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7. Abstract

Tank 241-C-106 headspace gas and vapor samples were collected and analyzed to help determine the potential risks to tank farm workers due to fugitive emissions from the tank. The drivers and objectives of waste tank headspace sampling and analysis are discussed in "Program Plan for the Resolution of Tank Vapor Issues" (Osborne and Huckaby 1994). Tank 241-C-106 was vapor sampled in accordance with "Data Quality Objectives for Generic In-Tank Health and Safety Issue Resolution (Osborne et al., 1994).

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Tank 241-C-106 Vapor Sampling and Analysis Tank Characterization Report

X.0 INTRODUCTION

Tank C-106 headspace gas and vapor samples were collected and analyzed to help determine the potential risks of fugitive emissions to tank farm workers. The drivers and objectives of waste tank headspace sampling and analysis are discussed in *Program Plan for the Resolution of Tank Vapor Issues* (Osborne and Huckaby 1994). Tank C-106 was vapor sampled in accordance with *Data Quality Objectives for Generic In-Tank Health and Safety Issue Resolution* (Osborne et al. 1994). Results presented here represent the best available data on the headspace constituents of tank C-106.

Gas and vapor concentrations in tank C-106 are very strongly affected by the active ventilation of the headspace. Unlike the passively ventilated waste tanks, it can not be assumed that the headspace is well-mixed by thermally-induced convection and diffusion. Though mixing is generally more vigorous in an actively ventilated tank headspace (other factors being equal), the discrete sources of fresh air and the single outlet would produce concentration gradients within the headspace. Therefore, while a strong argument can be made that samples collected from any central region of a passively ventilated headspace are representative of nearly the entire headspace, sample collection in tank C-106 is probably location-dependent.

Consequently, samples from tank C-106 were collected from a port on the exhaust header, and while the exhauster was operating. Though concentrations in the headspace are higher in some places and lower in others, the exhaust header was deemed the best place to sample to address the exposure risks to tank farm workers.

The active ventilation of tank C-106 affects its headspace gas and vapor concentrations in yet another way. Because tank C-106 is connected via a cascade line to tank C-105, which is in turn connected via a cascade line to tank C-104, gases and vapors from waste stored in tanks C-105 and C-104 may be drawn into the tank C-106 headspace. Thus, when considering the relationship between the waste in tank C-106 and the gases and vapors in the exhaust from that tank, it should be kept in mind that some constituents may actually be coming from tanks C-105 and C-104. Results of gas and vapor samples from tanks C-104 and C-105 provide evidence that tank C-104 is venting through its cascade line to tank C-105 (Huckaby 1995a, 1995b).

X.1 SAMPLING EVENT

Gas and vapor samples were collected from tank C-106 using the vapor sampling system (VSS) on February 15, 1994 by WHC Sampling & Mobile Laboratories (WHC 1995). Sample collection and analysis were performed as directed by the sample and analysis plan (WHC 1995, Appendix A). Air from the tank C-106 headspace was withdrawn from a port on the exhaust header at riser 2, and transferred via heated tubing to the VSS sampling manifold. All heated zones of the VSS were maintained at approximately 50 °C. Sampling media were prepared and analyzed by WHC, Oak Ridge National Laboratories (ORNL), Pacific Northwest Laboratories (PNL), and Oregon Graduate Institute of Science and Technology (OGIST) through a contract with Sandia National Laboratories.

Tank C-106 was the second tank to be sampled using the VSS, and was sampled only about 3 weeks after the first use of the VSS on a tank. Because the methods and equipment were relatively new, problems with sample handling (e.g., chain-of-custody and shipping) were encountered (WHC 1995, McVeety et al. 1995b). Sorbent trap collection problems noted in a subsequent sampling event appear to have affected several of the inorganic compound samples[1].

Flowrate and temperature measurements of the tank C-106 exhaust were made on February 4 and March 2, 1994 (Minter 1995). On those dates, the flowrate and temperature of the exhaust was determined to be 41.5 m^3/min (1,464 ft^3/min), 13.9 °C, and 46.4 m^3/min (1,638 ft^3/min), 19.4 °C, respectively. Given a calculated headspace volume of 2,120 m^3 (75,000 ft^3) these flowrates correspond to 1 turn-over of the headspace every 45 to 51 min. By contrast, the average exchange of air between a passively ventilated waste tank and the atmosphere due to barometric pressure fluctuations is less than 0.5 % of the headspace volume per day, which corresponds to 1 turn-over of the headspace every 200 days.

The 40 tank air samples and 6 ambient air control samples collected are listed in Table X-1 by analytical laboratory. Table X-1 also lists the 5 trip blanks provided by the laboratories. A general description of vapor sampling and sample analysis methods is given by Huckaby (1995c). The sampling equipment, sample collection sequence, sorbent trap sample air flow rates and flow times, chain of custody information, and a discussion of the sampling event itself are given in WHC 1995 and references therein.

