	<5	<10
7-14-95	16	<5	<10
7-17-95	<5	<5	<10
8-3-95	77	2	17
8-4-95	5	2	<5
8-7-95	210	3	38
8-29-97	280	2	26
10-22-97	280	5	22
1-23-98	91	3	19
4-17-98	80	2	18
8-19-98	60	<10	20
12-7-98	25	<10	<50
[H₂]_{Range} <5 - 210 ppm			
[H₂]_{Average} 99 ppm			
[H₂]/[N₂O]_{Range} 0.5 - 13			

Table B-16. Tank S-112 Vapor Sample Results.

Sample Date	H₂ (ppm)	CH₄ (ppm)	N₂O (ppm)
5-3-95	27	<5	<10
7-11-95	33	<5	<10
7-14-95	24	<5	<10
7-17-95	32	<5	<10
8-3-95	28	2	7
8-4-95	16	2	<5
8-7-95	27	2	9
8-25-97	28	<10	3
10-22-97	30	4	<10
6-5-98	28	<10	<10
9-14-98	30	<10	<10
12-7-98	<10	<10	<50
[H₂]_{Range} <10 - 33 ppm			
[H₂]_{Average} 26 ppm			
[H₂]/N₂O_{Range} 3 - 9 (Division by < values is not defined)			

Table B-17. Tank SX-101 Vapor Sample Results.

Sample Date	H₂ (ppm)	CH₄ (ppm)	N₂O (ppm)
6-2-95	8	2	<5
6-6-95	5	<5	<5
6-9-95	<5	2	<5
6-22-95	7	<5	<5
6-27-95	<5	<5	<5
6-30-95	<5	<10	<5
7-7-95	<5	<10	<5
9-11-95	<5	2	<5
9-15-95	n/r	n/r	n/r
9-19-95	n/r	2	n/r
9-25-95	10	2	n/r
10-4-95	n/r	4	n/r
3-20-96	n/r	n/r	n/r
3-20-96	n/r	n/r	n/r
8-25-97	32	2	9
11-13-97	<10	1	<10
01-27-98	9	2	<10
5-26-98	<10	2	<10
6-18-99	<10	<10	<10
[H₂]_{Range} <5 - 32 ppm			
[H₂]_{Average} 9.0 ppm			

Note:

n/r =not reported

Table B-18. Tank SX-102 Vapor Sample Results.

Sample Date	H ₂ (ppm)	CH ₄ (ppm)	N ₂ O (ppm)
6-2-95	35	2	6
6-6-95	16	<5	5
6-9-95	12	2	5
6-12-95	14	1	5
6-22-95	16	<5	30
6-27-95	26	<5	<5
7-7-95	13	<10	<5
8-18-95	<5	3	<5
8-25-95	5	2	<5
9-1-95	42	2	8
9-11-95	<5	2	<5
9-15-95	20	2	n/r
9-19-95	7	2	n/r
9-25-95	15	2	n/r
10-4-95	8	2	n/r
6-17-99	16	<10	<10
[H ₂] _{Range} <5 - 42 ppm			
[H ₂] _{Average} 16 ppm			
[H ₂]/[N ₂ O] _{Range} 0.5 - 6			

Note:

n/r =not reported

Table B-19. Tank SX-103 Vapor Sample Results.

Sample Date	H ₂ (ppm)	CH ₄ (ppm)	N ₂ O (ppm)
6-2-95	66	2	15
6-6-95	32	2	8
6-9-95	24	2	8
6-12-95	28	2	9
6-22-95	31	<5	7
6-27-95	47	<5	8
6-30-95	40	10	8
7-7-95	19	<10	<5
8-18-95	19	2	<5
8-25-95	16	3	5
9-1-95	63	<3	13
9-11-95	15	2	<5
9-15-95	45	2	8
9-19-95	16	2	n/r
9-25-95	37	2	n/r
10-4-95	23	3	n/r
3-20-96	6	n/r	n/r
3-20-96	10	n/r	<5
5-20-98	<10	2	<10
8-19-98	<10	<10	<10
[H ₂] _{Range}	<10 - 66 ppm		
[H ₂] _{Average}	28 ppm		
[H ₂]/[N ₂ O] _{Range}	2 - 6		

Note:

n/r= not reported

Table B-20. Tank SX-104 Vapor Sample Results.

Sample Date	H ₂ (ppm)	CH ₄ (ppm)	N ₂ O (ppm)
6-2-95	9	<5	<5
6-6-95	<5	<5	<5
6-9-95	2	2	<5
6-12-95	5	2	<5
6-22-95	<5	<5	<5
6-27-95	<5	<5	<5
6-30-95	<5	<10	<5
7-7-95	7	<10	<5
8-18-95	<5	3	<5
8-25-95	<5	2	<5
9-1-95	14	2	<5
9-11-95	<5	2	<5
9-15-95	n/r	2	n/r
9-19-95	7	1	n/r
9-25-95	28	2	n/r
10-4-95	5	1	n/r
11-13-97	<10	2	<10
02-19-98	<10	1	<10
5-20-98	<10	1	<10
8-19-98	<10	<10	<10
6-17-99	27	11	<10
[H ₂] _{Range} 2 - 28 ppm			
[H ₂] _{Average} 9 ppm			

Note:

n/r = not reported

Table B-21. Tank SX-105 Vapor Sample Results.

