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Seasonal Changes in the Composition of Passively Ventilated Waste Tank Headspace

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Executive Summary

The headspaces of four passively ventilated high-level radioactive waste tanks were sampled five times over a one-year period to evaluate seasonal changes in composition. Tanks BX-104, BY-108, C-107, and SX-102 ^(a) were selected for the study on the bases of their widely varying headspace compositions, waste types, and physical headspace conditions. Samples were collected and analyzed for inorganic vapors, permanent gases, and organic vapors.

Data from the 20 sampling events were compiled and reviewed. Raw mass spectral data for organic vapors were reprocessed by a single analyst. Measurement precision for results within individual sampling events, which includes both sampling and analytical random errors, was generally within the requirement of a 25% relative standard deviation.

Data were fit to an analysis of variance (ANOVA) model and tested for correlation with headspace temperature. The ANOVA results indicate that the majority of headspace constituents studied were at relatively constant levels during the year-long study. The percent relative standard deviation (RSD_{TIME}) of analyte means obtained for the five sampling events were generally low; only 15 of the 152 analytes had RSD_{TIME} values above 60%. These highest RSD_{TIME} values were obtained for 13 organic vapors in Tank BX-104 and two permanent gases in Tank C-107.

Concentrations of the principal waste gases and vapors, i.e., ammonia, hydrogen, nitrous oxide, and water, were limited to relatively narrow ranges. The RSD_{TIME} values for ammonia and water vapors were less than 20 %. Hydrogen and nitrous oxide had RSD_{TIME} values of less than 40% for Tanks BX-104, BY-108, and C-107, but as high as 70% in Tank C-107. The larger RSD_{TIME} values for these two gases in Tank C-107 are associated with gradual concentration increases of both gases in Tank C-107, a relatively hot, radiolytically active tank.

The most significant seasonal differences in organic vapor composition were observed in Tank BX-104. In this tank, the concentrations of many organic vapors were significantly higher in August 1996 than in the subsequent sampling events. Higher concentrations of individual organic species were measured in both triple sorbent trap and SUMMA canister samples. Though ammonia and nitric oxide were also observed at elevated levels in the August 1996 samples, hydrogen and nitrous oxide were not. These data do not clearly indicate any single cause for the elevated concentrations observed.

The correlation between headspace concentration and temperature was evaluated for each of the analytes. Only 28 of the 152 analytes considered had concentrations correlated with temperature at the 0.05 significance level. In general, seasonal changes in headspace organic vapor concentrations appear to be small compared with sampling and analytical errors. Therefore, adjustments of individual organic vapor concentrations for seasonal effects are generally not warranted.

(a) Tanks are officially designated with the prefix 241-. In this report the prefix has been dropped as it is in common usage.

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1.0 Introduction

1.1 Background

The gases and vapors in the Hanford Site high-level radioactive waste tanks are being characterized to resolve tank safety and industrial hygiene issues and to facilitate estimation of regulated air pollutant emissions (Brown et al. 1997). Characterization is accomplished by collecting and analyzing a set of headspace air samples.

Headspace characterization data are generally accepted as quantitatively valid for the time at which the samples were collected, but tank headspace compositions can change with time, and measurements made at one time may not be valid at other times. Headspace compositions are expected to change due to changes in tank chemistry, temperature, and ventilation rate. Seasonal changes in the headspace and waste temperatures, for example, can affect the rates of production, evaporation or desorption, and removal of many headspace constituents.

Prior to this study, only limited data were available to evaluate temporal headspace composition changes. Consideration of the physical isolation of the tanks and data that are available (primarily that from Tank C-103) (Huckaby and Story 1994) suggest that the tank headspaces do not change significantly from day to day.^(a) Seasonal and long-term changes in tank conditions, however, could have significant effects on the headspace composition, and very few pertinent data have been available to evaluate such effects.

This study evaluates the changes in headspace composition that occur during a one-year period using characterization data obtained from four passively ventilated tanks. Each tank was sampled at approximately three-month intervals. The characterization data have been compiled and analyzed by standard statistical methods to ascertain the magnitude and consistency of seasonal headspace composition changes.

1.2 Headspace Composition Changes

Waste tank headspace composition is the result of dynamic processes in the tank gas and condensed phases and is affected by the environment outside the tank. Whether the concentration of a constituent is increasing or decreasing in the headspace depends upon whether the processes that increase its concentration are faster than the processes that decrease its concentration. The primary removal processes have rates that increase linearly with the concentration of a constituent; therefore, the system is self-limiting, and concentrations tend toward a steady-state value.

Processes associated with the release of gases and vapors into the headspace include reactions that produce constituents (e.g., radiolysis of water to produce hydrogen, hydrolysis of tributyl phosphate to produce n-butanol), mass transfer of the constituents from their origin to the surface of the waste, and mass

(a) Significant short-term changes can occur due to the sudden release of trapped gases or to the use of, or a change in, an active ventilation system. These are not addressed in this study.

transfer across the waste phase-gas phase interface (i.e., desorption of dissolved gases and vapors, evaporation of liquids). Processes associated with the removal of gases and vapors from the headspace include radiolytic and chemical decomposition in the gas phase, absorption or condensation at the waste phase-gas phase interface, and bulk removal by ventilation of the headspace.

To the extent that these release and removal process rates are constant (or undergo change), the steady-state concentration of a constituent will likewise be constant (or change correspondingly). Waste tank headspace conditions tend to be relatively constant because the tanks are underground and thermally insulated from ambient temperature fluctuations. The tanks are generally not disturbed by intrusive activities or by the addition of new waste. Though it is not possible now to rule out all other factors, the two factors that are thought to have the most direct effects on the headspace composition are changes in temperature and ventilation rate.

Headspace temperatures are almost constant from one day to the next and vary only a few degrees about their mean during an entire calendar year, even though ambient temperature variations are many times larger. Headspace temperatures follow a sinusoidal pattern, being highest in October or November and lowest in April or May. This annual cycle is illustrated in Figures 1.1, 1.2, and 1.3, where the headspace temperatures of Tanks BY-108, C-107, and S-102 have been plotted as a function of date. Headspace (and waste) temperatures reach their maximums in fall because ground temperatures near the concrete tank dome are highest at that time. Similarly, headspace temperatures are lowest in the spring, because ground temperatures are at their annual minimum in spring.

Passive ventilation rates are affected by the difference between the headspace and ambient air temperatures, and consequently change with seasonal temperature changes. If this is a significant factor for a given tank, ventilation rates will be lower in the summer and higher in the winter. The concentrations of waste gases and vapors in the headspace of such a tank would be expected to rise correspondingly in summer and fall in winter, as the rate of removal of waste species by ventilation is reduced and increased, respectively. Other seasonally dependent factors may affect passive ventilation rates, such as seasonal winds that enhance ventilation and snow and ice cover, which may reduce ventilation leak pathways.

1.3 Selection of Study Tanks

Tanks BX-104, BY-108, C-107, and S-102 were selected as the subjects of this study. A partial list of the parameters considered in the selection of these four tanks is given in Table 1.1. These tanks were chosen for their diversity, so that to the extent possible, the observations from these tanks can be used to predict the behavior other tanks.

Tank C-107 is a hot, very high humidity, sludge tank with relatively low concentrations of organic vapors and the three principal waste gases (hydrogen, ammonia, and nitrous oxide). Tank BY-108 has the highest concentrations of ammonia of any tank that has been sampled, and the second highest total organic vapor concentration. Tank S-102 has primarily saltcake waste, relatively high concentrations of hydrogen and nitrous oxide, and moderate levels of organic vapors. Tank S-102 was also selected as a representative of 200 West farm tanks, which tend to have a higher proportion of volatile alcohols. Tank BX-104 was chosen because it is relatively cool, and, based on previous vapor sampling, it appeared to have either an unexpectedly high ventilation rate or a very dry surface. The concentration of organic vapors in Tank BX-104 is also relatively high.

Figure 1.1. Tank BY-108 Headspace Temperature

Figure 1.2. Tank C-107 Headspace Temperature

Figure 1.3. Tank S-102 Headspace Temperature

Table 1.1. Selection Criteria for Study Tanks

	BX-104^(a)	BY-108^(b)	C-107^(c)	S-102^(d)
Waste^(e)				
Sludge volume	96 kgal	154 kgal	237 kgal	4 kgal
Saltcake volume	0 kgal	74 kgal	0 kgal	545 kgal
Supernatant volume	3 kgal	0 kgal	0 kgal	0 kgal
Total waste volume	99 kgal	228 kgal	237 kgal	549 kgal
Headspace				
Volume	2,865 m ³	3,118 m ³	2,342 m ³	1,918 m ³
Temperature	22.8°C	25.7°C	45.9°C	24.3°C
Relative humidity	29 %	56 %	86 %	63 %
Hydrogen	< 94 ppmv	399 ppmv	< 80 ppmv	669 ppmv
Nitrous oxide	143 ppmv	641 ppmv	41 ppmv	509 ppmv
Ammonia	234 ppmv	1,040 ppmv	84 ppmv	412 ppmv
Carbon dioxide	74 ppmv	224 ppmv	654 ppmv	< 64 ppmv
Total organic vapors ^(f)	100 mg/m ³	510 mg/m ³	3.7 mg/m ³	9.4 mg/m ³
Notes	Very low humidity	NPH vapors very high	Carbon dioxide above ambient	Alcohol vapors very high
<p>(a) Tank BX-104 was sampled December 30, 1994. Headspace data from Huckaby and Bratzel (1995a). (b) Tank BY-108 was sampled October 27, 1994. Headspace data are from Huckaby and Bratzel (1995b). (c) Tank C-107 was sampled September 29, 1994. Headspace data are from Huckaby and Bratzel (1995c). (d) Tank S-102 was sampled March 14, 1995. Headspace data are from Huckaby and Bratzel (1995d). (e) Waste volumes are from Hanlon (1997). (f) Total organic vapor concentration values are from summation of individual constituents detected in triple sorbent traps analyzed by Oak Ridge National Laboratory (Huckaby and Bratzel 1995a, b, c, d).</p>				

1.4 Selection of Study Analytes

Seasonal and long-term composition changes in the tank headspaces could occur with any of the gases or vapors released by the waste. To determine whether such factors as compound volatility and source (i.e., evaporation or generation) have strong seasonal effects or not, it is important to examine all readily obtainable gas and vapor concentration data from the four selected tanks. The primary target compounds for this study were specified in the sampling and analysis plan (Buckley 1996) and are the same target analytes as specified for regular headspace characterization events.

2.0 Sample Collection and Analysis

2.1 Sampling Devices and Methods

Samples in this study were collected using either sorbent traps or SUMMA™ passivated canisters. Sorbent traps use adsorption or chemisorption to selectively remove vapors of interest from a metered amount of sample air. The analytes are extracted in the analytical laboratory, and the amount of each analyte is measured to determine its concentration in the sample air. Sorbent traps are effective for the inorganic vapors (e.g., ammonia, water) and many organic vapors but are not effective for permanent gases or highly volatile organic compounds. SUMMA passivated canisters are stainless steel vessels whose internal surfaces have been treated to minimize adsorption of vapors. In this study, evacuated SUMMA canisters were filled with headspace air and taken to the analytical laboratory for analysis. SUMMA canisters are effective for all permanent gases and non-polar organic vapors, and methods have been adapted to allow their use to measure certain semivolatile organic compounds and polar organic vapors.

Samples from Tank BX-104 were collected using the In Situ Vapor Sampling (ISVS) system. The ISVS system consists of an air pump and an accurate mass flow metering system to measure sorbent trap volumes and purge SUMMA canister transfer tubing. Sorbent trap samples are connected via narrow tubing to the ISVS manifold and lowered into the tank headspace to the desired elevation. SUMMA canister samples are collected via narrow perfluoroalkoxy (PFA) tubing that is lowered into the headspace to the desired elevation. The ISVS system has been demonstrated to be adequate for existing data needs (Huckaby et al. 1996).

Samples from Tanks BY-108, C-107, and S-102 were collected using the Vapor Sampling System (VSS). The VSS is a truck-mounted sampling platform that uses an air pump, accurate mass flow meters, and a heated stainless steel transfer tube and manifold to extract a stream of air from the tank headspace. Sorbent trap and SUMMA™ canister samples are collected directly from the manifold. Operation and testing of the VSS are discussed by Mahon et al. (1997).

2.2 Analytical Quality Assurance

All samples were analyzed by the PNNL Vapor Analytical Laboratory in accordance with *Hanford Analytical Services Quality Assurance Plan* (DOE 1995), *Quality Assurance Project Plan for Tank Vapor Characterization* (Keller 1994), and *Quality Assurance Plan for Activities Conducted by the Pacific Northwest National Laboratory Vapor Analytical Laboratory (VAL) and the Pacific Northwest National Laboratory Tank Vapor Characterization Project* (PNNL 1996).

2.3 Analytical Methods

2.3.1 Inorganic Vapors

Ammonia analyses were conducted on acidified carbon bead sorbent trap samples. Ammonia was removed from the sorbent media by liquid extraction and analyzed by an ion-specific electrode. Quality

control objectives were achieved using initial and continuing calibration verifications. Blank samples were run to detect the presence of contamination, and field samples were analyzed for comparative purposes.

Water vapor was measured by a gravimetric method. Water vapor was collected by the hygroscopic ammonia sorbent traps and two silica gel sorbent traps connected in series behind the ammonia sorbent trap. Each sorbent trap was accurately weighed before and after sample collection, and the difference in weights was assumed to be due to collected water vapor (all other condensable constituents are negligible). Quality control objectives were achieved by balance calibration, the use of standard weights, and use of field and trip blanks.

Tank BX-104 was also sampled for nitrogen dioxide (NO_2) and nitric oxide (NO). These compounds were collected using separate sorbent traps arranged in series with, and downstream of, the ammonia sorbent trap. The nitrogen dioxide sorbent trap was positioned directly downstream of the ammonia trap. An oxidizer tube (that converts nitric oxide to nitrogen dioxide) followed the nitrogen dioxide trap, and a second nitrogen dioxide sorbent trap followed to trap the nitric oxide (that has been oxidized to nitrogen dioxide). The nitrogen dioxide chemisorbed by the sorbent traps is desorbed as nitrite ions with deionized water, and analyzed by suppressed ion chromatography. Nitrogen dioxide was found to be below method detection limits in all samples.

Ammonia and water vapor results for Tanks BX-104, BY-108, C-107, and S-102 are listed in Tables A.2, A.3, A.4, and A.5, respectively, of the appendix. Table A.2 also lists the nitric oxide results for Tank BX-104.

2.3.2 Permanent Gases

SUMMA canister samples were analyzed for hydrogen, carbon dioxide, carbon monoxide, methane, and nitrous oxide. Aliquots of the sample were analyzed using a gas chromatograph coupled with a thermal conductivity detector. The analytes were identified by matching the sample peak retention time with a National Institute of Standards and Technology (NIST) traceable gas standard mixture. The same standard mixture was used to calibrate the method for quantitation. Quality control objectives were achieved using both initial and continuing calibration verifications. Blank samples were run to detect the presence of any contamination, and ambient air samples taken in the tank farm were analyzed for comparative purposes. Permanent gas results for Tanks BX-104, BY-108, C-107, and S-102 are listed in Tables A.2, A.3, A.4, and A.5, respectively, of the appendix.

