Pacific Northwest National Laboratory

Operated by Battelle for the
U.S. Department of Energy

Ventilation Rates Calculated from Hydrogen Release Data in Tanks Equipped with Standard Hydrogen Monitoring Systems (SHMS)

D. S. Sklarew
J. L. Huckaby

RECEIVED

SEP 24 1998

OSTI

September 1998

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

MASTER

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

PNNL-11926

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor Battelle Memorial Institute, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or Battelle Memorial Institute. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

PACIFIC NORTHWEST NATIONAL LABORATORY

operated by

BATTELLE

for the

UNITED STATES DEPARTMENT OF ENERGY

under Contract DE-AC06-76RLO 1830

Printed in the United States of America

**Available to DOE and DOE contractors from the
Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831;
prices available from (615) 576-8401.**

**Available to the public from the National Technical Information Service,
U.S. Department of Commerce, 5285 Port Royal Rd., Springfield, VA 22161**

This document was printed on recycled paper.

DISCLAIMER

**Portions of this document may be illegible
electronic image products. Images are
produced from the best available original
document.**

**Ventilation Rates Calculated from Hydrogen
Release Data in Tanks Equipped with Standard
Hydrogen Monitoring Systems (SHMS)**

D. S. Sklarew
J. L. Huckaby

September 1998

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest National Laboratory
Richland, Washington 99352

Summary

This report describes a method for estimating the ventilation rates of the high-level radioactive waste tank headspaces at the Hanford Site in Southeastern Washington State. The method, using hydrogen concentration data, is applied to all passively ventilated and selected mechanically ventilated tanks equipped with Standard Hydrogen Monitoring Systems (SHMS) and covers the time period from when the SHMS were installed through July 12, 1998. Results of the analyses are tabulated and compared with results from tracer gas studies (Huckaby et al. 1997, 1998) and similar analyses of SHMS data (Wilkins et al. 1997).

The method relies on instances of above-normal hydrogen releases and assumes the rate at which hydrogen is released by the waste is otherwise approximately constant. It also assumes that hydrogen is uniformly distributed in the tank headspace, so that at any given time the concentration of hydrogen in the effluent is approximately equal to the average headspace concentration and that measured by the SHMS. In general, the greatest single source of error in the method is the determination of the baseline hydrogen concentration, which in this study has been estimated by visual inspection of plotted data. Uncertainties in the calculated ventilation rates due to inaccurate baseline measurements are examined by performing a sensitivity analysis with upper and lower bounding values for the baseline concentration (in addition to the best estimate).

Table S.1 lists the tanks considered in this report and the range of estimated ventilation rates obtained for each tank. When multiple events of above-normal hydrogen releases were observed, the range of estimated ventilation rates is given. Resulting values and their variability are consistent with those determined using tracer gases.

Table S.1. Estimated Ventilation Rates Based on SHMS Hydrogen Data

Tank	Ventilation Rate (m ³ /h)	No. of Events	Tank	Ventilation Rate (m ³ /h)	No. of Events
A-101	12-20	11	SX-103 ^(a)	--	none
AX-101	25-71	7	SX-104 ^(a)	--	none
AX-103	122	8	SX-105 ^(a)	25-133	4
BY-103	22-27	2	SX-106 ^(a)	10-108	7
BY-105	--	none	SX-109 ^(a)	--	none
BY-106	6-14	2	T-110	--	none
BY-109	8.1-42	2	U-103	3.5-18	14
S-102	7.3	1	U-105	5.9-47	12
S-111	2.7-26	10	U-107	7.5-47	3
S-112	--	none	U-108	3.7-8.7	7
SX-101 ^(a)	--	none	U-109	4.0-11	7
SX-102 ^(a)	--	none			

(a) Actively ventilated.

References

Huckaby JL, JC Evans, KB Olsen, KM Remund, and DS Sklarew. 1997. *Measurements of Waste Tank Passive Ventilation Rates Using Tracer Gases*. PNNL-11683, Pacific Northwest National Laboratory, Richland, Washington.

Huckaby JL, JC Evans, DS Sklarew, and AV Mitroshkov. 1998. *Waste Tank Ventilation Rates Measured with a Tracer Gas Method, Fiscal Year 1998 Summary*. PNNL-11925, Pacific Northwest National Laboratory, Richland, Washington.