Sample Date	H ₂ (ppm)	CH ₄ (ppm)	N ₂ O (ppm)
6-2-95	16	<5	<5
6-6-95	5	<5	<5
6-9-95	5	2	<5
6-12-95	5	2	<5
6-22-95	<5	<5	<5
6-27-95	6	<10	<5
6-30-95	8	<10	<5
7-7-95	10	<10	<5
8-18-95	12	2	<5
8-25-95	<5	2	<5
9-1-95	54	2	10
9-11-95	<5	2	<5
9-15-95	12	2	n/r
9-19-95	5	2	n/r
9-25-95	21	2	n/r
10-4-95	12	2	n/r
3-20-96	n/r	n/r	n/r
3-20-96	n/r	n/r	n/r
8-25-97	97	2	26
11-13-97	<10	1	<10
2-19-98	87	3	20
5-20-98	<10	1	<10
8-19-98	<10	<10	<10
6-17-99	<10	<10	<10
[H ₂] _{Range} <5 - 97 ppm			
[H ₂] _{Average} 19 ppm			
[H ₂]/[N ₂ O] _{Range} 1 – 5			

Note:

n/r = not reported

Table B-22. Tank SX-106 Vapor Sample Results.

Sample Date	H ₂ (ppm)	CH ₄ (ppm)	N ₂ O (ppm)
6-2-95	48	2	25
6-6-95	12	2	10
6-9-95	12	2	9
6-12-95	13	2	12
8-18-95	15	2	<5
8-25-95	18	3	<5
9-1-95	89	3	7
9-11-95	27	2	6
9-15-95	66	2	22
9-19-95	27	3	6
9-25-95	70	2	16
10-4-95	42	3	8
3-20-96	20	n/r	14
3-20-96	25	n/r	14
8-25-97	130	3	39
11-13-97	9	1	6
2-19-98	72	9	160
5-20-98	<10	1	<10
8-19-98	<10	<10	<10
6-18-99	21	<10	<10
[H ₂] _{Range}		<10 - 89 ppm	
[H ₂] _{Average}		37 ppm	
[H ₂]/[N ₂ O] _{Range}		0.45 - 13	

Note:

n/r = not reported

Table B-23. Tank SX-109 Vapor Sample Results.

Sample Date	H₂ (ppm)	CH₄ (ppm)	N₂O (ppm)
6-2-95	15	2	5
6-6-95	7	2	<5
6-9-95	6	2	<5
6-12-95	8	<5	3
8-25-95	<5	1	<5
9-1-95	17	<5	<5
3-20-96	5	n/r	n/r
3-20-96	6	n/r	n/r
8-25-97	40	2	9
11-13-97	<10	1	<10
2-19-98	67	2	14
5-20-98	<10	1	<10
8-19-98	<10	<10	<10
6-18-99	<10	<10	<10
[H₂]_{Range} <5 - 67 ppm			
[H₂]_{Average} 15 ppm			
[H₂]/[N₂O]_{Range} 1 - 5			

Note:

n/r = not reported

Table B-24. Tank T-110 Vapor Sample Results.

Sample Date	H ₂ (ppm)	CH ₄ (ppm)	N ₂ O (ppm)
6-27-95	8	<10	<5
6-30-95	7	<10	<5
7-7-95	7	<10	<5
7-11-95	6	<5	<10
7-14-95	<5	<5	<10
7-17-95	<5	<5	<10
7-25-95	7	n/r	n/r
7-27-95	7	n/r	n/r
7-31-95	n/r	2	n/r
2-6-96	9	n/r	n/r
2-6-96	8	n/r	n/r
10-22-97	19	5	<10
1-22-98	<10	1	<10
4-17-98	<10	2	<10
7-15-98	10	<10	<10
10-23-98	<10	<10	<10
[H ₂] _{Range} <5 - 19 ppm			
[[H ₂] _{Average} 8.5 ppm			
[H ₂]/[N ₂ O] _{Range} Undetermined			

Note:

n/r = not reported

Table B-25. Tank U-102 Vapor Sample Results.

Sample Date	H₂ (ppm)	CH₄ (ppm)	N₂O (ppm)
7-15-98	395	<10	785
10-23-98	540	17	1100
[H₂]_{Range}	395 - 540		
[[H₂]_{Average}	468 ppm		
[H₂]/[N₂O]_{Range}	0.49 - 0.50		

Table B-26. Tank U-103 Vapor Sample Results.

