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CRYOGENICALLY TRAPPED TRACE CONTAMINANTS
ANALYZED BY IONIZING GAS CHROMATOGRAPHY



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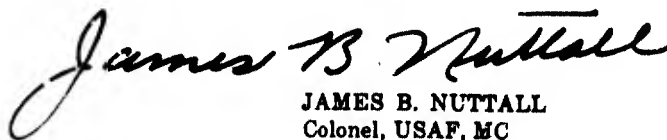
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FOREWORD

This report was prepared by Melpar, Inc., Falls Church, Va., under contract No. AF 41(609)-2958 and task No. 793002. The contract was monitored by James P. Conkle, Environmental Systems Branch, USAF School of Aerospace Medicine. The analyses of samples from a 28-day study of trace contaminants in a sealed environment at 258 mm. Hg total pressure were accomplished 14 March through 11 April 1966. The paper was submitted for publication on 21 May 1967.

The data as reported are raw data. Final determination of contaminant concentrations will be made by the sponsor, using information from this report and two other independent, parallel analyses accomplished by other organizations.

This report has been reviewed and is approved.



JAMES B. NUTTALL
Colonel, USAF, MC
Commander

ABSTRACT

The purpose of this work was to determine quantitatively the concentration of microcontaminants in a sealed environment system. The separation and identification of the cryogenically trapped trace contaminants were accomplished with liquid gas chromatography using a flame ionization detector.

Thirty-nine sets of samples were analyzed, each set consisting of 3 cylinders. Nine sets of samples were taken during a manned simulator run conducted at Brooks Air Force Base in October to November 1965, 29 sets from a similar run conducted in March to April 1966, and one sample set from a trapping efficiency run. The compounds contained in the sample cylinders were identified by their time of elution from a column and the amount measured with the aid of peak areas. The response characteristics of the chromatograph were calculated from responses obtained with standard mixtures.

CRYOGENICALLY TRAPPED TRACE CONTAMINANTS ANALYZED BY IONIZING GAS CHROMATOGRAPHY

I. INTRODUCTION

Gas liquid chromatography represents a good fractionation technic and, in most cases, separated components can be identified from their column elution times. This method is particularly useful when the concentration of the contaminants is so low that they cannot be detected by any other means. We used it in making quantitative determinations of compounds by comparing the areas of the response of identified sample compounds with areas of response of laboratory standards.

Atmospheric samples trapped cryogenically from the space simulator at Brooks Air Force Base, were received and analyzed by a standard procedure.¹ Special traps of 3 ml. volume, designed by Melpar, Inc., were used to collect fractions of the samples for analysis. Through the use of such traps it was possible to introduce the concentrated samples into the gas chromatograph without contaminating the cryogenic trapping cylinder. A total of 39 sets of samples was analyzed, each set consisting of three different gas samples collected at temperatures 0°, -78°, and -175° C.

Previous experience of Melpar in analyzing contaminants from space chambers has shown that the concentrations of such contaminants are too low to be analyzed by infrared spectrophotometry. Gas chromatography, a highly sensitive method of detection, is ideally suited to this work. In some instances, however, two or more components are eluted at the same time.

¹De Schmetzing, H., and J. H. Chaudet. Utilization of infrared spectrophotometry in microcontaminant studies in sealed environments. SAM-TR-67-2, Jan. 1967.

In these cases, unless an elaborate system of two or more columns is used, positive identification of the components cannot be realized. It is therefore suggested that as a complement to gas chromatography, a mass spectrometer be incorporated in future investigations.

II. EXPERIMENTS AND RESULTS

Gas chromatography

The instrument used for the separation and identification of samples was a Beckman hydrogen flame chromatograph equipped with a Thermotrac temperature programmer. The separation column used was 20 ft. long by 1/8 in. (I.D.). It contained a 40/60 mesh Teflon support coated with a 10% w/w mixture of 6% polyphenyl ether and 4% carbowax 20 M and operated at a helium flow rate of 20 ml. per minute. The column temperature was programmed over a period of 45 minutes from +50° to +150° C. The detector used was a Microtek flame ionization detector. The output of this detector was fed to the Beckman amplifier and this output, in turn, was fed to a Leeds & Northrup 0-1 mv. strip chart recorder.

Calibration standards, obtained from Matheson Co., Inc., were used to obtain detector response values and retention times of several compounds. These values were then used to convert detector response for sample components into weight values. All quantitation was realized by measuring peak areas.

Carbon dioxide determinations in each sample were made before the sample was concentrated. This was done by taking an aliquot of the sample through a rubber septum with a

syringe and injecting it onto a silica gel column. A cross-sectional ionization detector was used for detection, and the response obtained was related to a calibration curve for carbon dioxide.

Analysis of space simulator samples

A sample was analyzed from the -175° C. cylinder. To obtain this sample, a 3 ml. loop was evacuated to and connected to the sample cylinder. The cylinder was opened and the sample loop was adjusted to atmospheric pressure and then injected into the chromatograph. The unconcentrated sample of the unknown mixture prevented saturation of the amplifier by large amounts of certain compounds. This procedure allowed the analysis to be made in a range of amplification in which the response was more linear. The more volatile components, such as Freon and methane, were analyzed by this method since they could not be efficiently trapped by the concentration technique used.

More sensitive analyses of the less volatile components were obtained by concentrating the samples. Concentrated samples were prepared by allowing the contents of each sample cylinder to flow through a 3 ml. trap immersed in a carbon dioxide-acetone bath at the rate of 10 ml. per minute. After the flow of contaminants had ceased, the cylinder was pressurized to 50 lb./sq. in. with helium and the contents then flushed through the trap at the same rate as before.

Identification of the contaminants was made by relating observed retention times with those of known contaminants found in closed environments. The reference data of known contaminants were obtained by Melpar. Since the absolute retention of any column tends to change somewhat over an extended period of time because of column bleeding, gas flow changes, temperature, and other factors, a retention time standard was run before each set of samples. This standard was composed of hexane, acetone, methylene chloride, methyl

ethyl ketone, methanol, ethanol, isopropyl alcohol, chloroform, toluene, and allyl alcohol. When changes in the retention time of these compounds occurred, the master retention time table was modified proportionately to reflect them. Thus, it is believed that the compounds in the sample were properly identified.

Results of sample analyses

A total of 39 sets of samples was received and analyzed. Analyses were first made of 9 controlled experiments. The results of these experiments are listed in table I.

The second phase of this investigation was a 28-day study of the contaminants evolved from man and his environment within the space simulator. The results of this study are given in table II. All of the peaks noted on the recorder were given numbers and in those instances where a compound or peak could not be identified, the unknown compound was identified by the peak number.