2.3.3 Total Non-Methane Organic Compounds

SUMMA canister samples were analyzed to determine the total non-methane organic compound (TNMOC) concentration. The method was based on Environmental Protection Agency (EPA) procedure TO-12. The TNMOC vapors were pumped through a cryogenic concentrator and then analyzed using an flame ionization detector. Quantitation was achieved using a multiconcentration calibration curve generated using a NIST-traceable propane gas standard. Quality control objectives were achieved using both initial and continuing calibration verifications. Blank samples were run to detect the presence of any contamination, and ambient air samples taken in the tank farm were analyzed for comparative purposes. TNMOC results for Tanks BX-104, BY-108, C-107, and S-102 are listed in Tables A.2, A.3, A.4, and A.5, respectively, of the appendix.

2.3.4 Organic Vapors

Organic vapors were sampled with SUMMA canisters and commercially produced graphitized carbon triple sorbent traps (TSTs). Because these are fundamentally different sample collection devices, they involve different extraction and pretreatment methodologies. Extraction and concentration of organic vapors in SUMMA canisters were based on EPA procedure TO-14 for speciating organic vapors in ambient air. Modifications to the TO-14 method were made to address polar constituents and high concentrations not typically found in ambient air. Organic vapors adsorbed on TSTs were thermally desorbed and cryogenically concentrated prior to analysis.

After extraction and pretreatment, analytes from both SUMMA and TST samples were analyzed using a gas chromatograph for separation and a mass spectrometer for identification and quantitation. Both methods also employed two types of calibration standards. A certified compressed gas standard was used for the 39 compounds of the TO-14 method, and certified permeation tubes were used for the non-TO-14 analytes. Quality control objectives were achieved by using both initial and continuing calibration verifications. Blank samples were run to detect the presence of any contamination, and ambient air SUMMA samples collected in the tank farm were analyzed for comparative purposes.

To reduce variations associated with different analysts and procedural changes in data interpretation, all raw analytical data for organic vapors from both SUMMA and TST samples were compiled and re-examined by a single analyst. This eliminated variations due, for example, to changes in the choice of quantitation ions (the integration method of the analytical procedure was adjusted to improve quantitation after results from the initial sampling events had been published). Small errors, evident only when the data from all events could be compared, were also corrected. Values based on reintegration of mass spectral peaks were adopted only if the original peak baseline clearly differed from other analyses, or when reintegration resulted in at least a 5% change in the result.

SUMMA sample organic vapor results for Tanks BX-104, BY-108, C-107, and S-102 are given in Tables A.6, A.7, A.8, and A.9, respectively, of the appendix. Results from TST samples for Tanks BX-104, BY-108, C-107, and S-102 are given in Tables A.10, A.11, A.12, and A.13, respectively, of the appendix.

2.4 Ambient Air Samples, Trip and Field Blanks

Sorbent trap trip blanks were used to determine whether samples were exposed to contaminants during shipping or storage. Trip blanks accompany samples to the field but are not opened or intentionally exposed to vapors. Trip blanks were found to contain negligible levels of contaminants, and sample shipping and storage integrity were deemed to be good, with the following exceptions:

- TST trip blank samples from various sampling events on Tanks BX-104, BY-108, C-107 and S-102 contained appreciable amounts of methylene chloride. Headspace sample results for methylene chloride were consequently considered suspect and not included in this study.

- TST trip blank samples from sampling of Tanks BX-104, BY-108, and C-107 contained appreciable amounts of toluene. Headspace sample results for toluene in these tanks were consequently considered suspect and not included in this study.

Two SUMMA canister ambient air samples were collected at the beginning of each sampling event. Both samples were collected upwind of the tank; one via the sampling manifold, and the other by direct exposure to the atmosphere. Comparison of these samples indicated the sampling manifold to be free of contaminants in all events.

Field blank sorbent traps were used to assess contamination of samples during handling and also the extent of passive sampling during ISVS events. Field blanks were handled and treated like samples in every way except that air was never intentionally drawn through them. Field blanks associated with Tanks BY-108, C-107, and S-102 (where the VSS was used to collect samples) generally had negligible amounts of contaminants. Two notable exceptions, methylene chloride and toluene, were found in the field blanks for these tanks in approximately the same amounts as found in the corresponding trip blanks.

During ISVS events (i.e., when Tank BX-104 was sampled), field blanks were configured with identical lengths of tubing as sorbent trap samples and were lowered into the tank headspace with other samples. Because sorbent trap samples and field blanks in the ISVS method are physically exposed to tank vapors for short periods before and after actual sample collection, some amount of passive sampling by diffusion of vapors to the sorbent media occurs. (SUMMA canister samples are not affected by passive sampling.) Based on field blanks, passive sampling was generally negligible but may have been responsible for as much as 20% of the reported concentration of certain TST analytes from the August 1996 Tank BX-104 sampling event. Because passive sampling was different for different analytes, and the estimated errors due to passive sampling were comparable to other analytical errors, no correction of these TST data was attempted.

Table 2.1 lists the sampling event dates and average measured headspace temperatures for each date. Headspace temperatures listed in the table for Tanks BY-108, C-107, and S-102 are based on thermocouple tree readings. Because Tank BX-104 did not have an operational thermocouple tree, the listed values are readings of a thermocouple strapped to the vapor sampling tube bundle.

Table 2.1. Sample Dates and Headspace Temperatures

BX-104		BY-108		C-107		S-102	
Date	Headspace Temperature^(a) (°C)	Date	Headspace Temperature^(b) (°C)	Date	Headspace Temperature^(c) (°C)	Date	Headspace Temperature^(d) (°C)
8/22/96	22.5	1/23/96	25.7	1/17/96	40.7	1/26/96	25.8
12/12/96	22.3	3/28/96	24.1	3/26/96	38.8	4/4/96	24.1
2/6/97	19.6	9/10/96	27.9	9/5/96	43.1	9/19/96	29.0
4/7/97	19.1	11/14/96	28.0	12/17/96	41.3	12/19/96	26.5
6/10/97	20.0	1/30/97	24.1	2/7/97	38.6	2/11/97	23.9
<p>(a) Tank BX-104 does not have a working thermocouple instrumentation. Headspace temperature values listed are from a thermocouple attached to the vapor sampling probe.</p> <p>(b) Average reported temperatures for the functional headspace thermocouples in riser 8 of Tank BY-108 on 1/23/96 and 3/28/96 were 26.6 and 25.0 °C, respectively. These have been adjusted by -0.9 °C in Table 2.1 and in temperature correlations to account for a change in thermocouple instrument cabinet operations made in July 1996. The effect of the July 1996 change in operations is evident in Figure 1.1.</p> <p>(c) Reported headspace temperatures for the single functional headspace thermocouple in riser 5 of Tank C-107 on 1/17/96 and 3/26/96 were 41.7 and 39.8 °C, respectively. These have been adjusted by -1.0 °C in Table 2.1 and in temperature correlations to account for a change in thermocouple instrument cabinet operations made in July 1996. The effect of the July 1996 change in operations is evident in Figure 1.2.</p> <p>(d) Reported headspace temperatures for the single functional headspace thermocouple in riser 5 of Tank C-107 on 1/17/96 and 3/26/96 were 41.7 and 39.8 °C, respectively. These have been adjusted by -1.0 °C in Table 2.1 and in temperature correlations to account for a change in thermocouple instrument cabinet operations made in July 1996.</p>							

3.0 Statistical Analysis and Results

3.1 Data for Statistical Analysis

Statistical analyses were performed on the headspace characterization data from the five sampling events conducted on each of four tanks. Four to six headspace samples of each sample type (i.e., TST, SUMMA, and inorganic vapor sorbent traps) were collected during each sampling event. These data were segregated by tank, analyte, and type of sample (i.e., SUMMA, TST, and inorganic vapor sorbent traps), resulting in 152 independent data sets.

All headspace concentration data considered here were from analytes that were positively identified and quantitatively measured. Analytes which were consistently found to be below the analytical lower quantitation limit (or simply not detected) were excluded from the study, as were several analytes which were consistently found to be above the TST analytical upper quantitation limit. Several organic compounds were also excluded from the study because they were detected at significant levels in the field and/or trip blanks, as discussed in Section 2.4. A total of 2,635 headspace concentration measurements were included in the statistical analyses.

3.2 Analysis of Variance Results

The statistical model used in the analysis was the following one-way analysis of variance (ANOVA) model:

$$Y_{ij} = \mu + T_i + A_{ij}, \quad (3.1)$$

$$i = 1, 2, \dots, a; j = 1, 2, \dots, b_i.$$

In this equation, the subscript i denotes the sampling event and j denotes the sample number. In the vapor data, a was 5 and b_i was either 4 or 6. The terms in the model are as follows:

Y_{ij} = laboratory results from the j^{th} sample from the i^{th} sampling event;

μ = the grand mean;

T_i = the effect of the i^{th} sampling event (time);

A_{ij} = the effect of the j^{th} sample from the i^{th} sampling event;

a = the number of sampling events; and

b_i = the number of samples from the i^{th} sampling event.

The variables T_i and A_{ij} are assumed to be uncorrelated and normally distributed with means zero and variances $\sigma^2(T)$ and $\sigma^2(A)$, respectively. The sampling dates are assumed to be a random sample of dates within a year. Estimates of the mean concentration μ and the variance components $\sigma^2(T)$ and $\sigma^2(A)$ were

obtained using Restricted Maximum Likelihood Estimation (REML) techniques. REML techniques, applied to variance component estimation, are described by Harville (1977). The REML estimates were obtained using the statistical analysis package S-PLUS (StatSci 1995). A “^” over a symbol will be used to denote the REML estimate; e.g. $\hat{\mu}$ and $\hat{\sigma}^2$ are the REML estimates of μ and σ^2 .

The variance components $\sigma^2(T)$ and $\sigma^2(A)$ have the following interpretations:

- The variance due to time, $\sigma^2(T)$, is a measure of the variability between results obtained from different sampling events. This incorporates headspace composition, sampling, and analytical variabilities between different sampling events.
- The analytical and sampling variance, $\sigma^2(A)$, is a measure of the variability between samples collected during a given sampling event.

Another variance, the variance of the mean $\sigma^2(\bar{Y})$, is a measure of the uncertainty in the estimate of the mean concentration. When the data are balanced, the variance of the mean is

$$\sigma^2(\bar{Y}) = \frac{\sigma^2(T)}{a} + \frac{\sigma^2(A)}{ab},$$

where a is the number of sampling events and b is the number of samples per event. In the balanced case, the estimate of concentration given by the arithmetic mean, $\bar{Y}$, and estimates of the variance of the mean, $\sigma^2(\bar{Y})$ are approximately the same as the REML estimates $\hat{\mu}$ and $\hat{\sigma}^2(\hat{\mu})$.

The variance of the mean $\sigma^2(\hat{\mu})$ is needed so that confidence intervals on mean analyte concentrations can be computed. The upper and lower limits to a 95% confidence interval on the mean are

$$\begin{aligned} \text{LL}(95\%) &= \hat{\mu} - t_{(0.05, df)} \times \hat{\sigma}(\hat{\mu}) \\ \text{UL}(95\%) &= \hat{\mu} + t_{(0.05, df)} \times \hat{\sigma}(\hat{\mu}). \end{aligned}$$

In this equation, $t_{(0.05, df)}$ is the quantile from Student's t distribution for a two-sided 95% confidence interval with df degrees of freedom, $\hat{\mu}$ is the estimate of the mean concentration, and $\hat{\sigma}(\hat{\mu})$ is the estimate of the standard deviation (square root of the variance) of the mean. The degrees of freedom are the number of sampling times minus one; e.g., for five sampling times $t_{(0.05, 4)} = 2.776$.

The results of the computations are reported in Tables 3.1 to 3.3 for Tank BX-104, Tables 3.4 to 3.6 for Tank BY-108, Tables 3.7 to 3.9 for Tank C-107 and in Tables 3.10 to 3.12 for Tank S-102. For each analyte, the tables report the estimate of mean concentration $\hat{\mu}$, the limits to the confidence interval on the mean LL(95%) and UL(95%), and the relative standard deviation due to samples and analytical measurements. An RSD, in percent, is the standard deviation (square root of the variance) divided by the mean, times 100.

The ANOVA model defined in equation (3.1) was used to test the hypothesis that the variance between samples, $\sigma^2(T)$, was equal to zero. This variance was significantly different from zero, at the 0.05

significance level, for all but 9 of 152 analytes. For many of the analytes the sampling variability is significantly different from zero because the analytical measurement variability (in absolute terms) is extremely small. The analytes for which $\sigma^2(T)$ was not significantly different from zero are marked with a (a) in the tables.

3.3 Correlation Between Concentration and Temperature

The correlation between headspace concentration and temperature was evaluated for each of the analytes. A correlation is a measure of the linear dependence between concentration and temperature.^(a) The correlation coefficient is a dimensionless number between minus one and plus one. If the correlation coefficient is zero, there is no linear relationship between concentration and temperature and they are uncorrelated, and if it is plus or minus one, concentration and temperature are perfectly correlated. The sign of the correlation is the sign of the slope of the linear equation relating concentration and temperature.

Correlation coefficients for each of the 152 analytes have been computed and are listed in Tables 3.13, 3.14, 3.15, and 3.16 for Tanks BX-104, BY-108, C-107, and S-102, respectively. The correlation coefficients were computed using the five mean concentrations and five temperatures, with three degrees of freedom. Analytes have been sorted in these tables in order of decreasing correlation coefficients. Most analytes were found to be positively correlated with temperature, consistent with the expectation that gas evolution and evaporation of liquids increases with temperature. However, the correlations are generally not high, and confidence intervals (as defined by the upper and lower 95% confidence limits in Tables 3.13 through 3.16) are wide. The large uncertainty in the correlation between concentration and temperature data is directly related to the small number of sampling events conducted on each tank.

An alternative approach is to test whether the correlation coefficient is significantly different from zero. Using a test given by Snedecor and Cochran (1980), the correlation can be considered statistically significant (at the 0.05 level of significance for a two-tail test) if the estimate of the correlation coefficient is greater than 0.88 or less than -0.88. There are only 28 analytes, out of the total 152, that have correlations significantly different from zero.

(a) The temperature dependence of vapor pressure is not actually linear; a more appropriate relationship is the Clausius-Clapeyron equation, in which vapor pressure is proportional to $\exp(-C/T)$, where C is a constant and T is the absolute temperature. Over the temperature ranges of interest here (e.g., 292.2 K < T < 295.7 K in Tank BX-104), however, the relationship is very nearly linear.