Sample Date	H₂ (ppm)	CH₄ (ppm)	N₂O (ppm)
2-15-95	552	<61	875
2-15-95	557	<61	856
2-15-95	555	<61	904
5-3-95	780	21	910
6-27-95	740	21	750
6-30-95	780	19	790
7-7-95	840	20	880
7-11-95	830	16	1,240
7-14-95	620	13	830
7-17-95	360	8	500
7-25-95	460	10	630
7-27-95	440	6	630
7-31-95	470	10	660
10-22-97	660	21	940
1-22-98	410	7	640
5-20-98	800	17	1,210
8-21-98	130	<10	120
11-12-98	690	18	1,020
[H₂]_{Range}	130 - 840 ppm		
[H₂]_{Average}	593 ppm		
[H₂]/[N₂O]_{Range}	0.62 - 1.1		

Table B-27. Tank U-105 Vapor Sample Results.

Sample Date	H ₂ (ppm)	CH ₄ (ppm)	N ₂ O (ppm)
7-7-95	660	24	1,120
6-30-95	500	16	830
7-11-95	670	18	1,660
7-14-95	670	17	1,670
7-17-95	650	17	1,620
2-7-96 (not included in average calculations)	26 (bad valve on grab sampler)	n/r	390
2-7-96	460	n/r	1,260
5-9-96	500	20	1,360
12-9-97	850	20	2,200
12-15-97	270	12	700
3-18-98	260	10	725
6-26-98	990	30	2,865
9-14-98	1,490	50	4,700
[H ₂] _{Range} 260 - 1,490 ppm			
[H ₂] _{Average} 664 ppm			
[H ₂]/[N ₂ O] _{Range} 0.32 - 0.60			

Note:

n/r = not reported

Table B-28. Tank U-107 Vapor Sample Results.

Sample Date	H ₂ (ppm)	CH ₄ (ppm)	N ₂ O (ppm)
2-17-95	496	<12	701
2-17-95	505	<12	698
2-17-95	499	<12	703
6-20-95	280	<10	280
6-30-95	330	10	350
7-10-95	340	10	340
7-10-95	340	10	340
7-11-95	330	7	510
7-14-95	330	<5	490
7-17-95	310	6	410
7-25-95	380	n/r	580
7-27-95	430	n/r	640
7-31-95	380	n/r	520
2-7-96	260	n/r	490
2-7-96	256	n/r	490
5-9-96	260	<10	430
5-9-96	260	<10	430
12-15-97	685	17	1,130
3-18-98	242	7	460
5-20-98	530	11	1,040
8-21-98	285	<10	520
11-12-98	690	14	1,075
[H ₂] _{Range}	242 - 690 ppm		
[H ₂] _{Average}	383 ppm		
[H ₂]/[N ₂ O] _{Range}	0.5 - 1		

Note:

n/r = not reported

Table B-29. Tank U-108 Vapor Sample Results.

Sample Date	H ₂ (ppm)	CH ₄ (ppm)	N ₂ O (ppm)
6-27-95	430	11	330
6-30-95	410	8	310
7-7-95	500	10	360
7-11-95	470	10	530
7-14-95	450	8	510
7-17-95	430	18	450
9-11-95	490	7	530
9-11-95	480	8	550
9-18-95	n/r	2	n/r
9-18-95	8	1	n/r
2-7-96	296	n/r	370
2-7-96	145	n/r	120
5-9-96	520	10	600
5-9-96	530	20	600
12-15-97	605	17	745
3-18-98	435	10	640
7-15-98	28	<10	20
10-23-98	470	12	680
[H ₂] _{Range}		8 - 605 ppm	
[H ₂] _{Average}		394 ppm	
[H ₂]/[N ₂ O] _{Range}		0.7 - 1.4	

Note:

n/r = not reported

The samples taken on 9/18/95 were not included in the average calculation or range because the values are unusually low. A problem with the sample cylinder is suspected.

Table B-30. Tank U-109 Vapor Sample Results.

Sample Date	H ₂ (ppm)	CH ₄ (ppm)	N ₂ O (ppm)
7-7-95	460	11	390
7-11-95	410	8	460
7-14-95	420	7	520
7-17-95	390	7	470
2-7-96	212	n/r	273
2-7-96	215	n/r	272
5-9-96	240	10	29
5-9-96	240	10	30
12-15-97	430	14	590
3-18-98	350	9	610
5-20-98	530	12	820
8-21-98	260	<10	255
11-12-98	625	13	625
12-17-98	370	<10	605
[H ₂] _{Range} 212 - 625 ppm			
[H ₂] _{Average} 368 ppm			
[H ₂]/[N ₂ O] _{Range} .57 - 1.2			

Note:

n/r = not reported

Table B-31. AN Stack Monitor Grab Sample.

