United States
Environmental Protection
Agency

Office of Administration
and Resources Management

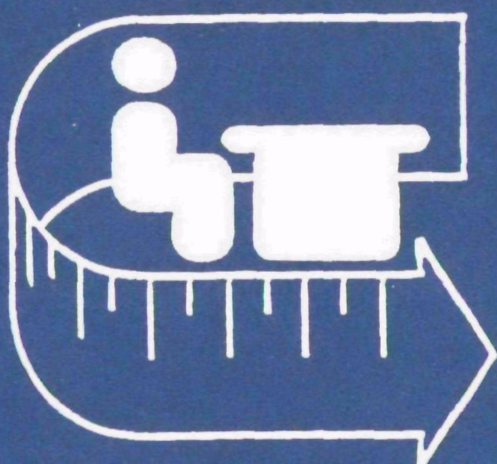
May 1990

EPA

Indoor Air Quality And Work Environment Study

EPA Headquarters' Building
SUPPLEMENT TO VOLUME 2

Results of Indoor Air Environmental Monitoring Study



Indoor Air Quality and Work Environment Study:

EPA Headquarters Buildings

Volume II:

Results of Indoor Air Environmental Monitoring Study

Supplement to Volume II:

Additional EPA Headquarters Air Monitoring Information

April 1990

ACKNOWLEDGEMENT

The primary objective of this supplemental report is to compile in a single document a number of independent small-scale indoor air quality monitoring studies. These studies are not directly related to the large-scale study that is the subject of Volume II; however, they do provide additional anecdotal information about indoor air quality at different times and locations throughout the EPA headquarters' buildings. The concept and contents of this supplement have been discussed and approved by EPA management, the National Federation of Federal Employees, and the American Federation of Government Employees.

The studies presented in this supplement were conducted during 1988 and early 1989 both at the EPA headquarters' buildings to evaluate indoor air quality and off-site to evaluate potential emissions from EPA carpets and office partitions. Several of these studies were not conducted by EPA's Office of Research and Development. Additionally, in some cases, the studies do not contain enough information to support an evaluation of measurement data or an interpretation of results. Therefore, the studies are compiled in this report without analysis, interpretation, or a summary of results.

CONTENTS

Introduction

In recent years, employees at the three headquarters buildings of the U.S. Environmental Protection Agency (EPA) have expressed concerns about indoor air pollution and work environment discomforts. Because of the difficulties encountered in determining the exact causes of these concerns, EPA's Office of Research and Development/Atmospheric Research and Exposure Assessment Laboratory has undertaken a systematic study of the nature and spatial distribution of employee health symptoms and comfort concerns in an attempt to determine if associations exist between employee responses and specific workplace conditions.

The report published with this supplement is the second of three volumes that investigate the perceived and actual quality of indoor air at EPA headquarters' buildings. The first volume (published in November 1989) presents a descriptive summary of the survey data returned by EPA employees from a February 1989 questionnaire. The second volume presents the results of environmental monitoring measurements. The third volume (planned for publication in the fall of 1990) will present the results of multivariate analyses of both sets of study results.

The research effort at EPA was coordinated and integrated with a parallel study conducted at the Library of Congress Madison Building. Both the EPA and Library of Congress studies used common study designs and survey instruments, although separate reports have been prepared for each agency. While certain features of these two studies are specific to the particular buildings involved, the study design, survey design, monitoring, and data analysis have been designed wherever possible to be applicable to the individuals and environments encountered in both buildings.

Information continues to be obtained by both EPA employees and management about the health of EPA employees and indoor air quality at headquarters' buildings. This supplement contains a number of draft and final studies which individually investigated headquarters' buildings indoor air quality. The studies were identified for inclusion by EPA managment, the National Federation of Federal Employees Local 2050, and the American Federation of Government Employees Local 3331. The studies are arranged in chronological order in the seven appendices following this introduction.

APPENDIX A

March 31, 1988, Technical Note

Report Summary: Indoor Air Analysis

March 31, 1988

MEMORANDUM

SUBJECT: Report Summary: Indoor Air Analysis

FROM: Sella M. Burchette, Environmental Scientist
Rajeshmal Singhvi, Chemist
Environmental Response Branch

TO: Timothy Fields, Director
Emergency Response Division

THRU: Joseph P. Lafornara, Chief
Environmental Response Branch

Rodney D. Turpin, Chief
Analytical Support Section
Emergency Response Branch

Attached please find a summarized format of the methodologies, data review, data discussion, and recommendations based on the findings of the air sampling efforts of March 4 and 5, 1988 at 401 M Street.

I. SUMMARY OF METHODOLOGIES:

A. Real-time monitoring
B. Sampling

MEDIA	TARGET COMPOUNDS	METHOD
Carbon 150mg	Aromatic Hydorcarbons Halogenated Hydorcarbons	1501 1003
2 Stage Silica Gel	Aliphatic Amines	221
3 Stage Silica Gel	Aromatic Amines	2002
Carbon 150 mg	Alcohols	1401
Cassettes	Diisocyanates	OSHA 42
Poly Foam Pufs	Pesticides & PCBs	Lewis & MacLeod
2 Stage Silica Gel	Inorganic Acids	7903
Tenax/CMS	Volatile Organics	TO1 GC/MS
Carbon 150 mg	Napthas	1550

II. DATA REVIEW

A. All data
B. Totals
C. Styrene
D. 1,1,1 TCA
E. Methylene Chloride

III. DATA DISCUSSION

A. Low ppb concentrations
B. Control levels
C. QA/QC

IV. RECOMMENDATIONS

A. Based on data-

B. Resample:
1. Formaldehyde
2. Air Intake
3. Employee monitoring

C. Workplace Environment:
1. Increased air flow
2. Temperature
3. People per square foot
4. Building Maintenance- cleaning agents

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AIR ANALYSES AT EPA HQ, WASHINGTON,DC

TARGET COMPOUNDS:

AROMATIC HYDROCARBONS(NIOSH 1501), BP 36-126 C HYDROCARBONS (NIOSH 1500) AND HALOGENATED HYDROCARBONS(NIOSH 1003)

1. N-PENTANE
2. 1,1-DICHLOROETHENE
3. T-1,2-DICHLOROETHENE
4. 1,1-DICHLOROETHANE
5 N-HEXANE
6. BROMOCHLOROMETHANE
7. CHLOROFORM
8 1,1,1-TRICHLOROETHANE
9. CYCLOHEXANE
10. CARBON TETRACHLORIDE
11. BENZENE
12. CYCLOHEXENE
13. N-HEPTANE
14. 1,2-DICHLOROPROPANE
15. METHYL CYCLOHEXANE
16. TOLUENE
17. N-OCTANE
18. CHLOROBENZENE
19. ETHYL BENZENE
20. M,P-XYLENE
21. O-XYLENE
22. STYRENE
23. BROMOFORM
24. CUMENE
25. ALPHA-METHYL STYRENE
26. 3-METHYLSTYRENE
27. 4-METHYLSTYRENE
28. 1,4,DICHLOROBENZENE
29. BENZYL CHLORIDE
30. HEXACHLOROETHANE
31. 4-TERT-BUTYL TOLUENE
32. NAPTHALENE

INES(NIOSH 221) AND AROMATIC AMINES(NIOSH 2002)

AMINE
AMINE
HYLAMINE
ROPYLAMINE
YLAMINE
ETHYLAMINE
ISOPROPYLAMINE
RIETHYLAMINE
CYCLOHEXYLAMINE
ANILINE
. O-TOLUIDINE
. 2,4-XYLIDINE
5. N,N-DIMETHYL-P-TOLUIDINE
46. N,N-DIMETHYLANILINE

A-6 2

ALCOHOLS (NIOSH 1401)

47. N-BUTYL ALCOHOL
48. SEC-BUTYL ALCOHOL
49. ISO-BUTYL ALCOHOL
50. N-PROPYL ALCOHOL

DIISOCYANATES (OSHA 42)

51. TOLUENE-2,4-DIISOCYANATE
52. TOLUENE-2,6-DIISOCYANATE

PESTICIDES AND PCB (LEWIS AND MACLEAD)

53. ALPHA BHC
54. BETA BHC
55. GAMMA BHC
56. DELTA BHC
57. HEPTACHLOR
58. ALDRIN
59. HEPTACHLOR EPOXIDE+ ENDOSULFAN I
60. DIELDRIN
61. 4,4'-DDE
62. ENDRIN
63. ENDOSULFAN II
64. 4,4'DDD
65. ENDRIN ALDEHYDE
66. ENDOSULFAN SULFATE
67. 4,4'DDT
68. AROCHLOR 1016
69. AROCHLOR 1232
70. AROCHLOR 1242
71. AROCHLOR 1248
72. AROCHLOR 1260

INORGANIC ACID (NIOSH 7903)

73. HYDROFLUORIC ACID
74. HYDROCHLORIC ACID
75. PHOSPHORIC ACID
76. HYDROBROMIC ACID
77. NITRIC ACID
78. SULFURIC ACID

VOLATILE ORGANICS (TO1 GC/MS)

79. VINYL CHLORIDE
80. 1,1-DICHLOROETHENE
81. TRICHLOROFLUOROMETHANE
82. METHYLENE CHLORIDE
83. T-1,2-DICHLOROETHENE
84. 1,1-DICHLOROETHANE
85. 1,2-DICHLOROETHANE
86. 1,1,1-TRICHLOROETHANE
87. CARBON TETRACHLORIDE
88. BENZENE
89. TRICHLOROETHENE
90. TOLUENE
91. TETRACHLOROETHENE
92. ETHYL BENZENE
93. M-XYLENE
94. O-XYLENE
95. STYRENE
96. M-ETHYLTOLUENE

NAPHTHAS(NIOSH 1550)

97. PETROLEUM ETHER
98. MINERAL SPIRITS

INDOOR AIR ANALYSIS AT EPA HQ WASHINGTON,DC.

INDOOR AIR ANALYSIS AT EPA HQ WASHINGTON,DC.

CONC. IN PPB

ROOM NO	BLANK TAT	2709BZ	2709FL	2709	2610 CONTROL	2610 CONTROL	2615	2615	2631	2631	[illegible]
DATE SAMPLED		3/4	3/4	3/5	3/4	3/5	3/4	3/5	3/4	3/5	
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
1,1-DICHLOROETHENE	ND	0.07	BMDL	ND	0.05	BMDL	BMDL	BMDL	0.07	0.6	
TRICHLOROFLUOROMETHANE	ND	0.2	0.4	0.2	1.4	0.3	0.6	0.2	0.3	0.2	
METHYLENE CHLORIDE	ND	2.6	2.8	1.1	5.1	23	6.7	6.2	13	14	
T-1,2-DICHLOROETHENE	ND	ND	ND	ND	0.1	ND	ND	ND	ND	ND	
1,1-DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
1,2-DICHLOROETHANE	ND	BMDL	BMDL	ND	0.08	ND	BMDL	ND	ND	ND	[illegible]
1,1,1-TRICHLOROETHANE	ND	0.6	0.5	0.4	1.7	3.7	0.8	1.7	15	11	[illegible]
CARBON TETRACHLORIDE	ND	0.08	0.07	BMDL	0.09	BMDL	0.09	BMDL	0.3	BMDL	0
BENZENE	BMDL	0.8	1.1	0.6	1.2	0.9	1.0	0.7	0.8	0.8	0
TRICHLOROETHENE	ND	0.07	0.09	BMDL	0.4	BMDL	0.2	BMDL	3.4	2.6	0
TOLUENE	BMDL	4.1	3.5	2.4	4.9	3.0	4.0	2.3	3.2	2.5	3
TETRACHLOROETHENE	ND	0.6	0.5	0.3	0.6	0.3	0.4	0.3	0.4	0.2	0
ETHYL BENZENE	BMDL	0.8	0.6	0.4	1.0	0.6	0.7	0.3	0.6	0.4	0
M-XYLENE	BMDL	2.2	1.9	1.1	2.4	1.8	1.9	1.0	1.8	1.4	1.
O-XYLENE	BMDL	0.9	0.8	0.4	1.1	0.7	0.8	0.4	0.8	0.6	0.
STYRENE	BMDL	0.5	0.4	0.4	1.0	0.8	0.4	0.2	0.5	0.4	0.
M-ETHYLTOLUENE	ND	1.1	1.0	0.6	1.2	0.9	1.1	0.6	1.4	1.2	1.

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INDOOR AIR ANALYSIS AT EPA HQ WASHINGTON,DC.

CONC. IN PPB

ROOM NO	2636	2636(AO)	2636(AO)	2710 CONTROL	2710 CONTROL	2710(DUP) CONTROL	3603	3603	3617	3617
DATE SAMPLED	3/5	3/4	3/5	3/4	3/5	3/5	3/4	3/5	3/4	3/5
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DICHLOROETHENE	ND	BMDL	BMDL	0.05	ND	ND	ND	BMDL	BMDL	0.2
TRICHLOROFLUOROMETHANE	0.2	0.2	0.2	0.2	0.1	BMDL	0.09	0.2	0.4	0.4
METHYLENE CHLORIDE	1.0	3.0	1.2	1.2	0.4	2.0	0.6	9.9	14	2.6
T-1,2-DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROETHANE	ND	BMDL	ND	BMDL	ND	ND	BMDL	ND	ND	BMDL
1,1,1-TRICHLOROETHANE	0.4	0.7	0.4	0.2	0.4	2.5	0.3	4.3	10	1.5
CARBON TETRACHLORIDE	0.1	0.05	BMDL	0.09	0.1	0.6	BMDL	BMDL	0.5	BMDL
BENZENE	0.7	0.9	0.7	0.6	0.7	0.7	0.4	0.8	1.1	0.6
TRICHLOROETHENE	BMDL	0.1	BMDL	0.05	ND	BMDL	0.05	0.2	0.1	BMDL
TOLUENE	2.0	3.4	1.8	1.9	1.3	1.3	3.4	4.0	3.3	3.6
TETRACHLOROETHENE	0.2	0.4	0.2	0.2	0.2	0.3	0.5	0.4	0.6	0.4
ETHYL BENZENE	0.3	0.6	0.3	0.4	0.3	0.3	0.8	0.6	0.7	0.6
M-XYLENE	1.3	1.7	0.9	1.1	0.9	0.9	2.0	1.8	2.1	1.9
O-XYLENE	0.4	0.8	0.3	ND	0.4	0.4	0.9	0.7	0.9	0.8
STYRENE	0.3	0.4	0.2	0.2	0.2	0.2	0.9	1.2	0.6	0.8
M-ETHYLTOLUENE	0.5	1.0	0.5	0.5	0.9	0.7	1.1	1.0	1.1	1.1

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INDOOR AIR ANALYSIS AT EPA HQ WASHINGTON,DC.