X.2 INORGANIC GASES AND VAPORS

Analytical results of sorbent trap and SUMMA™,[2] canister tank air samples for selected inorganic gases and vapors are given in Table X-2 in parts per million by volume (ppmv). Inorganic analyte sorbent traps were prepared and

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[1] Because of a valve-sequencing error, sample air volumes through specific sampling ports were not properly measured during sample job 7A of tank C-103. The error resulted in obvious and significant differences in sorbent trap results, but had no effect on SUMMA™ samples. McVeety et al. (1995a) also note that 1 valve on the sorbent trap station of the VSS may have not opened properly during the tank C-106 sampling event.

[2] SUMMA is a trademark of Molectrics, Inc., Cleveland, Ohio.

analyzed by PNL. SUMMA™ canisters were analyzed for inorganic analytes by OGIST. Reports by PNL (McVeety et al. 1995a) and OGIST (Rasmussen 1994a) describe sample preparation and analyses.

The relative standard deviations of the inorganic gas and vapor results are given in the last column in Table X-2. The precision of reported results is acceptable for the measured concentrations and methods used. Relative standard deviations range from about 13 % for nitrous oxide results to 20 % for carbon monoxide and hydrogen results. The precision reported depends both on sampling parameters (e.g., sample flow rate and flow time for sorbent traps) and analytical parameters (e.g., sample preparation, dilutions, etc.), and the relative standard deviations suggest adequate controls were maintained both in the field and in the laboratories.

X.2.1 Ammonia, Hydrogen, and Nitrous Oxide

Ammonia, hydrogen, and nitrous oxide are commonly detected in the waste tanks. Thought to be products of radiolysis and oxidation-reduction reactions of the waste, they appear ubiquitously with the high-level waste. These headspace constituents have been the most abundant waste artifacts in virtually every tank headspace sampled to date.

The reported ammonia concentration, ≤ 9 ppmv, is below the National Institute of Occupational Safety and Health (NIOSH) 8-hr recommended exposure limit (REL) of 25 ppmv for ammonia (NIOSH 1995). Ammonia has been observed in virtually all of the passively ventilated waste tanks sampled to date, at concentrations ranging from about 3 ppmv in tank C-108 (Lucke et al. 1995), to 1040 ppmv in tank BY-108 (McVeety et al. 1995b). Uncertainties associated with sorbent trap sample volumes limited the accuracy of this measurement. Active ventilation of the tank C-106 headspace accounts for the relatively low ammonia concentration in the tank C-106 exhaust.

The concentration of hydrogen in the exhaust from tank C-106 was determined to be 9.7 ppmv. Hydrogen in the waste tanks is of concern as a fuel. Given that the lower flammability limit (LFL) for hydrogen in air is about 4 % by volume, the measured 9.7 ppmv of hydrogen corresponds to < 0.03 % of its LFL, and indicates hydrogen is not a flammability concern.

The nitrous oxide concentration in the exhaust from tank C-106, 3.7 ppmv, is also well below the NIOSH 8-hr REL of 25 ppmv for nitrous oxide (NIOSH 1995). Nitrous oxide, also known as laughing gas, has been detected in the passively ventilated waste tanks at concentrations as low as about 12 ppmv in tank TX-105 (Klinger 1995), and as high as about 800 ppmv in tank C-103 (Huckaby and Story 1994).

Neither hydrogen nor nitrous oxide is highly soluble in the aqueous wastes of the tanks, so except for situations where bubbles are trapped within the waste and released episodically, the gases are released as they are generated. The concentration of these gases in the tank headspaces is consequently determined by a simple balance between their overall generation rate and the rate at which they are vented to the atmosphere. If the ventilation rate of tank C-106 when samples were collected (February 15, 1994) is estimated to be the average of its measured rates on February 4 and March 2, 1994 (i.e., 44.0 m^3/min), then the 9.7 ppmv of hydrogen and 3.7 ppmv of nitrous oxide equates to about 50 g of hydrogen and 420 g of nitrous oxide being exhausted each day.

X.2.2 Carbon Monoxide, Nitric Oxide, Nitrogen Dioxide, Water and Tritium

Carbon monoxide in the exhaust of tank C-106 headspace, measured to be 0.25 ppmv in SUMMA^{TM} samples (Rasmussen 1994a), is slightly above its concentration in ambient air, where it typically ranges from 0.05 to 0.15 ppmv. Ambient air samples collected at the beginning of the tank C-106 vapor sampling event were measured to have < 0.1 ppmv. Elevated waste tank headspace carbon monoxide concentrations are common (e.g., carbon monoxide concentration in tank C-103 was 26.7 ppmv, Huckaby and Story 1994), and are thought to be due to the decomposition of organic waste in the tanks.