Wilkins NE, RE Bauer, and DM Ogden. 1997. *Results of Vapor Space Monitoring of Flammable Gas Watch List Tanks*. HNF-SD-WM-TI-797, Lockheed Martin Hanford Corporation, Richland, Washington.

Acknowledgments

The authors thank Nancy Wilkins for supplying the SHMS data and calibration dates.

Contents

Summary	iii
Acknowledgments	v
1.0 Introduction	1
2.0 Method Description	3
3.0 Results	5
4.0 Discussion of Results	11
4.1 Comparison with Tracer Ventilation Rate Data	11
4.2 Comparison with Data in Wilkins et al. (1997)	11
4.3 Association of Gas Releases with Barometric Pressure Changes	11
5.0 References	13

Figures

1 Plot of Hydrogen Concentration Versus Time after Above-Normal Hydrogen Release in Tank U-103	6
2 Plot of Hydrogen Concentration Versus Time after Above-Normal Hydrogen Release in Tank U-105	6

Tables

1 Single-Shell Tanks Equipped with SHMS	2
2 Headspace Volumes and Dates of SHMS Data	4
3 Ventilation Rates by Tank and Gas Release Event	8
4 Comparison of Ventilation Rates with Values from Huckaby et al. (1997, 1998)	11
5 Comparison of Ventilation Rates with Values from Wilkins et al. (1997)	12

1.0 Introduction

Ventilation with the atmosphere is used to prevent accumulation of waste gases and vapors in the headspaces of the 177 high-level radioactive waste tanks at the Hanford Site in Southeastern Washington State. Mechanical exhausters are used to ensure sufficient airflow through the headspaces of 45 tanks, but the other 132 tanks are only passively ventilated with the atmosphere. Measurements of passive ventilation rates are needed for the resolution of several key safety issues associated with the rates of flammable gas production and release, the rates at which organic salt-nitrate salt mixtures dry out, and the estimation of the surface areas of organic liquid waste in the tanks.

Direct measurement of passive ventilation rates in the waste tanks using mass flow meters is impractical because ventilation occurs via multiple pathways to the atmosphere as well as through underground connections to other tanks that are difficult to access. A tracer gas method discussed in Huckaby et al. (1997, 1998) provides direct measurements of the rates at which gases are removed by ventilation and indirect measurements of the ventilation rates. The tracer method has been successfully applied to 14 tanks but requires significant fieldwork and laboratory sample analysis for each tank studied.

This report discusses and applies a method for estimating the ventilation rates of tanks equipped with the Standard Hydrogen Monitoring System (SHMS). Tank headspace hydrogen concentrations measured by the SHMS are observed to occasionally increase rapidly, then decrease logarithmically back to their steady-state values. The rapid increase in hydrogen concentration is thought to indicate that a relatively large amount of hydrogen has been released by the waste over a short time period. Hydrogen concentrations return to their normal values after the release is over, because the rate of hydrogen removal by ventilation temporarily exceeds the normal hydrogen release rate. Provided certain physical conditions are met (e.g., the headspace is well mixed), the logarithmic decrease in hydrogen concentration can be used to estimate the ventilation rate of the headspace during that time period. Wilkins et al. (1997) applied this method to 12 tanks and found their results were consistent with those from tracer gas studies.

In this study the hydrogen data from 23 single-shell tanks (SSTs) equipped with SHMS were examined for evidence of sudden releases, and significant release events were analyzed to estimate the ventilation rate of the tank. Table 1 lists the 23 SSTs considered in this report and designates each tank as either passively or actively ventilated. ^(a)

This report reexamines the results of Wilkins et al. and applies the method to all SST SHMS data available through July 12, 1998. A brief summary of the operating principles and specifications of the SHMS may be found in Section 2, and the mathematical interpretation of SHMS data is described in Section 3. Results obtained are discussed and compared with those obtained by the tracer gas method and Wilkins et al. (1997) in Section 4. Section 5 contains the cited references.

(a) Twelve double-shell tanks also have a SHMS, but all are actively ventilated, and their ventilation rates are periodically measured by direct methods.