The third phase of the investigation consisted of the analysis of one set of cylinders. These three cylinders were all trapped at temperatures of -175° C. The results are shown in table III. The prime interest of this set was to evaluate the efficiency of a trapping method.

III. CONCLUSIONS AND RECOMMENDATIONS

Liquid gas chromatography proved to be a good method for the analysis of samples trapped cryogenically in the space simulator. The peak areas corresponded well to the concentration of the component when the response factor was calculated from standard samples having a known concentration of compounds. Some components, however, had the same elution time and in such cases could not be differentiated. Some components were also not identified because no known material was found to have the same elution time as the unknown.

TABLE I

Composite analysis of gas samples from manned simulator experiment, Oct.-Nov. 1965

Com- puter No.	Component (mg.)	Sample								
		1	2	3	4	5	6	7	8	9
1	Carbon dioxide	1602.9	82.5	191.3			323.8	1258.7	265.0	1109.76
3	Freon 114	Eluted with No. 25	1.7 × 10 ⁻⁵							
4	Freon 22									
5	Pentane			1.1 × 10 ⁻³	5.3 × 10 ⁻¹					
6	Diethyl ether			1.9 × 10 ⁻³	5.0 × 10 ⁻³					
8	Acetone	3.6 × 10 ⁻⁵			3.1 × 10 ⁻⁴	1.8 × 10 ⁻⁴		3.5 × 10 ⁻⁵		3.6 × 10 ⁻⁵
9	Methyl acetate				4.5 × 10 ⁻⁵	4.9 × 10 ⁻⁴		1.2 × 10 ⁻³		3.8 × 10 ⁻³
10	n-Heptane			9.1 × 10 ⁻³			2.3 × 10 ⁻³			
11	Methyl ethyl ketone				2.1 × 10 ⁻⁴	4.7 × 10 ⁻⁴				
12	1,1,1-Trichloroethane	2.8 × 10 ⁻⁵		1.9 × 10 ⁻⁴			2.3 × 10 ⁻³			
13	Methanol	2.2 × 10 ⁻²	3.6 × 10 ⁻²	4.0 × 10 ⁻³		2.8 × 10 ⁻⁵				1.7 × 10 ⁻⁴
14	Benzene	5.6 × 10 ⁻⁴	8.6 × 10 ⁻⁵	4.8 × 10 ⁻³	1.5 × 10 ⁻³	9.0 × 10 ⁻⁴				4.1 × 10 ⁻⁴
15	Ethanol		4.8 × 10 ⁻⁴		1.1 × 10 ⁻³	4.1 × 10 ⁻³				1.4 × 10 ⁻⁴
16	Ethylene dichloride	1.0 × 10 ⁻⁴	8.1 × 10 ⁻⁴		3.6 × 10 ⁻⁴	3.2 × 10 ⁻⁴		2.3 × 10 ⁻⁴		5.6 × 10 ⁻⁵
17	Trichloroethylene	1.4 × 10 ⁻⁴	1.9 × 10 ⁻⁴	1.1 × 10 ⁻³	5.0 × 10 ⁻⁴	6.7 × 10 ⁻⁴		4.5 × 10 ⁻⁴		5.4 × 10 ⁻⁴
18	Chloroform		5.1 × 10 ⁻²							1.8 × 10 ⁻⁴
19	4-Methyl-2-pentanone									
20	Toluene	1.5 × 10 ⁻²	1.5 × 10 ⁻³	2.1 × 10 ⁻³	6.0 × 10 ⁻⁴			5.7 × 10 ⁻⁴		
21	Tetrafluoroethylene			6.8 × 10 ⁻³	3.2 × 10 ⁻³		1.0 × 10 ⁻³	1.9 × 10 ⁻³	2.7 × 10 ⁻³	6.0 × 10 ⁻³
22	m-Xylene		5.9 × 10 ⁻⁴	1.4 × 10 ⁻³	3.4 × 10 ⁻⁴	6.7 × 10 ⁻⁴		4.1 × 10 ⁻⁴	1.6 × 10 ⁻³	6.1 × 10 ⁻⁴
23	Cyclohexane			6.5 × 10 ⁻⁴	3.2 × 10 ⁻³	1.3 × 10 ⁻³		2.7 × 10 ⁻⁵	1.0 × 10 ⁻³	1.1 × 10 ⁻⁴
24	Methylene chloride			2.6 × 10 ⁻³	3.2 × 10 ⁻³	3.1 × 10 ⁻³	1.5 × 10 ⁻³	3.3 × 10 ⁻³	2.9 × 10 ⁻⁵	3.2 × 10 ⁻⁴
25	Isopropyl alcohol		3.5 × 10 ⁻⁴	6.7 × 10 ⁻³	1.0 × 10 ⁻⁴	1.2 × 10 ⁻⁴	1.1 × 10 ⁻³			4.5 × 10 ⁻⁵
26	Isobutyl alcohol		9.7 × 10 ⁻⁵		5.6 × 10 ⁻⁵	2.9 × 10 ⁻⁴	3.1 × 10 ⁻³	2.6 × 10 ⁻³	2.7 × 10 ⁻³	2.3 × 10 ⁻³
27	Chlorobenzene	3.8 × 10 ⁻⁴	7.9 × 10 ⁻⁴	3.6 × 10 ⁻⁴	3.2 × 10 ⁻⁴	3.6 × 10 ⁻⁴	1.1 × 10 ⁻⁴	5.6 × 10 ⁻⁴	2.6 × 10 ⁻³	2.3 × 10 ⁻⁴
28	o-Xylene	3.8 × 10 ⁻⁵		2.0 × 10 ⁻³	1.4 × 10 ⁻³	7.7 × 10 ⁻⁴	1.1 × 10 ⁻²	1.1 × 10 ⁻³	8.8 × 10 ⁻⁴	8.1 × 10 ⁻⁵
29	p-Xylene	Eluted with No. 22								
30	Butanol		1.6 × 10 ⁻⁴							
31	Acetaldehyde	Eluted with No. 38								
32	Ethyl acetate	Eluted with No. 18								
33	Hexane			4.5 × 10 ⁻³			2.7 × 10 ⁻⁴	5.0 × 10 ⁻⁴	1.5 × 10 ⁻³	

TABLE I (contd.)
 Composite analysis of gas samples from manned simulator experiment, Oct.-Nov. 1965