Nitric oxide and nitrogen dioxide concentrations in the tank C-106 headspace were both determined to be ≤ 0.1 ppmv. These are acid gases that would have very low equilibrium concentrations above the high pH aqueous supernate in tank C-106. The measurable presence of nitric oxide may be due to its formation from oxygen and nitrogen in the radiation field of the headspace. The NIOSH 8-hr REL is 25 ppmv for nitric oxide, and the 15-minute short term exposure limit (STEL) for nitrogen dioxide is 1 ppmv.

The water vapor concentration of tank C-106 exhaust was determined to be about 17.8 mg/L, using an assumed tank headspace temperature[3] of 19 °C and the ambient pressure of 985 mbar (739 torr). This corresponds to a water vapor partial pressure of 23.9 mbar (17.9 torr), to a dew point of 20.4 °C, and to a relative humidity of 109 %. While this greater-than saturated water vapor measurement could be meaningful if an aqueous aerosol existed, it is also likely that the tank exhaust is virtually saturated at the tank conditions, and errors in sample volumes, handling, or analysis account for the difference. Psychrometric measurements made on the exhaust from tank C-106 on February 4 and March 2, 1994 indicate that the relative humidity of the exhaust on those dates was virtually 100 %.

Silica gel sorbent traps were used to test for tritium. It is assumed that tritium produced by the waste combines with hydroxide ions to form tritium-substituted water. Evaporation of the tritium-substituted water would then result in airborne radioactive contamination. Silica gel sorbent traps adsorb virtually all (normal and tritium-substituted) water vapor from the sampled tank air, and are analyzed at the WHC 222-S laboratory. Analysis of the silica gel, which would have trapped approximately 60 mg of water vapor,

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[3] Temperatures in tank C-106 were measured, using existing thermocouple trees, on February 13 and 20, 1994. The average of 19 readings from the headspace was 19.0 °C, with a standard deviation of 1.0 °C.

indicated the total activity of the sample to be below the method detection limit of 50 pCi (WHC 1995).

X.3 ORGANIC VAPORS

Organic vapors in the tank C-106 exhaust were sampled using SUMMA™ canisters, which were analyzed by PNL and OGIST, and triple sorbent traps (TSTs), which were analyzed by ORNL. All laboratories used gas chromatography (GC) and mass spectroscopy (MS) to separate, identify, and quantitate the analytes. Descriptions of sample device cleaning, sample preparations, and analyses are given by Jenkins et al. (1994), Rasmussen (1994a), and McVeety et al. (1995a). In an attempt to provide ORNL with additional samples for scoping purposes, 7 of the TSTs were collected simultaneously, in parallel, with a single flow controller. Because flow through these 7 TSTs was very non-uniform, analytical results from these samples are not discussed here. A quantitative measurement of the total organic vapor concentration by the U.S. Environmental Protection Agency (EPA) task order 12 (TO-12) method was also performed by OGIST (EPA 1988, Rasmussen 1994a).

SUMMA™ sample results should be considered to be the primary organic vapor data for tank C-106. ORNL analyses of TST samples from this and other waste tanks generally agree with, support, and augment the SUMMA™ sample results. However, because certain WHC quality assurance requirements were not satisfied by ORNL, the quality assurance assessment of ORNL by Hendrickson (1995) should be reviewed before results unique to the TST samples are used for decision making.

X.3.1 Positively Identified Organic Analytes

Table X-3 lists the organic compounds positively identified and quantitated in SUMMA™ samples by OGIST. SUMMA™ analyses were performed according to the EPA TO-14 methodology (EPA 1988, Rasmussen 1994a). Averages reported are from analyses of 3 SUMMA™ canister samples. All of the compounds listed were detected in ambient air samples at virtually the same levels as in the tank C-106 exhaust samples. This probably indicates that either the compounds were not associated with the waste, or they were contaminants introduced during sample preparation, collection, or analysis.

Analysis of SUMMA™ samples by PNL according the same EPA TO-14 method indicated none of the 40 TO-14 analytes to be above the 0.002 ppmv quantitation limit (McVeety et al. 1995a provide the complete TO-14 analyte list). Data in Table X-3, which are strictly from OGIST, agree with the PNL analyses.

Jenkins et al. (1994) report the positive identification of 23 of 26 target analytes in TST samples. The target analyte list was based on advice from a panel of toxicology experts (Goheen 1994). The average concentrations of the 21 quantitatively measured target analytes, from the analysis of 2 TSTs, are given in Table X-4. Three target analytes, 1,2-dichloroethene, hexane, and heptane, were below the method detection limit. Two other target analytes, dibutylbutyl phosphonate (DBBP) and tributyl phosphate (TBP), were positively identified but not quantitatively measured. TBP was estimated to be present at 0.013 ppmv (0.15 mg/m^3) and DBBP was estimated to be present at 0.0027 ppmv (0.03 mg/m^3). These 2 compounds were found at very similar levels in tanks C-104 and C-105.

