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Results - August 1993 Samples

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7. Abstract

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Tank 241-C-111 is on the ferrocyanide Watch List. Gas and vapor samples were collected to assure safe conditions before planned intrusive work was performed. Sample analyses showed that hydrogen is about ten times higher in the tank headspace than in ambient air. Nitrous oxide is about sixty times higher than ambient levels. The hydrogen cyanide concentration was below 0.04 ppbv, and the average NO_x concentration was 8.6 ppmv.

8.

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LIST OF TERMS

CFC	Chlorofluorocarbon
CGM	Combustible Gas Meter
EPA	U. S. Environmental Protection Agency
HCN	Hydrogen Cyanide
kgal	Kilogallon
LEL	Lower Explosive Limit
mbar	Millibar
ng	Nanogram
NIOSH	National Institute for Occupational Safety and Health
NPH	Normal Paraffinic Hydrocarbon
OGIST	Oregon Graduate Institute of Science and Technology
OVM	Organic Vapor Monitor
PID	Photo-Ionization Detector
PNL	Pacific Northwest Laboratory
ppbv	Parts per Billion by Volume
ppmv	Parts per Million by Volume
pptv	Parts per Trillion by Volume
psig	Pounds per Square Inch Gauge
PTFE	Polytetrafluoroethylene
PUREX	Plutonium-Uranium Extraction Process
TBP	Tributyl Phosphate
TNMHC	Total Non-Methane Hydrocarbon
WHC	Westinghouse Hanford Company

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**TANK 241-C-111 HEADSPACE
GAS AND VAPOR SAMPLE RESULTS
AUGUST 1993 SAMPLES**

1.0 INTRODUCTION

This report summarizes results of vapor samples collected August 10, 1993, from the tank 241-C-111 headspace. The tank headspace was sampled by Westinghouse Hanford Company (WHC), and samples were analyzed by WHC, Pacific Northwest Laboratories (PNL), and Oregon Graduate Institute of Science and Technology (OGIST).

1.1 PURPOSE OF SAMPLING

Tank 241-C-111 is on the ferrocyanide Watch List, and according to the safety assessment for ferrocyanide Watch List tanks (Farley 1991), gas and vapor samples must be collected before intrusive work can be performed on the tank. Planned intrusive work to install an instrument tree in tank 241-C-111 thus required that the tank be sampled.

1.2 SCOPE OF SAMPLING

The ferrocyanide Watch List safety assessment requires a headspace flammability check using a combustible gas meter (CGM), and measurement of the organic vapor concentration using an organic vapor monitor (OVM) at three different levels within the tank. It also requires that certain hazardous compounds be sampled for, including hydrazine (N_2H_4), ammonia (NH_3), hydrogen cyanide (HCN), and nitrogen oxides (NO_x). These hazardous compounds were measured using colorimetric sorbent tubes (Dräger tubes¹).

The headspace was also sampled for HCN using midget impingers prepared and analyzed at PNL. The impingers contained a caustic solution that traps HCN for subsequent laboratory analysis. The potential existence of HCN has been an industrial hygiene issue, and evaluation of the HCN in tank 241-C-111 was part of the WHC strategy to resolve this issue.

Additionally, 9 SUMMA² canister tank headspace samples and 1 SUMMATM canister ambient air sample were collected. These SUMMATM canisters, described in Section 3.3, were supplied and analyzed by OGIST. These samples were collected to provide headspace composition information, and to provide tank headspace samples for the development of analytical methods that could be used to characterize other tank headspaces.

¹National Draeger, Inc., Pittsburgh, Pennsylvania.

²Molelectrics, Inc., Cleveland, Ohio.