Table 3.1. Tank BX-104 Inorganic and TNMOC Vapors REML Analysis Results and RSDs

Analyte	$\hat{\mu}$	LL(95%)	UL(95%)	RSD (time)	RSD (analytical)	RSD (mean)
Ammonia [ppmv]	208	166	250	16%	4%	7%
Hydrogen [ppmv]	91	73	109	16%	2%	7%
Nitrous oxide (N ₂ O) [ppmv]	129	117	142	8%	1%	3%
Nitric oxide (NO) [ppmv]	0.33	0.21	0.46	31%	6%	14%
TO-12 [mg/m ³]	88	56	120	29%	3%	13%
Water [mg/L]	15	13	17	12%	6%	6%

Table 3.2. Tank BX-104 SUMMA Organic Vapors REML Analysis Results and RSDs

Analyte	$\hat{\mu}$ (ppbv)	LL(95%) (ppbv)	UL(95%) (ppbv)	RSD (time)	RSD (analytical)	RSD (mean)
1-Butanol	4329	324	8334	73%	23%	33%
2-Butanone	216	76	356	52%	9%	23%
4-Methyl-2-Pentanone	17	0	34	81%	11%	36%
Acetone	1114	222	2007	63%	24%	29%
Acetonitrile	144	121	168	13%	5%	6%
Butane	362	20	705	76%	10%	34%
Butanenitrile	48	19	78	49%	8%	22%
Cyclohexanone	23	18	29	19%	11%	9%
Decane	20	16	25	18%	4%	8%
Dodecane	1220	813	1627	26%	12%	12%
Ethanol	240	107	374	44%	14%	20%
Heptane	41	33	49	15%	5%	7%
Hexane	63	50	75	16%	7%	7%
Hexanenitrile	20	11	29	37%	6%	17%
Methanol	814	442	1186	36%	17%	16%
Nonane	15	11	19	21%	4%	10%
Octane	23	21	26	8%	5%	4%
Pentane	111	76	146	25%	4%	11%
Pentanenitrile	15	6	24	46%	8%	21%
Propanenitrile	61	43	79	24%	5%	11%
Propanol	371	135	608	51%	8%	23%
Tetradecane	1314	179	2450	65%	41%	31%
Tetrahydrofuran	261	211	310	14%	10%	7%
Toluene	9	3	15	50%	3%	23%

Table 3.2 (contd)

Analyte	$\hat{\mu}$ (ppbv)	LL(95%) (ppbv)	UL(95%) (ppbv)	RSD (time)	RSD (analytical)	RSD (mean)
Trichlorofluoromethane	147	15	279	72%	8%	32%
Tridecane	3425	2060	4789	31%	17%	14%
Undecane	161	49	273	56%	6%	25%

Table 3.3. Tank BX-104 TST Sample REML Analysis Results and RSDs

Analyte	$\hat{\mu}$ (ppbv)	LL(95%) (ppbv)	UL(95%) (ppbv)	RSD (time)	RSD (analytical)	RSD (mean)
2-Butanone	189	0	415	96%	19%	43%
4-Methyl-2-pentanone	26	1	50	76%	15%	34%
Acetone	760	0	1659	95%	19%	43%
Acetonitrile	181	68	294	48%	25%	23%
Butane	351	20	682	75%	17%	34%
Butanenitrile	45	11	79	60%	19%	27%
Dodecane	275	149	402	0% ^(a)	64%	17%
Ethanol	422	0	847	79%	34%	36%
Heptane	42	20	65	42%	11%	19%
Hexane	69	30	108	45%	16%	21%
Hexanenitrile	12	5	19	43%	38%	21%
Methanol	860	310	1410	47%	37%	23%
Nonane	6	3	9	29% ^(a)	51%	18%
Octane	19	10	28	33%	29%	17%
Pentane	113	39	187	51%	25%	24%
Pentanenitrile	16	10	22	30%	20%	14%
Propanenitrile	59	29	89	40%	18%	18%
Propanol	431	87	775	63%	22%	29%
Tetradecane	334	184	483	0% ^(a)	62%	16%
Tetrahydrofuran	220	157	283	22%	12%	10%
Trichlorofluoromethane	132	18	245	69%	10%	31%
Tridecane	524	276	771	12% ^(a)	62%	17%
Undecane	38	17	59	0% ^(a)	77%	20%

(a) Not significantly different from zero at the 0.05 level of significance.

Table 3.4. Tank BY-108 Inorganic and TNMOC Vapor REML Analysis Results and RSDs

Analyte	$\hat{\mu}$	LL(95%)	UL(95%)	RSD (time)	RSD (analytical)	RSD (mean)
Ammonia [ppmv]	915	780	1050	12%	1%	5%
Hydrogen [ppmv]	442	296	589	27%	2%	12%
Nitrogen oxide (N ₂ O) [ppmv]	615	403	827	28%	1%	12%
TNMOC [mg/m ³]	259	202	317	18%	2%	8%
Water [mg/L]	16	14	18	9%	5%	4%

Table 3.5. Tank BY-108 SUMMA Sample Organic Vapor REML Analysis Results and RSDs

Analyte	$\hat{\mu}$ (ppbv)	LL(95%) (ppbv)	UL(95%) (ppbv)	RSD (time)	RSD (analytical)	RSD (mean)
1-Butanol	17229	12600	21857	21%	12%	10%
2-Butanone	531	324	737	31%	8%	14%
Acetone	2483	824	4142	53%	13%	24%
Benzene	27	17	36	29%	6%	13%
Butane	2230	1636	2825	15% ^(a)	29%	10%
Cyclohexane	166	117	214	23%	9%	11%
Decane	126	85	167	26%	10%	12%
Dodecane	786	375	1198	42%	9%	19%
Ethanol	1023	804	1241	0% ^(a)	33%	8%
Heptane	559	408	709	21%	7%	10%
Hexane	1151	754	1547	28%	5%	12%
Methanol	2125	1719	2531	8% ^(a)	24%	7%
Nonane	79	51	107	29%	6%	13%
Octane	166	134	197	15%	7%	7%
Pentane	1905	858	2953	43%	19%	20%
Propanol	537	345	729	28%	8%	13%
Tetrahydrofuran	891	682	1100	18%	8%	8%
Toluene	36	21	51	33%	6%	15%
Trichlorofluoromethane	47	18	76	49%	21%	22%
Tridecane	728	306	1150	42%	36%	21%
Undecane	243	155	330	28%	9%	13%

(a) Not significantly different from zero at 0.05 level of significance.

Table 3.6. Tank BY-108 TST Sample REML Analysis Results and RSDs

Analyte	$\hat{\mu}$ (ppbv)	LL(95%) (ppbv)	UL(95%) (ppbv)	RSD (time)	RSD (analytical)	RSD (mean)
2-Butanone	290	177	402	30%	18%	14%
4-Methyl-2-Pentanone	53	34	71	28%	10%	13%
Acetonitrile	251	166	335	23%	25%	12%
Benzene	30	24	35	14%	14%	7%
Butanenitrile	15	7	22	39%	23%	18%
Cyclohexane	185	146	224	16%	11%	8%
Decane	88	45	132	39%	13%	18%
Ethylbenzene	5	3	6	20%	12%	9%
Heptane	552	438	666	16%	5%	7%
Nonane	68	42	95	31%	12%	14%
Octane	191	169	213	9%	6%	4%
Propanenitrile	22	15	28	23%	18%	11%
Propanol	399	303	494	17%	16%	9%
Tetrahydrofuran	641	450	831	24%	5%	11%
Trichlorofluoromethane	24	11	38	42%	31%	20%
Undecane	197	94	301	42%	12%	19%
o-Xylene	7	5	9	21%	7%	10%
p/m-Xylene	13	6	21	47%	8%	21%

Table 3.7. Tank C-107 Inorganic and TNMOC Vapors REML Analysis Results and RSDs

Analyte	$\hat{\mu}$	LL(95%)	UL(95%)	RSD (time)	RSD (analytical)	RSD (mean)
Ammonia [ppmv]	60	47	73	18%	4%	8%
Carbon dioxide [ppmv]	754	604	903	16%	1%	7%
Hydrogen [ppmv]	696	86	1306	71%	1%	32%
Nitrous oxide (N ₂ O) [ppmv]	155	22	289	69%	2%	31%
TNMOC [mg/m ³]	3	2	4	28%	6%	12%
Water [mg/L]	55	42	69	20%	2%	9%

Table 3.8. Tank C-107 SUMMA Sample Organic Vapor REML Analysis Results and RSDs

Analyte	$\hat{\mu}$ (ppbv)	LL(95%) (ppbv)	UL(95%) (ppbv)	RSD (time)	RSD (analytical)	RSD (mean)
2-Butanone	33	15	52	30% ^(a)	61%	20%
Acetone	599	460	738	16%	17%	8%
Acetonitrile	887	418	1356	41%	22%	19%
Butanenitrile	43	33	53	18%	11%	8%
Ethanol	67	19	114	56%	23%	26%
Methanol	1046	316	1777	55%	19%	25%
Propanenitrile	135	105	165	17%	8%	8%
Propanol	11	8	14	21%	12%	10%

(a) Not significantly different from zero at 0.05 level of significance.

Table 3.9. Tank C-107 TST Sample REML Analysis Results and RSDs

Analyte	$\hat{\mu}$ (ppbv)	LL(95%) (ppbv)	UL(95%) (ppbv)	RSD (time)	RSD (analytical)	RSD (mean)
2-Butanone	21	13	30	31%	17%	14%
Acetone	322	199	444	30%	14%	14%
Acetonitrile	532	404	661	16%	20%	9%
Butanenitrile	40	34	45	12%	6%	5%
Pentanenitrile	5	2	8	43%	11%	19%
Propanenitrile	121	84	159	25%	7%	11%

Table 3.10. Tank S-102 Inorganic and TNMOC Vapors REML Analysis Results and RSDs

Analyte	$\hat{\mu}$	LL(95%)	UL(95%)	RSD (time)	RSD (analytical)	RSD (mean)
Ammonia [ppmv]	644	516	772	16%	2%	7%
Hydrogen [ppmv]	792	441	1144	36%	1%	16%
Nitrous oxide (N ₂ O) [ppmv]	763	499	1026	28%	1%	12%
TNMOC [mg/m ³]	16	14	19	13%	4%	6%
Water [mg/L]	14	12	17	14%	2%	6%

Table 3.11. Tank S-102 SUMMA Sample Organic Vapor REML Analysis Results and RSDs

Analyte	$\hat{\mu}$ (ppbv)	LL(95%) (ppbv)	UL(95%) (ppbv)	RSD (time)	RSD (analytical)	RSD (mean)
1-Butanol	544	226	861	47%	9%	21%
2-Butanone	64	41	87	29%	9%	13%
Benzene	16	9	24	36%	7%	16%
Butane	101	60	141	32%	10%	14%
Heptane	9	4	14	45%	10%	20%
Pentane	16	10	21	26%	18%	12%
Propanol	55	30	81	37%	9%	17%
Tetrachloroethylene	8	4	11	34%	8%	15%
Tetrahydrofuran	39	21	57	37%	7%	16%
Toluene	153	43	263	58%	5%	26%
Trichlorofluoromethane	43	23	63	36%	15%	17%

Table 3.12. Tank S-102 TST Sample REML Analysis Results and RSDs

Analyte	$\hat{\mu}$ (ppbv)	LL(95%) (ppbv)	UL(95%) (ppbv)	RSD (time)	RSD (analytical)	RSD (mean)
1-Butanol	574	164	983	57%	7%	26%
2-Butanone	53	31	76	33%	16%	15%
4-Methyl-2-Pentanone	10	7	13	26%	8%	12%
Acetone	272	171	373	29%	10%	13%
Acetonitrile	98	63	133	26%	21%	13%
Benzene	19	11	27	34%	2%	15%
Butane	69	31	107	44%	4%	20%
Heptane	13	5	21	47%	13%	21%
Hexane	10	6	13	28%	5%	12%
Nonane	3	2	4	37%	7%	17%
Pentane	15	9	21	33%	3%	15%
Propanol	58	30	87	38%	16%	18%
Tetrachloroethylene	9	7	10	13%	3%	6%
Tetrahydrofuran	47	19	75	49%	3%	22%
Toluene	160	40	280	60%	3%	27%
Trichlorofluoromethane	39	11	67	58%	7%	26%

Table 3.13. Tank BX-104 Correlations of Concentration and Headspace Temperature

Analyte	Sampling Device	Correlation Coefficient		
		Value	Lower 95% Confidence Limit	Upper 95% Confidence Limit
Water	sorbent trap	0.95	0.40	1.00
Methanol	SUMMA	0.94	0.35	1.00
Ethanol	SUMMA	0.90	0.07	0.99
Acetone	SUMMA	0.80	-0.29	0.99
Ammonia	sorbent trap	0.78	-0.34	0.98
Hexanenitrile	SUMMA	0.76	-0.37	0.98
Toluene	SUMMA	0.74	-0.41	0.98
TNMOC	SUMMA	0.72	-0.44	0.98
Dodecane	SUMMA	0.69	-0.49	0.98
Butanenitrile	SUMMA	0.67	-0.52	0.98
Trichlorofluoromethane	SUMMA	0.65	-0.55	0.97
Tridecane	TST	0.64	-0.55	0.97
1-Butanol	SUMMA	0.61	-0.59	0.97
4-Methyl-2-Pentanone	SUMMA	0.60	-0.60	0.97
Acetone	TST	0.59	-0.61	0.97
2-Butanone	SUMMA	0.59	-0.61	0.97
2-Butanone	TST	0.57	-0.63	0.97
Trichlorofluoromethane	TST	0.57	-0.63	0.97
Tetradecane	TST	0.57	-0.63	0.97
4-Methyl-2-Pentanone	TST	0.56	-0.63	0.97
Butanenitrile	TST	0.55	-0.64	0.96
Nitrous oxide (N ₂ O)	SUMMA	0.52	-0.67	0.96
Tetrahydrofuran	SUMMA	0.49	-0.69	0.96
Nonane	SUMMA	0.47	-0.70	0.96
Hydrogen	SUMMA	0.47	-0.71	0.96
Methanol	TST	0.47	-0.71	0.96
Pentanenitrile	SUMMA	0.40	-0.75	0.95
Hexanenitrile	TST	0.39	-0.75	0.95
Cyclohexanone	SUMMA	0.38	-0.76	0.95
Dodecane	TST	0.37	-0.76	0.94
Nonane	TST	0.35	-0.77	0.94
Ethanol	TST	0.34	-0.78	0.94
Acetonitrile	SUMMA	0.34	-0.78	0.94
Decane	SUMMA	0.32	-0.78	0.94
Tetrahydrofuran	TST	0.32	-0.78	0.94
Propanol	TST	0.28	-0.80	0.93
Acetonitrile	TST	0.26	-0.81	0.93
Propanenitrile	TST	0.26	-0.81	0.93
Propanenitrile	SUMMA	0.24	-0.82	0.93

Table 3.13 (contd)

Analyte	Sampling Device	Correlation Coefficient		
		Value	Lower 95% Confidence Limit	Upper 95% Confidence Limit
Propanol	SUMMA	0.19	-0.83	0.92
Heptane	SUMMA	0.09	-0.86	0.90
Pentanenitrile	TST	0.06	-0.87	0.89
Undecane	SUMMA	0.00	-0.88	0.88
Tridecane	SUMMA	-0.07	-0.90	0.87
Heptane	TST	-0.10	-0.90	0.86
Undecane	TST	-0.13	-0.91	0.85
Nitric oxide (NO)	sorbent trap	-0.15	-0.91	0.84
Butane	SUMMA	-0.18	-0.92	0.84
Octane	TST	-0.23	-0.92	0.82
Octane	SUMMA	-0.26	-0.93	0.81
Hexane	TST	-0.36	-0.94	0.77
Butane	TST	-0.36	-0.94	0.77
Pentane	TST	-0.41	-0.95	0.74
Pentane	SUMMA	-0.44	-0.95	0.72
Tetradecane	SUMMA	-0.53	-0.96	0.66
Hexane	SUMMA	-0.59	-0.97	0.61