Table 1. Single-Shell Tanks Equipped with SHMS

Passively Ventilated	Actively Ventilated
A-101	SX-101
AX-101	SX-102
AX-103	SX-103
BY-103	SX-104
BY-105	SX-105
BY-106	SX-106
BY-109	SX-109
S-102	
S-111	
S-112	
T-110	
U-103	
U-105	
U-107	
U-108	
U-109	

2.0 Method Description

The method for estimating ventilation rates from transient changes in the headspace hydrogen concentration relies on data from the SHMS. The SHMS consists of a temperature-controlled cabinet containing an air pump, piping, various types of instrumentation, intake and outlet probes that collect and return headspace air, and a variety of associated equipment. All the SHMS on the tanks listed in Table 1 contain a Whittaker electrochemical cell that is used to measure hydrogen on-line in the tank headspaces. The Whittaker electrochemical cell is based on the reduction of a metallic oxide (e.g., HgO or Ag₂O) and the oxidation of H₂. The net reaction is

A Whittaker cell contains a Kapton (polyamide) diffusion barrier that covers the hydrogen electrode, minimizing interferences from oxidizing agents such as NO₂, NO, N₂O, and unsaturated organics. The cell generates an electrical signal proportional to the hydrogen concentration (vol%) that is processed by a transmitter and sent to a data recorder. More detailed information may be found in Wilkins (1995). The cell is linear for hydrogen up to three orders of magnitude. As set up in the field, the detection limit is about 100 ppmv. Measurement accuracy is about ± 0.15 vol% with a resolution of 0.005 vol% (50 ppmv). Typically, two Whittaker cells are set up to cover both a low range, 0–1 vol% H₂, and a high range, 0–10 vol%. A mid-range standard of 1,000 ppmv H₂ is used for online calibration. Interferences with other gases such as ammonia, methane, nitrous oxide, or water vapor do not appear to be a problem (Schneider 1993).

The SHMSs were installed in March 1995 for many of the tanks listed in Table 1; installation occurred later for several tanks. Problems with condensation of water vapor have limited the operation of the SHMS on Tanks A-101 and AX-101, and problems with ammonium nitrate formation have limited SHMS operation on Tank AX-103 (Wilkins et al. 1997). Dates for which data are available for each tank are listed in Table 2, along with their headspace volumes.

Table 2. Headspace Volumes and Dates of SHMS Data

Tank	Estimated Headspace Volume (m³)	Dates SHMS Data Available
A-101	1,177	01/15/98 – 07/12/98
AX-101	1,953	11/15/96 – 03/15/97 07/31/97 – 08/05/97
AX-103	4,360	11/22/96 – 12/02/96 07/31/97 – 08/01/97
BY-103	2,467	09/30/95 – 07/12/98
BY-105	2,078	04/20/98 – 07/12/98
BY-106	1,551	09/30/95 – 07/12/98
BY-109	2,380	09/30/95 – 07/12/98
S-102	1,903	08/21/95 – 05/24/96
S-111	1,726	08/21/95 – 07/13/98
S-112	2,002	08/21/95 – 07/13/98
T-110	1,805	01/04/96 – 07/12/98
U-103	1,468	08/21/95 – 05/24/96 11/19/96 – 07/12/98
U-105	1,657	08/21/95 – 04/14/98
U-107	1,703	08/21/95 – 07/12/98
U-108	1,468	08/21/95 – 07/12/98
U-109	1,487	08/21/95 – 07/12/98
SX-101	3,106	08/21/95 – 07/12/98
SX-102	2,776	08/21/95 – 06/03/96
SX-103	2,364	08/21/95 – 08/12/97 06/08/98 – 07/12/98
SX-104	2,508	08/21/95 – 07/12/98
SX-105	2,246	08/21/95 – 07/12/98
SX-106	2,795	08/21/95 – 07/12/98
SX-109	3,908	08/21/95 – 07/12/98

3.0 Results

Gas release events were defined as an increase in hydrogen concentration in the headspace from the steady-state level followed by a decrease back to the steady-state level (Wilkins et al. 1997). Data were obtained from the Tank Farm Monitoring and Data Acquisition System (TMACS). Gas release events were identified by visually inspecting a plot of hydrogen concentration versus time for rapid increases in hydrogen concentration that were followed by a gradual decrease. An example of a SHMS data set that exhibits this feature is plotted in Figure 1. As shown in this figure, the hydrogen concentration in Tank U-103 rose to a maximum on February 20, 1996, then returned to a more or less normal concentration by mid-March.