Dichloromethane, benzene, and toluene were common to both the TST and SUMMA™ analyses. The SUMMA™ and TST sample results for benzene and toluene were in good agreement, both indicating the concentrations of these analytes to < 0.001 ppmv. Analyses of TSTs for dichloromethane do not agree with analyses of SUMMA™ samples by either OGIST or PNL. It was noted that dichloromethane had been used to clean sections of the VSS transport tubing and valves, and it is likely that its appearance in the TST samples was the result of residual contamination of valves in the sorbent trap sampling station of the VSS.

The most abundant positively identified organic analyte in the tank C-106 exhaust, neglecting the questionable dichloromethane results, was 1-butanol, measured to be present at about 0.011 ppmv. The next most abundant were n-tridecane, n-dodecane, and ethanenitrile (acetonitrile). None of these are at or above their industrial hygiene action levels, nor do they individually or cumulatively represent a flammability hazard.

X.3.2 Tentatively Identified Organic Analytes

In addition to targeted analytes, OGIST, ORNL, and PNL analytical procedures allow the tentative identification of other organic vapors. By the nature of the samples and their analysis, virtually all 3- to 15-carbon organic compounds present in the tank headspace above analytical detection limits are observable. The PNL list of tentatively identified compounds, with estimated concentrations, is given in Table X-5, and the ORNL list of tentatively identified compounds, and their estimated concentrations, is given in Table X-6. Estimated concentrations given in Tables X-5 and X-6 are in mg/m^3, based on dry air at 0 °C and 1.01 bar.

OGIST provided total-ion chromatograms for each of the tank C-106 exhaust SUMMA™ samples and assigned tentative identities to the significant peaks, but did not estimate their concentrations. Table X-7 lists the analytes tentatively identified compounds by OGIST, and designates which analytes were detected in each of the 3 SUMMA™ samples. As a rough guide, the analytes listed in Table X-7 were probably detected at greater than 0.001 ppmv. It should also be noted that some peaks in the total-ion chromatograms were not labeled, despite being relatively high, because confidence in assigning a chemical identity was very low.

Tentative identification of organic analytes was performed by comparing the MS molecular fragmentation patterns with a library of known MS fragmentation patterns. This method allows an organic analyte to be identified (with reasonable certainty) as an alkane, a ketone, an aldehyde, etc., and may also determine its molecular weight. The method usually does not, however, allow the unambiguous identification of structural isomers, and this ambiguity increases with analyte molecular weight. Entries in Table X-6 illustrate this, particularly near the bottom of the table where the analytes have higher molecular weights.

The ORNL and PNL methods used to tentatively identify and estimate concentrations are described by Jenkins et al. (1994) and McVeety et al. (1995a), respectively, and should be reviewed before this data is used for decision making. Results in Tables X-5 and X-6 are presented in terms of observed peaks, and are not adjusted for the occurrence of split chromatographic peaks (e.g., Cmpd # 1, 2, 3, and 4 in Table X-6) or the assignment of the same identity to different peaks (e.g., Cmpd # 53 and 66 in Table X-6). In these instances, the estimated concentration of a compound appearing as a doublet or triplet is simply the sum of the individual peak estimates.

The relative paucity of volatile compounds in Table X-6 (i.e., compared to Table X-7) may indicate problems occurred with the TST samples. The sampling and analysis plan specified an unusually large volume of sample air, 10 L, be drawn through the TSTs because low organic vapor concentrations were anticipated. These high sampling volumes and a correspondingly long water-removal process for the TSTs may have caused break-through (loss) of the more volatile analytes.

Concentrations given in Tables X-5 and X-6 should be considered rough estimates. The proper quantitation of all observed analytes is outside the scope and budget of these analyses, and the estimation of concentrations involves several important assumptions. The validity of each assumption depends on the analyte, and such factors as the specific configuration of the analytical instrumentation.

X.3.3 Total Nonmethane Organic Compounds

OGIST measured the total nonmethane organic compound (TNMOC) concentration in 3 SUMMA™ canister samples using the EPA TO-12 method (Rasmussen 1994a). The sample mean was 0.41 mg/m^3, with a standard deviation of 0.03 mg/m^3. This value is low compared to most passively ventilated waste tanks sampled to date. TO-12 method TNMOC measurements of other waste tanks have ranged from as high as 5,000 mg/m^3 in tank C-103 (Rasmussen and Einfeld 1994), to as low as 0.18 mg/m^3 in tank C-111 (Rasmussen 1994b), while the TNMOC concentration of clean ambient air ranges from about 0.03 to 0.1 mg/m^3. Ambient air samples collected upwind of tank C-106 at the beginning of the sampling event were measured to have 0.12 mg/m^3 of TNMOCs.