Table 3.14. Tank BY-108 Correlations of Concentration and Headspace Temperature

Analyte	Sampling Device	Correlation Coefficient		
		Value	Lower 95% Confidence Limit	Upper 95% Confidence Limit
Trichlorofluoromethane	SUMMA	0.97	0.59	1.00
Water	sorbent trap	0.96	0.54	1.00
Hydrogen	SUMMA	0.94	0.37	1.00
Pentane	SUMMA	0.94	0.33	1.00
Cyclohexane	SUMMA	0.92	0.23	1.00
Ammonia	sorbent trap	0.91	0.16	0.99
Nitrous oxide (N ₂ O)	SUMMA	0.90	0.10	0.99
Ethanol	SUMMA	0.90	0.09	0.99
1-Butanol	SUMMA	0.90	0.07	0.99
TNMOC	SUMMA	0.90	0.06	0.99
Dodecane	SUMMA	0.87	-0.07	0.99
Cyclohexane	TST	0.82	-0.21	0.99
Tetrahydrofuran	SUMMA	0.81	-0.25	0.99
Undecane	SUMMA	0.81	-0.25	0.99
2-Butanone	SUMMA	0.81	-0.25	0.99
Heptane	SUMMA	0.81	-0.26	0.99
Octane	SUMMA	0.79	-0.30	0.99
Hexane	SUMMA	0.77	-0.34	0.98
Decane	SUMMA	0.75	-0.38	0.98
Propanol	SUMMA	0.72	-0.44	0.98
Butane	SUMMA	0.69	-0.49	0.98
Acetonitrile	TST	0.68	-0.51	0.98
Ethylbenzene	TST	0.68	-0.51	0.98
Acetone	SUMMA	0.65	-0.55	0.97
p/m-Xylene	TST	0.63	-0.57	0.97
o-Xylene	TST	0.63	-0.57	0.97
Methanol	SUMMA	0.61	-0.59	0.97
Benzene	SUMMA	0.60	-0.60	0.97
Trichlorofluoromethane	TST	0.58	-0.62	0.97
Nonane	SUMMA	0.56	-0.64	0.96
Benzene	TST	0.56	-0.64	0.96
Toluene	SUMMA	0.55	-0.64	0.96
Heptane	TST	0.53	-0.66	0.96
Propanenitrile	TST	0.53	-0.66	0.96
Propanol	TST	0.46	-0.71	0.95
2-Butanone	TST	0.39	-0.75	0.95
Tetrahydrofuran	TST	0.17	-0.84	0.92
Octane	TST	0.11	-0.86	0.90
Butanenitrile	TST	-0.06	-0.89	0.87

Table 3.14 (contd)

Analyte	Sampling Device	Correlation Coefficient		
		Value	Lower 95% Confidence Limit	Upper 95% Confidence Limit
4-Methyl-2-Pentanone	TST	-0.10	-0.90	0.86
Tridecane	SUMMA	-0.20	-0.92	0.83
Nonane	TST	-0.38	-0.95	0.76
Decane	TST	-0.53	-0.96	0.66
Undecane	TST	-0.59	-0.97	0.61

Table 3.15. Tank C-107 Correlations of Concentration and Headspace Temperature

Analyte	Sampling Device	Correlation Coefficient		
		Value	Lower 95% Confidence Limit	Upper 95% Confidence Limit
Acetone	TST	0.93	0.28	1.00
2-Butanone	TST	0.89	0.02	0.99
Water	sorbent trap	0.81	-0.25	0.99
Butanenitrile	TST	0.55	-0.64	0.96
Ammonia	sorbent trap	0.49	-0.69	0.96
Carbon dioxide	SUMMA	0.47	-0.70	0.96
Acetonitrile	TST	0.41	-0.74	0.95
Butanenitrile	SUMMA	0.35	-0.77	0.94
Propanenitrile	TST	0.16	-0.84	0.91
Pentanenitrile	TST	-0.02	-0.89	0.88
Hydrogen	SUMMA	-0.13	-0.91	0.85
Nitrous oxide (N ₂ O)	SUMMA	-0.14	-0.91	0.85
Ethanol	SUMMA	-0.24	-0.93	0.81
2-Butanone	SUMMA	-0.42	-0.95	0.73
Propanol	SUMMA	-0.46	-0.95	0.71
Methanol	SUMMA	-0.48	-0.96	0.70
Acetone	SUMMA	-0.49	-0.96	0.69
Acetonitrile	SUMMA	-0.55	-0.96	0.65
TNMOC	SUMMA	-0.56	-0.97	0.63
Propanenitrile	SUMMA	-0.64	-0.97	0.56

Table 3.16. Tank S-102 Correlations of Concentration and Headspace Temperature

Analyte	Sampling Device	Correlation Coefficient		
		Value	Lower 95% Confidence Limit	Upper 95% Confidence Limit
Ammonia	sorbent trap	0.99	0.90	1.00
Toluene	SUMMA	0.97	0.61	1.00
Hydrogen	SUMMA	0.97	0.60	1.00
Benzene	SUMMA	0.96	0.53	1.00
Water	sorbent trap	0.95	0.40	1.00
Nitrous oxide (N ₂ O)	SUMMA	0.95	0.39	1.00
Trichlorofluoromethane	SUMMA	0.93	0.24	1.00
1-Butanol	SUMMA	0.92	0.23	1.00
Toluene	TST	0.91	0.12	0.99
Butane	TST	0.90	0.10	0.99
Heptane	SUMMA	0.89	0.04	0.99
Trichlorofluoromethane	TST	0.89	0.02	0.99
2-Butanone	SUMMA	0.88	-0.00	0.99
Tetrahydrofuran	TST	0.86	-0.08	0.99
Tetrahydrofuran	SUMMA	0.86	-0.08	0.99
Benzene	TST	0.86	-0.11	0.99
Propanol	TST	0.85	-0.14	0.99
1-Butanol	TST	0.85	-0.14	0.99
2-Butanone	TST	0.80	-0.27	0.99
Pentane	TST	0.80	-0.29	0.99
Propanol	SUMMA	0.77	-0.36	0.98
Acetone	TST	0.72	-0.44	0.98
Hexane	TST	0.71	-0.47	0.98
Nonane	TST	0.66	-0.53	0.98
Heptane	TST	0.60	-0.60	0.97
Pentane	SUMMA	0.18	-0.83	0.92
Acetonitrile	TST	0.10	-0.86	0.90
Tetrachloroethylene	SUMMA	0.01	-0.88	0.88
Butane	SUMMA	-0.18	-0.92	0.84
4-Methyl-2-Pentanone	TST	-0.57	-0.97	0.63
Tetrachloroethylene	TST	-0.63	-0.97	0.56
TNMOC	SUMMA	-0.70	-0.98	0.47

4.0 Discussion of Results

The headspaces of Tanks BX-104, BY-108, C-107, and S-102 were each sampled five times over approximately a 1-year period to evaluate seasonal changes in their headspace compositions. A small number of data were eliminated from this study because of identifiable problems, but the vast majority of quantitative results were considered valid and included. Measurement precision for results within individual sampling events, which includes both sampling and analytical random errors, was quite good, as evidenced by the low analytical RSDs listed in the sixth column of Tables 3.1 through 3.12.

Data were fit to an ANOVA model to evaluate the significance of differences between results from the different sampling events. The data (given in Tables A.2 through A.13) and ANOVA results (given in Tables 3.1 through 3.12) indicate that the majority of headspace constituents studied were at relatively constant levels during the year-long study. The variability of analyte means obtained for the five sampling events is quantified by RSD_{TIME} , given in the fifth column of Tables 3.1 through 3.12. Most RSD_{TIME} values are generally low, with only 15 of the 152 analytes having RSD_{TIME} values above 60 %. These were obtained for 13 organic vapors in Tank BX-104, and two permanent gases in Tank C-107.

Concentrations of the principle waste gas and vapors, i.e. ammonia, hydrogen, nitrous oxide, and water, were observed to fluctuate in a relatively narrow range. The RSD_{TIME} values for ammonia and water vapors were less than 20 % for each of the four tanks. RSD_{TIME} values for hydrogen and nitrous oxide were less than 40 % for Tanks BX-104, BY-108, and C-107, but as high as about 70 % in Tank C-107. The larger RSD_{TIME} values for these two gases in Tank C-107 are associated with gradual increases in the concentration of both gases in Tank C-107, which is a relatively hot, radiolytically active tank.

The most significant seasonal differences in organic vapor composition were observed for Tank BX-104, in which the concentrations of many organic vapors were significantly higher in August 1996 than in the subsequent sampling events. In that case, higher concentrations of individual organic species were measured in both TST and SUMMA samples, and a similarly elevated TNMOC concentration was measured in SUMMA samples. Computed RSD_{TIME} values for individual Tank BX-104 organic analytes were generally high because of the August 1996 data. Ammonia and nitric oxide were also observed at elevated levels in the August 1996 samples, but hydrogen and nitrous oxide were not. These data do not clearly indicate any single cause for the elevated concentrations observed.

Only 18 of the 130 SUMMA and TST sample organic vapor results were correlated with headspace temperature at the 95 % confidence level. Furthermore, results from SUMMA canister and TST samples tend to disagree on the whether significant correlations exist. For example, as indicated in Table 3.15, the Tank C-107 TST samples indicate acetone and 2-butanone concentrations to be positively correlated with temperature at the 95 % confidence level, but SUMMA samples for this tank actually suggest the correlation to be negative. This and other examples suggest that seasonal changes in headspace organic vapor concentrations were small compared to sampling and analytical errors. Correlations between inorganic and TNMOC vapor concentrations and temperature, if present, would not generally be obscured by such errors, because valid samples are easier to obtain and the analytical instrumentation for these measurements is inherently more accurate.

5.0 Conclusions

The headspace characterization data collected from Tanks BX-104, BY-108, C-107, and S-102 indicate that passively ventilated tank headspace compositions are relatively constant over a one-year period. While the concentrations of individual species were observed to undergo measurable changes, these changes were not consistent within logical chemical groupings of the compounds, and changes appeared to be random in many cases.

Correlations between the mean headspace concentrations of the five sampling events per tank and the headspace temperatures of each event were determined to be significant at the 0.05 significance level for 28 of the 152 analytes studied. Water vapor was highly correlated with temperature in three of the four tanks, and ammonia was correlated at the 0.05 significance level in two tanks. Though 18 organic analytes were found to be correlated with headspace temperature at the 0.05 significance level, TST and SUMMA results disagreed regarding which organic vapors are correlated with temperature.

In general, seasonal changes in headspace organic vapor concentrations appear to be small compared with sampling and analytical errors. Therefore, adjustments of individual organic vapor concentrations for seasonal effects are generally not warranted.

6.0 References

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Appendix

Analytical Results

Table A.1. Target Analyte Estimated Lower Quantitation Limits^(a)

Analyte	CAS Number	SUMMA Method Detection Limit	Sorbent Trap Method Detection Limit	TST Method Detection Limit	Units
1,1,2-trichloro-1,2,2-trifluoroethane	76-13-1	2		4	ppbv
1,2,4-trichlorobenzene	120-82-1	2		19	ppbv
1,2-dichlorobenzene	95-50-1	1		7	ppbv
1,4-dichlorobenzene	106-46-7	1		4	ppbv
1,3-dichlorobenzene	541-73-1	1		5	ppbv
1,2,4-trimethylbenzene	95-63-6	2		5	ppbv
1,3,5-trimethylbenzene	108-67-8	2		4	ppbv
1,1,2,2-tetrachloroethane	79-34-5	3		8	ppbv
1,2-dibromoethane	106-93-4	3		3	ppbv
1,1,2-trichloroethane	79-00-5	2		3	ppbv
1,1-dichloroethene	75-35-4	4		5	ppbv
1,2-dichloro-1,1,2,2-tetrafluoroethane	76-14-2	9		4	ppbv
1,2-dichloropropane	78-87-5	3		4	ppbv
1-butanol	71-36-3	5		23	ppbv
1-butanenitrile	109-74-0	6		5	ppbv
1,1,1-trichloroethane	71-55-6	3		4	ppbv
1,2-dichloroethane	107-06-2	3		2	ppbv
1-propanol	71-23-8	5		19	ppbv
1,1-dichloroethane	75-34-3	2		3	ppbv
2-butanone	78-93-3	4		7	ppbv
4-methyl-2-pentanone (hexone)	108-10-1	4		5	ppbv
ammonia	7664-41-7		0.71		ppmv
benzene	71-43-2	2		4	ppbv
bromomethane	74-83-9	6			ppbv
carbon monoxide	630-08-0	25			ppmv
carbon dioxide	124-38-9	17			ppmv
chlorobenzene	108-90-7	3		2	ppbv
chloroethane	75-00-3	9		14	ppbv
chloromethane	74-87-3	5		14	ppbv
chloroethene (vinyl chloride)	75-01-4	3		11	ppbv
cis-1,3-dichloropropene	10061-01-5	2		3	ppbv
cis-1,2-dichloroethene	156-59-2	4		6	ppbv
cyclohexane	110-82-7	5		11	ppbv
cyclohexanone	108-94-1	7		4	ppbv
dichlorodifluoromethane	75-71-8	3		8	ppbv
dichloromethane (methylene chloride)	75-09-2	3		43	ppbv
ethanenitrile (acetonitrile)	75-05-8	11		18	ppbv
ethanol	64-17-5	10		134	ppbv
ethylbenzene	100-41-4	3		3	ppbv
hydrogen	1333-74-0	17			ppmv
methane	74-82-8	50			ppmv
methanol	67-56-1	44		192	ppbv
n-heptane	142-82-5	2		3	ppbv
n-hexane	110-54-3	4		3	ppbv
n-butane	106-97-8	5		14	ppbv
n-decane	124-18-5	2		5	ppbv
n-undecane	1120-21-4	2		6	ppbv
n-tetradecane	629-59-4	2		15	ppbv
n-tridecane	629-50-5	4		66	ppbv
n-dodecane	112-40-3	6		34	ppbv
n-octane	111-65-9	2		5	ppbv
n-nonane	111-84-2	2		2	ppbv
n-pentane	109-66-0	6		9	ppbv
nitric oxide, ^(b) NO	10102-43-9		0.16		ppmv
nitrogen dioxide, NO ₂	10102-44-0		0.16		ppmv
nitrous oxide, N ₂ O	10024-97-2	17			ppmv
o-xylene	95-47-6	3		4	ppbv
p/m-xylene	106-42-3	14		6	ppbv
propanenitrile	107-12-0	8		8	ppbv
propanone (acetone)	67-64-1	7		28	ppbv

Table A.1 (contd)

Analyte	CAS Number	SUMMA Method Detection Limit	Sorbent Trap Method Detection Limit	TST Method Detection Limit	Units
pyridine	110-86-1	26		61	ppbv
styrene	100-42-5	2		3	ppbv
tetrachloroethylene	127-18-4	3		3	ppbv
tetrachloromethane	56-23-5	2		2	ppbv
tetrahydrofuran	109-99-9	2		3	ppbv
toluene	108-88-3	2		2	ppbv
total non-methane organic compounds	NA ^(c)	4			mg/m ³
trans-1,3-dichloropropene	10061-02-6	2		5	ppbv
trichloroethene	79-01-6	2		6	ppbv
trichlorofluoromethane	75-69-4	4		7	ppbv
trichloromethane (chloroform)	67-66-3	2		5	ppbv

(a) Method detection limits are defined to be the lower quantitation limit for the given analysis.