To calculate ventilation rates, it was necessary to calculate the rate of hydrogen decay after its concentration peaked. A mass balance on the hydrogen in the headspace gives

$$\frac{dC}{dt} = -\frac{v}{V}C + R \quad (3.1)$$

where C is the hydrogen concentration, v is the volumetric ventilation rate, V is the headspace volume, R is the rate at which hydrogen is released from the waste, and t is time. Assuming the ventilation and hydrogen release rates are approximately constant after a hydrogen release event, the hydrogen concentration will decrease and approach its steady state (baseline) value, C^* . At steady state

$$\frac{dC}{dt} = 0 \quad (3.2)$$

so, from equation (3.1),

$$R = \frac{v}{V}C^* \quad (3.3)$$

Substitution of this expression into equation (3.1) and integration of the result yields

$$\ln(C - C^*) = -\frac{v}{V}t + \ln(C_0 - C^*) \quad (3.4)$$

Here C_0 is the peak hydrogen concentration of a gas release event, and t has been chosen so that $t = 0$ when $C = C_0$. Note that equation (3.4) is in the form of a line with dependent variable $\ln(C - C^*)$, independent variable t , slope v/V , and intercept $\ln(C_0 - C^*)$. Linear regression of $\ln(C - C^*)$ versus t data can be used to obtain a best average value for v/V .

Determination of C^* was accomplished by visually inspecting plots of C versus t data and choosing a "best estimate." Because the consistency of hydrogen concentration data varied among tanks and dates, the accuracy with which C^* could be specified also varied. Figures 1 and 2 illustrate typical problems associated with the data and the difficulty of unambiguously determining C^* . Though the large peak in Figure 3.1 is relatively well defined, the concentration of hydrogen begins to rise again (around mid-March) before a true baseline concentration is established after the event. The C^* used in calculations is indicated by a horizontal line in Figure 1. In Figure 2, the hydrogen concentration in Tank U-105 has been plotted for the same time period as in Figure 1. In this tank, the hydrogen concentration is observed to fluctuate somewhat erratically. (The noise prominent in the data on the right side of Figure 2 is thought to be due to sunlight passing through the SHMS cabinet window.) Given the fluctuations in hydrogen

Figure 1. Plot of Hydrogen Concentration Versus Time after Above-Normal Hydrogen Release in Tank U-103

Figure 2. Plot of Hydrogen Concentration Versus Time after Above-Normal Hydrogen Release in Tank U-105

concentration, it is particularly hard to estimate C^* in Tank U-105. For the hydrogen peak occurring on February 7, 1998, C^* has been indicated by a horizontal line.

To estimate the uncertainties in calculated ventilation rates due to the uncertainty in C^* , upper and lower bounding values for C^* were estimated (again by visual inspection of the plotted data) and used to calculate upper and lower bounding values for the ventilation rate. In some cases, the best estimate for C^* corresponded to the upper or lower bound of the ventilation rate.

This approach was applied to each set of hydrogen versus time data associated with a hydrogen release event. Regression residuals were generated and used to statistically identify outlier data. Specifically, if the magnitude of the standardized residual was greater than 2 for a given data point, that point was eliminated from the data set, and the regression analysis was performed again. This was repeated until no outliers were identified, or until the change in slope was insignificant (usually no more than four times). (In a few cases in which a large number of data points were present and the data fluctuated significantly, the presence of a few outliers had little effect on the regression, and the outliers were ignored.) This criterion identifies data that are greater than two standard deviations from the best-fit line as outliers.

Equations (3.1) and (3.2) assume that the headspace is well mixed following a gas release event (which is reasonable based on Huckaby et al. 1997). Potential sources of error include determining exactly what constitutes a gas release event and determining the peak and endpoint of the event. Because the magnitude of the concentration difference between the peak and the endpoint was frequently small, as low as 0.01 vol% hydrogen, the error introduced by misjudging the beginning and end of the event could be significant.