	Date	H ₂ (ppm)	N ₂ O (ppm)	CH ₄ (ppm)
Steady-state	1/21/99	11	22	<10
Steady-state	7/19/99	19	22	4

Table B-32. Tank 241-AN-101 Grab Samples.

	Date	H2 (ppm)	N2O (ppm)	CH4 (ppm)
Steady-state	3/19/98	<10	<10	1
Steady-state	4/16/98	<10	<10	1
Steady-state	5/11/98	10	<10	2
Steady-state	6/9/98	<10	<10	<10
Steady-state	7/16/98	<10	<10	<10
Steady-state	8/21/98	<10	<10	<10
Steady-state	9/14/98	<10	<10	<10
Steady-state	10/9/98	<10	<10	<10

Table B-33. Tank 241-AN-103 Grab Samples. (2 sheets)

	Date	H2 (ppm)	N2O (ppm)	CH4 (ppm)
Steady-state	11/2/94	77	<10	<10
Steady-state	11/10/94	34	<10	<10
Steady-state	11/16/94	81	6	<10
Steady-state	11/22/94	22	<5	<10
Steady-state	11/30/94	230	14	<10
Steady-state	12/7/94	10	<5	<10
Steady-state	12/14/94	25	<5	<10
Steady-state	12/21/94	120	<10	<10
Steady-state	1/4/95	24	<10	<10
Steady-state	2/29/96	15	<5	<10
Steady-state	2/29/96	13	<5	<10
Steady-state	3/27/96	22	<5	<10
Steady-state	3/27/96	23	<5	<10
Steady-state	5/30/96	<5	<5	<10
Steady-state	5/30/96	<5	<5	<10
Steady-state	9/10/96	22	<10	<10
Steady-state	9/10/96	23	<10	<10
Steady-state	10/23/96	37	<10	<10

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Table B-33. Tank 241-AN-103 Grab Samples. (2 sheets)

	Date	H2 (ppm)	N2O (ppm)	CH4 (ppm)
Steady-state	10/23/96	32	<10	<10
Steady-state	11/7/96	21	<10	<10
Steady-state	11/7/96	19	<10	<10
Steady-state	12/19/96	18	<10	<10
Steady-state	12/19/96	19	<10	<10
Steady-state	1/29/97	197	19	<10
Steady-state	1/29/97	197	19	<10
Steady-state	3/12/97	20	<10	<10
Steady-state	3/12/97	13	<10	<10
GRE	8/23/95	800	39	<10
Steady-state	8/6/97	41	6	3
Steady-state	8/21/97	22	4	1
Steady-state	10/21/97	16	<10	3
Steady-state	11/7/97	16	<10	2
Steady-state	12/16/97	11	<10	1
Steady-state	1/23/98	18	<10	2
Steady-state	2/17/98	26	<10	2
Steady-state	3/19/98	<10	<10	2
Steady-state	4/16/98	<10	<10	2
Steady-state	5/11/98	15	<10	2
Steady-state	6/9/98	<10	<10	<10
Steady-state	7/16/98	17	<10	<10
Steady-state	8/21/98	20	<10	<10
Steady-state	9/14/98	<10	<10	<10
Steady-state	10/9/98	16	<10	<10
Steady-state	1/15/99	24	<10	<10
Steady-state	4/15/99	40	<10	<10
Steady-state	7/19/99	12	<10	5

Table B-34. Tank 241-AN-104 Grab Samples. (2 sheets)

	Date	H2 (ppm)	N2O (ppm)	CH4 (ppm)
Steady-state	11/2/94	47	<10	<10
Steady-state	11/16/94	59	7	<10
Steady-state	11/22/94	32	5	<10
Steady-state	11/30/94	67	8	<10
Steady-state	12/7/94	52	8	<10
Steady-state	12/14/94	58	10	<10
Steady-state	12/21/94	66	<10	<10
Steady-state	1/4/95	62	<10	<10
Steady-state	2/29/96	27	<5	<10
Steady-state	2/29/96	25	<5	<10
Steady-state	3/27/96	49	8	<10
Steady-state	3/27/96	51	8	<10
Steady-state	5/30/96	20	<5	<10
Steady-state	5/30/96	21	<5	<10
Steady-state	9/10/96	39	<10	<10
Steady-state	9/10/96	35	<10	<10
Steady-state	10/23/96	31	<10	<10
Steady-state	10/23/96	26	<10	<10
Steady-state	11/7/96	13	<10	<10
Steady-state	11/7/96	14	<10	<10
GRE	11/9/94	154	19	<10
Steady-state	12/19/96	17	<10	<10
Steady-state	12/19/96	19	<10	<10
Steady-state	1/29/97	26	<10	<10
Steady-state	1/29/97	23	<10	<10
Steady-state	3/12/97	14	<10	<10
Steady-state	3/12/97	13	<10	<10
Steady-state	8/6/97	35	7	3
Steady-state	8/21/97	20	5	2