No.	Component (mg.)	Sample												
		1	2	3	4	5	6	7	8	9				
34	Isopropyl ether			1.9 × 10 ⁻³										
35	Vinyl chloride		2.3 × 10 ⁻⁵	7.9 × 10 ⁻⁴	5.0 × 10 ⁻³									
36	Propyl acetate			1.2 × 10 ⁻³										
37	Allyl alcohol		6.7 × 10 ⁻⁵									2.3 × 10 ⁻⁴	4.2 × 10 ⁻⁴	
38	Freon 11	3.7 × 10 ⁻²	5.9 × 10 ⁻⁵									7.9 × 10 ⁻⁵	4.1 × 10 ⁻⁴	2.4 × 10 ⁻⁴
39	Carbon tetrachloride	Eluted with No. 19		4.0 × 10 ⁻⁴	3.6 × 10 ⁻⁴	3.3 × 10 ⁻⁴							9.0 × 10 ⁻⁵	
46	Indene													
48	Styrene													
52	Ethane										4.6 × 10 ⁻³			
55	Isoprene	Eluted with No. 6												1.2 × 10 ⁻²
56	Methyl cyclohexane	Eluted with No. 11												
57	Tetrahydrofuran	Eluted with No. 24												
59	p-Dioxane	Eluted with No. 20												
60	Dimethyl sulfide	Eluted with chloropropane												
71	Methane	Eluted with No. 52										4.5 × 10 ⁻⁵		
75	n-Propanol													
82	Ethyl benzene				4.8 × 10 ⁻⁴	1.1 × 10 ⁻⁴					3.0 × 10 ⁻³		2.0 × 10 ⁻⁵	
87	Octane	Eluted with Ethyl sulfide		4.6 × 10 ⁻³									4.4 × 10 ⁻⁴	
88	Decalin			1.5 × 10 ⁻³	4.0 × 10 ⁻³	5.4 × 10 ⁻³					7.2 × 10 ⁻⁴		5.1 × 10 ⁻³	2.5 × 10 ⁻³
90	Butyl acetate	Eluted with No. 28												
103	Methyl methacrylate	Eluted with No. 16												
109	Amyl alcohol	1.1 × 10 ⁻³												
110	Decane	2.2 × 10 ⁻⁴	4.6 × 10 ⁻³	2.2 × 10 ⁻³										
—	Amyl acetate			2.5 × 10 ⁻⁵	1.5 × 10 ⁻³	5.0 × 10 ⁻⁴							4.7 × 10 ⁻³	4.7 × 10 ⁻⁴
—	Isobutyl acetate		5.0 × 10 ⁻⁴										3.7 × 10 ⁻³	
—	Unknown (1)													
—	Unknown (2)			1.0 × 10 ⁻³	1.0 × 10 ⁻³									
—	Unknown (3)			3.8 × 10 ⁻⁵	4.4 × 10 ⁻⁴									
—	Unknown (4)													
—	Unknown (5)												1.8 × 10 ⁻³	1.9 × 10 ⁻³
—	Unknown (6)					2.8 × 10 ⁻⁴							1.1 × 10 ⁻⁴	

TABLE II

Composi e analyses of gas samples from 28-day study in manned simulator (Mar.-Apr. 1966)

Com- puter No.	Component (mg.)	Sample (date)					
		3-14	3-15	3-16	3-17	3-18	3-19
1	Carbon dioxide	82.21	3.39	0.21	1.12	39.41	1.47
2	Freon 12						
3	Freon 114						
4	Freon 22						
5	Pentane						
6	Diethyl ether				2.5×10^{-5}		
7	1,1-Dichloroethylene						
8	Acetone	2.9×10^{-3}	2.0×10^{-2}	4.5×10^{-2}	5.9×10^{-2}	3.7×10^{-2}	5.6×10^{-2}
9	Methyl acetate					1.1×10^{-2}	8.4×10^{-4}
10	n-Heptane						
11	Methyl ethyl ketone	Eluted with	No. 32				
12	1,1,1-Trichloroethane				1.0		
13	Methanol	1.3×10^{-2}	1.9×10^{-2}		2.0×10^{-4}		
14	Benzene		3.0×10^{-4}	1.2×10^{-4}		4.9×10^{-4}	2.2×10^{-4}
15	Ethanol	2.6×10^{-1}	7.1×10^{-1}	1.5×10^{-1}	1.3×10^{-3}	2.4×10^{-1}	9.0×10^{-2}
16	Ethylene dichloride	1.4×10^{-3}	1.2×10^{-3}	2.4×10^{-3}	3.8×10^{-3}	2.4×10^{-3}	1.4×10^{-3}
17	Trichloroethylene	Eluted with	No. 37				
18	Chloroform		5.0×10^{-3}				
19	4-Methyl-2-pentanone	3.0×10^{-3}	7.2×10^{-3}	1.3×10^{-2}	2.9×10^{-2}	2.0×10^{-2}	1.5×10^{-2}
20	Toluene	1.7×10^{-2}	3.1×10^{-2}	5.7×10^{-2}	7.6×10^{-2}	9.0×10^{-2}	4.1×10^{-2}
21	Tetrachloroethylene			8.9×10^{-4}	1.0×10^{-3}	2.8×10^{-3}	9.0×10^{-3}
22	m-Xylene	1.5×10^{-4}	3.8×10^{-4}	7.0×10^{-4}	2.9×10^{-3}	2.8×10^{-3}	3.5×10^{-3}
23	Cyclohexane	Eluted with	No. 9				
24	Methylene chloride	Eluted with	No. 15				
25	Isopropyl alcohol	2.3	1.2	2.73	3.3×10^{-2}	2.5	1.9
26	Isobutyl alcohol	3.6×10^{-5}	2.1×10^{-5}	7.5×10^{-4}	2.2×10^{-4}	1.6×10^{-4}	6.6×10^{-5}
27	Chlorobenzene				1.3×10^{-5}		
28	o-Xylene	2.4×10^{-4}	3.9×10^{-4}	9.7×10^{-4}	2.7×10^{-3}	2.9×10^{-3}	3.4×10^{-3}
29	p-Xylene	Eluted with	No. 22				
30	Butanol	Eluted with	No. 19				
31	Acetaldehyde	Eluted with	No. 38				
32	Ethyl acetate	1.6×10^{-2}	9.1×10^{-3}	4.2×10^{-2}	9.7×10^{-1}	4.7×10^{-2}	4.9×10^{-2}
33	Hexane						
34	Isopropyl ether						1.8×10^{-5}
35	Vinyl chloride						
36	Propyl acetate	Eluted with	No. 37				
37	Allyl alcohol	6.0×10^{-3}	1.9×10^{-3}	2.0×10^{-3}	1.5×10^{-2}	6.8×10^{-3}	2.1×10^{-3}
38	Freon 11						
39	Carbon tetrachloride	Eluted with	No. 19				
45	1,3-Dimethyl cyclohexane	Eluted with	No. 16				
46	Indene						
48	Styrene	4.8×10^{-5}	5.1×10^{-4}	2.2×10^{-4}	5.5×10^{-4}	4.7×10^{-4}	9.5×10^{-4}
52	Ethane						

TABLE II (contd.)