(b) Nitric oxide and nitrogen dioxide were not target analytes for Tanks BY-108, C-107, or S-102.

(c) Not applicable.

Table A.2. Tank BX-104 Inorganic Vapor, Permanent Gas, and TNMOC Results

Sample Date	Sample Identification Number	Ammonia (ppmv)	Hydrogen (ppmv)	Nitric oxide [NO] (ppmv)	Nitrous oxide [N ₂ O] (ppmv)	Water (mg/L)	TNMOC (mg/m ³)
August 22, 1996	S6086-A04.294		96		128		128
	S6086-A05.295		94		130		130
	S6086-A06.297		93		131		133
	S6086-A07.88R	264		0.43		18 JN	
	S6086-A08.89R	264		0.43		18 JN	
	S6086-A09.90R	254		0.43		17 JN	
	S6086-A10.91R	269		0.39		18 JN	
	Mean	263	94	0.42	130	18	130
December 12, 1996	Std. Dev.	6	2	0.02	2	0.4	3
	S7017-A04.128		102		136		80
	S7017-A05.130		96		139		82
	S7017-A06.134		99		137		85
	S7017-A07-16R	202		0.19		15 JN	
	S7017-A08-17R	209		0.19		17 JN	
	S7017-A09-18R	204		0.18		15 JN	
	S7017-A10-19R	213		0.20		18 JN	
February 6, 1997	Mean	207	99	0.19	137	16	82
	Std. Dev.	5	3	0.008	2	1	3
	V7004-A04.153		70		119		83
	V7004-A05.161		71		119		88
	V7004-A06.166		72		119		84
	V7004-A07-28R	157		0.25			
	V7004-A08-29R	185		0.26		13 JN	
	V7004-A09-30R	169		0.29		14 JN	
April 7, 1997	V7004-A10-31R	183		0.28		14 JN	
	Mean	174	71	0.27	119	13	85
	Std. Dev.	13	1	0.02	0	0.7	3
	V7014-A04.283		84		120		57
	V7014-A05.284		82		120		59
	V7014-A06.287		82		119		60
	V7014-A07.46R	192		0.35		13 JN	
	V7014-A08.46R	194		0.37		14 JN	
June 10, 1997	V7014-A09.46R	182		0.33		13 JN	
	V7014-A10.46R	190		0.35		14 JN	
	Mean	190	83	0.35	120	14	58
	Std. Dev.	5	1	0.02	0.6	0.6	1
	V7021-A04.288		106		141		85
	V7021-A05.289		109		140		84
	V7021-A06.294		109		141		88
	V7021-A07-52R	210		0.43		14 JN	
June 10, 1997	V7021-A08-53R	191		0.42		14 JN	
	V7021-A09-54R	215		0.41		14 JN	
	V7021-A10-55R	209		0.47		13 JN	
	Mean	206	108	0.43	141	14	86
	Std. Dev.	11	2	0.03	0.5	0.6	2

Table A.3. Tank BY-108 Inorganic Vapor, Permanent Gas, and TNMOC Results

Sample Date	Sample Identification Number	Ammonia (ppmv)	Hydrogen (ppmv)	Nitrous oxide [N ₂ O] (ppmv)	Water (mg/L)	TNMOC (mg/m ³)
January 23, 1996	S6004-A03.029		364	465		220
	S6004-A04.050		362	481		226
	S6004-A15.054		362	472		222
	S6004-A16.055		354	472		222
	S6004-A18.46S	862			15 JN	
	S6004-A19.47S	850			15 JN	
	S6004-A20.48S	871			16 JN	
	S6004-A21.49S	878			16 JN	
	S6004-A22.50S	871			16 JN	
	S6004-A23.51S	843			16 JN	
	S6004-A27.067		352	461		224
	S6004-A28.080		372	466		216
	Mean	863	361	470	16	222
	Std. Dev.	14	7	7	0.5	3
March 28, 1996	S6021-A05.212		353	499		245
	S6021-A06.215		352	502		245
	S6021-A07.220		352	514		239
	S6021-A17.S27	877			15 JN	
	S6021-A18.S28	884			15 JN	
	S6021-A19.S29	884			16 JN	
	S6021-A20.S30	894			15 JN	
	Mean	885	352	505	15	243
	Std. Dev.	7	1	8	1	3
September 10, 1996	S6092-A04.147		589	820		310
	S6092-A05.148		587	831		311
	S6092-A06.150		580	830		298
	S6092-A07.R01	1038			17 JN	
	S6092-A08.R02	1025			16 JN	
	S6092-A09.R03	1006			18 JN	
	S6092-A10.R04	1038			18 JN	
	Mean	1027	585	827	17	306
	Std. Dev.	15	5	6	1	7
November 14, 1996	S7009-A04.207		551	773		315
	S7009-A05.219		548	775		307
	S7009-A06.237		570	770		312
	S7009-A07-R97	1008			18 JN	
	S7009-A08-R98	1033			16 JN	
	S7009-A09-R99	1021			19 JN	
	S7009-A10-01R	1037			19 JN	
	Mean	1025	556	773	18	311
	Std. Dev.	13	12	3	1	4
January 30, 1997	V7003-A04.273		358	492		215
	V7003-A05.304		352	502		214
	V7003-A06.333		356	504		215
	V7003-A07-22R	775			14 JN	
	V7003-A08-23R	784			15 JN	
	V7003-A09-24R	784			15 JN	
	V7003-A10-25R	762			14 JN	
	Mean	776	355	499	15	215
	Std. Dev.	10	3	6	1	1

Table A.4. Tank C-107 Inorganic Vapor, Permanent Gas, and TNMOC Results

Sample Date	Sample Identification Number	Ammonia (ppmv)	Carbon dioxide (ppmv)	Hydrogen (ppmv)	Nitrous oxide [N ₂ O] (ppmv)	Water (mg/L)	TNMOC (mg/m ³)
January 18, 1996	S6001-A03.302		695	237	64		3.5
	S6001-A04.303		687	249	61		4.1
	S6001-A15.304		699	238	61		3.8
	S6001-A16.305		689	237	61		3.5
	S6001-A18.21S	75				49 JN	
	S6001-A19.22S	74				49 JN	
	S6001-A20.23S	75				49 JN	
	S6001-A21.24S					49 JN	
	S6001-A22.25S	79				50 JN	
	S6001-A23.26S	76				49 JN	
	S6001-A27.306		694	248	64		3.3
	S6001-A28.307		692	243	63		3.4
	Mean	76	693	242	62	49	3.6
	Std. Dev.	2	4	6	2	0.3	0.3
March 26, 1996	S6019-A05.032		566	258	48		2.9
	S6019-A06.057		575	253	61		2.8
	S6019-A07.059		579	251	60		2.8
	S6019-A17.S16	45				44 JN	
	S6019-A18.S17	51				48 JN	
	S6019-A19.S18	46				48 JN	
	S6019-A20.S19	47				48 JN	
	Mean	47	573	254	56	47	2.8
	Std. Dev.	3	7	4	7	2	0.1
September 5, 1996	S6091-A04.284		812	562	118		1.7
	S6091-A05.285		818	563	123		1.7
	S6091-A06.287		806	560	118		1.7
	S6091-A07.94R	61				73 JN	
	S6091-A08.95R	66				75 JN	
	S6091-A09.96R	64				74 JN	
	S6091-A10.97R	64				74 JN	
	Mean	64	812	562	120	74	1.7
	Std. Dev.	2	6	2	3	1	0.01
December 17, 1996	S7010-A04.246		872	1128	253		3.8
	S7010-A05.254		878	1130	255		3.8
	S7010-A06.256		872	1132	251		3.7
	S7010-A07-04R	60				53 JN	
	S7010-A08-05R	54				54 JN	
	S7010-A09-06R	58				54 JN	
	S7010-A10-07R	55				54 JN	
	Mean	57	874	1130	253	54	3.8
	Std. Dev.	3	3	2	2	0.6	0.03
February 7, 1997	V7005-A04.211		816	1294	284		3.8
	V7005-A05.212		818	1295	287		3.7
	V7005-A06.238		814	1290	284		3.6
	V7005-A07-34R	54				52 JN	
	V7005-A08-35R	55				52 JN	
	V7005-A09-36R	57				53 JN	
	V7005-A10-37R	57				53 JN	
	Mean	56	816	1293	285	53	3.7
	Std. Dev.	2	2	3	2	0.6	0.1

Table A.5. Tank S-102 Inorganic Vapor, Permanent Gas, and TNMOC Results

Sample Date	Sample Identification Number	Ammonia (ppmv)	Hydrogen (ppmv)	Nitrogen oxide [N ₂ O] (ppmv)	Water (mg/L)	TNMOC (mg/m ³)
January 27, 1996	S6007-A03.082		736	707		15
	S6007-A04.083		740	692		16
	S6007-A15.084		738	699		16
	S6007-A16.097		738	700		15
	S6007-A18.71S	622			14 JN	
	S6007-A19.72S	598				
	S6007-A20-73S	642				
	S6007-A21.74S	622			14 JN	
	S6007-A22.75S	632			14 JN	
	S6007-A23.76S	618			14 JN	
	S6007-A27.108		736	695		17
	S6007-A28.120		736	702		17
	S6007-A87.086		740	689		16
	S6007-A88.089		734	689		16
	Mean	622	737	697	14	16
	Std. Dev.	15	2	6	0.2	1
April 4, 1996	S6031-A05.148		613	646		15
	S6031-A06.223		620	644		16
	S6031-A07.231		632	648		15
	S6031-A17.S43	534			13 JN	
	S6031-A18.S44	571			13 JN	
	S6031-A19.S45	576			13 JN	
	S6031-A20.S46	573			13 JN	
	Mean	564	622	646	13	16
	Std. Dev.	20	10	2	0.2	0.1
September 19, 1996	S6093-A04.038		1159	1046		15
	S6093-A05.065		1191	1038		13
	S6093-A06.104		1187	1040		13
	S6093-A07.R07	787			18 JN	
	S6093-A08.R08	800			18 JN	
	S6093-A09.R09	800			18 JN	
	S6093-A10.R10	807			18 JN	
	Mean	799	1179	1041	18	14
	Std. Dev.	8	17	4	0.1	1
December 19, 1996	V6001-A04.272		965	918		17
	V6001-A05.276		963	919		17
	V6001-A06.312			906		17
	V6001-A07-10R	676			14 JN	
	V6001-A08-11R	678			14 JN	
	V6001-A09-12R	711			14 JN	
	V6001-A10-13R	691			15 JN	
	Mean	689	689	914	14	17
	Std. Dev.	16	16	7	0.5	0.1
February 11, 1997	V7006-A04.142		460	513		19
	V7006-A05.167		464	513		19
	V7006-A06.169		457	517		20
	V7006-A07-40R	536			13 JN	
	V7006-A08-41R	550			13 JN	
	V7006-A09-42R	550			13 JN	
	V7006-A10-43R	548			13 JN	
	Mean	546	460	514	13	19
	Std. Dev.	7	4	2	0.2	0.3

Table A.6. Tank BX-104 Organic Vapor Results from SUMMA Samples in ppbv

Sample Date	Sample Identification Number	1-Butanol	2-Butanone	4-Methyl-2-Pentanone	Acetone	Acetonitrile	Butane	Butanenitrile	Cyclohexanone	Decane	Dodecane	Ethanol	Heptane	Hexane
8/22/96	S8086-A04.294	10263	416	41	3042	187	217	93	22	22 J	1644	453	36	49
	S8086-A05.295	9539	422	38	2065	166	182	89	21	20 J	1481	332	39	48
	S8086-A06.297	6316	401	36	1954	160	170	87	21	20 J	1200	342	38	46
	Mean	8706	413	38	2353	171	190	89	21	21	1441	376	37	48
	Std. Dev.	2101	11	2	599	14	24	3	1	1	225	67	2	2
12/12/96	S7017-A04.128	2789	159	11	1189	136	414	42	32	20	1202	324	49	63
	S7017-A05.130	3670	162	10	1052	133	303	39	28	21	1584	308	47	66
	S7017-A06.134	3744	156	10	1017	128	281	38	32	22	1570	300	45	64
	Mean	3401	159	10	1086	132	333	40	30	21	1452	311	47	64
	Std. Dev.	531	3	1	91	4	71	2	2	1	216	13	2	2
2/6/97	V7004-A04.153	1401	118	7 J	588	122	240	34	23	17	674	72	50	73
	V7004-A05.161	1284	148	6 J	589	125	246	31	29	19	809	123	50	79
	V7004-A06.166	1159	129	6 J	557	119	240	28	21	17	663	115	45	76
	Mean	1281	132	7	578	122	242	31	25	17	715	103	49	76
	Std. Dev.	121	16	0.5	18	3	3	3	4	1	81	27	3	3
4/7/97	V7014-A04.283	2017	156	7 J	705	150	209	40	26	16	992	182	39	54
	V7014-A05.284	1562	193	6 J	718	156	208	33	23	17	1113	180	40	65
	V7014-A06.287	1387	214	6 J	649	153	189	31	20	16	1066	168	37	66
	Mean	1655	187	6	691	153	202	35	23	16	1057	177	39	62
	Std. Dev.	325	29	1	37	3	12	5	3	0.5	61	8	1	7
6/10/97	V7021-A04.288	6576	163	26	905	147	825	54	19	27	1351	252	37	57
	V7021-A05.289	6636	195	21	801	139	832	45	17	25	1479	223	33	64
	V7021-A06.294	6591	211	20	883	145	879	43	18	26	1473	232	33	68
	Mean	6601	190	22	863	144	845	47	18	26	1434	236	34	63
	Std. Dev.	31	24	3	55	4	29	5	1	1	72	15	2	6