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1.3 TANK 241-C-111 DESCRIPTION

Tank 241-C-111 is a single-shell tank first used in 1946. Cascade pipes connect it directly to tanks 241-C-110 and 241-C-112. It is 22.9 m (75 ft) in diameter and has a holding capacity of 2,006 m³ (530 kgal). It currently holds 216 m³ (57 kgal) of high-level radioactive sludge (Hanlon 1994). The sludge is classified as noncomplexed, and it is believed to be a mixture of first-cycle decontamination waste from the bismuth phosphate process, cladding waste, and ferrocyanide scavenging waste. The tank was placed on the ferrocyanide Watch List in January 1991.

2.0 DESCRIPTION OF SAMPLING

Gas and vapor samples were taken on August 10, 1993, between 1030 and 1200 hours. The ambient air temperature ranged from 25 to 27 °C (77 to 81 °F), and the barometric pressure fell from 1017.7 to 1017.0 mbar during sampling. Ambient air temperatures and pressures were measured at the PNL Weather Station at 0900 and 1100 hours.

Tank 241-C-111 waste and headspace temperatures are measured weekly. The average temperature in the headspace was 22.3 °C (72.1 °F) on August 5, 1993, and 22.9 °C (73.3 °F) on August 12, 1993. Thermocouples located at 0.61-m (2-ft) vertical intervals in the headspace indicate a relatively uniform temperature, which suggests the headspace may be convectively mixed. However, temperature measurement errors are too large to conclusively support this (Scaief 1991).

Vapor samples were taken from riser #6 at three elevations in the headspace. The in-tank sampling apparatus consisted of three commercially available, 1.27-cm (0.5-in.) outside diameter, convoluted, polytetrafluoroethylene (PTFE) plastic tubes, which were spirally wound with stainless steel wire. These tubes were attached to a flange mounted on the riser. The sample line extension lengths were:

Extension	Length	Elevation above waste
Short	4.42 m (14.5 ft)	6.86 m (22.5 ft)
Medium	7.53 m (24.7 ft)	3.75 m (12.3 ft)
Long	10.7 m (35.0 ft)	0.61 m (2.0 ft)

The PTFE tubes were attached to the in-tank side of the flange. These tubes were connected, with stainless steel feed-through tubes, to ball valves located on the out-of-tank side of the flange. Details of the sampling tubes, flange, and valves are given in drawing H-2-85178, Sheets 1 through 3 (WHC 1993b).

A portable sampling system, consisting of an air pump, flow meters (calibrated rotameters), and flow control (manual needle valves), was used to draw air from the tank through the sampling tubes. The system was subjected to a field vacuum test prior to sampling, and it held a vacuum measured at 406.4 mbar (12 in. Hg) for 10 minutes, with no indication of system leaks.

Each sample line was purged independently with a flow of approximately 6 L/min for 5 minutes before sampling began. This corresponds to replacing the internal volume of the sampling system and longest sampling line about 12 times with air from the tank. Further details of the sampling procedure are given in tank farm operating procedure TO-080-015, Rev. C-0.

No field or sampling system temperature monitoring or control were performed during the sampling. Consequently, water vapor present in the warm headspace of the waste tank could have condensed on the unheated walls of the sample line and/or in the sampling system. If this occurred, the concentrations of NH_3 , nitric oxide (NO), nitrogen dioxide (NO_2), HCN , N_2H_4 , and any water soluble vapors could be significantly diminished by absorption of these gases and vapors into the condensate. The reported analytical results for these species should therefore be considered uncertain.

Use of unheated sample lines to collect samples for flammable gas measurements should not significantly affect the validity of the results. The primary flammable components of the tank headspaces are hydrogen (H_2) and organic vapors, and these would be minimally affected by condensed water in unheated sample lines. The results do not indicate high levels of organic vapors are present in the tank, so it is not likely that condensation of these compounds occurred.

3.0 RESULTS

3.1 SAMPLING AND MOBILE LABORATORIES AND INDUSTRIAL HYGIENE

Analytical results from the WHC Sampling and Mobile Laboratories and WHC Industrial Hygiene follow. Further details are given by Pingel (1993).