Composite analyses of gas samples from 28-day study in manned simulator (Mar.-Apr. 1966)

Com- puter No.	Component (mg.)	Sample (date)					
		3-20	3-21	3-22	3-23	3-24	3-25
1	Carbon dioxide		1298.90	846	612	779	295
2	Freon 12						
3	Freon 114						
4	Freon 22						2.7×10^{-3}
5	Pentane						
6	Diethyl ether			5.4×10^{-3}	1.1×10^{-2}	1.1×10^{-2}	8.8×10^{-2}
7	1,1-Dichloroethylene						
8	Acetone	7.8×10^{-2}	2.5×10^{-2}	6.1×10^{-1}	1.7	8.4×10^{-1}	1.3×10^{-1}
9	Methyl acetate						
10	n-Heptane						
11	Methyl ethyl ketone						
12	1,1,1-Trichloroethane						
13	Methanol	1.6×10^{-4}		1.9×10^{-4}	2.6×10^{-3}	6.2×10^{-4}	9.3×10^{-4}
14	Benzene	6.9×10^{-4}				1.5×10^{-4}	2.4×10^{-4}
15	Ethanol	4.4×10^{-1}				5.0×10^{-2}	
16	Ethylene dichloride	2.6×10^{-3}		3.0×10^{-3}	3.5×10^{-3}	2.2×10^{-3}	1.3×10^{-3}
17	Trichloroethylene						
18	Chloroform	1.8×10^{-2}					
19	4-Methyl-2-pentanone	1.9×10^{-2}	2.1×10^{-4}	2.7×10^{-2}	2.2×10^{-2}	2.0×10^{-2}	2.1×10^{-2}
20	Toluene	9.5×10^{-2}	2.6×10^{-3}	5.3×10^{-2}	5.1×10^{-2}	4.5×10^{-2}	3.4×10^{-2}
21	Tetrachloroethylene		5.5×10^{-3}	2.8×10^{-2}	1.8×10^{-2}	1.5×10^{-2}	5.8×10^{-2}
22	m-Xylene	8.5×10^{-3}		4.1×10^{-3}	3.0×10^{-2}	2.9×10^{-3}	3.4×10^{-3}
23	Cyclohexane						
24	Methylene chloride						
25	Isopropyl alcohol	2.0	4.2×10^{-1}	2.9	1.2	8.5×10^{-1}	5.5×10^{-2}
26	Isobutyl alcohol	1.0×10^{-3}					
27	Chlorobenzene	5.1×10^{-3}					
28	o-Xylene	4.3×10^{-3}	1.1×10^{-4}	4.6×10^{-3}	3.8×10^{-3}	3.9×10^{-3}	4.8×10^{-3}
29	p-Xylene						
30	Butanol						
31	Acetaldehyde						
32	Ethyl acetate	2.7×10^{-2}			6.3×10^{-3}	1.9×10^{-2}	2.2×10^{-2}
33	Hexane						
34	Isopropyl ether						
35	Vinyl chloride						
36	Propyl acetate						
37	Allyl alcohol	9.3×10^{-3}		8.0×10^{-3}	6.0×10^{-3}	6.5×10^{-3}	8.0×10^{-3}
38	Freon 11	4.4×10^{-5}	3.6×10^{-5}			2.2×10^{-3}	
39	Carbon tetrachloride						
45	1,3-Dimethyl cyclohexane						
46	Indene	3.0×10^{-4}					
48	Styrene	1.0×10^{-3}	3.6×10^{-5}	8.0×10^{-4}	1.0×10^{-3}	1.5×10^{-3}	1.2×10^{-3}
52	Ethane			1.1×10^{-5}			

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TABLE II (contd.)

Composite analyses of gas samples from 28-day study in manned simulator (Mar.-Apr. 1966)

Com- puter No.	Component (mg.)	Sample (date)					
		3-26	3-27	3-28	3-29	3-30	3-31
1	Carbon dioxide	764	25.3	153.6	538	453.8	604.6
2	Freon 12						
3	Freon 114					8.4×10^{-5}	4.8×10^{-6}
4	Freon 22				9.0×10^{-6}	4.5×10^{-5}	4.8×10^{-6}
5	Pentane						
6	Diethyl ether	2.4×10^{-3}	9.6×10^{-6}	3.2×10^{-4}	3.4×10^{-1}	3.4×10^{-1}	3.2×10^{-1}
7	1,1-Dichloroethylene					5.8×10^{-5}	1.1×10^{-5}
8	Acetone		2.1×10^{-3}	6.0×10^{-2}	3.7×10^{-1}	1.1×10^{-1}	8.0×10^{-1}
9	Methyl acetate						
10	n-Heptane						
11	Methyl ethyl ketone						
12	1,1,1-Trichloroethane						
13	Methanol		4.9×10^{-4}		7.5×10^{-3}	5.7×10^{-3}	1.3×10^{-3}
14	Benzene	2.9×10^{-4}		1.3×10^{-4}	1.0×10^{-4}	2.2×10^{-4}	3.1×10^{-4}
15	Ethanol	8.6×10^{-2}	4.4×10^{-3}	2.6×10^{-2}			6.4×10^{-3}
16	Ethylene dichloride	3.4×10^{-3}	4.8×10^{-4}	1.0×10^{-3}	1.2×10^{-3}	2.6×10^{-3}	2.2×10^{-3}
17	Trichloroethylene						
18	Chloroform			1.4×10^{-3}		3.6×10^{-2}	
19	4-Methyl-2-pentanone	2.0×10^{-2}	6.2×10^{-3}	8.3×10^{-3}	7.5×10^{-3}		9.6×10^{-3}
20	Toluene	3.2×10^{-2}	5.5×10^{-3}	2.0×10^{-2}	2.0×10^{-2}	2.6×10^{-2}	3.5×10^{-2}
21	Tetrachloroethylene	2.4×10^{-2}	2.6×10^{-2}	9.0×10^{-3}	3.5×10^{-3}	1.1×10^{-2}	9.0×10^{-3}
22	m-Xylene	3.5×10^{-3}	8.9×10^{-4}	2.2×10^{-3}	2.5×10^{-3}	6.4×10^{-3}	4.2×10^{-3}
23	Cyclohexane						
24	Methylene chloride						
25	Isopropyl alcohol	4.0×10^{-1}	3.1×10^{-2}	9.1×10^{-2}	2.6×10^{-2}	5.8×10^{-2}	4.6×10^{-2}
26	Isobutyl alcohol					1.6×10^{-4}	2.1×10^{-5}
27	Chlorobenzene				4.2×10^{-5}		
28	o-Xylene	4.8×10^{-3}	1.7×10^{-3}	1.8×10^{-3}	2.3×10^{-3}	9.0×10^{-3}	5.9×10^{-3}
29	p-Xylene						
30	Butanol						
31	Acetaldehyde						
32	Ethyl acetate	2.5×10^{-2}	5.4×10^{-4}	6.8×10^{-3}	7.4×10^{-3}	2.2×10^{-2}	1.8×10^{-2}
33	Hexane						
34	Isopropyl ether						
35	Vinyl chloride						
36	Propyl acetate						
37	Allyl alcohol	1.1×10^{-2}	1.4×10^{-3}	2.0×10^{-3}	4.7×10^{-3}	3.0×10^{-3}	3.9×10^{-3}
38	Freon 11				5.4×10^{-5}	2.3×10^{-4}	2.5×10^{-5}
39	Carbon tetrachloride						
45	1,3-Dimethyl cyclohexane						
46	Indene		9.6×10^{-4}				
48	Styrene	1.6×10^{-3}	6.0×10^{-4}	7.9×10^{-4}	9.6×10^{-4}	1.2×10^{-3}	1.1×10^{-3}
52	Ethane						