X.3.4 Discussion of Organic Analytes

It is assumed here that the potential in-leakage of air, gases, and vapors from tank C-105 has no significant effect on the concentrations of these constituents in tank C-106 or its exhaust. While in-leakage of air from tank C-105 via the cascade line is possible, it is equally possible (based on what is currently known) that the flow of air is from tank C-106 to tank C-105 (Claybrook 1993).

A convenient way to consider the organic compounds listed in Tables X-3 through X-7 is to separate them into 2 categories: 1) Organic compounds added as waste that are still evaporating; and 2) organic compounds that have been generated by reactions of the original waste.

The first category encompasses all organic compounds that were placed into the tank as waste. It includes TBP, DBBP, and the semivolatile branched alkanes and normal paraffinic hydrocarbons (NPHs), all of which ostensibly came from the Plutonium-Uranium Extraction (PUREX) process. In the tank C-106 exhaust samples, these constituents were identified, but at very low levels.

The second category includes all organic compounds that were not placed into the tank as waste, but instead have been generated via radiolytic and chemical reactions of the waste. The majority of compounds listed in Tables X-3 through X-7 fall into this category, including the alcohols, aldehydes, ketones, nitriles, alkenes, cyclic alkanes, and volatile alkanes. By far the most abundant of these in the headspace are the short-chain volatile compounds, however, some long-chain low volatility compounds may also be waste reaction products.

Despite the generally low organic vapor concentrations, the following homologous series were tentatively identified in the tank C-106 exhaust samples:

1) straight-chain nitriles from ethanenitrile (acetonitrile) through nonanenitrile;

2) normal alkanes from propane through n-nonane[4];

3) straight-chain 2-ketones from propanone (acetone) through 2-heptanone;

4) straight-chain aldehydes from ethanal (acetaldehyde) through hexanal;

5) straight-chain 1-alkenes from propene through 1-hexene;

as well as several partially complete series of other functionally related organic compounds such as alcohols.

1-Butanol is prominent amongst the alcohols detected. It is known to be a degradation product of TBP, and has been found in virtually all of the waste tanks sampled to date.

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[4] n-Decane through n-pentadecane were also detected, however, these are principally constituents of the original waste and not waste reaction products.

In summary, the active ventilation of tank C-106 significantly reduces the organic vapor concentrations in the tank headspace and its exhaust. Though problems associated with the novelty of the sampling event and sample analysis may have occurred, the vapor concentrations are so low that there is little reason for concern about the toxicity or flammability of the exhaust. The constituents of the tank C-106 exhaust are typical of most NPH-rich tank headspaces.

Table X-1
Tank C-106 Gas and Vapor Sample Type and Number

Laboratory	Sampling Device	Nominal Sample Volume (L)	Target Analytes	Number of Samples
Oak Ridge National Laboratories	Triple Sorbent Trap	0.5 and 10	Organic vapors	10 tank air samples, + 1 trip blank
Oregon Graduate Institute of Science and Technology	SUMMA™ canister	6.0	Hydrogen, Nitrous Oxide, Carbon Monoxide, Organic vapors	3 tank air samples, 6 ambient air samples
Pacific Northwest Laboratories	Acidified Carbon Sorbent Trap	3.0	Ammonia	6 tank air samples + 1 trip blank
	Triethanolamine Sorbent Trap	3.0	Nitrogen Dioxide	6 tank air samples + 1 trip blank
	Oxidation Bed + Triethanolamine Sorbent Trap	3.0	Nitric Oxide	6 tank air samples + 1 trip blank
	Silica Gel Sorbent Trap	3.0	Water vapor	5 tank air samples + 1 trip blanks
	SUMMA™ canister	6.0	Organic vapors	3 tank air samples
WHC 222-S Laboratory	Silica Gel Sorbent Trap	3.0	Tritium-Substituted Water Vapor	1 tank air sample

Table X-2
Tank C-106 Inorganic Gas and Vapor Concentrations

Compound	CAS[1] number	Sample Type	Number of samples	Average (ppmv)	Standard Deviation (ppmv)	RSD[2] (%)
Ammonia, NH_3	7664-41-7	Sorbent Trap	6	≤ 9	--	--
Carbon Monoxide, CO	630-08-0	SUMMA™	3	0.25	0.05	20
Hydrogen, H_2	1333-74-0	SUMMA™	3	9.7	1.9	20
Nitric Oxide, NO	10102-43-9	Sorbent Trap	6	≤ 0.1	--	--
Nitrogen Dioxide, NO_2	10102-44-0	Sorbent Trap	6	≤ 0.1	--	--
Nitrous Oxide, N_2O	10024-97-2	SUMMA™	3	3.7	0.49	13
Water Vapor, H_2O	7732-18-5	Sorbent Trap	3	24,300 (17.8 mg/L)	3,670 (2.7 mg/L)	15