Table B-34. Tank 241-AN-104 Grab Samples. (2 sheets)

	Date	H2 (ppm)	N2O (ppm)	CH4 (ppm)
Steady-state	10/21/97	15	<10	4
Steady-state	11/7/97	17	<10	2
Steady-state	12/16/97	17	<10	1
Steady-state	1/23/98	15	<10	2
Steady-state	2/17/98	11	<10	1
Steady-state	3/19/98	<10	<10	2
Steady-state	4/16/98	12	<10	2
Steady-state	5/11/98	13	<10	2
Steady-state	6/9/98	14	<10	<10
Steady-state	7/16/98	13	<10	<10
Steady-state	8/21/98	14	<10	<10
Steady-state	9/14/98	<10	<10	<10
Steady-state	10/9/98	16	<10	<10

Table B-35. Tank 241-AN-105 Grab Samples. (2 sheets)

	Date	H2 (ppm)	N2O (ppm)	CH4 (ppm)
Steady-state	11/2/94	101	19	<10
Steady-state	11/9/94	220	31	<10
Steady-state	11/16/94	96	20	<10
Steady-state	11/22/94	98	20	<10
Steady-state	11/30/94	114	20	<10
Steady-state	12/7/94	69	14	<10
Steady-state	12/14/94	173	26	<10
GRE	8/23/95 (leaky canister)	<5	<5	<10
GRE	8/23/95 (leaky canister)	<5	<5	<10
Steady-state	2/29/96	40	8	<10
Steady-state	2/29/96	66	11	<10
Steady-state	3/27/96	40	8	<10
Steady-state	3/27/96	59	8	<10
Steady-state	5/30/96	49	10	<10
Steady-state	5/30/96	134	27	<10
GRE	5/30/96	4,200	860	60
GRE	5/30/96	10,700	2,000	110
Steady-state	9/10/96	<5	<10	<10
Steady-state	9/10/96	20	<10	<10
Steady-state	10/23/96	23	<10	<10
Steady-state	10/23/96	15	<10	<10
Steady-state	11/7/96	<10	<10	<10
Steady-state	11/7/96	<10	<10	<10
Steady-state	12/19/96	15	<10	<10
Steady-state	12/19/96	16	<10	<10
Steady-state	1/30/97	37	<10	<10
Steady-state	1/30/97	37	<10	<10
GRE	4/6/97 (leaky canister)	180	240	7
Steady-state	8/6/97	89	18	3

Table B-35. Tank 241-AN-105 Grab Samples. (2 sheets)

	Date	H2 (ppm)	N2O (ppm)	CH4 (ppm)
Steady-state	8/21/97	20	7	2
Steady-state	10/21/97	8	<10	3
Steady-state	11/7/97	29	<10	2
Steady-state	12/16/97	13	<10	2
GRE	8/2/99	770	365	19

Table B-36. Tank 241-AN-107 Grab Samples.)

	Date	H2 (ppm)	N2O (ppm)	CH4 (ppm)
Steady-state	3/19/98	35	95	3
Steady-state	4/16/98	32	115	3
Steady-state	5/18/98	20	45	2
Steady-state	6/9/98	17	30	<10
Steady-state	7/16/98	<10	<10	<10
Steady-state	8/21/98	14	70	<10
Steady-state	9/22/98	35	90	<10
Steady-state	10/9/98	<10	<10	<10
Steady-state	1/21/99	35	100	12
Steady-state	4/15/99	26	70	<10

Table B-37. AW Stack Monitor Grab Sample.

	Date	H2 (ppm)	N2O (ppm)	CH4 (ppm)
Steady-state	2/12/99	<10	<10	<10
Steady-state	8/27/99	16	<10	<10

Table B-38. Tank 241-AW-101 Grab Samples. (2 sheets)

	Date	H2 (ppm)	N2O (ppm)	CH4 (ppm)
Steady-state	9/28/94	467	8	<10
Steady-state	9/28/94	465	9	<10
Steady-state	10/27/94	240	<10	<10
Steady-state	11/2/94	173	<10	<10
Steady-state	11/10/94	400	<10	<10
Steady-state	11/16/94	380	10	<10
Steady-state	11/22/94	170	5	<10
Steady-state	12/7/94	120	5	<10
Steady-state	12/14/94	260	6	<10
Steady-state	12/21/94	400	8	<10
Steady-state	12/8/95	220	<10	<10
Steady-state	12/8/95	230	<10	<10
Steady-state	9/4/96	62	<5	<10
Steady-state	9/4/96	47	<5	<10
Steady-state	10/21/96	30	<10	<10
Steady-state	10/21/96	22	<10	<10
Steady-state	12/12/96	39	<10	<10
Steady-state	12/12/96	38	<10	<10
Steady-state	1/29/97	34	<10	<10
Steady-state	1/29/97	35	<10	<10
Steady-state	3/12/97	20	<10	<10
Steady-state	3/12/97	23	<10	<10
Steady-state	7/13/97	20	<10	<10
Steady-state	7/13/97	<10	<10	<10
GRE	10/6/94 (leaky canister)	12	5	<10
GRE	10/6/94 (leaky canister)	13	5	<10
GRE	10/21/94	2,960	94	31
GRE	10/21/94	2,980	93	30
GRE	11/30/94	910	31	<10