The passively ventilated tanks for which gas release events were identified are listed in Table 3, along with calculated ventilation rates. Ventilation rates were also tabulated for seven actively ventilated tanks, SX-101, SX-102, SX-103, SX-104, SX-105, SX-106, and SX-109, for comparison. Tanks BY-105, S-112, T-110, SX-101, SX-102, SX-103, SX-104, and SX-109 did not appear to have peaks that met the criterion for gas release events. Ventilation rates were calculated with equation (3.4) and headspace volumes given in Table 2. Data collected on dates that the SHMSs were calibrated or dates with known system problems were eliminated from consideration.

Table 3. Ventilation Rates by Tank and Gas Release Event

Tank	Gas Release Event Dates ^(a)	Hydrogen Baseline Concentration ^(b) (vol %)	Calculated Ventilation Rate (m ³ /h)		
			Lower Bound	Best Estimate	Upper Bound
A-101	02/04/98 – 02/12/98	0 (-.002,.002)	12	13	14
	02/15/98 – 02/20/98	0 (-.002,.002)	13	14	15
	02/21/98 – 03/02/98	0 (-.002,.002)	11	13	16
	03/13/98 – 03/20/98	0 (-.002,.001)	10	13	16
	03/25/98 – 04/01/98	0 (-.002,.001)	11	13	14
	04/11/98 – 04/20/98	-.002 (-.003,0)	11	12	13
	04/23/98 – 04/28/98	-.003 (-.005,0)	15	19	20
	05/06/98 – 05/10/98	.007 (.003,.010)	9.6	12	14
	05/12/98 – 05/18/98	.007 (.003,.010)	13	18	23
	06/10/98 – 06/15/98	.007 (.003,.010)	15	18	22
	06/25/98 – 06/28/98	.014 (.010,.018)	17	20	25
AX-101	12/04/96 – 12/08/96	.022 (.020,.026)	21	25	42
	12/10/96 – 12/14/96	.022 (.020,.026)	30	35	58
	12/27/96 – 12/30/96	.022 (.020,.026)	32	40	80
	01/01/97 – 01/05/97	.022 (.020,.025)	33	47	71
	01/25/97 – 01/28/97	.022 (.020,.024)	29	42	67
	02/12/97 – 02/13/97	.022 (.019,.024)	56	56	83
	02/16/97 – 02/18/97	.021 (.019,.023)	54	69	96
	02/26/97 – 03/01/97	.018 (.015,.020)	48	71	71
AX-103	11/21/96 – 11/26/96	.013 (.010,.015)	82	122	163
BY-103	12/28/95 – 01/01/96	.007 (.004,.012)	18	22	33
	12/30/96 – 01/04/97	.002 (-.001,.005)	20	27	40
BY-106	12/04/97 – 12/11/97	.003 (.001,.007)	12	14	17
	12/25/97 – 01/11/98	.003 (0,.005)	5.2	6.0	6.3
BY-109	02/08/96 – 02/14/96	-.006 (-.014,-.001)	30	42	58
	09/09/97 – 09/15/97	.02 (-.014,-.004) ^(c)	5.1	8.1	8.1
S-102	12/22/95 – 01/03/96	.043 (.024,.067)	5.3	7.3	14
S-111	11/09/95 – 11/24/95	.013 (0,.020)	2.1	2.7	3.2
	12/04/95 – 12/11/95	.013 (0,.020)	3.8	4.9	5.9
	12/14/95 – 01/15/96	.013 (0,.020)	3.4	4.4	5.4
	02/21/96 – 02/26/96	0 (-.004,.001)	15	26	26
	01/02/97 – 02/03/97	.0001 (0,.002)	6.1	6.2	6.9
	10/13/97 – 10/25/97	.015 (.009,.017)	8.4	14	14
	11/03/97 – 11/17/97	.0001 (0,.008)	3.8	4.0	6.7
	02/06/98 – 02/14/98	.025 (.013,.030)	7.1	7.1	20
	02/21/98 – 03/02/98	.020 (.013,.027)	3.3	4.5	4.5
	05/14/98 – 05/26/98	0 (-.008,.004)	10	18	19
S-112	None				
T-110	None				

Table 3 (contd)