TABLE II (contd.)

Composite analyses of gas samples from 28-day study in manned simulator (Mar.-Apr. 1966)

Com- puter No.	Component (mg.)	Sample (date)					
		4-1	4-2	4-3	4-4	4-5	4-6
1	Carbon dioxide	556.9	399.3	265.2	43.4	367.4	127.9
2	Freon 12						
3	Freon 114		2.4×10^{-5}	1.1×10^{-3}		1.8×10^{-5}	
4	Freon 22	1.1×10^{-5}	1.2×10^{-5}	1.4×10^{-3}		9.6×10^{-6}	
5	Pentane						
6	Diethyl ether	4.6×10^{-1}	4.8×10^{-1}	3.2×10^{-2}	2.6×10^{-4}		
7	1,1-Dichloroethylene						
8	Acetone	8.6×10^{-1}	5.9×10^{-1}	8.4×10^{-1}	1.8×10^{-1}	1.5×10^{-1}	3.4×10^{-2}
9	Methyl acetate						
10	n-Heptane						
11	Methyl ethyl ketone						
12	1,1,1-Trichloroethane			4.1×10^{-3}			
13	Methanol	4.6×10^{-4}	7.1×10^{-4}	4.0×10^{-4}			
14	Benzene	2.4×10^{-4}		1.2×10^{-4}	7.8×10^{-5}		
15	Ethanol	4.0×10^{-3}	1.7×10^{-2}			3.1×10^{-4}	4.4×10^{-3}
16	Ethylene dichloride	2.4×10^{-3}	1.8×10^{-3}	2.2×10^{-3}	1.0×10^{-3}	5.8×10^{-5}	
17	Trichloroethylene						
18	Chloroform						
19	4-Methyl-2-pentanone	7.1×10^{-3}	9.5×10^{-3}	8.3×10^{-3}	3.9×10^{-3}	3.7×10^{-4}	1.4×10^{-4}
20	Toluene	2.7×10^{-2}	1.9×10^{-2}	2.3×10^{-2}	7.0×10^{-3}	3.0×10^{-4}	1.4×10^{-4}
21	Tetrachloroethylene	1.4×10^{-3}	3.7×10^{-3}	1.7×10^{-2}			
22	m-Xylene	2.5×10^{-3}	3.6×10^{-3}	1.3×10^{-3}	1.1×10^{-3}	1.0×10^{-4}	1.8×10^{-5}
23	Cyclohexane						
24	Methylene chloride						
25	Isopropyl alcohol	5.3×10^{-2}	1.2×10^{-3}	2.3×10^{-2}	1.2×10^{-2}	6.5×10^{-3}	4.2×10^{-3}
26	Isobutyl alcohol						
27	Chlorobenzene					1.2×10^{-5}	
28	o-Xylene	3.7×10^{-3}	5.3×10^{-3}	4.6×10^{-3}	2.2×10^{-3}	2.3×10^{-4}	1.8×10^{-4}
29	p-Xylene						
30	Butanol						
31	Acetaldehyde						
32	Ethyl acetate	2.7×10^{-2}	2.2×10^{-2}	2.7×10^{-2}	4.1×10^{-3}	8.0×10^{-4}	
33	Hexane						
34	Isopropyl ether						
35	Vinyl chloride						
36	Propyl acetate						
37	Allyl alcohol	3.7×10^{-3}	7.5×10^{-3}	3.6×10^{-3}	3.5×10^{-3}	9.0×10^{-3}	9.2×10^{-4}
38	Freon 11	4.4×10^{-5}	2.0×10^{-4}		4.2×10^{-5}		
39	Carbon tetrachloride						
45	1,3-Dimethyl cyclohexane						
46	Indene						
48	Styrene	1.1×10^{-3}	1.6×10^{-3}	1.2×10^{-3}	5.5×10^{-4}	3.0×10^{-5}	
52	Ethane						

TABLE II (contd.)

Composite analyses of gas samples from 28-day study in manned simulator (Mar.-Apr. 1966)

Com- puter No.	Component (mg.)	Sample (date)				
		4-7	4-8	4-9	4-10	4-11
1	Carbon dioxide	678.6	1210.1	285	103.4	431
2	Freon 12					
3	Freon 114				2.5×10^{-5}	
4	Freon 22				1.1×10^{-2}	
5	Pentane					
6	Diethyl ether			1.4×10^{-8}	2.2×10^{-5}	3.6×10^{-8}
7	1,1-Dichloroethylene					
8	Acetone	2.9×10^{-2}	1.2×10^{-1}	1.3×10^{-1}	9.4×10^{-2}	2.0×10^{-1}
9	Methyl acetate					
10	n-Heptane					
11	Methyl ethyl ketone					
12	1,1,1-Trichloroethane					
13	Methanol					
14	Benzene		Eluted with	octane		
15	Ethanol		2.2×10^{-2}	5.3×10^{-4}	3.7×10^{-3}	
16	Ethylene dichloride			2.4×10^{-5}	1.5×10^{-8}	2.8×10^{-5}
17	Trichloroethylene					
18	Chloroform					
19	4-Methyl-2-pentanone	7.5×10^{-5}				
20	Toluene	1.0×10^{-4}	5.8×10^{-4}	1.0×10^{-4}	2.2×10^{-4}	1.7×10^{-4}
21	Tetrachloroethylene					
22	m-Xylene	4.8×10^{-5}	9.6×10^{-5}	1.8×10^{-5}	5.4×10^{-4}	2.7×10^{-5}
23	Cyclohexane					
24	Methylene chloride					
25	Isopropyl alcohol	1.8×10^{-3}	5.2×10^{-3}	2.4×10^{-3}	2.1×10^{-3}	9.8×10^{-4}
26	Isobutyl alcohol				3.6×10^{-4}	
27	Chlorobenzene					
28	o-Xylene	4.8×10^{-5}	2.0×10^{-4}	8.1×10^{-5}	9.0×10^{-5}	8.4×10^{-5}
29	p-Xylene					
30	Butanol					
31	Acetaldehyde					
32	Ethyl acetate			3.8×10^{-4}	2.5×10^{-4}	6.3×10^{-4}
33	Hexane					
34	Isopropyl ether					
35	Vinyl chloride					
36	Propyl acetate					
37	Allyl alcohol	2.7×10^{-5}		2.7×10^{-3}	2.4×10^{-3}	1.8×10^{-3}
38	Freon 11					
39	Carbon tetrachloride					
45	1,3-Dimethyl cyclohexane					
46	Indene					
48	Styrene		1.8×10^{-5}		8.4×10^{-5}	
52	Ethane	5.0×10^{-4} 1.7×10^{-3}				

TABLE II (contd.)