3.1.1 Combustible Gas Meter

Headspace flammability was measured with an Industrial Scientific Corporation Model TMX410 combustible gas meter (CGM). This type of CGM uses the catalytic bead method to measure flammability. The CGM was calibrated using pentane on August 10, 1993 before being used at tank 241-C-111. A post-calibration test was performed. CGMs measure gas and vapor fuel content in terms of the lower explosive limit (LEL). The flammability test is performed before other activities, and intrusive work can continue only if the readings are below 20% of the LEL.

The TMX410 CGM is also capable of measuring the oxygen (O_2) content of air. Calibration of the CGM for O_2 was performed at the same time the catalytic bead was calibrated. CGM readings of ambient air and of the tank headspace at each of the three sampling elevations are:

Elevation	LEL	O_2
Ambient Air	0%	21.1%
6.86 m	0%	21.1%
3.75 m	0%	21.1%
0.61 m	0%	21.1%

3.1.2 Organic Vapor Monitor

An organic vapor monitor (OVM) was used to measure the total amount of organics in the headspace at each of the three elevations. OVMs use a photo-ionization detector (PID) to estimate the concentration of organic vapors in air. The PID senses the absorption of ultraviolet light by certain vapors. The instrument was zeroed before each test, and its response checked with an isobutylene gas standard before and after its use in the tank farm. The OVM also responds to NH_3 in roughly a 1:12.9 relationship, when calibrated with isobutylene. That is, 12.9 parts per million by volume (ppmv) of NH_3 would result in the OVM reporting 1 ppmv of organic vapor. The maximum amount detected is reported.

Elevation	Total Organic Concentration
6.86 m	0 ppmv
3.75 m	0 ppmv
0.61 m	0 ppmv

3.1.3 Colorimetric Sorbent Tubes (Dräger™ Tubes)

Colorimetric sorbent tubes are 6-mm (0.25-in.)-diameter, 75 to 100-mm (3 to 4-in.)-long glass tubes packed with sorbent media that change color when exposed to specific analytes. Sample air is drawn through the tube at a fixed maximum flow rate using a hand pump, with each stroke of the hand pump corresponding to a pre-set volume of air. As analyte is introduced and reacts with the sorbent media, the sorbent changes color. The color change progresses along the length of the tube as more of the analyte is introduced, so the amount of analyte can be estimated from the location of the color interface and the number of strokes of the hand pump.

The estimated concentration of analyte can be adjusted for barometric pressure and air temperature. However, colorimetric sorbent tube results are not considered quantitative, and should only be considered estimates. Many

tubes also have cross sensitivities, which can lead to false results. For example, the Dräger™ tube for N_2H_4 also responds to NH_3 , so a false positive for N_2H_4 could be indicated if NH_3 is present in the sample.

Dräger™ brand colorimetric sorbent tubes, Dräger™ tubes, were used to estimate concentrations of the following analytes in tank 241-C-111:

Analyte	Indicated Concentration	Lower Detection Limit
Hydrogen Cyanide (HCN)	<2 ppmv	2 ppmv
Hydrazine (N_2H_4)	<0.2 ppmv	0.2 ppmv
Nitrogen Oxides (NO_x , NO)	<0.5 ppmv	0.5 ppmv
Ammonia (NH_3)	<5 ppmv	5 ppmv

3.2 PACIFIC NORTHWEST LABORATORY

3.2.1 Hydrogen Cyanide

Liquid-filled impingers prepared by PNL were used to sample for HCN. Liquid-filled impingers remove and concentrate selected analytes in an air sample by bubbling the air through a liquid that absorbs the analyte. A caustic solution (0.1 Molar sodium hydroxide [NaOH] in water) was used in midget impingers to sample for HCN in tank 241-C-111. HCN is highly soluble in a caustic solution, and dissociates to the nonvolatile cyanide ion (CN^-) in solution. This method of sampling for HCN is the National Institute for Occupational Safety and Health (NIOSH) method 7904 (NIOSH 1984).