1. CAS = Chemical Abstracts Service.

2. RSD = relative standard deviation.

Table X-3
Tank C-106 Positively Identified Organic Compounds in OGIST SUMMA™ Samples

Cmpd #	Compound	CAS[1] Number	Average (ppmv)	Standard Deviation (ppmv)	RSD[2] (%)
1	Dichlorodifluoromethane	75-71-8	0.0002	0.0001	50
2	Chloromethane	74-87-3	0.00013	0.00006	43
3	1,3-Butadiene	106-99-0	0.00043	0.00006	13
4	Trichlorofluoromethane	75-69-4	0.00063	0.00012	18
5	1,1-Dichloroethene (Vinylidene chloride)	75-35-4	0.00013	0.00006	43
6	Dichloromethane (methylene chloride)	75-09-2	0.0019	0.0020	103
7	1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	0.00013	0.00006	43
8	Trichloromethane (chloroform)[3]	67-66-3	0.0001	--	--
9	1,1,1-Trichloroethane	71-55-6	0.0002	0.0001	50
10	Benzene	71-43-2	0.00047	0.00006	12
11	Tetrachloromethane (carbon tetrachloride)	56-23-5	0.00013	0.00006	43
12	Toluene	108-88-3	0.00083	0.00067	80
13	Ethyl benzene[4]	100-41-4	0.0001	--	--
14 & 15	m-Xylene & p-Xylene[5]	108-38-3 106-42-3	0.0002	0.0001	50
16	o-Xylene[4]	95-47-6	0.0001	--	--

1. CAS = Chemical Abstracts Service.

2. RSD = relative standard deviation.

3. Detected in only 1 sample.

4. Detected in only 2 samples.

5. These analytes coelute, so the given concentration is their sum.

Table X-4
Tank C-106 Positively Identified Organic Compounds in TST Samples

Cmpd #	Compound	CAS[1] Number	Average (ppmv)	Standard Deviation (ppmv)	RSD[2] (%)
1	Ethanenitrile (acetonitrile)	75-05-8	0.0023	0.0010	44
2	Propanone (acetone)	67-64-1	0.00018	0.00025	141
3	Dichloromethane (methylene chloride)	75-09-2	0.092	0.042	46
4	Propanenitrile	107-12-0	< 0.0001	< 0.0001	141
5	Benzene	71-43-2	0.00022	< 0.0001	42
6	1-Butanol	71-36-3	0.011	0.014	114
7	Butanenitrile	109-74-0	0.00033	0.00033	101
8	2-Pentanone	107-87-9	< 0.0001	< 0.0001	114
9	Toluene	108-88-3	0.00025	< 0.0001	16
10	Pentanenitrile	110-59-8	< 0.0001	< 0.0001	141
11	2-Hexanone	591-78-6	< 0.0001	< 0.0001	69
12	n-Octane	111-65-9	< 0.0001	< 0.0001	141
13	Hexanenitrile	628-73-9	< 0.0001	< 0.0001	45
14	2-Heptanone	110-43-0	< 0.0001	< 0.0001	87
15	n-Nonane	111-84-2	< 0.0001	< 0.0001	25
16	Heptanenitrile	629-08-3	< 0.0001	< 0.0001	62
17	2-Octanone	111-13-7	< 0.0001	< 0.0001	48
18	Octanenitrile	124-12-9	< 0.0001	< 0.0001	51
19	Nonanenitrile	2243-27-8	< 0.0001	< 0.0001	11
20	n-Dodecane	112-40-3	0.0036	0.0006	16
21	n-Tridecane	629-50-5	0.0087	0.0004	5

1. CAS = Chemical Abstract Service.

2. RSD = relative standard deviation.

Table X-5
Tank C-106 Tentatively Identified Compounds in PNL SUMMA™ Samples

Cmpd #	Compound	CAS[1] Number	Average (mg/m^3)	Standard Deviation (mg/m^3)
1	1-Butanol	71-36-3	0.06	0.00
2	n-Tridecane	629-50-5	0.13	0.03
Sum of tentatively identified compounds:			0.19	