Tank	Gas Release Event Dates ^(a)	Hydrogen Baseline Concentration ^(b) (vol%)	Calculated Ventilation Rate (m ³ /h)		
			Lower Bound	Best Estimate	Upper Bound
U-103	11/08/95 – 11/11/95	.0008 (.0004,.012)	17	17	18
	11/25/95 – 11/27/95	.002 (0,.008)	17	18	23
	12/12/95 – 12/26/95	-.020 (-.030,-.008)	4.7	5.4	6.6
	02/20/96 – 02/28/96	-.030 (-.045,-.015)	7.3	9.1	12
	12/10/96 – 12/19/96	.021 (.017,.023)	1.7	7.7	8.7
	02/17/97 – 02/25/97	.020 (.014,.025)	5.5	7.0	9.0
	02/27/97 – 03/14/97	.018 (.010,.020)	3.8	4.8	5.2
	03/16/97 – 03/29/97	.018 (.010,.020)	2.8	3.5	3.8
	08/15/97 – 08/29/97	.1 (.090,.11)	3.9	6.6	8.9
	11/01/97 – 11/08/97	.06 (.057,.066)	13	13	19
	12/08/97 – 12/18/97	.051 (.036,.056)	7.0	13	19
	01/02/98 – 01/11/98	.052 (.035,.063)	6.7	10	18
	02/22/98 – 03/08/98	.054 (.050,.064)	6.3	8.0	14
	05/13/98 – 05/23/98	.065 (.059,.0710)	4.5	5.6	7.3
	12/12/95 – 01/03/96	-.002 (-.008,.001)	4.9	5.9	6.8
U-105	02/07/96 – 02/13/96	.006 (0,.012)	22	23	34
	02/20/96 – 03/02/96	.003 (0,.011)	11	11	16
	11/20/96 – 12/03/96	.050 (.040,.060)	5.5	6.4	8.4
	12/10/96 – 12/17/96	.050 (.040,.060)	12	18	22
	12/18/96 – 12/23/96	.050 (.040,.060)	18	25	47
	01/10/97 – 01/11/97	.050 (.040,.060)	31	47	104
	02/17/97 – 02/25/97	.011 (.008,.015)	8.0	9.3	12
	02/27/97 – 03/14/97	.011 (.007,.015)	8.0	11	11
	05/19/97 – 05/30/97	.017 (0,.018)	7.7	27	30
	12/10/97 – 12/30/97	0 (-.002,.006)	7.4	8.1	9.8
	01/02/98 – 01/11/98	0 (-.002,.003)	6.2	6.4	6.8
	12/13/95 – 12/24/95	-.005 (-.010,-.001)	8.2	9.5	11
U-107	02/21/96 – 03/01/96	-.009 (-.011,-.002)	7.0	7.5	9.7
	12/28/96 – 12/31/96	.039 (.034,.042)	44	47	49
	04/05/97 – 04/11/97	.008 (0,.02)	22	24	28
	04/15/97 – 04/20/97	.008 (0,.02)	10	12	14
	11/08/95 – 11/21/95	-.035(-.037,-.032)	6.4	7.5	7.6
U-108	12/13/95 – 12/31/95	.023 (.016,.027)	5.2	6.2	7.1
	09/13/96 – 09/23/96	.040 (.030,.060)	6.3	7.5	7.5
	11/20/96 – 12/01/96	.040 (.038,.050)	4.0	4.1	4.7
	12/10/96 – 12/19/96	.040 (.038,.050)	3.6	3.7	4.4
	01/01/97 – 01/13/97	.06 (.045,.065)	5.1	8.7	11
	01/02/98 – 01/29/98	.04 (.034,.044)	4.3	5.3	6.7
	12/13/95 – 12/20/95	.140 (.135,.150)	6.0	6.6	8.2
U-109	01/19/96 – 01/24/96	.090 (.085,.093)	11	11	12
	02/22/96 – 02/25/96	.056 (.050,.060)	5.0	5.8	6.4
	10/26/96 – 10/29/96	Strange shape	Eliminate		
	11/20/96 – 12/01/96	0 (-.004,.003)	3.7	4.0	4.2
	12/11/96 – 12/20/96	.028 (.021,.037)	5.8	8.0	11
	01/12/97 – 01/18/97	0 (-.004,.008)	7.8	8.7	9.8
	01/02/98 – 01/10/98	.091 (.067,.098)	3.7	6.8	8.8

Table 3 (contd)