Table A.6. Tank BX-104 Organic Vapor Results from SUMMA Samples in ppbv

Sample Date	Sample Identification Number	Hexanenitrile	Methanol	Nonane	Octane	Pentane	Pentanenitrile	Propanenitrile	Propanol	Tetradecane	Tetrahydrofuran	Toluene	Trichlorofluoromethane	Tridecane	Undecane
8/22/96	S8086-A04.294	31	1294	20	20	72	23	83	525	597	315	17	346	3687	152
	S8086-A05.295	31	961	21	23	67	22	80	409	248	338	18	321	2425	148
	S8086-A06.297	31	958	21	23	63	22	77	419	293	305	17	305	2462	149
	Mean	31	1071	20	22	67	23	80	451	380	320	17	324	2858	150
	Std. Dev.	0.2	193	0.3	2	4	0.3	3	64	190	17	0.4	20	718	2
12/12/96	S7017-A04.128	21	1455	11	22	133	12	46	301	1095	230	8	105	2631	142
	S7017-A05.130	18	1138	13	24	133	12	48	303	1064	250	8	104	4070	135
	S7017-A06.134	19	1015	13	23	129	11	46	301	1265	244	8	101	4392	139
	Mean	20	1203	12	23	131	12	47	302	1141	241	8	103	3698	139
	Std. Dev.	1	227	1	1	2	1	1	1	108	10	0.3	2	938	3
2/6/97	V7004-A04.153	13	569	14	26	139	9	46	201	621	197	6	62	1897	88
	V7004-A05.161	13	628	15	28	141	8	49	218	597	222	7	65	2047	104
	V7004-A06.166	11	596	13	26	132	8	47	216	431	216	7	62	1862	91
	Mean	12	598	14	27	137	8	47	212	550	212	7	63	1935	94
	Std. Dev.	1	30	1	1	4	1	2	10	104	13	0.3	2	98	9
4/7/97	V7014-A04.283	16	656	12	22	113	11	56	230	2037	215	5	73	3648	92
	V7014-A05.284	15	663	13	24	125	10	63	231	2077	268	6	86	3963	113
	V7014-A06.287	12	577	13	22	119	9	63	218	1944	289	6	77	3656	111
	Mean	14	632	13	23	119	10	60	226	2019	258	6	79	3756	105
	Std. Dev.	2	48	1	1	6	1	4	7	69	38	0.2	7	180	12
6/10/97	V7021-A04.288	23	552	16	22	98	25	66	670	1939	237	8	153	4673	328
	V7021-A05.289	21	542	16	21	98	22	69	645	3830	277	9	164	5344	297
	V7021-A06.294	21	603	16	22	101	21	74	683	1672	305	9	177	4612	325
	Mean	22	566	16	22	99	23	70	666	2480	273	9	165	4876	317
	Std. Dev.	1	33	0.2	1	2	2	4	19	1177	34	0.3	12	406	17

Table A.7. Tank BY-108 Organic Vapor Results from SUMMA Samples in ppbv

Sample Date	Sample Identification Number	1-Butanol	2-Butanone	Acetone	Benzene	Butane	Cyclohexane	Decane	Dodecane	Ethanol	Heptane	Hexane
1/23/96	S6004-A03.029	20425	414	2179	21	2235	143	127	618	1011	521	1004
	S6004-A04.050	17087	313	1921	16	1937	134	103	424	895	442	900
	S6004-A15.054	18873	351	1864	20	1854	137	114	487	896	481	975
	S6004-A16.055	22057	381	1962	20	2178	128	118	516	957	452	925
	S6004-A27.067	19238	346	1841	20	1797	133	111	561	858	466	950
	S6004-A28.080	15728	284	2022	18	1977	157	118	630	1319	553	1078
	Mean	18901	348	1965	19	1996	139	115	539	989	486	972
	Std. Dev.	2270	46	124	2	175	10	8	79	170	43	63
3/28/96	S6021-A05.212	13946	432	541	28	699	119	63	459	405	544	973
	S6021-A06.215	13354	439	1736	27	736	107	57	444	438	560	895
	S6021-A07.220	8278	368	1905	29	3400	156	107	606	1918	464	1048
	Mean	11859	413	1394	28	1612	127	75	503	920	522	972
	Std. Dev.	3116	39	744	1	1549	26	27	90	864	51	77
9/10/96	S6092-A04.147	21349	673	4866	38	2375	221	161	968	1244	741	1723
	S6092-A05.148	21457	646	4621	37	2183	198	156	928	1174	716	1594
	S6092-A06.150	19747	710	4963	41	2394	218	175	1004	1291	794	1763
	Mean	20851	676	4817	39	2317	212	164	967	1236	750	1693
	Std. Dev.	958	32	176	2	117	13	9.8	38	59	40	88
11/14/96	S7009-A04.207	17904	655	2076	26	3384	215	140	1187	1123	622	1200
	S7009-A05.219	20658	762	2165	29	2682	206	145	1334	1149	606	1194
	S7009-A06.237	20357	774	2166	28	2851	189	141	1326	977	560	1161
	Mean	19640	730	2136	28	2972	203	142	1282	1083	596	1185
	Std. Dev.	1511	66	52	2	366	13	2.6	83	93	32	21
1/30/97	V7003-A04.273	14651	459	2211	21	2288	161	136	678	981	453	918
	V7003-A05.304	15895	509	2095	21	2482	137	128	645	942	434	942
	V7003-A06.333	13869	493	2020	20	2261	144	130	606	828	432	934
	Mean	14805	487	2109	21	2344	147	131	643	917	440	931
	Std. Dev.	1022	26	96	0.6	121	12	4	36	80	12	12

Table A.7. Tank BY-108 Organic Vapor Results from SUMMA Samples in ppbv

Sample Date	Sample Identification Number	Methanol	Nonane	Octane	Pentane	Propanol	Tetrahydrofuran	Toluene	Trichlorofluoromethane	Tridecane	Undecane
1/23/96	S6004-A03.029	2201	85	178	1414	511	851	27	46	505	230
	S6004-A04.050	1825	71	152	2034	411	651	25	35	355	181
	S6004-A15.054	1930	75	158	1836	484	781	26	32	404	210
	S6004-A16.055	2035	76	160	2148	471	791	24	60	407	230
	S6004-A27.067	1867	73	152	1834	467	765	25	31	408	203
	S6004-A28.080	2710	72	165	788	438	646	26	65	434	255
	Mean	2095	76	161	1676	464	747	25	45	419	218
	Std. Dev.	330	5	10	502	35	82	1	15	50	26
3/28/96	S6021-A05.212	1091	64	132	838	234	917	36	17	500	147
	S6021-A06.215	1121	61	143	886	273	966	38	20	517	124
	S6021-A07.220	3119	69	102	1676	406	787	29	28	698	192
	Mean	1777	65	126	1133	304	890	34	21	572	154
	Std. Dev.	1162	4	21	471	90	92	4	6	110	35
9/10/96	S6092-A04.147	2756	117	191	2419	647	1077	56	63	1060	342
	S6092-A05.148	2642	113	185	2167	621	1034	54	57	930	332
	S6092-A06.150	2822	127	209	2407	663	1126	60	65	895	366
	Mean	2740	119	195	2331	644	1079	57	62	962	347
	Std. Dev.	91	7	12	142	21	46	3	4.2	87	17
11/14/96	S7009-A04.207	1962	65	176	3299	658	974	32	74	528	262
	S7009-A05.219	2033	68	186	3075	708	1067	35	80	481	274
	S7009-A06.237	1959	66	176	3125	688	1076	34	80	510	257
	Mean	1985	66	179	3166	685	1039	34	78	506	264
	Std. Dev.	42	2	6	118	25	56	2	3	24	9
1/30/97	V7003-A04.273	2178	69	168	1254	580	673	31	28	1568	241
	V7003-A05.304	2083	69	168	1218	618	722	30	28	1603	226
	V7003-A06.333	1874	68	165	1208	572	714	30	27	474	222
	Mean	2045	69	167	1227	590	703	30	28	1215	230
	Std. Dev.	156	0.6	2	24	25	26	0.6	0.6	642	10

Table A.8. Tank C-107 Organic Vapor Results from SUMMA Samples in ppbv

Sample Date	Sample Identification Number	2-Butanone	Acetone	Acetonitrile	Butanenitrile	Ethanol	Methanol	Propanenitrile	Propanol
1/18/96	S6001-A03.302	27	603	889	42	66	1127	117	8.6
	S6001-A04.303	27	469	695	44	47	887	119	7.2
	S6001-A15.304	29	683	976	56	73	1205	124	11
	S6001-A16-305	27	600	879	40	67	1233	117	9.1
	S6001-A27.306	28	661	967	55	66	1130	124	8.8
	S6001-A28.307	28	688	1025	46	77	1296	126	10
	Mean	28	617	905	47	66	1146	121	9.0
	Std. Dev.	1	82	117	7	10	143	4	1
3/26/96	S6019-A05.032	19	779	1403	26	143	2158	116	15
	S6019-A06.057	19	568	1167	26	95	1612	118	12
	S6019-A07.059	24	1029	2052	35	152	2341	166	18
	Mean	21	792	1541	29	130	2037	133	15
	Std. Dev.	3	231	458	5	31	379	28	3
9/5/96	S6091-A04.284;	30	528	628	42	59	610	101	11
	S6091-A05.285	26	537	654	44	63	705	105	11
	S6091-A06.287	24	541	661	42	61	691	104	11
	Mean	27	535	648	43	61	669	103	11
	Std. Dev.	3	7	17	2	2	51	2	0.3
12/17/96	S7010-A04.246	33	533	660	48	47	630	159	9.3
	S7010-A05.254	34	520	654	50	47	1003	158	9.4
	S7010-A06.256	32	506	626	51	46	585	153	8.8
	Mean	33	520	647	50	47	739	157	9.2
	Std. Dev.	1	13	18	1	1	229	3	0.3
2/7/97	V7005-A04.211	119	533	698	47	47	635	166	12 J
	V7005-A05.212	33	538	703	49	22 J	640	164	11 J
	V7005-A06.238	30	512	676	45	19 J	642	156	10 J
	Mean	61	528	693	47	29	639	162	11
	Std. Dev.	51	14	15	2	16	4	5	1

Table A.9. Tank S-102 Organic Vapor Results from SUMMA Samples in ppbv

Sample Date	Sample Identification Number	1-Butanol	2-Butanone	Benzene	Butane	Heptane	Pentane	Propanol	Tetrachloro-ethylene	Tetrahydrofuran	Toluene	Trichloro-fluoromethane
1/27/96	S6007-A03.082	464	48	15	99	7.8	10	34	8.4	50	115	46
	S6007-A04.083	394	46	14	122	7.6	10	33	8.0	43	110	35
	S6007-A15.084	431	56	16	92	9.1	12 J	41	10	50	132	44
	S6007-A16.097	425	49	15	90	8.0	10	33	8.6	48	117	44
	S6007-A27.108	418	56	14	112	6.2	9.7 J	41	8.5	46	113	56
	S6007-A28.120	434	53	15	97	8.3	10	41	8.4	48	113	33
	S6007-A87.086	384	47	13	104	7.2	8.5 J	37	7.8	43	105	51
	S6007-A88.089	455	50	15	100	7.8	8.7	37	8.5	48	114	39
	Mean	426	51	15	102	7.8	10	37	8.5	47	115	44
	Std. Dev.	27	4	1	11	1	1	4	0.7	3	8	8
4/4/96	S6031-A05.148	381	43	14	175	7.3	10 J	38	5.5 J	35	107	23
	S6031-A06.223	494	41	14	151	7.7	25	40	5.7 J	31	98	48
	S6031-A07.231	389	40	11	136	5.2	18	36	4.3 J	29	83	41
	Mean	421	41	13	154	6.7	18	38	5.2	32	96	37
	Std. Dev.	63	1	2	20	1	7	2	0.7	3	12	13
9/19/96	S6093-A04.038	1070	94	24	117	13	16	75	5.4	54	297	69
	S6093-A05.065	923	99	24	100	13	16	77	5.6	56	298	72
	S6093-A06.104	957	86	24	96	13	16	76	5.3	53	299	70
	Mean	983	93	24	104	13	16	76	5.4	54	298	70
	Std. Dev.	77	7	0.07	11	0.3	0.4	1	0.2	1	0.7	1
12/19/96	V6001-A04.272	535	70	21	70	13	23	80	11	44	170	38
	V6001-A05.276	532	71	21	71	13	20	80	11	45	173	40
	V6001-A06.312	505	72	20	71	12	22	79	11	44	169	39
	Mean	524	71	21	71	13	22	80	11	44	171	39
	Std. Dev.	16	1	0.3	1	0.2	1	1	0.2	1	2	1
2/11/97	V7006-A04.142	312	60	10	70	4.0 J	15	40	7.3	16	79	26
	V7006-A05.167	343	57	11	78	4.3	15	42	7.9	18	87	28
	V7006-A06.169	328	60	11	76	4.1	11 J	40	7.4	17	84	27
	Mean	328	59	11	75	4.1	14	41	7.5	17	83	27
	Std. Dev.	15	2	0.5	4	0.1	2	2	0.3	0.7	4	1

Table A.10. Tank BX-104 Organic Vapor Results from TST Samples in ppbv

Sample Date	Sample Identification Number	2-Butanone	4-Methyl-2-Pentanone	Acetone	Acetonitrile	Butane	Butanenitrile	Dodecane	Ethanol	Heptane	Hexane	Hexanenitrile	Methanol
8/22/96	S6086-A11.1173	569	65	2254	E 309	231	98	297	935	52	65	21	1565
	S6086-A12.1174	517	60	2101	E 356	223	100	493	E 860	52	65	30	1606
	S6086-A13.1175	436	55	1730	E 272	198	80	135	694	46	58	14	1148
	Mean	507	60	2028	312	218	93	308	830	50	63	22	1440
	Std. Dev.	67	5	270	43	17	11	179	124	4	4	8	254
12/12/96	S7017-A11.1332	94	19	494	123	247	42	537	E 409	34	62	9.8	1162
	S7017-A12.1333	67	11	249	71	136	18	221	142	J 28	42	5.8	J 451
	S7017-A13.1334	61	9.7	258	64	133	21	124	141	J 24	39	4.3	J 417
	Mean	74	13	334	86	172	27	294	230	29	47	6.6	677
	Std. Dev.	18	5	139	32	65	13	216	154	5	12	3	421
2/6/97	V7004-A11.1382	173	22	500	308	471	43	166	1023	70	144	8.2	1719
	V7004-A12.1383	119	18	371	200	337	38	316	594	69	115	10.0	1016
	V7004-A13.1384	123	20	398	172	339	40	589	E 646	73	115	12	886
	Mean	138	20	423	227	383	40	357	754	71	125	10	1207
	Std. Dev.	30	2	68	72	77	2	214	234	2	17	2	448
4/7/97	V7014-A11.1400	89	16	430	155	242	35	368	180	36	66	13	593
	V7014-A12.1401	54	9.3	289	97	149	20	66	64	J 24	46	6.7	J 321
	V7014-A13.1402	56	11	263	86	152	22	194	67	J 28	46	9.1	270
	Mean	66	12	327	113	181	26	209	104	29	53	9.5	394
	Std. Dev.	20	3	90	37	53	8	151	66	6	11	3	173
6/10/97	V7021-A11.1411	160	28	682	157	836	44	450	170	38	61	18	481
	V7021-A12.1412	176	25	761	193	841	43	83	238	33	59	12	771
	V7021-A13.1413	142	21	623	153	733	35	89	159	28	51	9.2	495
	Mean	159	24	689	168	803	41	207	189	33	57	13	582
	Std. Dev.	17	3	69	22	61	5	210	42	5	5	5	163