Table B-38. Tank 241-AW-101 Grab Samples. (2 sheets)

	Date	H2 (ppm)	N2O (ppm)	CH4 (ppm)
GRE	8/2/95	2,850	46	25
GRE	8/2/95	2,850	47	23
Steady-state	8/21/97	14	<10	1
Steady-state	10/21/97	12	<10	2
Steady-state	11/7/97	19	<10	1
Steady-state	12/16/97	41	<10	2

Table B-39. Tank 241-AY-102 Grab Samples.

	Date	H2 (ppm)	N2O (ppm)	CH4 (ppm)
Steady-state	8/6/97	18	<10	2
Steady-state	8/6/97	18	<10	2
Steady-state	8/13/97	15	<10	<10
Steady-state	8/21/97	15	<10	1
Steady-state	11/11/97	21	<10	2
Steady-state	12/16/97	20	<10	2
Steady-state	1/23/98	14	<10	1
Steady-state	2/18/98	<10	<10	2
Steady-state	3/19/98	14	<10	2
Steady-state	4/16/98	59	<10	1
Steady-state	5/21/98	57	<10	2
Steady-state	6/9/98	64	<10	<10
Steady-state	7/16/98	8	<10	<10
Steady-state	8/21/98	73	<10	<10
Steady-state	10/26/98	52	<10	<10
Steady-state	4/13/99	30	<10	<10

Table B-40. Tank 241-AZ-101 Grab Samples.

	Date	H2 (ppm)	N2O (ppm)	CH4 (ppm)
Steady-state	8/21/98	65	<10	<10
Steady-state	10/26/98	51	<10	<10
Steady-state	1/21/99	37	<10	<10
Steady-state	5/21/99	40	<10	<10
Steady-state	9/10/99	61	<10	<10

Table B-41. Tank 241-AZ-102 Grab Samples.

	Date	H2 (ppm)	N2O (ppm)	CH4 (ppm)
Steady-state	11/20/98	185	<10	<10
Steady-state	1/21/99	<10	<10	<10
Steady-state	5/21/99	50	<10	<10
Steady-state	9/10/99	95	<10	<10

Table B-42. Tank 241-SY-102 Grab Samples.

	Date	H2 (ppm)	N2O (ppm)	CH4 (ppm)
Steady-state	3/18/98	<10	<10	2
Steady-state	4/17/98	<10	<10	2
Steady-state	5/21/98	<10	<10	2
Steady-state	6/11/98	<10	<10	<10
Steady-state	7/15/98	<10	<10	<10
Steady-state	8/19/98	<10	<10	<10
Steady-state	9/14/98	<10	<10	<10
Steady-state	10/23/98	<10	<10	<10

Table B-43. Tank 241-SY-103 Grab Samples. (2 sheets)

	Date	H2 (ppm)	N2O (ppm)	CH4 (ppm)
Steady-state	8/18/94	19	<10	<10
Steady-state	8/18/94	19	<10	<10
Steady-state	8/25/94	16	<10	<10
Steady-state	8/25/94	38	18	<10
Steady-state	9/1/94	63	39	11
Steady-state	9/1/94	3	<10	<10
Steady-state	9/7/94	<40	<10	<10
Steady-state	9/7/94	38	32	<10
Steady-state	9/15/94	27	23	<10
Steady-state	9/15/94	15	<10	<10
Steady-state	9/23/94	28	12	<10
Steady-state	9/23/94	48	23	<10
Steady-state	10/6/94	16	<5	<10
Steady-state	10/6/94	22	5	<10
Steady-state	10/19/94	22	4	<10
Steady-state	10/19/94	28	6	<10
GRE	3/2/95	1,070	630	20
GRE	3/2/95	1,440	900	20
GRE	8/24/95	750	450	12
GRE	8/24/95	890	540	15
GRE	6/7/96	1,130	860	23
GRE	6/7/96	1,160	860	22
GRE	6/7/96	1,070	800	20
GRE	6/7/96	360	150	<10
GRE	7/15/96	1,810	1,330	40
GRE	7/15/96	1,810	1,300	40
Steady-state	8/25/97	25	12	<10
Steady-state	10/22/97	45	22	6
Steady-state	11/20/97	10	<10	1
Steady-state	12/16/97	18	10	2