INDOOR AIR ANALYSIS AT EPA HQ WASHINGTON,DC.

CONC. IN PPB

ROOM NO	BLANK TAT	2709BZ	2709	2610 CONTROL	2615	2615	2631	2631	2636	2636	263[illegible]
DATE SAMPLED		3/4	3/5	3/4	3/4	3/5	3/4	3/5	3/4	3/5	[illegible]
ALKANES	0.13	15.4	5.7	39.5	26.8	20.7	14.9	7.9	18.5	9.5	
ALKENES/CYCLOALKANES(TOTA	0.04	0.9	0.7	2.5	9.4	ND	3.3	9.1	ND	0.7	
ACETONE	0.04	2.4	2.6	4.3	2.8	1.4	1.4	1.6	2.1	2.2	
METHYL ETHYL KETONE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
ETHANOL	ND	2.0	0.8	5.5	4.4	2.6	3.4	ND	3.4	ND	
2-BUTANOL	ND	2.5	ND	ND	ND	ND	ND	ND	ND	ND	
2-PROPANOL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	[illegible]
CHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	[illegible]
DICHLOROBENZENE ISOMER	ND	ND	BMDL	0.6	ND	ND	ND	0.4	ND	ND	[illegible]
C3 ALKYLBENZENE	ND	6.1	3.7	ND	0.3	4.3	5.6	10.6	5.9	2.9	[illegible]
ACETIC ACID	0.09	ND	ND	ND	ND	ND	ND	ND	ND	ND	[illegible]
CHLOROMETHANE	0.06	ND	ND	ND	ND	ND	ND	ND	ND	ND	[illegible]
BENZALDEHYDE	BMDL	ND	ND	ND	ND	ND	ND	ND	ND	ND	[illegible]
2,3-BUTANEDIONE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	[illegible]
2-METHYLPROPANAL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	[illegible]
TERPENE ISOMER	ND	1.1	0.8	4.6	ND	ND	ND	ND	ND	ND	[illegible]
PETROLEUM ETHER NIOSH1550				20							
MINERAL SPIRIT NIOSH 1550				50	100			40	40		
N-PROPYL ALCOHOL 1401											7

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APPENDIX B

June 22, 1988, Technical Note

Preliminary Data for Warehouse and Navy Yard (Revised)

June 22, 1988

MEMORANDUM

SUBJECT: Preliminary Data for Warehouse and Navy Yard (Revised)

FROM: Sella M. Burchette, Environmental Scientist
Rajeshmal Singhvi, Chemist
Environmental Response Branch

TO: Timothy Fields, Jr., Director
Emergency Response Division

THRU: Rodney D. Turpin, Chief
Analytical Support Section
Environmental Response Branch

Attached please find the preliminary analytical results for VOCs, Formaldehyde, and 4 Phenylcyclohexene from the carpeting and Harter wall partitions sampled in 401 M Street Warehouse and Navy Yard storage facility respectively.

Attachment

Warehouse Analysis Results

Carpet Off Gases Collected

in the Warehouse at 401 M Street, S.W.

Washington, DC

5/6/88

TABLE 1

Analysis Results

Carpet Off Gases Collected in the Warehouse at 401 M Street, S.W.

Washington, DC - 5/6/88

Results are reported in PPB

Compounds Identified	Charcoal Tubes GC/FID Results*	Tenax/CMS GC/MS Results
Toluene	22.1	13.0
Ethylbenzene	4.6	3.7
M and P Xylene	4.6	8.6
O-xylene#		3.0
Styrene#	31.0	33.0
Cumene	4.1	6.9[c]
Dichlorobenzene isomer	68.1	18.0[c]
4 Phenyl cyclohexene[a,b]	~~70.7~~	Presence confirmed
Propyl benzene	N/A	2.5[c]
Trimethylbenzene isomer	N/A	3.6[c]
Ethyl toluene isomer	N/A	5.1[c]
n-decane	N/A	4.3[c]
C_{11} Alkane	N/A	6.9[c]
Total other VOC	-	14.7[c]

* Average of triplicate analysis

a - Calculated with respect to 1-Phenyl 1-Cyclohexene

b - The compound presence was confirmed by GC/MS analysis

c- Calculated with respect to toluene

#- Indicate coeluting compounds (GC/FID)

* N/A - Not analyzed

TABLE II

Analysis Results

Carpet Off Gases Analysis

in the Warehouse for Formaldehyde

(EPA Method TO-5)

Compound	Conc (PPB)
Formaldehyde	9.9*

* Average of 4 separate sample analysis (5/6/88)
(4/29/88)

Navy Yard Analysis Results

Paneling Off Gases Collected

in the Navy Yard, Washington, DC

5/6/88

TABLE III

Analysis Results

Harter Partition off gases collected in the Navy Yard on 5/6/88

Results are reported in PPB

Washington, DC - 5/6/88

Compound Identified	Tenax GC/MS	Charcoal Tube GC/FID
Toluene	2.0	3.2
Ethyl benzene	0.6	ND
M and P Xylene	1.9	ND
O-Xylene	0.6	ND
Acetic Acid[a]	6.6	NA
Methyl benzoate[a]	1.9	NA
Dichlorobenzene isomers[a]	0.3	ND
Total other VOC	5.0	-

a = Calculated with respect to Toluene

ND = Not Detected

NA = Not Analyzed

TABLE IV

Analysis Results

Harter Partition Off Gases Collected in the Navy Yard

Washington, DC

(EPA Method TO-5)

5/6/88

Compound	Conc (PPB)*
Formaldehyde	26.0*

*Average of duplicate samples

APPENDIX C

June 27, 1988, Technical Memorandum

Preliminary Results Summary:
Indoor Air Monitoring Phase II

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

EDISON, NEW JERSEY 08837

June 27, 1988

MEMORANDUM

SUBJECT: Preliminary Results Summary: Indoor Air Monitoring Phase II

FROM: Rajeshmal Singhvi, Chemist
Environmental Response Branch

Sella M. Burchette, Environmental Scientist
Environmental Response Branch

TO: Timothy Fields Jr., Director
Emergency Response Division

THRU: Joseph P. Lafornara, Chief
Environmental Response Branch

Rodney D. Turpin, Chief
Analytical Support Branch
Environmental Response Branch

On May 24-25, 1988, the Environmental Response Team, assisted by the Response Engineering Analytical Contractor (REAC), and coordinated with Research Triangle Park, collected indoor air samples in several offices listed in Table 1, at EPA HQ, 401 M Street, Washington, DC. This was a follow-up study of the previous indoor air study conducted on March 4-5, 1988 by the Environmental Response Team.

The target compounds were selected based on a previous study (Phase I), Warehouse carpet off gases analyses results and the inputs from various experts around the country. The selected organic Compounds (volatile organic compounds, 4- Phenylcyclohexene and formaldehyde) are listed in Table 2. Also, carbon monoxide, carbon dioxide temperature and relative humidity was measured.

Two sets of 12-16 hours time weight average air samples were collected and analyzed by REAC using modified standard methods at the EPA/ERT Analytical Laboratories in Edison, N.J. The methodologies and results are included in Appendix A.

4-Phenylcyclohexene(4PC), one of the compounds traced to carpet off gases constituents was found in almost all the offices monitored including control rooms (2710,3304 and 1015), with the old carpeting. 4pc data are presented in the Bar Graph 1. Also, total volatile organic compounds were found in the indoor air, are summarized in Bar Graph 2.

The air analysis results show 150 ppb of 2,2-dimethylhexane in Room 2827 on May 25, 1988, and did not detect any on May 24, 1988. Investigation is underway to determine the source of this compound.

The carbon dioxide, carbon monoxide, temperature, and relative humidity was found to be normal for office environment during 8:30 am to 3:35 pm on May 25, 1988.

On May 24 and 25, 1988, approximately 400 ppb of formaldehyde was found in Room 2632. A subsequent resampling was conducted on June 3, 1988 and found less than 9 ppb of formaldehyde. The sampling train for formaldehye was placed on the cardboard box on May 24 and 25, 1988, probably resulting in higher results.

Day Care Center class # 5 air analyses results show 186 ppb of total alkanes. The presence of several household products in the day care center contributed the presence of 186 ppb of alkanes and 18 ppb of limonene. 4pc was not detected in the day care center.

Table 3 contains typical values reported by several researchers for indoor air concentration for toluene, benzene, ethyl benzene, xylenes, alkanes (pentane and lower), alkane (hexane and high molecular weight hydrocarbobs), methylene chloride, trichloroethylene, tetrachloroethylene, and 1,1,1-trichloroethane. Only in three cases, (day care center class # 5 on June 3, 1988 and Rooms 2827 and 3304 on May 25, 1988), the concentration of alkanes exceeded the typical values reported in Table 3.

TABLE-1

INDOOR AIR MONITORING PHASE II

SAMPLING LOCATIONS (ROOM NUMBER)

S-226(NEW ROOM)
S-274
S-216 (XEROX ROOM)
2811
2827
2807.5
2710 (CONTROL)
2632
ROOF
3241
3304 (CONTROL)
935 EAST TOWER
1015 EAST TOWER (CONTROL)

2632 RESAMPLED FOR FORMALDEHYDE ON 6/3/88
DAY CARE CENTER OUTSIDE FRONT ENTRANCE
DAY CARE CENTER CLASS#3
DAY CARE CENTER CLASS#5

TABLE-2

INDOOR AIR MONITORING PAHSE II

LIST OF TARGET COMPOUNDS

vinylchloride
1,1-dichloroethene
trichlorofluoromethane
methylenechloride
t-1,2-dichloroethene
1,2-dichloroethane
1,1,1-trichloroethane
carbon tetrachloride
benzene
trichloroethene
ethylbenzene
o,m,p-xylene
styrene
m-ethyltoluene
4-PHENYLCYCLOHEXENE
4-ter-butyl toluene
FORMALDEHYDE

n-pentane
n-hexane
chloroform
cyclohexane
n-heptane
1,2-dichloropropane
methyl cyclohexane
n-octane
bromoform
cumene
alpha-methyl styrene
m,p-methylstyrene
o,p-dichlorobenzene
benzylchloride
hexachloroethane
napthalene

TABLE-2 (continued)