Tank	Gas Release Event Dates ^(a)	Hydrogen Baseline Concentration ^(b) (vol%)	Calculated Ventilation Rate (m ³ /h)		
			Lower Bound	Best Estimate	Upper Bound
SX-101	None				
SX-102	None				
SX-103	None				
SX-104	None				
SX-105	12/12/95 – 12/13/95	-.010 (-.015,-.007)	111	133	151
	12/28/96 – 01/08/97	.019 (.015)	20	25	
	08/19/97 – 08/21/97	.009 (.004,.014)	57	75	119
	02/17/98 – 02/23/98	.009 (.007,.011)	33	42	48
SX-106	10/26/95 – 11/3/95	-.017(-.021,-.015)	16	10	25
	12/12/95 – 12/13/95	-.028 (-.031,-.024)	60	64	70
	02/20/96 – 02/24/96	-.034(-.037,-.029)	45	86	86
	11/19/96 – 11/21/96	-.001 (-.002,0)	73	82	94
	12/10/96 – 12/12/96	-.003 (-.005,0)	69	97	97
	08/17/97 – 08/28/97	0 (-.004,.003)	13	14	17
	01/01/98 – 01/02/98	-.007 (-.01,-.006) strange shape	89	108	117
SX-109	None				
(a) From peak H ₂ concentration to endpoint. (b) Best estimate (lower and upper bounds). (c) Calibration seemed to jump; best estimate is upper bound.					

4.0 Discussion of Results

4.1 Comparison with Tracer Ventilation Rate Data

A comparison of the ventilation rates obtained from an analysis of the SHMS data with that obtained from tracer studies is shown in Table 4. While SHMS data are available for 23 SSTs, and tracer data are available for 14 SSTs, the overlap of both types of data occur for only five tanks. The SHMS data predates the tracer data in all cases, so comparison of ventilation rates for the same time periods is not possible. However, no recent configuration changes that would have affected the ventilation rates of these tanks were identified, so a comparison is still reasonable. The average values are within a factor of three for S-102, U-103, and U-105, and within a factor of 5 for AX-103, though the tracer results are consistently lower than the SHMS results. The ventilation rate ranges for these four tanks from the two independent methods exhibit a fair degree of overlap, especially if the lower and upper bounds of the SHMS data are included.

Table 4. Comparison of Ventilation Rates with Values from Huckaby et al. (1997, 1998)

Tank	Ventilation Rate (m ³ /h)	
	SHMS method ^(a)	Tracer method*
AX-103	122	20-42 (25)
S-102	7.3	2.1-5.7 (3.6)
U-103	3.5-18 (9.3)	2.2-5.7 (3.6)
U-105	5.9-47 (16)	7.4-8.8 (8.5)
(a) Range of data is given; number in () is average of all available data (best estimates for SHMS data).		

4.2 Comparison with Data in Wilkins et al. (1997)

Ventilation rates obtained by Wilkins et al. (1997) from SHMS data are compared with the current results in Table 5. A few of the values reported in Wilkins et al. were considered in this report to be from events that were too weak, had the wrong peak shape, or had data that were too scattered to be useful. The subjectivity associated with using the SHMS data to estimate ventilation rates is reflected in the differences between the results of this study and of Wilkins et al. It is also not clear from their discussion that Wilkins et al. included the C^* terms in equation (3.4) in their analysis, and some of the disagreement between results listed in Table 5 may be associated with this problem.

4.3 Association of Gas Releases with Barometric Pressure Changes

It has been observed that gas releases in the SSTs were associated with changes in barometric pressure (Wilkins et al. 1997). A decrease in pressure would be expected to decrease the solubility of hydrogen (and other gases) in the waste and allow trapped gas bubbles to expand and rise. A decrease in barometric pressure can thus serve as the impetus for a significant hydrogen release, and approximately two-thirds of the hydrogen releases examined in this study did occur when the barometric pressure was dropping or had reached a minimum. However, that one-third of the hydrogen releases studied occurred while the barometric pressure was rising suggests the correlation is not very strong, and many decreases in barometric pressure do not trigger significant gas releases.