Table B-43. Tank 241-SY-103 Grab Samples. (2 sheets)

	Date	H2 (ppm)	N2O (ppm)	CH4 (ppm)
Steady-state	1/22/98	<10	<10	2
Steady-state	2/18/98	<10	<10	2
Steady-state	3/18/98	<10	<10	2
Steady-state	4/17/98	<10	<10	2
Steady-state	5/21/98	<10	<10	2
Steady-state	6/11/98	7	<10	<10
Steady-state	7/15/98	17	<10	<10
Steady-state	8/19/98	<10	<10	<10
Steady-state	9/14/98	13	<10	<10
GRE	10/23/98	480	200	<10
Steady-state	4/14/99	10	10	<10
Steady-state	5/14/99	25	11	<10
Steady-state	8/27/99	37	21	<10

APPENDIX C

FLAMMABLE GAS SCREENING FOR THE LOWER FLAMMABILITY LIMIT

Attachment to Funderburke, W. M., 1996, *Transmittal of Defense Nuclear Facilities (DNFSB) Recommendation 93-5, Revision 1, Milestone 5.4.3.5.G [Letter Reporting Completion of Flammable Gas Safety Screening of Remaining Passively Ventilated Single Shell Tanks (SSTs) to Determine if Steady-State Vapors Are Less Than 25 Percent of the Lower Flammability Limit (LFL)]*, (letter to S. Marchetti, Fluor Daniel Hanford, Inc., October 24), Duke Engineering & Services, Inc., Richland, Washington.

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RESULTS OF VAPOR PHASE SAMPLING OF THE HANFORD PASSIVELY VENTILATED SINGLE-SHELL TANKS

All 134 passively ventilated single-shell tanks have had their vapor phase sampled for flammable gas either by use of the vapor sampling system (VSS) truck (Bratzel et al. 1995) or by direct measurement on a stream extracted from the tank's dome space using a combustible gas meter (CGM) (Grigsby and Leach 1996). The results of this sampling for each tank are presented in the attached table. The table lists each tank, the date the tank was sampled, the type of sampling performed and the resulting percentage of the lower flammability limit obtained.

The tank that showed the highest percentage of the lower flammability limit (LFL) is tank 241-C-103. The result reported for this tank is only 13% of the LFL, well below the action limit of 25% of the LFL. This tank has a floating organic layer on its surface and is expected to have relatively higher concentrations of both flammable organic vapors and hydrogen. The next highest tank was tank 241-S-101 at 7% of the LFL. Of the 134 tanks sampled only 27 showed flammable gas concentrations above 1% of the LFL.

The purpose of this sampling is to understand the steady state concentration of flammable gas in these tanks under normal operating conditions. There was no attempt made to sample during periods of restricted passive ventilation or gas release events. While these conditions may occur and would result in elevated flammable gas conditions in the tank, it is important to understand that the normal condition for the dome space is nonflammable even in tanks that only experience passive ventilation.

References:

- Bratzel, D. R., H. Babad, and J. L. Huckaby, 1995, *Headspace Gas and Vapor Characterization Summary for 43 Vapor Program Suspect Tanks*, Section 3.2.1 pages 8-9, WHC-SD-WM-ER-514, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Grigsby, J. M., and C. E. Leach, 1996, *Flammable Gas/Slurry Growth Unreviewed Safety Question: Justification for Continued Operation for the Tank Farms at the Hanford Site*, Appendix A Section A4.1, pages A12-A13, WHC-SD-WM-JCO-007, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

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Tank #	Sample Date	Sample Type	Total LFL (%)
SST Passive			
A-101	04/09/95	VSS	2.5
A-102	11/10/95	VSS	0.93
A-103	11/09/95	VSS	1.38
A-104	01/11/96	CGM	0
A-105	01/19/96	CGM	0
A-106	08/12/96	CGM	2
AX-101	04/15/95	VSS	0.32
AX-102	06/28/95	VSS	0
AX-103	04/21/95	VSS	<0.31
AX-104	01/14/96	CGM	0
B-101	03/26/96	CGM	0
B-102	04/18/96	VSS	0
B-103	02/08/95	VSS	0
B-104	03/26/96	CGM	0
B-105	06/06/96	CGM	0
B-106	04/26/96	CGM	0
B-107	06/06/96	CGM	2
B-108	04/26/96	CGM	0
B-109	06/12/96	CGM	0
B-110	04/26/96	CGM	0
B-111	03/19/96	CGM	0
B-112	08/30/95	CGM	0
B-201	06/04/96	CGM	0
B-202	06/04/96	CGM	0
B-203	11/20/95	CGM	0
B-204	04/26/96	CGM	0