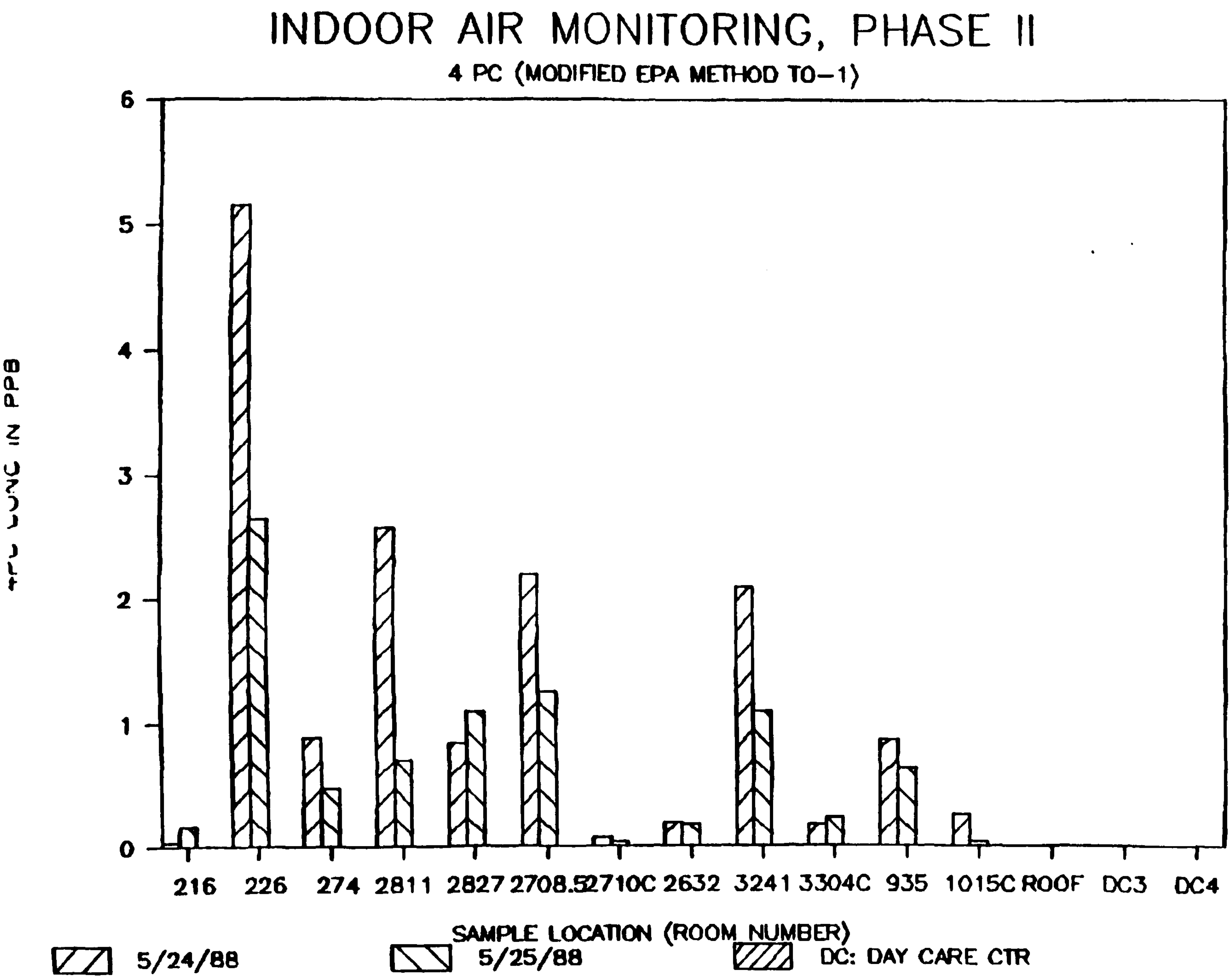
INDOOR AIR MONITERING PHASE II

LIST OF NON TARGET COMPOUNDS

n-hexane
2,2,6-trimethyloctane
C10 alkane
alkane,>C11
phenol + C11 alkane
alkane + C10 alkene/cycloalkane
octanal
C4 alkylbenzene
n-undecane
napthalene
C4 alkane
C9 alkane + C3 alkylbenzene
2,2 dimethyl decane
C10 terpene
N-nitro-N-phenyl-benzeneamine
C6 cycloalkane
C12 alkane
2-butoxyethanol
2,2,4,6,6-pentamethylheptane
C12 alkane + limonene
2-butoxyethanol + styrene
C11 alkane + C3 alkylbenzene
alkane + ethyltoluene
2-methylbutane
n-pentane + trichlorofluoromethane
2-oxy-propanoic acid
C7 alkane
alkane + trimethylbenzene
2-furancarboxaldehyde
2-furanethanol
benzaldehyde
phenol
chloromethane
2-furanmethanol
decahydronapthalene
C12H24O3 ester (1)
C12H24O3 ester (2)
acetic acid + C8 alkane
acetic acid butyl ester
dichlorobenzene isomer
4-methyl-2,6bis(1,1-dimethylethyl)phenol

acetaldehyde
C8 alkene/cycloalkane
hexanal
n-nonane
heptanal
2-butoxyethanol
alkane
2-methylpropane
n-butane
benzaldehyde
C8 alkene/cycloalkane
C8 alkane
siloxane
C9 alkane
n-octane
limonene
n-butane + CO2
n-tridecane
C13 alkane + siloxane
n-butylether
2-butyltetrahydrofuran
C11 alkane
n-decane
C11 alkane
3-methyl-5-propylnonane
siloxane + C3 alkylbenzene
alkane + C3 alkylbenzene
nonanal
C5 alkylbenzene
n-heptane
C3 alkylbenzene
2-(2-butoxyethoxy)-ethanol
acetone
2-propanol
2,2-dimethylhexane
octanal
decanal
pentadecane
acetic acid
C16H10pah
C6 alkane

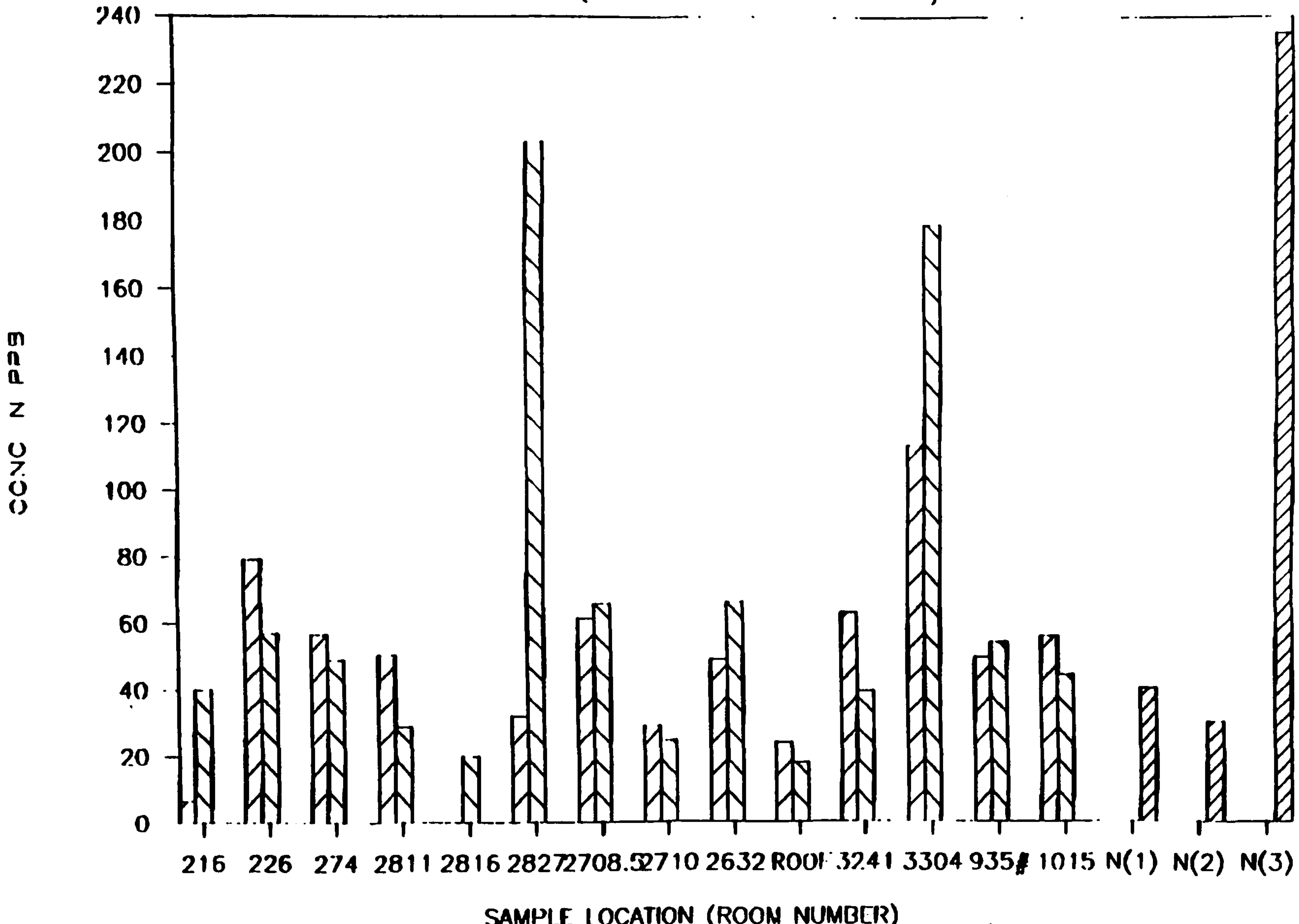
BAR GRAPH -1



INDOOR AIR MONITORING, PHASE II
4 PC (MODIFIED EPA METHOD TO-1)
4PC CONC IN PPB
0
1
2
3
4
5
6
216
226
274
2811
2827
2708.5
2710C
2632
3241
3304C
935
1015C
ROOF
DC3
DC4
SAMPLE LOCATION (ROOM NUMBER)
5/24/88
5/25/88
DC: DAY CARE CTR

INDOOR AIR MONITORING, PHASE II

TOTAL VOC (MODIFIED EPA METHOD TO -1)



5/24/88 5/25/88 6/3/88 N- DAY CARE CENTER

N(1) Outside day care center

N(2) Class#3 day care center

N(3) Class#5 day care center

TABLE -3

TYPICAL INDOOR CONCENTRATIONS OF SELECTED COMPOUNDS

Compound	Concentration (ppb)	Common Sources
Toluene	3 - 160 (1) 33.7 (3), 14.6 (4) 2.4 (5)	Petroleum based cleaning solvents, Paints & paint removers, spray deodorants, Nail base-coat & polish, Furniture polish; silicon caulking
Benzene	3 - 16 (1) 9.4 (2) 16.3 (3), 3.1 (4) 4.7 (6a & 6d), 1.4 (6e & 6f) 3.4 (6g)	Same sources as toluene with exception of nail basecoat and polish; cigeratte smokers in house-hold; Additional source -particle board
Ethyl benzene	1 - 9 (1) 1.5 (2 & 6a), 9.3 (3) 1.2 (4 & 6c), 1.1 (6b) 1.8 (6d), 0.6 (6e & 6h) 0.4 (6f), 0.5(6g)	Same sources as benzene with exception of particle board
Xylenes	3 - 29 (1) 1.2 - 3.7 (2) 2.0 - 28.8 (6) 28.8 (3), 4.8 (4)	Same sources as ethyl benzene
Alkanes (pentane and lower)	no data in ppb	Same sources as toluene plus general cleaning solvents, floor waxes, lower MW alkanes also occassionally used as spray propellents

TABLE 3 (cont.)

TYPICAL INDOOR CONCENTRATIONS OF SELECTED COMPOUNDS

Compound	Concentration (ppb)	Common Sources
Alkane (hexane and higher molecular weight hydrocarbons)	1.4 - 122 (1)	Some glass cleaners, room deodorizers, floor polishes, wood stains, and furniture polish
(basically pentane and hexane will be found in any substance containing petroleum distillates or kerosene)		
Methylene Chloride	372 (3) 6 (*)	Tar removers & tire patch, paint strippers, some mothballs, car engine cleaners & common spray can propellant
(* value found in detached table w/ no reference)		
Trichloroethylene	.4 - 13 (1) 0.5 (2), 3.5 (3) 0.3 (4 & 6c), 0.4 (6a) 0.5 (6b), 0.2 (6d & 6g) 0.1 (6e & 6), <0.1 (6f)	General cleaning solvents, metal cleaners, tire patches, & degreasers
Tetrachloroethane	0.6 - 29 (1) 0.3 - 1.2 (6) 2.5 (3), 0.6 (4) 0.9 (5)	Latex paints, residual dry cleaning solvents in clothing, metal degreasers, dewaxing and stripping solvents, upholstery cleaners, general household cleaning solvents.
1,1,1-Trichloroethane (Methyl Chloroform)	1.7 (2) 2.7 - 53 (1) 4.0 (3), 3.1 (6a) 2.2 (6b), 3.3 (6c) 4.8 (6d), 1.3 (6e) 0.8 (6f), 4.8 (6g) 6.8 (6h)	General cleaning solvents, dry cleaning solvents, non-caustic drain cleaners, carpet & upholstery cleaners, metal cleaners, auto engine cleaners, and degreaser compounds.

TABLE 3 (cont.)

TYPICAL INDOOR CONCENTRATIONS OF SELECTED COMPOUNDS (REFERENCES)

(1) "Indoor Air and Human Health"; R.B. Gammage & S.V. Kaye, ed.; Lewis Publishers, Inc., 1985; "Volatile Organic Compounds in Indoor Air: An Overview of Sources, Concentrations, and Health Effects", Sterling, D.A.; pp. 387-402.

(2) Environment International, Vol. 12, 369, 1986; "Total Exposure Assessment Methodology (TEAM) Study: Personal Exposures, Indoor-Outdoor Relationships, and Breath Levels of Volatile Organic Compounds in New Jersey"; Wallace, L.A., et. al. (concentrations are the reported Geometric Mean of overnight personal air values)

(3) "Proceedings of the 3rd International Conference on Indoor Air Quality and Climate"; B. Berglund, T. Lindvall, & J. Sundell, ed.; Liber Tryck AB, Stockholm, 1984; "Integrating 'Real Life' Measurements of Organic Pollution in Indoor and Outdoor Air of Homes in Northern Italy", M. De Bortoli et. al.; pp. 21-26.

(4) "Proceedings of the 3rd International Conference on Indoor Air Quality and Climate"; B. Berglund, T. Lindvall, & J. Sundell, ed.; Liber Tryck AB, Stockholm, 1984; "Volatile Hydrocarbons in Dutch Homes", E. Lebret, et. al.; pp. 169-174.

(5) "Proceedings of the 3rd International Conference on Indoor Air Quality and Climate"; B. Berglund, T. Lindvall, & J. Sundell, ed.; Liber Tryck AB, Stockholm, 1984; "Sources and Characterization of Organic Air Contaminants Inside Manufactured Housing", D.K. Monteith, T.H. Stock, & W.E. Seifert, Jr.; pp. 285-290.

(6) "The Total Exposure Assessment Methodology (TEAM) Study: Summary and Analysis: Volume 1"; L.A. Wallace, U.S. EPA Report # EPA/600/6-87/002a, June 1987. Concentration data used were mean values from Tables 25, 26 & 46. Reference suffices indicate the location and times for the collected data: 6a - New Jersy, Fall 1981; 6b - New Jersey, Summer 1982; 6c - Ne} Jersey, Winter 1983; 6d - Los Angeles, CA, Jan. 1984; 6e - Los Angeles CA, May 1984; 6f - Contra Costa County CA, June 1984; 6g - Greensboro NC, May 1982; and 6h - Devils Lake ND, October 1982.