Table 5. Comparison of Ventilation Rates with Values from Wilkins et al. (1997)

Tank	Date	Ventilation Rate (m ³ /h)	
		This study	Wilkins et al. (1997)
BY-109	2/96	42	59
S-102	12/95	SHMS pump off	24
	12/95	7.3	5
S-111	11/95	2.7	3
	12/95	4.9	7
	12/95	4.4	7
	2/96	26	7
S-112	1/96	none	7
U-103	10/95	none	4
	11/95	17, 18	12
	12/95	5.4	3
	2/96	9.1	19
U-105	12/95	5.9	15
	2/96	23, 11	8
U-107	12/95	9.5	8
	2/96	7.5	5
U-108	10/95	none	5
	11/95	7.5	7
	12/95	6.2	5
U-109	9/95	too weak	7
	10/95	too weak	8
	12/95	6.6	3
SX-104	12/95	none	51
	2/96	none	34
SX-105	12/95	133	170
	12/96	25	68
SX-106	10/95	20	51
	12/95	64	85
	2/96	86	59
SX-109	12/95	none	51

5.0 References

Huckaby JL, JC Evans, KB Olsen, KM Remund, and DS Sklarew. 1997. *Measurements of Waste Tank Passive Ventilation Rates Using Tracer Gases*. PNNL-11683, Pacific Northwest National Laboratory, Richland, Washington.

Huckaby JL, JC Evans, DS Sklarew, and AV Mitroshkov. 1998. *Waste Tank Ventilation Rates Measured with a Tracer Gas Method, Fiscal Year 1998 Summary*. PNNL-11925, Pacific Northwest National Laboratory, Richland, Washington.

Schneider TC. 1993. *Whittaker Standard Hydrogen Monitoring Cell Interference Test Report*. WHC-SD-WM-TRP-135, Westinghouse Hanford Company, Richland, Washington.

Wilkins NE. 1995. *Results of Gas Monitoring of Double-Shell Flammable Gas Watch List Tanks*. WHC-SD-WM-TI-682, Lockheed Martin Hanford Corporation, Richland, Washington.

Wilkins NE, RE Bauer, and DM Ogden. 1997. *Results of Vapor Space Monitoring of Flammable Gas Watch List Tanks*. HNF-SD-WM-TI-797, Lockheed Martin Hanford Corporation, Richland, Washington.

Distribution

**No. of
Copies**

Offsite

**2 DOE Office of Scientific and Technical
Information**

H. Babad
2540 Cordoba Court
Richland, WA 99352

H.K. Fauske
Fauske and Associates, Inc.
16W070 W. 83rd St.
Burr Ridge, IL 60521

B. C. Hudson
P.O.Box 271
Lindsborg, KS 67456

J.L. Kovach
P.O. Box 29151
70000 Huntley Road
Columbus, OH 43229

T.S. Kress
102-B Newridge Road
Oak Ridge, TN 37830

T.E. Larson
2711 Walnut St.
Los Alamos, NM 87545

D.A. Powers
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185

**No. of
Copies**

Onsite

5 DOE Richland Operations Office

S.O. Branch	S7-54
C. A. Groendyke	S7-54
W.F. Hendrickson	S7-54
D.H. Irby	S7-54
J.A. Poppitti	S7-54

23 PHMC Team

S.A. Barker	R2-11
G.S. Barney	T5-12
W.B. Barton	R2-12
R.E. Bauer	S7-73
R.J. Cash	S7-73
J.M. Grigsby	S7-14
D.C. Hedengren	R2-11
K.M. Hodgson	R2-11
T.A. Hu	R2-11
G.D. Johnson	S7-73
N.W. Kirch	R2-11
J.G. Kristofzski	R2-12
J.E. Meacham (3)	S7-73
D.J. McCain	R2-12
M.A. Payne	R2-58
D.A. Reynolds	R2-11
L.M. Sasaki	R2-12
L.M. Stock	S7-14
J. Schofield	S7-12
D.T. Vladimiroff	S7-20
A.B. Webb	R1-44

**No. of
Copies**

**No. of
Copies**

30 Pacific Northwest National Laboratory

S.Q. Bennett	K7-90
J.W. Brothers (5)	K9-20
R.T. Hallen	P8-38
J. L. Huckaby (10)	K6-80

L.M. Peurrung	P7-41
D.S. Sklarew (5)	K6-96
C.W. Stewart	K7-15
W.C. Weimer	P7-27
Information Release (5)	K6-01