1. CAS = Chemical Abstract Service.

Table X-6
Tank C-106 Tentatively Identified Organic Compounds in TST Samples

Cmpd #	Compound	CAS[1] Number	Average (mg/m^3)	Standard Deviation (mg/m^3)
1	Carbon Dioxide	124-38-9	0.064	0.016
2	Carbon Dioxide	124-38-9	0.29	0.22
3	Carbon Dioxide	124-38-9	1.2	0.30
4	Carbon Dioxide	124-38-9	2.8	1.5
5	1-Propene, 2-methyl-	115-11-7	0.045	0.064
6	Acetic Acid	64-19-7	0.018	0.012
7	Cyclotrisiloxane, hexa-methyl-	541-05-9	0.0042	0.0018
8	2-Methylbutanenitrile and others		0.0040	0.0056
9	Cyclotetrasiloxane, octamethyl-	556-67-2	0.015	0.001
10	n-Undecane	1120-21-4	0.0024	0.0007
11	Benzeneacetic acid, .alpha., 4-bis[(tri-methylsilyl)oxyl-, trimethylsilyl ester	37148-64-4	0.0036	0.00001
12	C4-2-Pyrrolidinone		0.0018	0.0026
13	Undecane, 2,6-dimethyl-	17301-23-4	0.0093	0.0034
14	C4-Piperidine		0.0015	0.0021
15	Undecane, 5,7-dimethyl-	17312-83-3	0.00060	0.00084
16	C12 or C13 Alkene		0.00067	0.00094
17	C12 or C13 Alkene		0.0017	0.0024
18	Dodecane, 6-methyl-	6044-71-9	0.00060	0.00084
19	Alkene		0.0018	0.0025
20	C13 Alkane		0.0020	0.0029
21	Undecane, 2,10-dimethyl-	17301-27-8	0.0038	0.0054
22	Dodecane, 4,6-dimethyl-	61141-72-8	0.027	0.008
23	Methyl fluorene + alkene		0.00092	0.00130

Cmpd #	Compound	CAS[1] Number	Average (mg/m^3)	Standard Deviation (mg/m^3)
24	1-Tridecene	2437-56-1	0.0029	0.0006
25	3-Tetradecene, (E)-	41446-68-8	0.0050	0.00002
26	C13 or C14 alkene		0.0025	0.0006
27	C13 Alkane		0.0030	0.0022
28	C13 Alkane		0.0013	0.0019
29	1-Pentadecene	13360-61-7	0.0011	0.0015
30	Alkene		0.0010	0.0014
31	Tridecane, 6-methyl-	13287-21-3	0.0082	0.0028
32	Alkyl cyclohexane		0.00072	0.00102
33	Alkane		0.00089	0.00126
34	1-Tetradecene	1120-36-1	0.00081	0.00114
35	C13 or C14 Alkane		0.0048	0.0014
36	C7-Cyclohexane		0.0085	0.0031
37	Tridecane, 4-methyl-	26730-12-1	0.0068	0.0013
38	Tridecane, 2-methyl-	1560-96-9	0.011	0.001
39	Trace Component		0.00096	0.00136
40	C14 Alkane		0.010	0.002
41	Dodecane, 2,7,10-trimethyl-	74645-98-0	0.045	0.001
42	3-Dodecanone	1534-27-6	0.0023	0.0033
43	n-Tetradecane	629-59-4	0.11	0.01
44	C14 Alkane		0.0056	0.0080
45	C14 or C15 Alkane		0.0083	0.0118
46	C14 or C15 Alkane		0.0043	0.0001
47	C15 Alkane		0.0042	0.00003
48	C14 or C15 Alkane		0.0059	0.0007
49	C14 or C15 Alkane		0.0034	0.0005
50	C14 or C15 Alkane		0.0068	0.0006
51	C14 or C15 Alkane		0.039	0.005

Cmpd #	Compound	CAS[1] Number	Average (mg/m^3)	Standard Deviation (mg/m^3)
52	C14 or C15 Alkane		0.0049	0.0001
53	5-Undecanone, 2,methyl-	50639-02-6	0.0062	0.0018
54	C15 or C16 Alkene		0.0010	0.0015
55	Trace Component		0.00093	0.00131
56	3-Tridecanone	1534-26-5	0.010	0.006
57	n-Pentadecane	629-62-9	0.042	0.003
58	Alkanol		0.0024	0.0034
59	Cyclohexane, 1-(1,5-dimethylhexyl)-4-methyl-	29799-19-7	0.0013	0.0019
60	Trace Component		0.00060	0.00086
61	Trace Component		0.00063	0.00090
62	Trace Component		0.00088	0.00124
63	Trace Component		0.00069	0.00097
64	C9-Cyclohexane		0.0019	0.0027
65	Alkene		0.00063	0.00090
66	5-Undecanone, 2-methyl-	50639-02-6	0.0054	0.0041
67	Alkanone		0.0047	0.0066
68	Tetradecanoic acid, butyl ester		0.0035	0.0028
69	3-Dodecanone	1534-27-6	0.0037	0.0052
70	n-Hexadecane	544-76-3	0.0073	0.0030
71	C16 or C17 alkanone		0.0056	0.0055
72	Tributyl phosphate isomer		0.0015	0.0021
73	Unknown (Need CI)		0.0011	0.0015
74	Dibutyl butyl phosphonate	78-46-6	0.028	0.023
75	Trace Component		0.0013	0.0019
76	Tributylphosphate	126-73-8	0.14	0.08
77	Alkanone		0.0012	0.0016