Sampling precision was addressed by collecting three impinger samples. Sampling efficiency (i.e., the fraction of HCN present in the sample collected by the impinger) was determined by using a second (breakthrough) impinger in series behind the primary impinger. It was assumed any HCN not collected by the primary impinger would be collected by the breakthrough impinger. All primary and breakthrough impinger solutions were analyzed using the same procedure.

The three HCN sample impingers were lowered down into the tank headspace. Placing the sampling media in the headspace eliminates the loss of analytes by adsorption on the transfer tubing walls or by absorption into vapor condensate. Further details about the sampling procedure are given in the tank farm operating procedure TO-080-015 Rev. C-0 (WHC 1993a). Drawings H-2-85178, Rev. 3 and H-2-73341 (WHC 1993b, WHC 1986) show the sampling equipment.

PNL received the HCN samples from tank 241-C-111 on August 19, 1993. Sample analyses were completed on August 24, 1993. A discussion of the sample and laboratory blank analyses is given by Lerner and Pool (1993). As indicated in the following table, the tank 241-C-111 HCN concentration was determined from the three samples to be less than 0.04 parts per billion by volume (ppbv), and no HCN was detected in the breakthrough impinger solutions.

CN ⁻ mass/sample	HCN Concentration
< 1.2 ng	< 0.04 ppbv
< 1.2 ng	< 0.04 ppbv
< 1.2 ng	< 0.04 ppbv

3.2.2 Oxides of Nitrogen and Sulfur

The impinger solutions used to sample for HCN were also analyzed for oxides of nitrogen (NO_x) and sulfur oxide (SO_x). NO_x and SO_x are effectively absorbed as acid gases by the 0.1 Molar aqueous NaOH solution, and stably held as ions in solution. Analyses of the bubbler solutions for nitrate reported by Lerner and Pool 1993, converted to gas phase NO_x concentrations, are listed in the following table. Lerner and Pool advise that the SO_x results are invalid because the NaOH trapping solution was incompatible with the analytical method, ion chromatography configured with conductimetric detection.

Bubbler	NO _x
S - 1	(a)
M - 1	8.4 ppmv
L - 1	8.7 ppmv

(a) Nitrate off-scale on first run; insufficient sample to run again.

3.3 OREGON GRADUATE INSTITUTE OF SCIENCE AND TECHNOLOGY

SUMMATM canister tank samples were analyzed by OGIST. SUMMATM canisters are stainless steel containers with internal surfaces electropolished to minimize the adsorption of sample constituents. SUMMATM canisters used to sample tank 241-C-111 were cleaned and certified as clean using the U. S. Environmental Protection Agency (EPA) TO-12 methodology (EPA 1988) at OGIST. The canisters were evacuated at OGIST before shipment to WHC.

Three SUMMATM canister samples were collected at each of the three headspace elevations. The sample-filled canisters were then pressurized at OGIST by adding 8 psig of helium to each canister (Rasmussen and Einfeld 1994). The exact dilution ratios were determined by analyzing the diluted sample by gas chromatograph with a thermal conductivity detector and comparing the nitrogen (N₂) measured in the sample to the ambient N₂ level. Measured dilution ratios ranged from 1.54 to 1.88.

3.3.1 Permanent Gas Analysis

The canisters were analyzed for H_2 , methane (CH_4), carbon dioxide (CO_2), carbon monoxide (CO), nitrous oxide (N_2O), and selected chlorofluorocarbons (CFCs) by gas chromatography, using selective detectors as follows:

H_2 , CO	Mercuric oxide reduction detector
CH_4	Flame ionization detector
CO_2	Thermal conductivity detector
N_2O , CFCs	Electron capture detector

Tables 1 and 2 list results of the analyses. The H_2 level in this tank is about ten times greater than the background level. N_2O is about sixty times higher in the headspace than in the ambient air. CO and CH_4 levels in the tank headspace are the same as the ambient levels. CO_2 in the tank headspace is at a lower concentration than in the ambient air. Analysis for CFCs indicated carbon tetrachloride, trichloroethylene, and tetrachloroethylene were each below method detection limits. No statistically significant differences in the concentrations of these gases were observed between the SUMMATM canister samples from the three headspace elevations. This suggests that the headspace may be mixed by convection.