Table A.10. Tank BX-104 Organic Vapor Results from TST Samples in ppbv

Sample Date	Sample Identification Number	Nonane	Octane	Pentane	Pentanenitrile	Propanenitrile	Propanol	Tetradecane	Tetrahydrofuran	Trichlorofluoromethane	Tridecane	Undecane
8/22/96	S6086-A11.1173	9.3	19	91	22	102	779	438	E 297	311	839	E 34
	S6086-A12.1174	14	26	88	24	99	723	669	E 299	280	1266	E 57
	S6086-A13.1175	6.5	14	79	18	82	624	217	E 258	267	425	E 15
	Mean	10	20	86	21	94	709	441	284	286	843	35
	Std. Dev.	4	6	6	3	11	78	226	23	23	420	21
12/12/96	S7017-A11.1332	7.0	19	119	13	48	351	506	E 217	80	761	E 63
	S7017-A12.1333	2.9	14	69	8.2	26	141	261	146	69	373	23
	S7017-A13.1334	1.8	11	64	7.0	25	159	156	160	80	216	12
	Mean	3.9	15	84	9.5	33	217	307	174	76	450	33
	Std. Dev.	3	4	30	3	13	117	179	38	7	281	27
2/6/97	V7004-A11.1382	4.5	24	277	17	82	453	175	251	81	280	16
	V7004-A12.1383	6.4	31	192	16	64	228	327	E 216	78	507	E 34
	V7004-A13.1384	11	39	192	18	64	241	534	E 217	73	872	E 70
	Mean	7.2	31	220	17	70	307	345	228	77	553	40
	Std. Dev.	3	8	49	1	11	126	180	20	4	299	28
4/7/97	V7014-A11.1400	7.6	20	117	16	53	276	328	E 196	82	522	E 45
	V7014-A12.1401	2.4	11	70	9.0	35	98	71	144	70	110	10
	V7014-A13.1402	4.4	16	73	11	34	139	189	153	68	290	25
	Mean	4.8	15	87	12	40	171	196	165	74	308	27
	Std. Dev.	3	5	26	4	11	93	128	28	8	207	17
6/10/97	V7021-A11.1411	7.9	20	93	24	59	789	780	E 259	149	907	E 119
	V7021-A12.1412	3.2	13	93	20	63	757	162	263	158	228	23
	V7021-A13.1413	2.7	10	81	17	51	702	191	223	131	257	21
	Mean	4.6	15	89	20	58	750	378	249	146	464	54
	Std. Dev.	3	5	7	3	6	44	349	22	13	384	56

Table A.11. Tank BY-108 Organic Vapor Results from TST Samples in ppbv

Sample Date	Sample Identification Number	2-Butanone	4-Methyl-2-Pentanone	Acetonitrile	Benzene	Butanenitrile	Cyclohexane	Decane	Ethylbenzene	Heptane	Nonane	Octane	O-Xylene	p-m-Xylene	Propanenitrile	Propanol	Tetrahydrofuran	Trichlorofluoromethane	Undecane
1/23/96	S6004-A05.707	313	47	244	25	9.5	216	112	4.4	595	86	181	7.1	15	18	500	849	30	274
	S6004-A06.708	315	47	246	25	8.5	164	103	4.2	600	86	176	6.7	14	18	476	816	26	282
	S6004-A08.710	313	43	217	26	6.3	142	99	4.5	552	80	179	7.1	15	17	482	822	32	252
	S6004-A09.711	383	49	79	35	7.3 J	183		6.2	618	97	196	7.5	18	14	551	902	38	
	S6004-A10.715	331	47	194	27	4.9	161	108	5.1	590	89	191	7.3	16	14	430	815	27	278
	Mean	331	46	196	27	7.3	173	106	4.9	591	88	185	7.1	16	16	488	841	31	271
	Std. Dev.	30	2	69	4	2	28	6	1	24	6	9	0.3	1	2	44	37	4	13
3/28/96	S6021-A08.825	233	70	299	42	23	168	138	5.1	563	98	221	7.9	16	27	418	657	21	280
	S6021-A09.826	210	60	228	28	26	161	138	4.5	556	87	205	7.0	14	23	354	659	20	303
	S6021-A10.834	199	69	276	29	21	185	150	4.8	609	95	210	7.2	15	25	391	679	19	326
	Mean	214	66	267	33	23	171	142	4.8	576	94	212	7.4	15	25	388	665	20	303
	Std. Dev.	17	6	36	8	3	12	7	0.3	28	6	8	0.4	1	2	32	12	1	23
9/10/96	S6092-A11.1217	453	37	395	33	19	258	85	5.5	693 E	70	188	7.7	16	26	500	741	20	165
	S6092-A12.1218	412	31	326	32	12	230	68	4.7	633	58	178	6.8	15	23	399	676	17	135
	S6092-A13.1219	414	33	317	33	13	221	72	5.1	627	59	178	7.2	16	24	406	713	17	137
	Mean	426	34	346	33	15	236	75	5.1	651	62	181	7.2	16	24	435	710	18	146
	Std. Dev.	23	3	43	1	4	19	9	0.4	36	6	6	0.4	1	1	56	33	2	17
11/14/96	S7009-A11.1208	94	81	370	35	23	182	74	5.1	573	63	224	8.3	17	36	486	578	58	153
	S7009-A12.1212	236	62	244	30	14	210	45	5.0	520	40	194	7.4	17	22	270	480	37	98
	S7009-A13.1214	298	67	211	34	16	184	52	5.6	514	46	201	8.9	19	23	419	569	25	105
	Mean	209	70	275	33	17	192	57	5.2	536	50	206	8.2	18	27	392	543	40	119
	Std. Dev.	105	10	84	3	5	16	15	0.3	33	12	16	1	1	8	110	54	17	30
1/30/97	V7003-A11.1362	268	52	249	23	17	170	73	2.9 J	439	55	177	4.4	2.2 J	20	340	464	12	164
	V7003-A12.1363	211	41	140	22	10	145	43	2.6 J	379	36	152	3.8 J	2.0 J	13	198	422	9.3	106
	V7003-A13.1364	318	45	138	23	7.7	145	71	3.1 J	397	51	178	4.6	2.4 J	14	310	442	16	173
	Mean	266	46	176	22	11	153	62	2.9	405	47	169	4.3	2.2	15	283	443	12	147
	Std. Dev.	54	6	63	0.6	5	14	17	0.2	31	10	15	0.4	0.2	4	75	21	3	36

Table A.12. Tank C-107 Organic Vapor Results from TST Samples in ppbv

Sample Date	Sample Identification Number	2-Butanone	Acetone	Acetonitrile	Butanenitrile	Pentanitrile	Propanenitrile
1/18/96	S6001-A05.773	22	278	551	38	4.8	96
	S6001-A06.774	23	294	532	37	4.8	100
	S6001-A07.775	26	374	790	40	4.1	112
	S6001-A08.776	22	293	721	36	3.7	100
	S6001-A09.777	22	355	710	37	3.7	109
	S6001-A10.778	19	300	696	36	3.7	104
	Mean	22	316	667	37	4.1	103
	Std. Dev.	2	39	102	2	1	6
3/26/96	S6019-A08.800	14	166	197	36	2.6	105
	S6019-A09.801	14	200	521	34	2.6	85
	S6019-A10.802	11	237	581	36	4.4	98
	S6019-A11.803	13	220	503	32	3.5	83
	Mean	13	206	450	34	3.2	93
	Std. Dev.	1	30	173	2	1	10
9/5/96	S6091-A12.1202	23	404	570	40	4.1	108
	S6091-A13.1203	31	482	638	43	3.7	116
	S6091-A14.1204	25	394	563	39	4.0	108
	Mean	27	427	590	41	4.0	111
	Std. Dev.	4	48	41	2	0.2	5
12/17/96	S7010-A11.1273	33	364	541	51	9.5	173
	S7010-A12.1274	24	405	379	43	8.2	154
	S7010-A13.1275	29	479	384	47	8.6	181
	Mean	29	416	435	47	8.8	169
	Std. Dev.	5	58	92	4	1	14
2/7/97	V7005-A11.1374	8.5	184	453	36	6.4	121
	V7005-A12.1375	19	285	520	39	7.0	140
	V7005-A13.1376	18	270	528	41	7.2	134
	Mean	15	246	500	39	6.9	132
	Std. Dev.	6	54	41	3	0.45	9

Table A.13. Tank S-102 Organic Vapor Results from TST Samples in ppbv

Sample Date	Sample Identification Number	1-Butanol	2-Butanone	4-Methyl-2-Pentanone	Acetone	Acetonitrile	Benzene	Butane	Heptane	Hexane	Nonane	Pentane	Propanol	Tetrachloro-ethylene	Tetrahydrofuran	Toluene	Trichlorofluoromethane
1/27/96	S6007 A05.806	626	59	8.7	243	51	18	63	11	9.5	3.2	15	60	10.0	53	121	28
	S6007 A06.807	621	59	11	276	85	18	57	11	9.0	3.1	14	57	9.8	53	122	30
	S6007 A07.808	574	65	8.5	266	66	19	63	11	10	3.4	15	54	10	54	123	31
	S6007 A08.809	647	65	8.8	265	69	18	63	11	9.1	3.4	15	43	10	54	121	29
	S6007 A09.810	653	58	8.1	265	63	19	59	11	9.3	3.2	15	61	10	55	123	32
	S6007 A10.811	629	56	9.1	241	62	18	56	11	8.6	3.1	14	59	9.9	54	118	27
	Mean	625	60	9	259	66	18	60	11	9	3	15	55	10.0	54	121	30
	Std. Dev.	28	4	1	14	11	0.4	3	0.2	0.5	0.1	0.4	7	0.1	0.8	2	2
4/4/96	S6031-A08.888	572	40	13	213	86	20	65	20	10	3.6	16	47	8.9	42	132	29
	S6031-A09.889	554	36	11	230	68	19	62	20	10	3.4	16	50	8.9	42	130	32
	S6031-A11.892	479	47	14	248	86	20	68	12	12	3.9	17	57	9.9	44	138	30
	Mean	535	41	13	230	80	20	65	17	11	3.6	16	51	9.2	43	133	31
	Std. Dev.	49	5	1	18	10	0.3	3	4	0.7	0.2	0.5	5	0.6	1	4	2
9/19/96	S6093-A11.1231	1092	68	6.1	348	120	28	115	20	12	4.1	22	91	6.8	79	319	77
	S6093-A12.1232	1094	84	6.5	421	103	29	120	21	12	4.2	22	100	6.9	81	326	79
	S6093-A13.1233	1089	93	6.7	465	131	29	122	21	13	4.9	23	105	7.2	83	337	82
	Mean	1092	82	6.4	412	118	29	119	21	12	4.4	22	99	7.0	81	327	79
	Std. Dev.	3	13	0.3	59	14	0.8	4	0.5	0.4	0.4	0.6	7	0.2	2	9	3
12/19/96	V6001-A11.1348	375	29	12	191	86	19	70	11	10	2.6	14	31	8.8	37	143	33
	V6001-A12.1349	373	33	12	222	88	19	63	11	9.6	2.5	13	35	9.2	37	142	25
	V6001-A13.1350	492	56	12	186	107	20	66	11	9.9	2.8	14	67	9.5	42	144	37
	Mean	413	39	12	200	94	19	66	11	10.0	2.6	14	45	9.2	39	143	32
	Std. Dev.	68	14	0.1	19	12	0.3	3	0.1	0.4	0.2	0.6	19	0.3	3	1	6
2/11/97	V7006-A11.1115	206	46	8.2	271	91	10	37	5.0	5.3	1.4	8.1	42	8.4	19	76	25
	V7006-A12.1116	171	43	8.4	269	182	10	35	4.9	5.2	1.3	8.6	42	8.5	19	75	24
	V7006-A13.1117	232	42	9.0	237	129	10.0	35	5.1	5.3	1.4	8.3	41	8.9	19	77	23
	Mean	203	44	8.5	259	134	10	35	5.0	5.3	1.4	8.4	42	8.6	19	76	24
	Std. Dev.	30	2	0.4	19	46	0.1	1	0.1	0.1	0.04	0.2	0.4	0.2	0.2	1	1

Table A.8. Tank C-107 Organic Vapor Results from SUMMA Samples in ppbv

2/7/97

V7005-A04.211	119	533	698	47	47		635	166	12	J
V7005-A05.212	33	538	703	49	22	J	640	164	11	J
V7005-A06.238	30	512	676	45	19	J	642	156	10	J
Mean	61	528	693	47	29		639	162	11	
Std. Dev.	51	14	15	2	16		4	5	1	

Table A.9. Tank S-102 Organic Vapor Results from SUMMA Samples in ppbv

Sample Date	Sample Identification Number	1-Butanol	2-Butanone	Benzene	Butane	Heptane	Pentane	Propanol	Tetrachloro-ethylene	Tetrahydro-furan	Toluene	Trichloro-fluoromethane
1/27/96	S6007-A03.082	464	48	15	99	7.8	10	34	8.4	50	115	46
	S6007-A04.083	394	46	14	122	7.6	10	33	8.0	43	110	35
	S6007-A15.084	431	56	16	92	9.1	12 J	41	10	50	132	44
	S6007-A16.097	425	49	15	90	8.0	10	33	8.6	48	117	44
	S6007-A27.108	418	56	14	112	6.2	9.7 J	41	8.5	46	113	56
	S6007-A28.120	434	53	15	97	8.3	10	41	8.4	48	113	33
	S6007-A87.086	384	47	13	104	7.2	8.5 J	37	7.8	43	105	51
	S6007-A88.089	455	50	15	100	7.8	8.7	37	8.5	48	114	39
	Mean	426	51	15	102	7.8	10	37	8.5	47	115	44
	Std. Dev.	27	4	1	11	1	1	4	0.7	3	8	8
4/4/96	S6031-A05.148	381	43	14	175	7.3	10 J	38	5.5 J	35	107	23
	S6031-A06.223	494	41	14	151	7.7	25	40	5.7 J	31	98	48
	S6031-A07.231	389	40	11	136	5.2	18	36	4.3 J	29	83	41
	Mean	421	41	13	154	6.7	18	38	5.2	32	96	37
	Std. Dev.	63	1	2	20	1	7	2	0.7	3	12	13
9/19/96	S6093-A04.038	1070	94	24	117	13	16	75	5.4	54	297	69
	S6093-A05.065	923	99	24	100	13	16	77	5.6	56	298	72
	S6093-A06.104	957	86	24	96	13	16	76	5.3	53	299	70
	Mean	983	93	24	104	13	16	76	5.4	54	298	70
	Std. Dev.	77	7	0.07	11	0.3	0.4	1	0.2	1	0.7	1
12/19/96	V6001-A04.272	535	70	21	70	13	23	80	11	44	170	38
	V6001-A05.276	532	71	21	71	13	20	80	11	45	173	40
	V6001-A06.312	505	72	20	71	12	22	79	11	44	169	39
	Mean	524	71	21	71	13	22	80	11	44	171	39
	Std. Dev.	16	1	0.3	1	0.2	1	1	0.2	1	2	1