Cmpd #	Compound	CAS[1] Number	Average (mg/m^3)	Standard Deviation (mg/m^3)
78	Pentadecanoic acid, butyl ester		0.0041	0.0058
79	Trace Component		0.00073	0.00103
80	Heptadecane	629-78-7	0.0015	0.0022
81	Alkane		0.0027	0.0021
82	Hexadecanoic acid, butyl ester	111-06-8	0.0013	0.0019
83	Phthalate		0.00091	0.00129
84	Hexadecanoic acid		0.00080	0.00113
Sum of tentatively identified compounds:			5.0539	

1. CAS = Chemical Abstract Service

Table X-7
Tank C-106 Tentatively Identified Compounds in OGIST SUMMA™ Samples

Cmpd #	Compound	Sample Number[1]			CAS[2] Number
		1	2	3	
1	Carbonyl Sulfide (OCS)		x		463-58-1
2	Propene	x	x	x	115-07-1
3	Propane		x		74-98-6
4	2-Methylpropane	x	x	x	75-28-5
5	2-Methylpropene	x			115-11-7
6	1-Butene	x	x	x	106-98-9
7	n-Butane	x	x	x	106-97-8
8	trans-2-Butene	x	x	x	624-64-6
9	Cyclobutane	x	x	x	287-23-0
10	cis-2-Butene	x	x	x	590-18-1
11	Ethanol			x	64-17-5
12	Ethanenitrile (acetonitrile)	x	x	x	75-05-8
13	2-Methylbutane	x		x	78-78-4
14	Propanone (acetone)	x	x	x	67-64-1
15	Propanal (propionaldehyde)		x		123-38-6
16	1-Pentene	x	x	x	109-67-1
17	2-Propanol	x	x	x	67-63-0
18	n-Pentane	x	x	x	109-66-0
19	Carbon disulfide	x	x	x	75-15-0
20	Nitromethane		x		75-52-5
21	2-Methylpropanal	x			78-84-2
22	Propanenitrile	x	x	x	107-12-0
23	2-Methyl-2-propenal (methacrolein)	x			78-85-3
24	1-Propanol	x	x	x	71-23-8
25	3-Buten-2-one (methylvinyl ketone)	x	x	x	78-94-4
26	Butanal	x	x	x	123-72-8
27	2-Butanone	x	x	x	78-93-3

Cmpd #	Compound	Sample Number[1] 1	2	3	CAS[2] Number
28	1-Hexene	x	x	x	592-41-6
29	2-Butanol	x	x	x	78-92-2
30	n-Hexane	x	x	x	110-54-3
31	Tetrahydrofuran	x	x	x	109-99-9
32	2-Methyl-1-propanol	x			78-83-1
33	2-Butenal (crotonaldehyde)	x	x		4170-30-3
34	Butanenitrile	x	x	x	109-74-0
35	1-Butanol	x	x	x	71-36-3
36	2-Pentanone	x	x	x	107-87-9
37	2-Methylbutanenitrile	x	x	x	
38	Pentanal			x	110-62-3
39	2-Heptene	x	x	x	592-77-8
40	n-Heptane	x	x		142-82-5
41	2,4,4-Trimethyl-1-pentene	x			107-39-1
42	ethanoic acid (acetic acid)	x		x	64-19-7
43	Pentanenitrile	x	x	x	110-59-8
44	2-Hexanone	x	x	x	591-78-6
45	3-Methylheptane		x		589-81-1
46	Hexanal	x		x	66-25-1
47	n-Octane	x	x	x	111-65-9
48	Hexanenitrile	x		x	628-73-9
49	4-Heptanone	x	x	x	123-19-3
50	3-Heptanone	x	x	x	106-35-4
51	2-Heptanone	x	x	x	110-43-0
52	3-Heptanol	x		x	589-82-2
53	2-Butoxyethanol	x			111-76-2
54	n-Nonane			x	111-84-2
55	Octanal	x		x	124-13-0

Cmpd #	Compound	Sample Number[1]			CAS[2] Number
		1	2	3	
56	n-Decane	x	x	x	124-18-5
57	2-Ethyl-1-hexanol	x		x	104-76-7
58	Nonanal	x		x	124-19-6
59	n-Undecane	x	x	x	1120-21-4
60	Decanal	x			112-31-2
61	n-Dodecane	x	x	x	112-40-3
62	2,6-Dimethylundecane	x	x	x	17301-23-4
63	n-Tridecane	x	x	x	629-50-5
64	n-Tetradecane	x	x	x	629-59-4

1. An x is placed in the column if the analyte was tentatively identified in that sample. Here 1 = sample S4006-01.B15; 2 = sample S4006-02.B15; and 3 = sample S4006-03.B15 (Rasmussen 1994a, WHC 1995).

2. CAS = Chemical Abstract Service.

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