APPENDIX A

SAMPLING AND ANALYSES PROCEDURES:

MEDIA	TARGET COMPOUNDS	TOTAL SAMPLE VOLUME	METHOD
CHARCOAL 600MG	VOC AND 4PC	1000L (1.1 L/MIN)	GC/FID NIOSH METHODS CONFIRMED BY GC/MS
TENAX/CMS	VOC AND 4PC	18L (25ML/MIN)	MODIFIED TO-1 GC/MS
SODIUM BISULFITE SOLUTION	FORMALDEHYDE	100L (140ML/MIN)	NIOSH 3500

Table 1A

Analysis Results

Room No.	CO (PPM)	CO_2 (PPM)	% RH	Room Temp (°F)	Time
S-216	7	400	61	75.7	4:30 pm
S-226	8	400	69	74.8	4:35 "
S-274	8	400	59	74.9	4:37 "
2811	7	400	51	71.4	4:42 "
2827	8	400	68	69.9	4:45 "
2708 1/2	7	400	60	77.8	4:50 "
2710 C	7	375	61	72.0	4:55 "
2632	7	400	61	72.8	4:59 "
3241	7	400	50	78.0	5:10 "
3304 C	7	350	60	74.0	5:15 "
935	7	400	52	77.0	5:25 "
1015 C	8	400	49	76.7	5:30 "
Roof	8	300	71	85.0	5:12 "

Table 2A

Analysis Results

Room No.	CO (PPM)	CO_2 (PPM)	% RH	Room Temp (°F)	Time
S-216	7	250	59	79.0	8:40 am
	4	275	63	77.0	11:15 am
	5	500	67	76.5	2:30 pm
S-226	7	300	60	78.5	8:27 am
	5	300	60	75.0	11:00 am
	5	350	62	73.9	2:35 pm
S-274	6	325	52	77.0	8:34 am
	4	300	61	75.0	11:54 am
	5	375	51	72.2	2:40 pm
2811	6	300	59	72.0	8:45 am
	5	275	55	73.0	11:09 am
	5	275	59	70.0	2:50 pm
2827	5	275	65	71.0	8:48 am
	5	375	60	68.1	11:13 am
	5	275	61	72.0	3:00 pm
2708 1/2	5	275	61	72.0	8:53 am
	5	300	61	74.0	11:18 am
	5	425	60	71.7	3:05 pm
2710 C	5	275	69	69.0	8:52 am
	5	275	69	68.0	11:20 am
	5	450	65	70.0	3:08 pm
2632	5	275	60	73.0	9:04 am
	5	275	59	71.0	11:24 pm
	5	525	67	73.0	3:17 pm
3241	5	350	50	76.0	9:20 am
	5	300	59	77.0	11:30 am
	4	375	52	75.0	3:54 pm
3304 C	5	300	61	73.0	9:30 am
	6	275	61	73.0	11:40 am
	4	375	52	72.0	3:26 pm

(Cont'd) Table 2A

Room No.	CO (PPM)	CO_2 (PPM)	% RH	Room Temp (°F)	Time
935	5	350	60	76.0	9:36 am
	6	325	65	75.0	11:55 am
	4	350	43	74.0	3:45 pm
1015 C	5	350	60	77.0	9:45 am
	5	350	59	77.0	11:50 am
	5	-	56	76.0	3:50 pm
Roof	5	200	79	59.0	9:07 am
	4	275	84	62.0	11:08 am
	3	300	86	65.5	3:25 pm

Table 3A

Formaldehyde Analysis Results

Conc. Units ppb

Location	5/24/88	5/25/88
New Room (S-226)	<4.1	<4.1
S-274	48.9	7.3
2811	9.0	<4.1
2818	NA	<4.1
2827	46.4	<4.1
2708.5	<4.1	36.6
2710	58.7	<4.1
2632	429.0	284.0
Roof	<4.1	9.0
3241	58.7	5.7
3304	<4.1	<4.1
935	<4.1	<4.1
1015	<4.1	<4.1

Table 4A

Formaldehyde Analysis Results

Conc. Units ppb

Location	6/3/88
2632-1	2.4
2632-2	<2.4
2632-3	2.4
2632-4	<2.4
2632-5	3.3
2632-6	9.0
2710	2.4
Day Care Center (Outside)	9.0
Day Care Center (Class #3)	2.4
Day Care Center (Class #5)	4.8

TARGET COMPOUNDS

TABLE 5A

INTERIOR AIR ANALYSIS BY GC/MS

SITE NAME : WATERSIDE MALL, WASHINGTON, DC.

SAMPLE LOCATION :	S-216	S-216	S-226 NEW ROOM	S-226 NEW ROOM	S-276	S-276	2811	2811	2814(a)
SAMPLE NAME/NUMBER :	217-01	507-01	217-02	507-02	217-05	507-03	217-04	507-04	507-05
DATE SAMPLED :	5/24/88	5/25/88	5/24/88	5/25/88	5/24/88	5/25/88	5/24/88	5/25/88	5/25/88
DATE ANALYZED :	5/27/88	6/06/88	5/28/88	6/06/88	5/28/88	6/04/88	5/28/88	6/04/88	6/06/88
FILE :	B0030	B0098	B0061	B0100	B0042	B0101	B0043	B0102	B0103
parameter	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
vinyl chloride	ND	0.00	ND	ND	ND	ND	ND	ND	ND
1,1-dichloroethene	ND	0.00	ND	0.76	ND	ND	ND	0.21	ND
trichlorofluoromethane	ND	2.10	1.09	ND	0.55	ND	0.19	1.60	ND
methylene chloride	0.04	1.74	4.06	2.13	1.12	ND	ND	4.21	0.15
trans-1,2-dichloroethene	ND	0.00	ND	ND	ND	ND	ND	ND	ND
1,1-dichloroethane	ND	0.00	ND	ND	ND	ND	ND	ND	ND
1,2-dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-trichloroethane	0.14	6.30	1.06	5.76	0.53	2.98	0.21	0.85	2.54
carbon tetrachloride	ND	0.10	0.05	0.12	ND	0.15	ND	0.12	0.05
benzene	0.09	0.00	0.61	0.55	0.25	0.51	0.25	0.79	0.20
trichloroethylene	ND	0.00	0.08	0.07	0.06	ND	ND	0.06	ND
toluene	1.28	2.94	11.11	4.90	5.91	4.26	7.39	3.35	2.52
tetrachloroethylene	0.15	0.52	0.90	0.57	0.76	0.71	0.63	0.54	2.04
ethyl benzene	0.18	0.53	0.46	0.43	0.71	0.48	0.92	0.38	0.33
m-xylene	0.56	1.42	1.19	1.31	2.21	1.50	3.04	0.76	1.03
o-xylene	0.28	0.53	0.35	0.55	0.81	0.63	0.99	0.23	0.38
styrene	0.28	0.94	0.21	0.34	0.61	0.45	1.58	0.42	0.40
meta ethyltoluene	0.12	0.18	0.44	0.11	1.04	0.59	1.08	0.23	0.16
4-phenylcyclohexene	0.04	0.14	5.15	2.65	0.89	0.48	2.58	0.78	NA

(a). Only sampled on 5/25/88.
NA. Not Analyzed for; scan terminated before compound elution.

TABLE 5A (cont'd)

NON-TARGET COMPOUNDS

INTERIOR AIR ANALYSES BY GC/MS

SITE NAME : WATERSIDE MALL, WASHINGTON, DC.

SAMPLE LOCATION	:	8-216	8-216	NEW ROOM	NEW ROOM	8-274	8-274	2811	2811	2814(e)
SAMPLE NAME/NUMBER	:	217-01	507-01	217-02	507-02	217-03	507-03	217-04	507-04	507-05
DATE SAMPLED	:	5/24/88	5/25/88	5/24/88	5/25/88	5/24/88	5/25/88	5/24/88	5/25/88	5/25/88
DATE ANALYZED	:	5/27/88	6/06/88	5/28/88	6/06/88	5/28/88	6/06/88	5/28/88	6/06/88	6/06/88
FRN	:	80050	80098	80041	80099	80042	80101	80043	80102	80103
parameter		ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
alkanes		0.60	4.40	13.30	6.70	20.90	9.50	5.00	5.40	1.00
alkenes/cycloalkanes		0.20	3.10	----	1.90	----	----	----	----	----
alkylbenzenes, C3-C5		----	----	----	----	----	----	2.90	1.00	1.30
polyaromatic hydrocarbons (PAH)		----	----	----	----	----	----	----	----	----
acetaldehyde		0.20	----	----	----	----	----	----	0.90	----
benzaldehyde		0.10	----	2.90	----	----	----	----	----	----
other aldehydes		0.50	----	----	----	----	----	1.50	----	0.50
alcohols		0.20	2.00	----	----	----	----	----	----	0.80
phenols		----	----	----	----	----	----	----	----	----
limonene		----	----	1.40	----	2.40	----	1.00	----	2.70
dichlorobenzene isomers		----	----	----	----	----	----	----	----	----
chloromethane		----	----	----	----	----	----	----	----	----
siloxane		----	2.00	----	----	5.00	14.40	10.40	2.90	2.90
acetone		----	1.40	----	----	----	----	----	1.10	----
acetic acid		----	----	----	----	----	----	----	----	----
acetic acid butyl ester		----	----	----	----	----	----	----	----	----
N-nitro-N-phenyl-benzenamine		----	----	----	----	----	----	----	----	----
C12H24O3 ester (1)		0.20	2.80	14.00	9.80	11.00	5.00	4.20	1.20	----
C12H24O3 ester (2)		1.60	4.90	20.80	14.00	1.70	7.00	5.40	1.80	----
other organics		----	----	----	2.30	----	----	----	----	----

(1) Propanoic acid, 2 methyl-2,2-dimethyl-1-(2-hydroxy-1-methylethyl)propyl ester.

(2) Propanoic acid, 2 methyl-3-hydroxy-2,4,4-trimethylpentyl ester.

TABLE 5A (cont')

TARGET COMPOUNDS

INTERIOR AIR ANALYSIS BY GC/MS

SITE NAME : WATERSIDE MALL, WASHINGTON, DC.

SAMPLE LOCATION	:	2827	2827	2708.5	2708.5	2710	2710	2632	2632
SAMPLE NAME/NUMBER	:	217-05	507-06	217-06	507-07	217-07	507-08	217-08	507-09
DATE SAMPLED	:	5/24/88	5/25/88	5/24/88	5/25/88	5/24/88	5/25/88	5/24/88	5/25/88
DATE ANALYZED	:	5/28/88	6/07/88	5/28/88	6/07/88	5/31/88	6/07/88	5/31/88	6/07/88
FN	:	B0044	B0113	B0039	B0114	B0050	B0115	B0051	B0117
parameter		ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
vinyl chloride		ND	ND	ND	ND	ND	ND	ND	ND
1,1-dichloroethene		ND	0.98	ND	1.51(a)	ND	ND	ND	ND
trichlorofluoromethane		0.45(a)	2.20	0.2(a)	1.32(a)	0.44(a)	1.09	0.11	ND
methylene chloride		1.16	6.26	1.94(a)	2.09(a)	0.32(a)	0.34	ND	0.42
trans-1,2-dichloroethene		ND	ND	ND	ND	ND	ND	ND	ND
1,1-dichloroethane		ND	ND	0.02	ND	ND	ND	ND	ND
1,2-dichloroethane		ND	ND	ND	ND(1)	ND	ND	ND	ND
1,1,1-trichloroethane		0.47	3.01	0.17	1.06	0.30	2.27	0.33	1.55
carbon tetrachloride		0.06	ND	ND	0.09	ND	ND	ND	ND
benzene		0.26	0.77	0.15	ND(1)	0.15	0.06	0.10	0.05
trichloroethylene		ND	ND	ND	0.10	ND	ND	ND	ND
toluene		0.13	3.09	6.72	2.99	10.46	0.27	14.08	6.86
tetrachloroethylene		0.61	0.46	0.95	5.28	1.34	5.80	1.13	4.30
ethyl benzene		0.80	0.38	0.67	0.27	0.75	0.38	1.05	0.65
m-xylene		2.35	1.15	2.08	0.76	1.97	1.23	3.34	2.12
o-xylene		0.84	0.46	0.68	0.28	0.54	0.46	1.29	0.77
styrene		0.43	0.38	0.52	0.22	0.28	0.47	0.98	0.71
meta ethyltoluene		0.46	0.59	0.59	0.22	0.08	0.38	0.93	0.60
4-phenylcyclohexene		0.84	1.10	2.20	1.26	0.07	0.03	0.19	0.18

(a). Split peak, added integration peaks.
(1). Compound maybe present, spectrum was overshadowed by a hydrocarbon peak.

NON-TARGET COMPOUNDS

INTERIOR AIR ANALYSIS BY GC/MS

TABLE 5A (cont'd)

SITE NAME : WATERSIDE MALL, WASHINGTON, DC.

SAMPLE LOCATION :	2827	2827	2708.5	2708.5	2710	2710	2632	2632
SAMPLE NAME/NUMBER :	217-05	507-06	217-06	507-07	217-07	507-08	217-08	507-09
DATE SAMPLED :	5/24/88	5/25/88	5/24/88	5/25/88	5/24/88	5/25/88	5/24/88	5/25/88
DATE ANALYZED :	5/28/88	6/07/88	5/28/88	6/07/88	5/31/88	6/07/88	5/31/88	6/07/88
FRN :	B0044	B0113	B0039	B0116	B0050	B0115	B0051	B0117
parameter	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
alkanes	1.70	153.50 ##	20.30	40.40	2.30	6.70	5.10	32.30
alkenes/cycloalkanes	----	----	----	----	----	----	----	----
alkylbenzenes, C3-C5	1.60	----	----	----	1.40	1.50	3.10	----
polyaromatic hydrocarbons (PAH)	----	----	2.30	----	----	----	----	----
acetaldehyde	----	----	2.30	----	----	----	1.40	----
benzaldehyde	----	2.40	1.60	----	----	----	----	----
other aldehydes	2.60	13.80	----	----	----	----	1.00	----
alcohols	1.10	2.90	----	----	----	----	----	----
phenols	----	----	----	----	0.80	0.80	----	----
limonene	1.00	----	0.90	----	1.50	----	1.70	2.30
dichlorobenzene isomers	----	----	----	----	0.50	0.80	1.10	1.60
chloroethane	----	----	----	----	----	----	----	----
siloxanes	----	7.30	----	2.90	----	1.30	1.70	2.30
acetone	3.60	2.50	----	----	----	----	----	----
acetic acid	----	----	1.30	----	1.90	----	----	----
acetic acid butyl ester	----	----	----	1.10	0.40	----	1.00	----
N-nitro-N-phenyl-benzenamine	----	----	----	----	----	----	----	----
C12H24O3 ester (1)	1.30	----	6.20	1.30	1.30	0.70	3.40	3.90
C12H24O3 ester (2)	2.20	----	9.60	2.50	1.90	1.00	5.10	5.50
other organics	----	----	----	----	----	----	----	----

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(1) Propanoic acid, 2 methyl-2,2-dimethyl-1-(2-hydroxy-1-methylethyl)propyl ester.
(2) Propanoic acid, 2 methyl-3-hydroxy-2,4,4-trimethylpentyl ester.