Table A.9. Tank S-102 Organic Vapor Results from SUMMA Samples in ppbv

2/11/97	V7006-A04.142	312	60	10	70	4.0	J	15	40	7.3	16	79	26
	V7006-A05.167	343	57	11	78	4.3		15	42	7.9	18	87	28
	V7006-A06.169	328	60	11	76	4.1		11	J 40	7.4	17	84	27
	Mean	328	59	11	75	4.1		14	41	7.5	17	83	27
	Std. Dev.	15	2	0.5	4	0.1		2	2	0.3	0.7	4	1

Table A.10. Tank BX-104 Organic Vapor Results from TST Samples in ppbv

Sample Date	Sample Identification Number	2-Butanone	4-Methyl-2-Pentanone	Acetone	Acetonitrile	Butane	Butanenitrile	Dodecane	Ethanol	Heptane	Hexane	Hexanenitrile	Methanol
#	S6086-A11.1173	569	65	2254 E	309	231	98	297	935	52	65	21	1565
	S6086-A12.1174	517	60	2101 E	356	223	100	493 E	860	52	65	30	1606
	S6086-A13.1175	436	55	1730 E	272	198	80	135	694	46	58	14	1148
	Mean	507	60	2028	312	218	93	308	830	50	63	22	1440
	Std. Dev.	67	5	270	43	17	11	179	124	4	4	8	254
#	S7017-A11.1332	94	19	494	123	247	42	537 E	409	34	62	9.8	1162
	S7017-A12.1333	67	11	249	71	136	18	221	142 J	28	42	5.8 J	451
	S7017-A13.1334	61	9.7	258	64	133	21	124	141 J	24	39	4.3 J	417
	Mean	74	13	334	86	172	27	294	230	29	47	6.6	677
	Std. Dev.	18	5	139	32	65	13	216	154	5	12	3	421
#	V7004-A11.1382	173	22	500	308	471	43	166	1023	70	144	8.2	1719
	V7004-A12.1383	119	18	371	200	337	38	316	594	69	115	10.0	1016
	V7004-A13.1384	123	20	398	172	339	40	589 E	646	73	115	12	886
	Mean	138	20	423	227	383	40	357	754	71	125	10	1207
	Std. Dev.	30	2	68	72	77	2	214	234	2	17	2	448
#	V7014-A11.1400	89	16	430	155	242	35	368	180	36	66	13	593
	V7014-A12.1401	54	9.3	289	97	149	20	66	64 J	24	46	6.7 J	321
	V7014-A13.1402	56	11	263	86	152	22	194	67 J	28	46	9.1	270
	Mean	66	12	327	113	181	26	209	104	29	53	9.5	394
	Std. Dev.	20	3	90	37	53	8	151	66	6	11	3	173
#	V7021-A11.1411	160	28	682	157	836	44	450	170	38	61	18	481
	V7021-A12.1412	176	25	761	193	841	43	83	238	33	59	12	771
	V7021-A13.1413	142	21	623	153	733	35	89	159	28	51	9.2	495
	Mean	159	24	689	168	803	41	207	189	33	57	13	582
	Std. Dev.	17	3	69	22	61	5	210	42	5	5	5	163

Table A.10. Tank BX-104 Organic Vapor Results from TST Samples in ppbv

Sample Date	Sample Identification Number	Nonane	Octane	Pentane	Pentanenitrile	Propanenitrile	Propanol	Tetradecane	Tetrahydrofuran	Trichlorofluoromethane	Tridecane	Undecane
##	S6086-A11.1173	9.3	19	91	22	102	779	438 E	297	311	839 E	34
	S6086-A12.1174	14	26	88	24	99	723	669 E	299	280	1266 E	57
	S6086-A13.1175	6.5	14	79	18	82	624	217 E	258	267	425 E	15
	Mean	10	20	86	21	94	709	441	284	286	843	35
	Std. Dev.	4	6	6	3	11	78	226	23	23	420	21
##	S7017-A11.1332	7.0	19	119	13	48	351	506 E	217	80	761 E	63
	S7017-A12.1333	2.9	14	69	8.2	26	141	261	146	69	373	23
	S7017-A13.1334	1.8 J	11	64	7.0	25	159	156	160	80	216	12
	Mean	3.9	15	84	9.5	33	217	307	174	76	450	33
	Std. Dev.	3	4	30	3	13	117	179	38	7	281	27
##	V7004-A11.1382	4.5	24	277	17	82	453	175	251	81	280	16
	V7004-A12.1383	6.4	31	192	16	64	228	327 E	216	78	507 E	34
	V7004-A13.1384	11	39	192	18	64	241	534 E	217	73	872 E	70
	Mean	7.2	31	220	17	70	307	345	228	77	553	40
	Std. Dev.	3	8	49	1	11	126	180	20	4	299	28
##	V7014-A11.1400	7.6	20	117	16	53	276	328 E	196	82	522 E	45
	V7014-A12.1401	2.4	11	70	9.0	35	98	71	144	70	110	10
	V7014-A13.1402	4.4	16	73	11	34	139	189	153	68	290	25
	Mean	4.8	15	87	12	40	171	196	165	74	308	27
	Std. Dev.	3	5	26	4	11	93	128	28	8	207	17
##	V7021-A11.1411	7.9	20	93	24	59	789	780 E	259	149	907 E	119
	V7021-A12.1412	3.2	13	93	20	63	757	162	263	158	228	23
	V7021-A13.1413	2.7	10	81	17	51	702	191	223	131	257	21
	Mean	4.6	15	89	20	58	750	378	249	146	464	54
	Std. Dev.	3	5	7	3	6	44	349	22	13	384	56

Table A.11. Tank BY-108 Organic Vapor Results from TST Samples in ppbv

Sample Date	Sample Identification Number	2-Butanone	4-Methyl-2-Pentanone	Acetonitrile	Benzene	Butanenitrile	Cyclohexane	Decane	Ethylbenzene	Heptane	Nonane	Octane	o-Xylene	p/m-Xylene	Propanenitrile	Propanol	Tetrahydrofuran	Trichlorofluoromethane	Undecane
1/23/96	S6004-A05.707	313	47	244	25	9.5	216	112	4.4	595	86	181	7.1	15	18	500	849	30	274
	S6004-A06.708	315	47	246	25	8.5	164	103	4.2	600	86	176	6.7	14	18	476	816	26	282
	S6004-A08.710	313	43	217	26	6.3	142	99	4.5	552	80	179	7.1	15	17	482	822	32	252
	S6004-A09.711	383	49	79	35	7.3 J	183		6.2	618	97	196	7.5	18	14	551	902	38	
	S6004-A10.715	331	47	194	27	4.9	161	108	5.1	590	89	191	7.3	16	14	430	815	27	278
	Mean	331	46	196	27	7.3	173	106	4.9	591	88	185	7.1	16	16	488	841	31	271
	Std. Dev.	30	2	69	4	2	28	6	1	24	6	9	0.3	1	2	44	37	4	13
3/28/96	S6021-A08.825	233	70	299	42	23	168	138	5.1	563	98	221	7.9	16	27	418	657	21	280
	S6021-A09.826	210	60	228	28	26	161	138	4.5	556	87	205	7.0	14	23	354	659	20	303
	S6021-A10.834	199	69	276	29	21	185	150	4.8	609	95	210	7.2	15	25	391	679	19	326
	Mean	214	66	267	33	23	171	142	4.8	576	94	212	7.4	15	25	388	665	20	303
	Std. Dev.	17	6	36	8	3	12	7	0.3	28	6	8	0.4	1	2	32	12	1	23
9/10/96	S6092-A11.1217	453	37	395	33	19	258	85	5.5	693 E	70	188	7.7	16	26	500	741	20	165
	S6092-A12.1218	412	31	326	32	12	230	68	4.7	633	58	178	6.8	15	23	399	676	17	135
	S6092-A13.1219	414	33	317	33	13	221	72	5.1	627	59	178	7.2	16	24	406	713	17	137
	Mean	426	34	346	33	15	236	75	5.1	651	62	181	7.2	16	24	435	710	18	146
	Std. Dev.	23	3	43	1	4	19	9	0.4	36	6	6	0.4	1	1	56	33	2	17
11/14/96	S7009-A11.1208	94	81	370	35	23	182	74	5.1	573	63	224	8.3	17	36	486	578	58	153
	S7009-A12.1212	236	62	244	30	14	210	45	5.0	520	40	194	7.4	17	22	270	480	37	98
	S7009-A13.1214	298	67	211	34	16	184	52	5.6	514	46	201	8.9	19	23	419	569	25	105
	Mean	209	70	275	33	17	192	57	5.2	536	50	206	8.2	18	27	392	543	40	119
	Std. Dev.	105	10	84	3	5	16	15	0.3	33	12	16	1	1	8	110	54	17	30
1/30/97	V7003-A11.1362	268	52	249	23	17	170	73	2.9 J	439	55	177	4.4	2.2 J	20	340	464	12	164
	V7003-A12.1363	211	41	140	22	10	145	43	2.6 J	379	36	152	3.8 J	2.0 J	13	198	422	9.3	106
	V7003-A13.1364	318	45	138	23	7.7	145	71	3.1 J	397	51	178	4.6	2.4 J	14	310	442	16	173
	Mean	266	46	176	22	11	153	62	2.9	405	47	169	4.3	2.2	15	283	443	12	147
	Std. Dev.	54	6	63	0.6	5	14	17	0.2	31	10	15	0.4	0.2	4	75	21	3	36

Table A.12. Tank C-107 Organic Vapor Results from TST Samples in ppbv

Sample Date	Sample Identification Number	2-Butanone	Acetone	Acetonitrile	Butanenitrile	Pentanenitrile	Propanenitrile
1/18/96	S6001-A05.773	22	278	551	38	4.8	96
	S6001-A06.774	23	294	532	37	4.8	100
	S6001-A07.775	26	374	790	40	4.1	112
	S6001-A08.776	22	293	721	36	3.7	100
	S6001-A09.777	22	355	710	37	3.7	109
	S6001-A10.778	19	300	696	36	3.7	104
	Mean	22	316	667	37	4.1	103
	Std. Dev.	2	39	102	2	1	6
3/26/96	S6019-A08.800	14	166	197	36	2.6	105
	S6019-A09.801	14	200	521	34	2.6	85
	S6019-A10.802	11	237	581	36	4.4	98
	S6019-A11.803	13	220	503	32	3.5	83
	Mean	13	206	450	34	3.2	93
	Std. Dev.	1	30	173	2	1	10
9/5/96	S6091-A12.1202	23	404	570	40	4.1	108
	S6091-A13.1203	31	482	638	43	3.7	116
	S6091-A14.1204	25	394	563	39	4.0	108
	Mean	27	427	590	41	4.0	111
	Std. Dev.	4	48	41	2	0.2	5
12/17/96	S7010-A11.1273	33	364	541	51	9.5	173
	S7010-A12.1274	24	405	379	43	8.2	154
	S7010-A13.1275	29	479	384	47	8.6	181
	Mean	29	416	435	47	8.8	169
	Std. Dev.	5	58	92	4	1	14

Table A.12. Tank C-107 Organic Vapor Results from TST Samples in ppbv

2/7/97	V7005-A11.1374	8.5	184	453	36	6.4	121
	V7005-A12.1375	19	285	520	39	7.0	140
	V7005-A13.1376	18	270	528	41	7.2	134
	Mean	15	246	500	39	6.9	132
	Std. Dev.	6	54	41	3	0.45	9

Table A.13. Tank S-102 Organic Vapor Results from TST Samples in ppbv

Sample Date	Sample Identification Number	1-Butanol	2-Butanone	4-Methyl-2-Pentanone	Acetone	Acetonitrile	Benzene	Butane	Heptane	Hexane	Nonane	Pentane	Propanol	Tetrachloroethylene	Tetrahydrofuran	Toluene	Trichlorofluoromethane
1/27/96	S6007 A05.806	626	59	8.7	243	51	18	63	11	9.5	3.2	15	60	10.0	53	121	28
	S6007 A06.807	621	59	11	276	85	18	57	11	9.0	3.1	14	57	9.8	53	122	30
	S6007 A07.808	574	65	8.5	266	66	19	63	11	10	3.4	15	54	10	54	123	31
	S6007 A08.809	647	65	8.8	265	69	18	63	11	9.1	3.4	15	43	10	54	121	29
	S6007 A09.810	653	58	8.1	265	63	19	59	11	9.3	3.2	15	61	10	55	123	32
	S6007 A10.811	629	56	9.1	241	62	18	56	11	8.6	3.1	14	59	9.9	54	118	27
	Mean	625	60	9	259	66	18	60	11	9	3	15	55	10.0	54	121	30
	Std. Dev.	28	4	1	14	11	0.4	3	0.2	0.5	0.1	0.4	7	0.1	0.8	2	2
4/4/96	S6031-A08.888	572	40	13	213	86	20	65	20	10	3.6	16	47	8.9	42	132	29
	S6031-A09.889	554	36	11	230	68	19	62	20	10	3.4	16	50	8.9	42	130	32
	S6031-A11.892	479	47	14	248	86	20	68	12	12	3.9	17	57	9.9	44	138	30
	Mean	535	41	13	230	80	20	65	17	11	3.6	16	51	9.2	43	133	31
	Std. Dev.	49	5	1	18	10	0.3	3	4	0.7	0.2	0.5	5	0.6	1	4	2
9/19/96	S6093-A11.1231	1092	68	6.1	348	120	28	115	20	12	4.1	22	91	6.8	79	319	77
	S6093-A12.1232	1094	84	6.5	421	103	29	120	21	12	4.2	22	100	6.9	81	326	79
	S6093-A13.1233	1089	93	6.7	465	131	29	122	21	13	4.9	23	105	7.2	83	337	82
	Mean	1092	82	6.4	412	118	29	119	21	12	4.4	22	99	7.0	81	327	79
	Std. Dev.	3	13	0.3	59	14	0.8	4	0.5	0.4	0.4	0.6	7	0.2	2	9	3
12/19/96	V6001-A11.1348	375	29	12	191	86	19	70	11	10	2.6	14	31	8.8	37	143	33
	V6001-A12.1349	373	33	12	222	88	19	63	11	9.6	2.5	13	35	9.2	37	142	25
	V6001-A13.1350	492	56	12	186	107	20	66	11	9.9	2.8	14	67	9.5	42	144	37
	Mean	413	39	12	200	94	19	66	11	10.0	2.6	14	45	9.2	39	143	32
	Std. Dev.	68	14	0.1	19	12	0.3	3	0.1	0.4	0.2	0.6	19	0.3	3	1	6

Table A.13. Tank S-102 Organic Vapor Results from TST Samples in ppbv

2/11/97

V7006-A11.1115	206	46	8.2	271	91	10	37	5.0	5.3	1.4	J	8.1	J	42	8.4	19	76	25
V7006-A12.1116	171	43	8.4	269	182	10	35	4.9	5.2	1.3	J	8.6	J	42	8.5	19	75	24
V7006-A13.1117	232	42	9.0	237	129	10.0	35	5.1	5.3	1.4	J	8.3	J	41	8.9	19	77	23
Mean	203	44	8.5	259	134	10	35	5.0	5.3	1.4		8.4		42	8.6	19	76	24
Std. Dev.	30	2	0.4	19	46	0.1	1	0.1	0.1	0.04		0.2		0.4	0.2	0.2	1	1

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