Composite analyses of gas samples from 28-day study in manned simulator (Mar.-Apr. 1966)

Com- puter No.	Component (mg.)	Sample (date)					
		3-14	3-15	3-16	3-17	3-18	3-19
55	Isoprene	Eluted with No. 6					
56	Methyl cyclohexane						
57	Tetrahydrofuran						
58	Cyclohexene						
59	p-Dioxane	Eluted with No. 20					
60	Dimethyl sulfide						
73	Methyl cyclohexene	9.6×10^{-5}	1.1×10^{-4}	6.0×10^{-5}		1.2×10^{-3}	
75	n-Propanol	1.1×10^{-3}	1.9×10^{-3}	1.6×10^{-3}	4.9×10^{-2}	9.8×10^{-3}	
76	Heptane						
77	2,5-Dimethyl furan					2.9×10^{-5}	1.5×10^{-5}
79	Butyraldehyde		4.4×10^{-4}	9.6×10^{-5}		5.7×10^{-3}	
82	Ethyl benzene	Eluted with No. 22					
84	Ethyl formate						
87	Octane	Eluted with No. 73					
88	Decalin	5.5×10^{-5}			6.3×10^{-4}		5.7×10^{-5}
90	Butyl acetate	1.5×10^{-4}	2.3×10^{-4}	8.7×10^{-4}	1.4×10^{-3}	1.6×10^{-3}	1.0×10^{-3}
100	Mesitylene	2.9×10^{-5}		4.7×10^{-5}	3.0×10^{-4}	9.4×10^{-5}	2.3×10^{-4}
103	Propionic acid				3.0×10^{-4}	2.4×10^{-4}	7.4×10^{-4}
105	1,1-Dichloroethane						
108	Methyl methacrylate	Eluted with No. 26					
109	Amyl alcohol	1.1×10^{-2}	1.8×10^{-1}	4.1×10^{-1}	7.3×10^{-1}	1.2	7.6×10^{-1}
110	Decane						
.....	Amyl acetate	7.2×10^{-5}	3.8×10^{-4}	8.9×10^{-4}	4.6×10^{-3}	1.6×10^{-3}	3.5×10^{-3}
.....	Furfural		7.9×10^{-5}	3.6×10^{-4}	5.0×10^{-4}	3.0×10^{-4}	6.9×10^{-4}
.....	Furfural alcohol						
.....	Diethyl benzene						
.....	Tetrachloroethane	7.2×10^{-5}	5.4×10^{-5}	2.5×10^{-4}	6.1×10^{-4}	4.4×10^{-4}	6.6×10^{-4}
.....	Tert-butyl benzene						
	(12A) Unknown						
	(14B) Unknown				1.3×10^{-4}		
	(15A) Unknown				1.6×10^{-4}		
	(15-1) Unknown						
	(17A) Unknown						
	(17-1) Unknown						
	(17-2) Unknown						
	(18-A-1) Unknown						
	(18-A-2) Unknown						
	(18-1) Unknown						
	(19-2) Unknown						
	(19-B) Unknown						
	(19-1) Unknown						
	(19-2) Unknown						
	(19-S) Unknown						
	(22) Unknown						

TABLE II (contd.)

Composite analyses of gas samples from 28-day study in manned simulator (Mar.-Apr. 1966)

Com- puter No.	Component (mg.)	Sample (date)					
		3-20	3-21	3-22	3-23	3-24	3-25
55	Isoprene						
56	Methyl cyclohexane						
57	Tetrahydrofuran				1.2×10^{-1}		
58	Cyclohexene						
59	p-Dioxane						
60	Dimethyl sulfide			3.1×10^{-5}	7.7×10^{-5}	1.2×10^{-5}	3.2×10^{-5}
73	Methyl cyclohexene	6.5×10^{-5}				1.5×10^{-4}	2.6×10^{-4}
75	n-Propanol	9.8×10^{-3}			4.7×10^{-3}	3.6×10^{-3}	4.9×10^{-3}
76	Heptane						
77	2,5-Dimethyl furan	2.3×10^{-5}					
79	Butyraldehyde	6.7×10^{-3}					
82	Ethyl benzene						
84	Ethyl formate						
87	Octane						
88	Decalin	4.2×10^{-5}		2.5×10^{-4}	8.9×10^{-5}	2.0×10^{-4}	1.9×10^{-4}
90	Butyl acetate	1.0×10^{-3}	2.3×10^{-4}	2.6×10^{-3}	2.1×10^{-3}	1.5×10^{-3}	1.5×10^{-3}
100	Mesitylene	1.8×10^{-4}	3.6×10^{-5}	4.8×10^{-4}	3.1×10^{-4}	3.1×10^{-4}	1.6×10^{-4}
103	Propionic acid			1.9×10^{-4}	1.5×10^{-4}	2.1×10^{-3}	2.4×10^{-3}
105	1,1-Dichloroethane						
108	Methyl methacrylate						
109	Amyl alcohol	1.8	2.6×10^{-2}	1.5	1.0	9.8×10^{-1}	1.00
110	Decane	6.0×10^{-5}					
	Amyl acetate	2.5×10^{-3}	2.6×10^{-3}	5.5×10^{-3}	4.5×10^{-3}	4.0×10^{-3}	5.2×10^{-3}
	Furfural	8.8×10^{-4}	6.3×10^{-5}	1.4×10^{-3}	1.2×10^{-3}	1.2×10^{-3}	1.1×10^{-3}
	Furfural alcohol						3.6×10^{-5}
	Diethyl benzene			1.4×10^{-5}			
	Tetrachloroethane	1.1×10^{-3}	7.3×10^{-5}	8.0×10^{-4}	1.3×10^{-4}	1.8×10^{-3}	1.3×10^{-3}
	Tert-butyl benzene	9.4×10^{-5}		1.2×10^{-4}		3.9×10^{-5}	
	(12A) Unknown						
	(14B) Unknown						
	(15A) Unknown			3.4×10^{-4}		9.9×10^{-5}	
	(15-1) Unknown						
	(17A) Unknown				1.7×10^{-5}		
	(17-1) Unknown						
	(17-2) Unknown						
	(18-A-1) Unknown						
	(18-A-2) Unknown						
	(18-1) Unknown						
	(18-2) Unknown						
	(19-B) Unknown						9.7×10^{-5}
	(19-1) Unknown						
	(19-2) Unknown						
	(19-3) Unknown						
	(22) Unknown						

TABLE II (contd.)