150 ppb of 2,2-dimethylhexane

TARGET COMPOUNDS

INTERIOR AIR ANALYSIS BY GC/MS

SITE NAME	: WATERSIDE MALL, WASHINGTON, DC.								
SAMPLE LOCATION	:	ROOF	ROOF	3241	3241	3306	3306	9350	9350
SAMPLE NAME/NUMBER	:	217-09	507-10	217-10	507-11	217-11	507-12	217-12	507-13
DATE SAMPLED	:	5/24/88	5/25/88	5/24/88	5/25/88	5/24/88	5/25/88	5/24/88	5/25/88
DATE ANALYZED	:	5/31/88	6/07/88	5/31/88	6/08/88	5/31/88	6/08/88	5/31/88	6/08/88
FRN	:	80052	80118	80053	80122	80054	80126	80055	80124
parameter		ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
vinyl chloride		ND	ND	ND	ND	ND	ND	ND	ND
1,1-dichloroethene		ND	ND	ND	ND	0.33	0.18	ND	ND
trichlorofluoromethane		0.05	1.39	0.92(a)	1.95	4.09	2.21	0.97	(b)
methylene chloride		0.08	0.29	1.28	0.40	1.38	2.56	0.50	(b)
trans-1,2-dichloroethene		ND	ND	ND	ND	ND	ND	ND	ND
1,1-dichloroethane		ND	ND	ND	ND	0.03	ND	ND	ND
1,2-dichloroethane		ND	ND	ND	ND	ND	0.08	ND	ND
1,1,1-trichloroethane		0.09	0.28	5.10	0.27	11.70	1.79	0.34	0.26
carbon tetrachloride		ND	ND	1.06	ND	0.06	0.14	ND	ND
benzene		0.10	0.08	0.19	0.05	0.33	0.76	0.07	0.02
trichloroethylene		ND	ND	0.05	ND	0.03	0.13	ND	ND
toluene		5.96	0.13	8.91	0.63	8.66	4.99	5.69	5.79
tetrachloroethylene		0.77	0.27	0.10	1.45	12.52	1.26	0.83	0.83
ethyl benzene		0.73	0.23	0.80	0.57	0.50	0.48	0.82	0.50
m-xylene		2.58	0.83	2.01	1.88	1.56	1.65	2.65	1.63
o-xylene		1.08	0.32	0.72	0.60	0.56	0.59	0.88	0.66
styrene		ND	0.12	0.46	0.53	0.26	0.33	0.51	0.48
meta ethyltoluene		1.14	0.02	0.60	0.41	0.60	0.26	0.46	0.20
4-phenylcyclohexene		ND	ND	2.10	1.10	0.17	0.23	0.87	0.63

#. East Tower sample.
(a). Split peak, added integration peaks.
(b). Quantitation Report results inconclusive, manual integration and quantitation to be preferred and reported.

NON-TARGET COMPOUNDS

TABLE 5A (cont'd)

INDOOR AIR ANALYSIS BY GC/MS

SITE NAME : WATERSIDE MALL, WASHINGTON, DC.

SAMPLE LOCATION :	ROOF	ROOF	3241	3241	3304	3304	9350	9350
SAMPLE NAME/NUMBER :	217-09	507-10	217-10	507-11	217-11	507-12	217-12	507-13
DATE SAMPLED :	5/26/88	5/25/88	5/26/88	5/25/88	5/26/88	5/25/88	5/26/88	5/25/88
DATE ANALYZED :	5/31/88	6/07/88	5/31/88	6/08/88	5/31/88	6/08/88	5/31/88	6/08/88
RUN :	00052	00118	00053	00122	00054	00126	00055	00124
parameter	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
alkanes	1.40	2.80	16.00	10.30	56.30	100.50	16.40	43.40
alkenes/cycloalkanes	----	1.20	----	----	2.00	----	----	----
alkylbenzenes, C3-C5	4.00	----	----	----	----	----	----	----
polyaromatic hydrocarbons (PAH)	0.80	0.40	----	----	----	----	----	----
acetaldehyde	----	----	----	----	----	----	----	----
benzaldehyde	----	2.90	----	----	----	----	----	----
other aldehydes	2.80	3.90	1.00	----	----	----	----	----
alcohols	----	----	4.00	----	2.90	16.00	7.00	----
phenols	----	----	1.50	----	----	----	----	----
limonene	----	----	1.50	6.20	----	----	----	----
dichlorobenzene isomers	----	0.50	1.40	1.20	4.40	4.50	----	----
chloroethane	----	----	----	----	----	----	----	----
siloxanes	1.20	3.20	----	1.50	----	----	4.50	----
acetone	----	----	----	----	----	----	----	----
acetic acid	0.50	----	----	----	----	----	----	----
acetic acid butyl ester	----	----	----	----	----	----	----	----
N-nitro-N-phenyl-benzenamine	----	----	----	1.00	----	----	----	----
C12H24O3 ester (1)	----	----	4.50	4.30	----	----	2.30	----
C12H24O3 ester (2)	----	----	7.40	6.40	6.30	----	6.10	----
other organics	----	----	----	----	----	----	----	----

(1) Propanoic acid, 2 methyl-2,2-dimethyl-1-(2-hydroxy-1-methylethyl)propyl ester.
(2) Propanoic acid, 2 methyl-3-hydroxy-2,4,4-trimethylpentyl ester.

TABLE 5A (cont'd

TARGET COMPOUNDS

INDOOR AIR ANALYSIS BY GC/MS

SITE NAME : WATERSIDE MALL, WASHINGTON, DC.

SAMPLE LOCATION	:	1013#	1025#	NURSERY(1)	NURSERY(2)	NURSERY(3)
SAMPLE NAME/NUMBER	:	207-13	507-16	514-01	514-02	514-03
DATE SAMPLED	:	5/24/88	5/25/88	6/03/88	6/03/88	6/03/88
DATE ANALYZED	:	5/31/88	6/08/88	6/08/88	6/08/88	6/08/88
[illegible]	:	80856	80125	80128	80129	80130
parameter		ppb	ppb	ppb	ppb	ppb
vinyl chloride		ND	ND	ND	ND	ND
1,1-dichloroethene		ND	0.02	ND	0.11	0.21
trichlorofluoromethane		ND	4.31	ND	7.33	15.46
methylene chloride		0.30	9.12	ND	0.81	ND
trans-1,2-dichloroethene		ND	ND	ND	ND	ND
1,1-dichloroethane		ND	ND	ND	ND	ND
1,2-dichloroethane		ND	ND	ND	ND	ND
1,1,1-trichloroethane		0.35	3.99	0.07	0.52	0.46
carbon tetrachloride		ND	0.15	ND	0.10	0.11
benzene		0.85	0.89	0.18	0.40	0.45
trichloroethylene		ND	0.32	ND	0.12	0.10
toluene		0.65	4.07	5.99	2.07	2.56
tetrachloroethylene		0.60	0.70	0.36	0.39	0.42
ethyl benzene		1.00	0.36	0.77	0.13	0.20
m-xylene		1.79	0.87	2.35	0.17	0.53
o-xylene		0.77	0.19	0.92	0.07	0.19
styrene		0.44	0.13	ND	0.05	0.15
meta ethyltoluene		0.73	0.05	0.50	ND	0.10
4-phenylcyclohexene		0.25	0.05	ND	ND	ND

#. [illegible] hour sample.
(1). Outside.
(2). Class No.3.
(3). Class No.5.

TARGET COMPOUNDS

INTERIOR AIR ANALYSIS BY GC/MS

TABLE 5 (cont'd)

SITE NAME : WATERSIDE MALL, WASHINGTON, DC.

				Class #3	Class A5
SAMPLE LOCATION :	10150	10150	NURSERY(1)	NURSERY(2)	NURSERY(3)
SAMPLE NAME/NUMBER :	217-13	507-14	514-01	514-02	514-03
DATE SAMPLED :	5/24/88	5/25/88	6/03/88	6/03/88	6/03/88
DATE ANALYZED :	5/31/88	6/08/88	6/08/88	6/08/88	6/08/88
FRN :	00056	00125	00128	00129	00130
parameter	ppb	ppb	ppb	ppb	ppb
alkanes	41.00	13.20	22.60	11.50	186.50
alkanes/cycloalkanes	----	----	----	----	----
alkylbenzenes, C3-C5	----	----	6.40	----	----
polyaromatic hydrocarbons (PAH)	----	----	----	----	----
acetaldehyde	----	----	----	----	----
benzaldehyde	----	----	----	----	----
other aldehydes	----	----	----	----	----
alcohols	----	----	----	0.30	----
phenols	----	----	----	----	----
limonene	----	----	----	0.30	10.00
dichlorobenzene isomers	----	----	----	----	----
chloromethane	----	----	----	----	----
siloxane	2.00	----	----	----	----
acetone	----	1.10	----	3.70	9.40
acetic acid	----	----	----	0.60	----
acetic acid butyl ester	----	----	----	----	----
N-nitro-N-phenyl-benzenamine	----	----	----	----	----
C12H24O3 ester (1)	2.70	----	----	----	----
C12H24O3 ester (2)	3.50	----	----	----	----
other organics	----	----	----	0.60	----

(1) Propanoic acid, 2 methyl-2,2-dimethyl-1-(2-hydroxy-1-methylethyl)propyl ester.
(2) Propanoic acid, 2 methyl-3-hydroxy-2,4,4-trimethylpentyl ester.

TARGET COMPOUNDS

TABLE 5A (cont)

INTERIOR AIR ANALYSIS BY GC/MS

SITE NAME : WATERSIDE MALL, WASHINGTON, DC.

SAMPLE LOCATION :	LOT BLANK	TRIP BLANK	TRIP BLANK	LOT BLANK	TRIP BLANK
SAMPLE NAME/NUMBER :	217-LB(1)	217-TB(1)	507-TBA(1)	507-LBA(1)	514-TB(2)
DATE SAMPLED :	5/24/88	5/26/88	5/25/88	5/25/88	6/03/88
DATE ANALYZED :	5/27/88	5/31/88	6/06/88	6/6/88	6/08/88
FRN :	B0028	B0049	B0096	B0097	B0127
parameter	ppb	ppb	ppb	ppb	ppb
vinyl chloride	ND	ND	ND	ND	ND
1,1-dichloroethene	ND	ND	1.42	ND	ND
trichlorofluromethane	ND	0.85	0.16	ND	1.12
methylene chloride	0.11	0.15	ND	0.14	0.96
trans-1,2-dichloroethene	ND	ND	ND	ND	ND
1,1-dichloroethane	ND	ND	ND	ND	ND
1,2-dichloroethane	ND	ND	ND	ND	ND
1,1,1-trichloroethane	ND	0.29	1.42	ND	ND
carbon tetrachloride	ND	ND	ND	ND	ND
benzene	ND	0.04	0.25	0.03	0.04
trichloroethylene	ND	ND	ND	ND	ND
toluene	ND	0.28	0.05	0.09	0.09
tetrachloroethylene	ND	0.02	ND	ND	ND
ethyl benzene	ND	0.04	0.01	ND	0.03
m-xylene	ND	0.12	0.03	ND	0.03
o-xylene	ND	0.05	ND	ND	ND
styrene	ND	0.12	0.03	ND	0.02
meta ethyltoluene	ND	0.04	ND	ND	ND
4-phenylcyclohexene	ND	ND	ND	ND	ND

(1): Concentrations equivalent to a 18.0 liter sample volume
(2): Concentrations equivalent to a 14.7 liter sample.

TABLE 5A (cont'd)

TARGET COMPOUNDS

INTERIOR AIR ANALYSIS BY GC/MS

SITE NAME : WATERSIDE MALL, WASHINGTON, DC.