3.3.2 Total Non-Methane Hydrocarbon Analysis

The total non-methane hydrocarbon (TNMHC) levels were determined using the EPA standard method TO-12 (EPA 1988) and are listed in Table 1. Replicate analyses were performed on each sample; the mean and percent standard deviation for each sample are listed. The results were judged to be accurate because they are within the linearity of the method. All tank vapor measurements of TNMHC are comparable and in the range of 0.2 to 0.3 mg/m³. Consistent with the gas analyses, TNMHC measurements do not indicate a statistically significant organic vapor gradient with headspace elevation.

The ambient sample TNMHC level was determined to be 5.5 mg/m³, which is much higher than expected in a "clean air" sample. The ambient air sample TNMHC results are believed to be incorrect, and the source of error is not known.

3.3.3 Organic Vapor Speciation

EPA TO-14 methodology was applied to analyze C_3 (hydrocarbons containing 3 carbon atoms) through C_{15} (hydrocarbons containing 15 carbon atoms) organic vapors in the samples. This methodology uses cryogenic concentration of the condensable organic vapors, separation by gas chromatography, and identification and quantitation by mass spectroscopy (EPA 1988). Concentration levels for the 42-compound EPA Method TO-14 were determined. Those compounds that had concentrations above the method detection limits are

listed in Table 3. None of the five potential carcinogens in the target list (vinyl chloride, 1,3-butadiene, chloroform, benzene, and carbon tetrachloride) were observed at significant concentrations in the headspace samples.

Besides the 42 target analytes, the TO-14 methodology allows identification of many other organic vapors. Identification is properly considered tentative, but for many compounds the certainty of identification is very high. Quantitation of tentatively identified compounds was not attempted. Rasmussen and Einfeld (1994) provide labeled total-ion chromatograms for each of the nine SUMMATM canister samples from tank 241-C-111. Based on peak height, the dominant organic vapors are, with relatively high confidence that identification is correct and approximately in order of decreasing concentration: tridecane, acetone, dodecane, 2-methylpropene, hexanal, tetradecane, heptanal, and octanal. Table 4 lists all tentatively and positively identified compounds in approximate order of chromatographic elution.

Dodecane, tridecane, and tetradecane constitute the primary components of the normal paraffinic hydrocarbon (NPH) diluent for tributyl phosphate (TBP) used in the plutonium-uranium extraction (PUREX) process. Their presence (and the absence of certain other semivolatile organic vapors) in tank 241-C-111 would suggest that the tank has stored organic wash waste originating from the PUREX processes. Most of the volatile organic compounds observed in tank 241-C-111 appear to be degradation products of the NPH (e.g., shorter chain ketones and aldehydes).

Of interest is the fact that n-butanol was not present at a significant concentration in tank 241-C-111. n-Butanol is a degradation product of TBP. The coincidence of NPH and n-butanol is to be expected given the fact that NPH was a TBP diluent, and n-butanol has indeed been observed wherever NPH vapors have been found elsewhere in the waste tanks.

4.0 SUMMARY

Tank 241-C-111 headspace gases and vapors were monitored and sampled on August 10, 1993. The sampling event was performed to assure safe conditions before planned intrusive work could be performed.

Field monitoring indicated fuel to be at less than 1% of the LEL, O₂ to be present at the normal level for air, less than 1 ppmv of ultraviolet light-absorbing organic compounds, less than 2 ppmv of HCN, less than 0.2 ppmv of hydrazine, less than 0.5 ppmv of nitrogen oxides (NO and NO₂), and less than 5 ppmv of NH₃. With the exception of O₂, which was normal, all monitored compounds were below the method detection limits.