Composite analyses of gas samples from 28-day study in manned simulator (Mar.-Apr. 1966)

Com- puter No.	Component (mg.)	Sample (date)					
		3-26	3-27	3-28	3-29	3-30	3-31
55	Isoprene						
56	Methyl cyclohexane					2.5×10^{-3}	
57	Tetrahydrofuran		2.1×10^{-3}				
58	Cyclohexene						
59	p-Dioxane						
60	Dimethyl sulfide	1.8×10^{-5}			3.0×10^{-4}	3.4×10^{-4}	3.6×10^{-5}
73	Methyl cyclohexene	2.7×10^{-4}		1.1×10^{-5}	1.5×10^{-4}	1.5×10^{-4}	2.3×10^{-4}
75	n-Propanol	3.5×10^{-3}	1.4×10^{-4}	1.5×10^{-3}	2.0×10^{-3}	1.8×10^{-2}	8.5×10^{-3}
76	Heptane						
77	2,5-Dimethyl furan						2.1×10^{-5}
79	Butyraldehyde					5.2×10^{-3}	3.9×10^{-4}
82	Ethyl benzene						
84	Ethyl formate						
87	Octane						
88	Decalin	3.0×10^{-4}	1.6×10^{-4}	1.7×10^{-4}	1.2×10^{-4}	4.4×10^{-4}	2.0×10^{-4}
90	Butyl acetate	2.1×10^{-3}	1.4×10^{-3}	8.9×10^{-4}	6.6×10^{-4}	1.6×10^{-3}	8.1×10^{-4}
100	Mesitylene	2.8×10^{-4}	2.0×10^{-4}	1.2×10^{-4}	2.0×10^{-4}	4.4×10^{-4}	2.0×10^{-4}
103	Propionic acid	2.1×10^{-3}	1.1×10^{-3}	8.2×10^{-4}	1.1×10^{-3}	3.3×10^{-3}	1.6×10^{-3}
105	1,1-Dichloroethane						
108	Methyl methacrylate						
109	Amyl alcohol	4.8×10^{-1}	2.5×10^{-1}	5.1×10^{-1}	6.5×10^{-1}	1.5	1.0
110	Decane						
.....	Amyl acetate	5.6×10^{-3}	2.9×10^{-3}	2.7×10^{-3}	2.4×10^{-3}	4.9×10^{-3}	3.2×10^{-3}
.....	Furfural	1.6×10^{-3}	9.2×10^{-4}	5.1×10^{-4}	8.0×10^{-5}	2.1×10^{-3}	1.2×10^{-3}
.....	Furfural alcohol	4.5×10^{-5}	3.4×10^{-5}			6.8×10^{-5}	7.2×10^{-5}
.....	Diethyl benzene	3.6×10^{-5}	3.6×10^{-5}			4.8×10^{-5}	3.7×10^{-5}
.....	Tetrachloroethane	1.9×10^{-3}	8.2×10^{-4}	5.3×10^{-4}	4.8×10^{-4}	1.5×10^{-2}	9.8×10^{-4}
.....	Tert-butyl benzene	9.6×10^{-5}	4.3×10^{-5}	5.5×10^{-5}	3.4×10^{-5}	1.8×10^{-4}	1.2×10^{-4}
	(12A) Unknown						1.9×10^{-5}
	(14B) Unknown						
	(15A) Unknown	1.2×10^{-4}	7.9×10^{-5}		5.9×10^{-5}	1.1×10^{-4}	1.3×10^{-4}
	(15-1) Unknown				4.2×10^{-5}		
	(17A) Unknown						
	(17-1) Unknown				1.1×10^{-5}		
	(17-2) Unknown				2.4×10^{-5}		
	(18-A-1) Unknown				2.6×10^{-5}		
	(18-A-2) Unknown				1.8×10^{-5}		
	(18-1) Unknown				6.0×10^{-5}		
	(18-2) Unknown				1.1×10^{-4}		
	(19-B) Unknown		6.2×10^{-5}				
	(19-1) Unknown				1.4×10^{-5}		
	(19-2) Unknown				4.3×10^{-5}		
	(19-3) Unknown				1.4×10^{-4}		
	(22) Unknown		1.9×10^{-4}				

TABLE II (contd.)

Composite analyses of gas samples from 28-day study in manned simulator (Mar.-Apr. 1966)

Com- puter No.	Component (mg.)	Sample (date)					
		4-1	4-2	4-3	4-4	4-5	4-6
55	Isoprene						
56	Methyl cyclohexane						
57	Tetrahydrofuran		2.0×10^{-3}	2.5×10^{-3}		2.5×10^{-3}	
58	Cyclohexene						
59	p-Dioxane						
60	Dimethyl sulfide	3.2×10^{-5}	2.7×10^{-5}	2.3×10^{-5}			
73	Methyl cyclohexene	4.3×10^{-5}			1.7×10^{-5}	2.4×10^{-4}	7.8×10^{-5}
75	n-Propanol	7.2×10^{-3}	1.1×10^{-2}	9.1×10^{-3}	3.2×10^{-3}		
76	Heptane						
77	2,5-Dimethyl furan						
79	Butyraldehyde			1.0×10^{-4}			
82	Ethyl benzene						
84	Ethyl formate						
87	Octane						
88	Decalin	1.6×10^{-4}	3.3×10^{-4}	3.1×10^{-4}	1.8×10^{-4}		5.4×10^{-5}
90	Butyl acetate	6.5×10^{-4}	9.4×10^{-4}	9.8×10^{-4}	4.6×10^{-4}	3.9×10^{-5}	2.0×10^{-5}
100	Mesitylene	1.8×10^{-4}	1.7×10^{-4}	7.2×10^{-4}	1.0×10^{-4}	1.2×10^{-5}	
103	Propionic acid	1.7×10^{-3}	1.5×10^{-3}	1.6×10^{-3}	9.4×10^{-4}	4.8×10^{-4}	
105	1,1-Dichloroethane						
108	Methyl methacrylate						
109	Amyl alcohol	8.1×10^{-1}	7.9×10^{-1}	8.2×10^{-3}	3.7×10^{-1}	1.5×10^{-2}	7.2×10^{-3}
110	Decane					5.0×10^{-5}	
	Amyl acetate	2.1×10^{-3}	4.2×10^{-3}	3.5×10^{-3}	1.6×10^{-3}	8.5×10^{-5}	1.2×10^{-5}
	Furfural	8.9×10^{-4}	1.6×10^{-3}	1.2×10^{-3}	7.1×10^{-4}	7.2×10^{-5}	6.5×10^{-5}
	Furfural alcohol	2.5×10^{-5}	8.6×10^{-5}	5.8×10^{-5}	8.6×10^{-5}		
	Diethyl benzene	1.4×10^{-5}	3.9×10^{-5}	2.9×10^{-5}	2.7×10^{-5}		
	Tetrachloroethane	1.0×10^{-3}	1.2×10^{-3}	9.0×10^{-4}	6.1×10^{-4}	5.5×10^{-5}	
	Tert-butyl benzene	3.6×10^{-5}	1.1×10^{-4}	1.1×10^{-4}			
	(12A) Unknown						
	(14B) Unknown						
	(15A) Unknown	7.2×10^{-5}	3.3×10^{-5}	1.3×10^{-4}	6.4×10^{-5}	3.6×10^{-5}	
	(15-1) Unknown						
	(17A) Unknown						
	(17-1) Unknown						
	(17-2) Unknown						
	(18-A-1) Unknown						
	(18-A-2) Unknown						
	(18-1) Unknown						
	(18-2) Unknown						
	(19-B) Unknown						
	(19-1) Unknown						
	(19-2) Unknown						
	(19-3) Unknown						
	(22) Unknown						