SAMPLE LOCATION	:	LOT BLANK	TRIP BLANK	TRIP BLANK	LOT BLANK	TRIP BLANK
SAMPLE NAME/NUMBER	:	217-LB(1)	217-TB(1)	507-TBA(1)	507-LBA(1)	514-TB(2)
DATE SAMPLED	:	5/26/88	5/26/88	5/25/88	5/25/88	6/03/88
DATE ANALYZED	:	5/27/88	5/31/88	6/06/88	6/6/88	6/08/88
FAN	:	00028	00049	00096	00097	00127
parameter		ppb	ppb	ppb	ppb	ppb
alkanes		1.60	----	0.20	----	0.39
alkenes/cycloalkanes		0.10	----	----	----	0.08
alkylbenzenes, C3-C5		----	0.30	0.70	0.30	0.20
polyaromatic hydrocarbons (PAH)		----	----	0.40	----	----
acetaldehyde		----	0.20	1.20	0.30	0.60
benzaldehyde		----	----	----	0.10	----
other aldehydes		----	0.20	1.00	0.59	0.20
alcohols		----	----	----	0.10	0.10
phenols		----	0.20	----	----	0.08
limonene		----	----	----	----	----
dichlorobenzene isomers		bmdl	0.20	----	----	0.09
chloromethane		----	----	----	----	----
siloxane		0.20	0.70	1.20	0.30	0.40
acetone		0.10	----	0.30	0.07	0.70
acetic acid		----	----	----	----	----
acetic acid butyl ester		----	----	----	----	----
N-nitro-N-phenyl-benzenamine		----	0.20	----	----	----
C12H24O3 ester (1)		----	----	----	----	----
C12H24O3 ester (2)		----	----	----	----	----
other organics		----	----	----	0.10	----

(1) Propanoic acid, 2 methyl-2,2-dimethyl-1-(2-hydroxy-1-methylethyl)propyl ester.
(2) Propanoic acid, 2 methyl-3-hydroxy-2,4,4-trimethylpentyl ester.

APPENDIX D

July 15, 1988, Internal EPA Report

AN INDOOR AIR QUALITY MEASUREMENT STUDY AT THE EPA HEADQUARTERS FACILITY IN WASHINGTON, DC

AN INDOOR AIR QUALITY MEASUREMENT STUDY
AT THE EPA HEADQUARTERS FACILITY IN WASHINGTON, DC

by

V.R. Highsmith, C.E. Rodes, A.J. Hoffman, and J.D. Pleil

Environmental Monitoring Systems Laboratory
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July 15, 1988

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AN INDOOR AIR QUALITY MEASUREMENT STUDY AT THE EPA HEADQUARTERS FACILITY IN WASHINGTON, DC

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INTRODUCTION

The United States Environmental Protection Agency (EPA) headquarters is located in the Waterside Mall office complex at 401 M Street SW, Washington, DC. Approximately 5000 personnel work in this facility performing administrative, technical, and office related tasks. The facility is structurally complex with an integral parking garage and two high rise sections (the East and West towers) interconnected by an office section located over a shopping mall. The heating, ventilation, and air conditioning (HVAC) system is equally complex, incorporating more than 20 independent air handling systems.

In October 1987, the EPA Office of Administration at headquarters initiated an office renovation program for the Waterside Mall complex which included the installation of new carpeting, divider partitions, and office furnishings. In most areas, a nylon pile carpet and fibrous padding were scheduled for installation without the use of adhesives. In high traffic areas, a similar nylon pile carpet manufactured with a latex backing was to be installed with adhesives. Other facility improvements, e.g. painting, cleaning, waxing, etc, were also ongoing. An increase was noted in complaints, illnesses, and absences from employees working in and near the refurbished offices. These complaints were tentatively linked by the employees and management with the implementation of the refurbishment program. The complaints of personal discomfort included eye and nasal area irritations, nausea, headaches, and skin rashes. Several employees experiencing significant irritations were advised by health personnel not to return to the newly renovated office areas until the problem could be rectified.

An EPA Task Force was formed during February, 1988 to review the employee complaints and determine if a direct relationship existed between these discomfort symptoms and the renovation program and provide recommendations for any necessary corrective actions. The personnel in the newly refurbished offices were temporarily relocated, pending problem identification. The EPA Environmental Response Team (ERT) from Edison, N.J. was asked to collect a limited number of samples during March, 1988 to determine the concentrations of possible irritants, primarily Volatile Organic Compounds (VOC's), present in the office environment. The ERT's initial tests identified no compounds at levels of concern based on previous indoor or ambient air quality studies. A concurrent literature search by the Office of Toxic Substances revealed the recent identification by Van Ert, et al. (1987) of 4-phenyl-cyclohexene (referred to as 4-PC) as a possible causative agent in buildings with indoor air quality problems. This compound is an extremely odorous organic by-product of the reaction of 1,3-butadiene and styrene inherent in the latex manufacturing process used to bond the fibers to the carpet backing. The presence of this compound, according to the Van Ert, et al. report (also discussed by Vogelmann, et al. (1988) at the 1988 American Industrial Hygienist Association meeting in May and Van Ert at a program review for the EPA Indoor Air program held at RTP on June 7, 1988) in concentrations exceeding approximately 1 ppb produces personal discomfort symptoms in sensitive individuals similar to those reported by the EPA employees. He also noted that the odor threshold for 4-PC appears to be below 0.5 ppb.

In order to further investigate the possible link between the indoor air quality and carpeting, samples were taken directly from a new roll and from carpeting installed 2 months previously. They were forwarded to the Environmental Monitoring Systems Laboratory (EMSL) at RTP on May 11, 1988 for evaluation. Gas chromatography/mass spectrometry (GC/MS) analyses of both the headspace gases being emitted from the carpet samples and methylene chloride extracts of the carpet revealed that 4-PC was present in both samples in concentrations well above the background level. The chromatograms from the headspace analysis of the new and 2 month old samples are shown in Figure 1. The non-availability at that time of high purity 4-PC from which to develop analytical standards prevented accurate quantification; however, the concentration of 4-PC was estimated to be in the range of 90 ppb for the new sample and approximately 50 ppb for the older sample. The large peak to the right of the 4-PC peak was identified as 2,6-bis(1,1-dimethylethyl)4-methylphenol, also know as butylated hydroxy toluene or BHT, an anti-oxidant preservative commonly found in foods and medicines. In this case it appears to be a constituent of the latex used in the carpeting. The new carpet sample was also examined under simulated chamber conditions (at room temperature only) to estimate the decay rate at 1 air change per hour for selected organic constituents. The results of this test (see Figure 2) suggest that 4-PC does not diminish at either the same rate or in the same manner as styrene, which also outgasses from carpeting. An extrapolation of these data suggests that 4-PC has an estimated half life under the conditions of the test of about 8 days. The latter result is consistent with the findings of Van Ert, et al. (1987), who also noted that a period of approximately 2 months was required to decrease to the 1 ppb level in a room situation.

The EPA Task Force, in concert with employee and employee union representatives, recommended that a second, more extensive problem identification program be conducted to better characterize the existing Waterside Mall indoor air environment and propose mitigation strategies. It was recognized that this effort would only be partially representative of the conditions present during the initial round of employee complaints. The RTP laboratories conducting studies under the Indoor Air Program were contacted and requested to assist the Task Force by: 1) collecting and analyzing samples at the EPA facility to determine the presence and concentration of possible irritants and 2) conducting chamber studies to better characterize selected emission sources and to assist in developing appropriate mitigation strategies. The Environmental Monitoring Systems Laboratory took the lead at RTP in the monitoring activities, while the Air and Energy Engineering Laboratory (AEERL) planned the chamber studies. The ERT was also requested to conduct a parallel investigation on a slightly different scale. The present report is primarily concerned with the EMSL monitoring activities and analytical results.

PRELIMINARY TESTS

A team of RTP scientists from EMSL and AEERL visited the EPA headquarters complex on May 13, 1988 to survey the Waterside Mall facility, informally interview affected employees, evaluate newly renovated as well as non-renovated areas by collecting some air samples, inspect the air handling systems, and meet with the EPA Headquarters Indoor Air and Task Force representatives. Areas carpeted within the past six months were noted to have a sharp distinguishing odor attributed to the new carpet. Some refurbished areas also included new partitions and office furniture. A damaged new partition was examined and found to contain a center of compressed hardboard covered by a fibrous material with cloth exterior. In several areas visited, attempts to measure the flowrates from the HVAC vents into the office work areas yielded minimal (and often unmeasurable) flow into the rooms. Instantaneous grab samples were collected from the air in two newly refurbished rooms into evacuated canisters. These samples, stored at ambient conditions, were analyzed on May 17, 1988 by GC/MS. The presence of the suspected 4-PC compound was confirmed in these samples. Accurate quantification was still not possible because standard materials had not yet been developed, but the levels were estimated to be substantially less than the earlier carpet head space analysis.

FOLLOW-UP STUDY

A more extensive monitoring study was planned and conducted in the headquarters facility from May 23 thru the 25, 1988 by EMSL/RTP personnel. Samples for particulate, semi-volatile organic compound (SVOC), VOC, and aldehyde analyses were collected during two daytime (7AM to 7PM) and one nighttime (7PM to 7AM) 12 hour sampling periods. Samples were collected simultaneously in two newly refurbished offices representing different parts of the Waterside complex, two nearby but unrefurbished offices, and one outdoor (roof) location. Carbon dioxide (CO_2), temperature, and relative humidity were monitored and air exchange rates (AER's) estimated. Bulk particle and semi-volatile organic samples were collected over the entire period to assist in target compound identification. The ERT monitoring study was conducted in a broader range of office locations for VOC's, aldehydes and CO_2 concurrently with the EMSL measurements using different monitoring techniques.

Limitations

Several factors had an impact on the design and implementation of this study. The time between the EPA Task Force's request for assistance and EMSL/RTP's response was extremely short and provided minimal preparation time. The time constraints limited to some degree the number and type of samples that could be collected. The chemical and physical characteristics of 4-PC were relatively unknown in the indoor air community prior to this study. It had not been routinely included in prior EMSL indoor monitoring programs and the methodologies needed for analytical analysis had not been previously attempted. A sample of high purity 4-PC from which to prepare standards was only located immediately prior to the initiation of the first sampling period. The retention and removal characteristics of 4-PC from the evacuated canisters and SVOC collection substrates had to be determined in parallel with the sampling study.

Experimental

On May 23, 1988 the EMSL/RTP team arrived at the Waterside Mall facility and set-up the particulate and gaseous monitors. Sampled areas included two newly renovated office areas, room 3241 in the Mall area (designated Mall 3241) and East Tower 935 and two existing office areas, Mall 3304 and East Tower 1015. Monitors were also setup on the Mall roof to represent an outdoor location. The Mall 3241 refurbished office area included newly installed carpet, panels, and furniture while the East Tower area included only newly installed carpet. The Mall 3304 and East Tower 1015 offices served as paired control areas. These offices had not been refurbished, had experienced no or few incidences of employee illnesses that could be directly related to the facility renovations, were in close proximity to the newly refurbished offices, and were supplied by the same air handling system as the newly refurbished areas. The outdoor monitors on the Mall roof were placed in close proximity to the fresh air intake of the HVAC system affecting the Mall offices sampled. Three consecutive 12 hour sampling periods (changeover at 7AM and 7PM) were conducted from 7AM on Tuesday, May 24 through 7PM on Wednesday, May 25.

PM_{10} dichotomous samplers (0.0167 m^3/min) were operated at each location to collect FINE (less than 2.5 um, aerodynamic diameter) and COARSE (2.5 to 10.0 um) particles on pre-weighed Teflon 37mm diameter filters. Particle samples collected on Teflon media were conditioned at 20 deg C and 40% RH for 24 hours prior to pre- and post- gravimetric analyses. PUF/XAD-2 cartridges were installed immediately below the dichotomous FINE particle filter for collection of SVOC's.

VOC's were collected by integrating collection over the entire sampling period using flow controlled passive samplers as described in the EPA Indoor Air Methods compendium (1988). The identification of 4-PC as a target compound required a significant amount of methods evaluation to qualify and optimize the collection and analysis schemes. Additional instantaneous VOC samples were collected at selected times by opening an evacuated canister in the office environment as a grab sample.

All evacuated VOC canisters (12-hour and grab) were analyzed by GC/MS for selected target compounds (4-PC, styrene, toluene, and o-xylene). Other organic species routinely detected by the EMSL/EPA lab were not quantified for most of the samples, as the GC/MS operating system was calibrated and setup specifically to provide maximum sensitivity for 4-PC. The target compounds listed eluted in the 4-PC maximized operating range. Detailed GC/MS VOC analyses were conducted on the two May 13 grab samples and the May 25 7AM Mall 3241 and East Tower 935 12-hour samples.

Estimates of the Air Exchange Rate (AER) were made in each office area using the SF_6 (an inert tracer) active decay technique and sequential syringe samplers. Prior to the initiation of each 7AM sample period, the newly refurbished office areas were closed off from the other office areas and a known volume of SF_6 released. The amount was based on the calculated office air volume -- without considering exchange rates between offices, HVAC system inputs/mixtures, or building exchanges with outdoor air. The SF_6 was allowed to mix in the area for 1 hour before the doors were opened and sampling initiated. Syringe samplers were operated in both newly refurbished and control office areas to estimate mixing and the transfer of pollutants within the building. The SF_6 syringes were analyzed by gas chromatography.

Instantaneous CO_2 concentrations were monitored at each sampling location at approximately hourly intervals using a portable CO_2 monitor borrowed from NIOSH. The monitor was calibrated by NIOSH immediately prior to shipment, but was not recalibrated at Waterside, since a standard CO_2 mixture was not available. The CO_2 data are expected to provide a relative pattern of concentrations with the accuracy estimated to be +/- 50 ppm. Indoor humidity and temperature were monitored at each location using recording hygrothermographs that had been calibrated prior to the initiation of sampling.

Integrated bulk particle and associated vapor phase SVOC samples were collected from 5PM on Monday through 7AM on Thursday using medium flow (0.113 m^3/min) samplers. The particle samples were collected on 102mm quartz fiber filters while the SVOC samples were collected on XAD-2 adsorbent filled canisters installed immediately below the particle filter. One medium flow sampler was operated in Mall 3241 while a second sampler was operated in the carpet storage area located in the Mall basement. Upon completion of sampling, these samples were frozen (-4 deg C) until extracted and analyzed for SVOC target compound identification.