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Tank #	Sample Date	Sample Type	Total LFL (%)
BX-101	04/24/96	CGM	0
BX-102	06/24/96	CGM	0
BX-103	03/26/96	CGM	0
BX-104	12/30/94	VSS	0.4
BX-105	04/24/96	VSS	0
BX-106	12/19/95	CGM	0
BX-107	11/17/95	VSS	0.1
BX-108	08/29/95	CGM	0
BX-109	04/24/96	CGM	0
BX-110	10/02/95	CGM	0
BX-111	04/24/96	CGM	03
BX-112	04/16/95	CGM	0
BY-101	08/08/96	CGM	0
BY-102	11/21/95	VSS	0.26
BY-103	11/01/94	VSS	0.1
BY-104	06/24/94	VSS	1
BY-105	07/07/94	VSS	0.3
BY-106	07/08/94	VSS	0.2
BY-107	10/26/94	VSS	2.3
BY-108	10/27/94	VSS	3.4
BY-109	08/08/96	CGM	0
BY-110	11/11/94	VSS	0.4
BY-111	11/16/94	VSS	0.2
BY-112	11/18/94	VSS	0.1
C-101	09/01/94	VSS	1.8
C-102	08/23/94	VSS	1.2
C-103	05/24/94	VSS	13

HNF-SD-WM-TI-797 REV 5

Tank #	Sample Date	Sample Type	Total LFL (%)
C-104	03/03/94	VSS	0.3
C-107	09/29/94	VSS	0.6
C-108	08/05/94	VSS	0
C-109	08/09/94	VSS	0.3
C-110	08/24/94	VSS	0.2
C-111	09/13/94	VSS	0.03
C-112	08/11/94	VSS	0.5
C-201	08/31/95	CGM	0
C-202	08/31/95	CGM	0
C-203	08/29/95	CGM	0
C-204	06/03/96	CGM	0
S-101	04/03/96	CGM	7
S-102	03/14/95	CGM	2
S-103	05/17/96	CGM	0
S-104	03/19/96	CGM	0
S-105	12/07/95	VSS	0.09
S-106	05/17/96	CGM	0
S-107	09/30/95	CGM	4
S-108	12/06/95	VSS	0.09
S-109	05/17/96	CGM	0
S-110	12/05/95	VSS	0.45
S-111	03/21/95	VSS	1.1
S-112	07/11/95	VSS	0.1
SX-113	08/18/95	CGM	0
SX-115	03/08/96	CGM	0
T-101	07/30/96	CGM	0
T-102	05/09/96	CGM	0

HNF-SD-WM-TI-797 REV 5

Tank	Sample Date	Sample Type	Total LFL (%)
T-103	02/15/96	CGM	0
T-104	02/07/96	VSS	0
T-105	05/09/96	CGM	0
T-106	05/09/96	CGM	0
T-107	12/18/95	VSS	0.1
T-108	05/09/96	CGM	0
T-109	05/09/96	CGM	0
T-110	08/31/95	VSS	0.1
T-111	12/20/95	VSS	0.2
T-112	05/09/96	CGM	0
T-201	07/31/96	CGM	0
T-202	08/09/96	CGM	2
T-203	03/19/96	CGM	0
T-204	07/31/96	CGM	0
TX-101	06/14/96	CGM	0
TX-102	06/20/96	CGM	0
TX-103	06/17/96	CGM	0
TX-104	07/23/96	CGM	0
TX-105	12/21/94	VSS	0
TX-106	07/23/96	CGM	0
TX-107	01/17/96	CGM	0
TX-108	07/17/96	CGM	0
TX-109	07/17/96	CGM	1
TX-110	07/17/96	CGM	0
TX-111	10/12/95	VSS	0.78
TX-112	07/24/96	CGM	0
TX-113	06/18/96	CGM	0

HNF-SD-WM-TI-797 REV 5

Tank	Sample Date	Sample Type	Total LFL (%)
TX-114	06/18/96	CGM	0
TX-115	08/01/96	CGM	0
TX-116	03/19/96	CGM	0
TX-117	03/19/96	CGM	0
TX-118	12/16/94	VSS	0.3
TY-101	04/06/95	VSS	0
TY-102	04/05/96	CGM	0
TY-103	04/11/95	VSS	0.2
TY-104	04/27/95	VSS	0
TY-105	08/06/96	CGM	2
TY-106	08/18/95	CGM	0
U-101	02/14/96	CGM	1
U-102	04/30/96	CGM	3
U-103	02/15/95	VSS	1.9
U-104	05/10/96	CGM	0
U-105	02/21/95	VSS	0.2
U-106	03/08/95	VSS	1.2
U-107	02/17/95	VSS	1.6
U-108	08/29/95	VSS	1.85
U-109	08/16/95	VSS	2.33
U-110	03/19/96	CGM	2
U-111	02/28/95	VSS	1.1
U-112	07/03/96	CGM	2
U-201	08/18/95	CGM	0
U-202	08/18/95	CGM	0
U-203	08/09/95	VSS	0
U-204	08/08/95	VSS	0