Gas and vapor samples were collected and sent to OGIST and PNL. Nine SUMMATM canister tank headspace samples were analyzed at OGIST. Tables 1 and 2 list individual sample analyses, sample averages, and relative standard deviations for selected analytes from the SUMMATM canister samples. Low levels of CFCs were detected; results are summarized in Table 3. Table 4

lists, in approximately the order of chromatographic elution, organic analytes tentatively identified from full-scan analyses using the EPA TO-14 methodology.

Liquid-filled impinger samples were analyzed for acid gases (i.e., HCN, NO, NO₂, and SO_x). Analyses indicated HCN in the headspace to be below 0.04 ppbv. The average tank headspace NO_x concentration, estimated from 2 of the bubbler samples, was 8.6 ppmv. Analyses for SO_x were performed but determined to be unreliable.

Table 1. EPA TO-12 and Miscellaneous Analyses.

Sample	Time	Elevation above waste (m)	Dilution Ratio	TNMHC ¹ ($\mu\text{g}/\text{m}^3$) RSD ² (%)	H ₂ (ppbv)	CO (ppbv)	CH ₄ (ppbv)	CO ₂ (ppmv)	N ₂ O (ppbv)
JH-09	1045	0.61	1.68	316 0.5	15108	119	591	235	37442
JH-02	1048	0.61	1.79	282 0.8	15208 15348	97 97	610	243	39255
JH-01	1051	0.61	1.65	285 2.1	15223 15142	99 106	NA	NA	37985
JH-03	1105	3.75	1.70	225 2.6	15659	95	580	231	39421
H-21	1108	3.75	1.82	212 2.1	15557	96	546	230	39998
JH-04	1111	3.75	1.67	239 2.1	15427 15247	109 110	604	239	38221
H-22	1129	6.86	1.74	281 4.4	15919 15825	94 94	532	237	39082
H-19	1131	6.86	1.82	275 2.0	15415	109	592	240	38569 37858
H-20	1133	6.86	1.88	250 3.8	15903 15858	96 98	585	239	39668
Sample Average (standard deviation)				263 33	15477 284	102 2	580 27	237 4	38810 869
JH-10 (ambient)	1135	--	1.58	5520 6.0	1617	117	2297	436	639

1. TNMHC = total non-methane hydrocarbons

2. RSD = relative standard deviation.

Table 2. Chlorofluorocarbon Analysis.

Sample	Elevation above waste (m)	CCl ₂ F ₂ (pptv) ¹	CCl ₃ F (pptv)	CCl ₂ F-CClF ₂ (pptv)	CH ₂ CCl ₃ (pptv)	CCl ₄ (pptv)
JH-09	0.61	ND	539	131	57	25
JH-02	0.61	ND	550 544	125 118	54 54	27
JH-01	0.61	ND	551	97	54	25
JH-03	3.75	ND	544	139	44	22
H-21	3.75	ND	533	155	49	22
JH-04	3.75	ND	534	159	50	---
H-22	6.86	ND	572	84	59	21
H-19	6.86	ND	568 562	100 84	67 66	22 24
H-20	6.86	ND	560	122	62	23
Sample average (standard deviation)		-- --	549 14	122 27	55 7	23.5 2
JH-10 (ambient)		618	350	73	186	115

1. pptv = parts per trillion by volume.

Table 3. EPA TO-14 Analysis.
(2 sheets)