The bulk medium flow particle and XAD-2 cartridges were separately extracted with methylene chloride. The extracts were concentrated and each analyzed for the target compounds by GC/MS. The PUF/XAD-2 samples were independently extracted with an ethyl ether/hexane mixture. Each extract was concentrated and analyzed for 4-PC, para-dichlorobenzene, styrene, o-xylene, and toluene.

Aldehydes were collected on 2,4-dinitrophenylhydrazine (DNPH) coated silica gel cartridges. The DNPH tubes were analyzed by liquid chromatography for selected aldehydes using the method of Tejada (1986).

Quality Assurance

Laboratory prepared sampling filters and substrates were stored in an area away from suspected or confounding sources prior to sampling. Teflon filter media, VOC canisters, and SF_6 syringes were stored at ambient conditions. PUF/XAD-2 cartridges were individually stored in sealed Teflon bags. DNPH tubes were stored in individual vials in a refrigerator. Following completion of the sample period, Teflon and VOC samples were stored at ambient conditions until returned to the laboratory for analysis. PUF/XAD-2 samples were frozen (-15 deg C) until shipped to the laboratory for extraction/analysis. Field blank Teflon, VOC, PUF/XAD-2, and aldehyde samples were also collected during the monitoring program. With the exception of the VOC sampler, a collocated set of monitors was set up and operated in the refurbished Mall 3241 office to obtain estimates of sampling precision. Based on the collocated measurements the coefficients of variation for the particle concentrations were +/- 17, 14 and 18 % for the FINE, COARSE and PM_{10} fractions, respectively. The precision for the 4-PC measurements in the 1 ppb range using evacuated canisters was estimated to be +/- 13 %. The precision for analysis (only) was estimated to be +/- 3 %. The precision of the 4-PC measurements using the SVOC approach was estimated to be approximately +/- 20%, or better.

RESULTS

Several observations were made during the sampling that may have had an impact on the results being reported. A very noticeable increase in office air movement was observed by the RTP team members on Monday, May 23rd. Comments to the same effect were made by headquarters employees working near the sampling locations, noting that the air quality seemed much improved. Significant increases in supply vent outputs were recorded in most locations by late Tuesday, May 24. An inspection of the mechanical fan rooms servicing the areas being monitored revealed that these areas had apparently just been cleaned and that new filters had recently been placed into the system. Although confirmation has not yet been obtained, it is surmised that substantial changes were made to the HVAC systems in the affected areas prior to and shortly after sampling was initiated.

The indoor temperature remained relatively constant in all areas during the study, ranging from 23 to 27 deg C. A significant decrease in overall indoor relative humidity (RH) was observed at all locations during the second day as shown in Figures 3 and 4. Generally the humidity levels were in the comfort zone. The general downward trend possibly indicates that changes were being made in the HVAC system operation or the outdoor RH (not recorded) was affecting the system.

The AER measured in Mall 3241 during the daytime sampling period on May 24 was very low and estimated to be 0.2 air changes/hour (ACH). SF_6 was observed in Mall 3304 during this test, indicating some transfer of air from Mall 3241 by the HVAC system. The AER for East Tower 935 for the same time period was much higher, 1.5 ACH. Concurrently SF_6 was observed in East Tower 1015. Attempts to measure the AER on May 25 were nearly negated by the changes that were being made to the air handling systems. Although the procedure used on the previous day was duplicated, only the first two syringes (out of 12) in both Mall 3241 and East Tower 935 contained quantities of SF_6 above the detection level. None of the Mall 3304 or East Tower 1015 syringes contained measurable SF_6 levels. The AER for both areas are estimated to have been improved by at least a factor of 10 from Tuesday to Wednesday to a level well above 2.0 ACH. This supports the physical observations recorded during the sampling program.

Figures 5 and 6 summarize the CO_2 levels observed during the study for the Mall and East Tower offices, respectively. The CO_2 generally increased from slightly above the normal outdoor background level to a maximum of 700-800 ppm around noon or early in the afternoon. Even the peak levels are relatively low and suggest that occupant density was the only source of CO_2 (no tobacco smoking was observed during sampling).

The results of analyses on the particulate samples collected are summarized in Table 1. Indoor particle concentrations are quite low for both size fractions at all locations and the size distributions are nearly identical for the office areas monitored. Nighttime indoor particulate concentrations were generally lower than daytime values. Increased COARSE particle concentrations, which are normally associated with human and mechanical activity, were observed during the daytime sampling periods. The indoor and outdoor FINE particle concentrations are essentially identical, within the range of experimental error.

Analysis of the 12-hour VOC samples as shown in Table 2 yielded low (as compared to those reported by Vogelmann, et al. for a newly carpeted home) but detectable 4-PC values in both Mall 3241 and East Tower 935. The newly renovated Mall office averaged 1.5 ppb of 4-PC, which is approximately 10 times the values observed in Mall 3304. The 4-PC concentrations in East Tower 935 averaged 0.9 ppb which was significantly higher than the East Tower 1015 concentrations. The poorer AER in the Mall locations during sampling accounts at least in part for the difference in levels. No 4-PC was observed in the outdoor samples.

Unlike the 4-PC, the levels of toluene, o-xylene, and styrene values in the Mall offices were slightly higher than the concentrations in the East Tower. No significant differences were observed between newly carpeted and existing areas for these three VOC's. This suggests that there are sources present for these compounds other than the carpeting. The grab VOC sample concentrations were comparable to the corresponding 12-hour values. No appreciable differences were observed in VOC concentrations between the preliminary grab samples collected on May 13 and those collected on May 24 in Mall 3241 and East Tower 935.

The results of more detailed VOC analyses carried out on 4 selected samples reveal typical concentrations of various organic compounds found in the indoor and outdoor environment. Data from the canisters collected on May 13 and 25 are given in Table 3. The only notable results (but probably of no real concern) are those showing elevated levels of Freon 11 on both days and slightly elevated levels of dichloromethane and 1,1,1-trichloroethane on May 25 in East Tower 935. The source of the Freon 11 has not been determined.

Unlike many of the other Freons, it is not used as a refrigerant, but often in the manufacture of foam rubber. The other two organics are solvents, reflecting some maintenance or personal activities that occurred between the sampling dates. In general the VOC data in the extended speciations did not indicate significant changes in concentrations over the 11 day period between the preliminary grab sampling on May 13 and the more extensive tests on the 24 and 25.

Analysis of the bulk medium flow particle sample extracts indicated that 4-PC was not detected in the particle phase. 4-PC was, however, the most significant compound identified in the Mall 3241 and storage area bulk vapor phase SVOC samples. The 4-PC concentration in the basement sample was relatively large and masked all other potentially present compounds. This sample was collected immediately adjacent to the ends of a large number of new carpet roles, and could be considered similar to a headspace collection. All of the target organic compounds -- 4-PC, toluene, styrene and o,m,p-xylenes -- were identified in the Mall 3241 bulk SVOC sample. In addition p-dichlorobenzene (commonly found in air fresheners and pesticides), 2-butoxyethanol (found in cleaning solvents), and methyl benzoate (a perfume constituent) were also identified along with a series of alkanes and branched alkanes (C8 to C14). For Mall 3241 and East Tower 935 the alkane levels increased significantly in the daytime, as a result of sources associated with increased office worker activities.

Analysis of the dichotomous sampler PUF/XAD-2 vapor phases SVOC extracts yielded 4-PC concentrations as shown in Table 4, comparing very favorably with those determined through the VOC collection and analysis scheme. This suggests that even though more analytical development work is needed, both procedures can be used to quantify this compound. Two additional peaks eluting soon after 4-PC were not positively identified. Based on peak area, the concentration of these two unknowns approximates the 4-PC concentration. Mass and infrared spectra indicate the two hydrocarbons are similar with both containing hydroxyl as well as carbonyl functional groups. The PUF/XAD-2 background masked out the quantification of the other target SVOC compounds.

Analysis of the DNPH cartridges showed no significant differences in the carbonyl concentrations (see Table 5) in any of the office areas with the exception of formaldehyde. The formaldehyde levels in Mall 3241 were slightly higher than Mall 3304 concentrations, while the levels in East Tower 1015 were somewhat higher than East Tower 935. The single (slightly) elevated East Tower nighttime value of 51.1 ppb on May 24 is probably an outlier, but should be cross-checked with the ERT results. None of the formaldehyde levels could be considered as unusually high and the levels do not appear to correlate with the renovation activities. Nighttime formaldehyde measurements were higher (by 4-5 ppb) than the daytime concentrations, which is consistent with turning the HVAC system off at night.

DISCUSSION/CONCLUSIONS

The primary objective of this study was to better characterize the Waterside Mall environmental situation in an expedient manner. In order to accommodate time constraints some compromises were made in the study design, but none that affected our ability to estimate the quality of the data. The data set is recognized to be very limited and, most importantly, not necessarily representative of the prior conditions, but reasonable inferences can be made as to the conditions that may have existed when the health complaints were the most prevalent. The initial low AER, measured at the outset of the experiment, may have been typical of many of the offices in the Waterside facility prior to readjustments of the HVAC systems. Based on the subjective comments of the office occupants and sampling team members, the significant air movement at the end of the experiment was atypical and refreshing. The low AER's during work hours, combined with turning the HVAC systems completely off over the weekend and back on just prior to the Monday workday, could have resulted in uncomfortable environmental conditions for many employees, even without the presence of irritating pollutants. Uneven air distribution and resulting stagnant areas would make localized situations even worse. The AER measurements attempted after the first study day indicate that if the number and strength of indoor pollutant sources can be limited, improvements can be made to make the Waterside HVAC systems acceptable (up to ASHRAE standards) in the areas studied for at least significant portions of year. The proposed HVAC system evaluation should be implemented to identify and rectify any ventilation problems.

The pollutant measurements made during the study indicate that based on the Waterside locations sampled, there are currently only a limited number of pollutant sources and concentrations present that have been identified in previous studies as causing problems. Even assuming that the current air exchange rates have been adjusted artificially high as a safety measure, the carbon dioxide levels, used as a surrogate for other pollutants, should pose no comfort problems at proper AER levels with the current occupant density. The indoor particulate levels were very low, reflecting primarily outdoor FINE particle loadings and indicating no real inside sources of concern. No biological measurements were made, but should be considered on a limited scale if satisfactory explanations for the employee health complaints cannot be found. However, it is not anticipated that biological contamination would be associated with the renovation activities.

The organic compounds outgassing from the carpeting, including 4-PC and styrene, were positively identified in the vapor phase (only) and quantified by two independent techniques. The relatively low concentration levels at the time of the measurements on May 24 and 25 indicate that significant outgassing has already occurred. Based on consideration of a) our headspace testing of samples of the new carpet, b) the May 24 levels in Mall 3241, c) the single room levels reported by Van Ert, et al. (1987) and Vogelmann, et al. (1988) - admittedly for different brands of carpet, and d) their outgassing decay rate studies in residential experiments, the 4-PC levels could easily have been in the 5 to 15 ppb range prior to the study in the newly renovated Waterside offices. The chamber experiments planned to be conducted by AEERL/RTP should help to estimate the maximum levels under various conditions, the rate of outgassing decay, and the best strategies to reduce the 4-PC concentration levels. Observations by our lab personnel while mixing the 4-PC standards suggest that the odor threshold may be below the 0.5 ppb level. This may be important in dealing with some of the responses to the presence of the 4-PC odor. Based on the discussions lead by Mark Van Ert at the EPA Indoor Air program review, 1 ppb was mentioned as a target reduction level to eliminate health responses for a majority of individuals. With the appropriate HVAC adjustments at the Waterside facilities and appropriately outgassing the carpeting prior to installation, the office level of 4-PC can be reduced below the 1 ppb level.

The other organic compounds identified as VOC's or SVOC's after preliminary review do not appear to be at concentration levels reported to be of concern in previous studies. A more detailed review of the VOC data comparing them to previous Total Exposure Assessment Monitoring (TEAM) study results should be conducted. The identification in the SVOC samples of the anti-oxidant BHT was surprising, but probably of little consequence, given its long history as an additive in foods and drugs. The formaldehyde levels were also below expected levels of concern, and did not appear to correlate with the renovation activities.

Even though this has been a very limited study, some positive contributions were made in characterizing the indoor environment in portions of the Waterside facilities and in the area of methods development for 4-PC. If continued health work shows that this compound is a significant contributor to indoor air quality problems, the monitoring methods developed will be very useful. Mark Van Ert noted that their health response tests for 4-PC were very preliminary and need to be followed by more definitive tests to better establish threshold levels for sensitive populations. The experiences gained in the process of collecting the study data will contribute to developing better indoor air quality investigation protocols.

ACKNOWLEDGMENTS

A number of EPA personnel and supporting organizations assisted in this measurement study to provide the results as expediently as possible. The field collection of samples and the weighing of particulate filters were done by Mack Wilkins (EMSL/RTP) and Charlie Weant of Northrop Services. Karen Oliver, Bob Whiton and Jeff Childers of Northrop Services conducted many of the VOC and SVOC analyses on-site at RTP in coordination with the authors and Nancy Wilson (EMSL/RTP). Samples of the pure 4-PC material were provided by Bob Lewis (EMSL/RTP) and Mark Van Ert (Univ. of Arizona). Analyses of the aldehyde samples were provided by Roy Zweidinger and Sylvestre Tejada of ASRL/RTP. Extended VOC speciations were conducted by Battelle Columbus personnel. The PUF/XAD extractions were done by PEI. Analyses of the SF_6 samples were done by Accurex. A special thanks to Joe Peach of NIOSH for the loan of a CO_2 monitor.