TABLE II (contd.)

Composite analyses of gas samples from 28-day study in manned simulator (Mar.-Apr. 1966)

Com- puter No.	Component (mg.)	Sample (date)				
		4-7	4-8	4-9	4-10	4-11
55	Isoprene					
56	Methyl cyclohexane					
57	Tetrahydrofuran					3.2×10^{-4}
58	Cyclohexene					
59	p-Dioxane					
60	Dimethyl sulfide					Eluted with chloropropane
73	Methyl cyclohexene			7.2×10^{-8}	2.4×10^{-5}	
75	n-Propanol			2.0×10^{-4}	2.2×10^{-5}	
76	Heptane					Eluted with ethyl sulfide
77	2,5-Dimethyl furan					
79	Butyraldehyde		1.3×10^{-5}		1.1×10^{-5}	
82	Ethyl benzene					
84	Ethyl formate					
87	Octane					
88	Decalin	5.7×10^{-5}	1.2×10^{-5}		2.4×10^{-5}	
90	Butyl acetate	1.8×10^{-5}	2.1×10^{-4}		2.4×10^{-5}	
100	Mesitylene					
103	Propionic acid					
105	1,1-Dichloroethane					9.0×10^{-3}
108	Methyl methacrylate					
109	Amyl alcohol	1.2×10^{-3}	9.9×10^{-2}	3.0×10^{-3}	1.3×10^{-3}	1.8×10^{-5}
110	Decane					2.4×10^{-5}
	Amyl acetate		1.8×10^{-5}		1.8×10^{-5}	
	Furfural		2.4×10^{-5}		4.5×10^{-5}	
	Furfural alcohol					
	Diethyl benzene			1.8×10^{-5}	1.2×10^{-5}	
	Tetrachloroethane		1.2×10^{-5}			
	Tert-butyl benzene					
	(12A) Unknown		5.7×10^{-5}			
	(14B) Unknown		1.2×10^{-5}			
	(15A) Unknown					
	(15-1) Unknown					
	(17A) Unknown					
	(17-1) Unknown					
	(17-2) Unknown					
	(18-A-1) Unknown					
	(18-A-2) Unknown					
	(18-1) Unknown					
	(18-2) Unknown					
	(19-B) Unknown					
	(19-1) Unknown					
	(19-2) Unknown					
	(19-3) Unknown					
	(22) Unknown					

TABLE III

Analysis of gas samples evaluating the efficiency of a trapping method

Computer No.	Compound	Molecular weight	Elution time	Total (mg.)
Cylinder No. 3				
8	Acetone	58.08	11' 48"	6×10^{-4}
11	Methyl ethyl ketone	72.1	18' 36"	4.7×10^{-4}
20	Toluene	92.13	31' 42"	6×10^{-4}
Cylinder No. 10				
8	Acetone	58.08		1.1×10^{-2}
Cylinder No. 28				
8	Acetone	58.08	12' 24"	2.7×10^{-2}
11	Methyl ethyl ketone	72.1	19' 18"	2.0×10^{-2}
14	Benzene	78.11	22' 30"	2.8×10^{-2}
20	Toluene	92.13	32' 18"	2.7×10^{-2}
25	Isopropyl alcohol	60.09	15' 30"	9.0×10^{-3}
33	Hexane	86.17	8' 12"	4.9×10^{-2}
	Chloropropane	78.54	10' 12"	3.8×10^{-2}

As seen in table II, the background, assumed to be samples 3-14 through 3-20, contained as many as 20 contaminants. The concentration of amyl alcohol was high throughout the experiment. After the men were placed in the chamber—this point can be detected by the considerable increase of CO₂—acetone built up to a maximum of 1.7 mg. in sample 3-23. Sample 3-29 had the most contaminants, a total of 40. The number of unknown compounds was between 1 and 3, except in one sample in which it rose to 11. As many as 15 compounds had the same elution time as

others; the separation of these was not possible. In the efficiency standards, one set had very low concentrations and a nonconcentrated sample gave no results.

For future analysis of space simulator samples, a double chromatographic system would furnish better identification. In some cases, a mass spectrometric determination would be necessary to identify the unknown compounds. For quantitative results, the response of the detector should be calibrated every day with known standard mixtures.

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13 ABSTRACT

The purpose of this work was to determine quantitatively the concentration of microcontaminants in a sealed environmental system. The separation and identification of the cryogenically trapped trace contaminants were accomplished with liquid gas chromatography using a flame ionization detector.

Thirty-nine sets of samples were analyzed, each set consisting of 3 cylinders. Nine sets of samples were taken during a manned simulator run conducted at Brooks Air Force Base in October to November 1965, 29 sets from a similar run conducted in March to April 1966, and one sample set from a trapping efficiency run. The compounds contained in the sample cylinders were identified by their time of elution from a column and the amount measured with the aid of peak areas. The response characteristics of the chromatograph were calculated from responses obtained with standard mixtures.

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Aerospace medicine Ionizing gas chromatography Microcontaminants in a sealed environment Space cabin simulator, materials in Gas chromatography Atmospheric samples trapped cryogenically						

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