Sample	Elevation above waste (m)	CCl ₂ F ₂ (ppbv)	CH ₃ Cl (ppbv)	CH ₃ Br (ppbv)	CH ₃ -CH ₂ Cl (ppbv)	CCl ₃ F (ppbv)	CH ₂ =CCl ₂ (ppbv)	CH ₂ Cl ₂ (ppbv)
JH-09	0.61	0.2	1.6	0.1	0.4	0.7	0.1	0.2
JH-02	0.61	0.1	1.2	0.1	0.2	0.7	0.1	0.1
JH-01	0.61	0.1	0.5	0.1	0.2	0.7	0.1	0.2
JH-03	3.75	0.1	1.5	0.1	ND ¹	0.7	ND	0.2
H-21	3.75	0.3	2.4	ND	ND	0.5	0.2	0.1
JH-04	3.75	0.2	0.8	ND	ND	0.5	0.1	0.1
H-22	6.86	0.2	1.5	ND	ND	0.6	0.1	0.1
H-19	6.86	0.1	1.3	ND	ND	0.6	0.1	0.1
H-20	6.86	0.1	1.7	ND	ND	0.6	0.1	0.1
Sample Average (standard deviation)		0.16 0.07	1.4 0.5	0.04 0.05	0.09 0.1	0.62 0.08	0.10 0.05	0.13 0.05
JH-10 (ambient)		0.1	0.5	ND	ND	ND	0.1	ND

1. ND = not detected.

Table 3. EPA TO-14 Analysis.
(2 sheets)

Sample	Elevation above waste (m)	CCl ₂ F-CClF ₂ (ppbv)	Benzene (ppbv)	Toluene (ppbv)	m & p-Xylene (ppbv)	o-Xylene (ppbv)	1,2,4-Trimethyl Benzene (ppbv)
JH-09	0.61	0.1	0.2	0.2	0.1	ND	ND
JH-02	0.61	0.1	0.2	0.2	0.1	ND	ND
JH-01	0.61	0.1	0.3	0.1	ND ¹	ND	ND
JH-03	3.75	ND	0.3	0.1	ND	ND	ND
H-21	3.75	0.1	0.3	0.2	0.1	0.1	ND
JH-04	3.75	0.1	0.3	0.2	0.1	ND	ND
H-22	6.86	ND	0.3	0.2	0.1	ND	ND
H-19	6.86	0.1	0.2	0.4	0.1	ND	0.1
H-20	6.86	0.1	0.3	0.3	0.1	ND	ND
Sample average (standard deviation)		0.08 <u>0.04</u>	0.27 <u>0.05</u>	0.21 <u>0.09</u>	0.08 <u>0.04</u>	-- --	-- --
JH-10 (ambient)		ND	0.2	ND	ND	ND	ND

1. ND = not detected.

Table 4. Tentatively and Positively Identified Compounds.
(In Approximate Order of Chromatographic Elution)

1	Carbonyl Sulfide (OCS)	32	2-Hexanone
2	Dichlorodifluoromethane (Freon 12)	33	Hexanal
3	Chloromethane	34	2,2,4-Trimethylhexane
4	2-Methylpropane	35	2,4-Dimethylheptane
5	2-Methyl-1-propene	36	2,5-Dimethylheptane
6	Butane	37	Ethylbenzene
7	Trimethylfluorosilane	38	m-Xylene
8	Ethanenitrile (acetonitrile)	39	p-Xylene
9	2-Methylbutane	40	3-Heptanone
10	Propanone (acetone)	41	2-Heptanone
11	Trichlorofluoromethane (Freon 11)	42	2,2-Dimethyloctane
12	Pentane	43	Heptanal
13	Dichloromethane	44	o-Xylene
14	Carbon Disulfide	45	6-Methyl-2-heptanone
15	Methyl Nitrate	46	Benzaldehyde
16	2-Methyl-2-propanol	47	6-Methyl-5-hepten-2-one
17	1,1,1-Trichlorotrifluoroethane (Freon 113)	48	2-Octanone
18	Nitromethane	49	2-Pentylfuran
19	Trimethylsilanol	50	Octanal
20	Butanal	51	Nonanal
21	Butanone	52	Undecane
22	Benzene	53	Decanal
23	2-Pentanone	54	Dodecane
24	Pentanal	55	2,6-Dimethylundecane
25	Methanoic acid	56	3-Methyldodecane
26	Methylcyclohexane	57	Tridecane
27	Ethanoic acid	58	Tetradecane
28	2,3,4-Trimethylpentane		
29	Toluene		
30	2,3-Dimethylhexane		
31	Cyclopentanone		

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