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Table 1. Particle Mass Concentrations by Size Fraction

		CONCENTRATIONS, micrograms/cubic meter						
		5/24/				5/25/88		
		7AM to 7PM		7PM to 7AM		7AM to 7PM		
LOCATION	Size		collocated		collocated		collocated	MEANS
Mall 3241	FINE	12.2	16.3	13.1	12.5	10.7	11.1	12.0
	COARSE	15.9	20.8	4.7	6.2	21.4	20.0	14.0
	TOTAL	28.1	37.1	17.8	18.7	32.1	31.1	26.0
Mall 3304	FINE	11.2		11.0		8.8		10.3
	COARSE	19.0		2.9		3.0		8.3
	TOTAL	30.2		13.9		11.8		18.6
East Tower 935	FINE	9.6		8.8		6.2		8.2
	COARSE	19.1		3.1		12.5		11.6
	TOTAL	28.7		11.9		18.7		19.8
East Tower 935	FINE	9.3		11.7		5.2		8.7
	COARSE	5.0		2.0		18.0		8.6
	TOTAL	14.3		13.7		23.2		17.1
Mall Roof	FINE	15.4		9.0		10.1		11.5
	COARSE	9.0		2.6		8.8		6.8
	TOTAL	24.4		11.6		18.9		18.3

MEANS do not include collocated data

FINE = <2.5 micrometers
COARSE = 2.5 to 10 micrometers
TOTAL = <10 micrometers

Table 2. Volatile Organic Compounds (VOC's) by the SUMMA Canister Method

LOCATION	Compound	5/13/88 7AM to 7PM grab	5/24/ 7AM to 7PM	5/24/ 7PM to 7AM	5/25/88 7AM to 7PM	MEANS
		CONCENTRATIONS, parts per billion (ppb) by volume				
Mall 3241	4-PC	1.0	1.4	1.5	1.5	1.5
	Toluene	3.1	5.4	7.9	8.8	7.4
	o-Xylene	1.9	2.7	8.6	3.0	4.8
	Styrene	0.0	0.0	0.5	0.0	0.2
Mall 3304	4-PC		0.1	0.2	0.0	0.1
	Toluene		5.1	7.7	6.9	6.6
	o-Xylene		3.3	7.3	3.2	4.6
	Styrene		0.0	0.3	0.0	0.1
East Tower 935	4-PC	0.6	0.8	0.9	na	0.9
	Toluene	3.0	5.5	5.3	na	5.4
	o-Xylene	1.6	2.3	5.1	na	3.7
	Styrene	0.1	0.3	0.5	na	0.4
East Tower 1015	4-PC		0.1	0.5	0.4	0.3
	Toluene		1.7	4.5	5.2	3.8
	o-Xylene		1.7	5.4	3.3	3.5
	Styrene		0.2	0.2	0.0	0.1
Mall Roof	4-PC		0.0	0.0	0.0	0.0
	Toluene		2.2	3.0	3.4	2.9
	o-Xylene		2.5	3.4	1.6	2.5
	Styrene		0.0	0.0	0.0	0.0

Conversion factors (Multiply ppb values to get ug/m3):

	factor
4-PC	6.07
Toluene	3.80
O-Xylene	4.39
Styrene	4.30

na = not analyzed
MEAN does not include grab samples

Table 3. Extended VOC Speciation of Selected Canisters

Compound	Concentration, parts per billion (ppb) by volume			
	May 13, 1988		May 25, 1988	
	Mall 3241	East Tower 935	Mall 3241	East Tower 935
Freon 12	1.09	3.12	0.83	0.53
Methyl Chloride	*	0.24	0.48	0.51
Freon 114	*	*	*	*
Vinyl Chloride	*	*	*	*
Methyl Bromide	*	*	*	*
Ethyl Chloride	*	*	*	*
Freon-11	3.81	26.91	1.79	47.22
1,1-Dichloroethene	*	*	*	*
Dichloromethane	0.66	0.56	0.63	5.12
3-Chloropropene	*	*	0.15	0.12
Freon-113	0.12	4.80	0.15	0.34
1,1-Dichloroethane	*	*	*	*
cis-1,2-Dichloroethene	*	*	*	*
Trichloromethane	0.13	0.16	*	0.14
1,2-Dichloroethane	*	*	0.15	*
1,1,1-Trichloroethane	1.01	2.88	1.22	6.38
Benzene	0.72	0.57	0.69	0.77
Carbon Tetrachloride	0.13	0.11	0.11	0.11
1,2-Dichloropropane	*	*	*	*
Trichloroethene	0.18	*	0.10	0.22
cis-1,3-Dichloropropene	*	*	*	*
Trans-1,3-Dichloropropene	*	*	*	0.10
1,1,2-Trichloroethane	*	*	*	*
Toluene	3.22	2.60	4.26	4.20
1,2-Dibromoethane	*	*	*	*
Tetrachloroethene	0.87	0.73	0.72	0.54
Chlorobenzene	*	*	*	*
Ethyl Benzene	0.35	0.30	0.36	0.36
O-Xylene	0.42	0.94	0.41	0.45
M,P-Xylene	1.01	0.81	1.09	1.10
Styrene	0.36	0.38	0.22	*
1,1,2,2-Tetrachloroethane	*	*	*	*
4-Ethyl Toluene	0.19	0.21	0.14	0.16
1,3,5-Trimethylbenzene	0.19	0.18	0.13	0.15
1,2,4-Trimethylbenzene	0.59	0.54	0.47	0.53
Benzyl Chloride	*	*	0.12	*
O-Dichlorobenzene	*	*	*	*
M-Dichlorobenzene	*	*	0.72	0.15
P-Dichlorobenzene	0.45	*	*	*
1,2,4-Trichlorobenzene	0.17	*	*	*
Hexachlorobutadiene	*	*	*	*

* = less than 0.10 ppb

Table 4. Collection and Analysis for 4-PC as a Semi-Volatile Organic Compound (SVOC)

CONCENTRATIONS, parts per billion (ppb) by volume

LOCATION	=====5/24/===== 7AM to 7PM	collocated	=====5/24/===== 7PM to 7AM	collocated	====5/25/88==== 7AM to 7PM	collocated	MEANS	
Mall 3241	1.0	1.1	1.1	1.1	na	0.8	1.1	(1.5)
Mall 3304	0.1		0.2		0.0		0.1	(0.1)
East Tower 935	0.5		0.7		1.2		0.8	(0.9)
East Tower 1015	0.3		0.3		0.2		0.3	(0.3)
Mall Roof	0.0		0.0		0.0		0.0	(0.0)

Conversion factor (Multiply ppb values to get ug/m3):

	factor
4-PC	6.07

MEANS in parentheses are VOC results from Table 2

na = not analyzed

MEANS do not include collocated data

Table 5. Formaldehyde and other Carbonyls by the Tejada Method

CONCENTRATIONS, parts per billion (ppb) by volume

LOCATION	Compound	5/24/88 7AM to 7PM	collocated	5/24/88 7PM to 7AM	collocated	5/25/88 7AM to 7PM	collocated	MEANS
Mall 3241	Formaldehyde	27.6	27.1	31.6	33.4	23.4	22.9	27.5
	other Carbonyls	18.6	18.3	24.9	26.7	16.8	16.5	20.1
	unknowns	1.5	0.9	0.9	1.3	0.5	0.6	1.0
	Total Carbonyls	47.7	46.3	57.4	61.4	40.6	39.9	48.6
Mall 3304	Formaldehyde	20.0		25.9		16.2		20.7
	other Carbonyls	16.9		23.5		13.4		17.9
	unknowns	1.0		1.0		0.6		0.9
	Total Carbonyls	37.9		50.4		30.2		39.5
East Tower 935	Formaldehyde	21.7		25.9		24.9		23.0
	other Carbonyls	21.9		18.0		21.5		20.0
	unknowns	1.1		0.7		1.0		0.9
	Total Carbonyls	44.7		44.6		47.4		44.7
East Tower 1015	Formaldehyde	23.0		51.1		21.4		31.8
	other Carbonyls	20.5		35.6		24.5		26.9
	unknowns	1.2		1.6		1.0		1.3
	Total Carbonyls	44.7		88.3		43.9		59.0
Mall Roof	Formaldehyde	3.4		4.0		1.5		3.0
	other Carbonyls	4.8		4.9		3.4		4.4
	unknowns	0.5		0.4		0.2		0.4
	Total Carbonyls	8.8		9.3		5.0		7.7

MEANS do not include collocated data

APPENDIX E

August 23, 1988, Technical Memorandum

Evaluation of Organic Emissions from Waterside Mall Carpets and Office Partitions

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

AIR AND ENERGY ENGINEERING RESEARCH LABORATORY
RESEARCH TRIANGLE PARK
NORTH CAROLINA 27711

DATE: August 25, 1988

SUBJECT: Evaluation of Organic Emissions from Waterside Mall Carpets and Office Partitions

FROM: Bruce A. Tichenor
Indoor Air Branch (MD-54)

TO: David J. Weitzman
Director, Occupational Health and Safety Staff (PM-273)

The purpose of this memorandum is to present the results of the study conducted by the Indoor Air Branch to evaluate the emissions from samples of carpet and partitions received from your office.

Please call me (FTS 629-2991) if you have any questions or need additional details concerning our study.

INTRODUCTION

As part of the Agency's effort to deal with indoor air quality complaints in the Waterside Mall EPA Headquarters facility, the Indoor Air Branch, Air and Energy Engineering Research Laboratory (AEERL), was asked to evaluate the emission characteristics of carpeting and office partitions being used in office renovation activities and to investigate possible means for reducing or eliminating these emissions.

FACTORS AFFECTING EMISSIONS AND INDOOR CONCENTRATIONS

A number of factors may affect the rate of emissions of organic compounds from carpets and partitions, including:

Composition of Materials - The materials used in the carpet (and partitions) obviously affect the potential for emissions. For example, the styrene-butadiene rubber (SBR) latex adhesive used to bind the carpet pile to the back is suggested as the source of 4-phenylcyclohexene (4-PC) emissions. The carpet padding may also act as an organic source. For the partition, the fabric, insulation material, and the pressed wood core could all be sources of organic emissions.

Methods of Installation - Solvent emissions from carpet adhesives are known sources of indoor organics.

Material Age - The age of the carpet (and partition) and the time since installation are important in determining emission rates, since new materials generally have higher emission rates than aged materials.

Environmental Variables - Temperature, humidity, air exchange, and the concentration of organics in the air may affect the rate at which organics are emitted from the carpets or partitions.

Finally, several additional factors may affect the indoor organic concentrations:

Building Air Exchange Rate - The building's air exchange rate (amount of outside air infiltration) determines the dilution and flushing in the building. For a given organic emission rate, the higher the air exchange rate, the lower the indoor organic concentration. The air exchange rate is expressed in air changes per hour (ACH or hr^{-1}).

HVAC System - The operation of the HVAC (Heating, Ventilating, Air Conditioning) system in the building affects the mixing and movement of air. Buildings are generally well-mixed when the HVAC fan (air handling unit) is operating. This would cause the organic concentrations to be fairly consistent from room to room. Inadequate mixing can cause higher concentrations to occur in some rooms.

Sink Effects - Materials in the building may adsorb organics and gradually release them over time. Such an effect would lower initial concentrations but extend the exposure time.

STUDY OBJECTIVES

A short term study was conducted to answer two questions:

1) What are the emission factors (e.g., ug/m^2-hr) and decay rates for the carpet and partition? The organic compounds of interest are 4-phenylcyclohexene (4-PC) and aldehydes.

2) Would airing out the carpet prior to installation be effective in reducing the organic emissions?

STUDY PLAN

A modest experimental program was developed to meet the study objectives. The approach included: a) emission characterization using small environmental test chambers and b) IAQ modeling to evaluate indoor concentrations as a function of emission rates and building ventilation parameters.

A study consisting of two phases was conducted:

Phase I - An initial screening evaluation to develop sampling and analysis strategies.

Phase II - a) Tests to provide estimates of emission factors and decay rates; b) Estimate, using simple IAQ models, the effect of air exchange on indoor concentrations; c) Estimate the effectiveness of airing out the carpet prior to installation.

RESULTS

Phase I - Initial Screening Evaluation

The small chamber test facility at AEERL uses gas chromatography (GC) with flame ionization detection (FID) to measure the levels of organics emitted from indoor materials. Sampling is conducted by adsorption on Tenax/charcoal followed by thermal desorption and concentration in a purge and trap device. This methodology has proven successful in evaluating a large variety of indoor materials. In some cases, high boiling point compounds (such as 4-PC) may be incompatible with Tenax/charcoal sampling, and other adsorbents may be required.

The preliminary screening study involved: 1) evaluation of our standard Tenax/charcoal sampling strategy; 2) investigation of a "graphitized carbon" sorbent; 3) investigation of cryo-trapping as an alternative to thermal purge and trap.

Under "normal" circumstances, the Tenax/charcoal cartridges are desorbed at about 220°C. At this temperature, the 4-PC was not effectively removed from the sorbent. Thus, desorption at 300°C was used. At this temperature, the Tenax "breaks down" and a number of artifacts are produced. However, a reasonable calibration curve for 4-PC was produced at this elevated temperature. However, results using this technique when sampling the chamber effluent were less encouraging. Sufficient data were generated using this method to produce estimates of the emission factor and decay rate for 4-PC, but overall the method lacked reliability.

The investigations of a "graphitized carbon" and cryo-trapping showed that both appeared to be improvements over the high temperature Tenax/charcoal desorption. Unfortunately, insufficient time was available to fully explore these techniques as applied to 4-PC. Any future work on 4-PC emissions would involve these alternatives.

Aldehyde sampling was conducted using DNPH cartridges followed by HPLC.

Phase II - a) Estimates of Emission Factors and Decay Rates

Small chamber studies were conducted under a single set of environmental conditions (i.e., T = 20°, RH = 50%, ACH = 1) on the following materials:

- New carpet
- "Old" carpet (6 month old sample removed from a Waterside Mall office)
- Office partition (~15cm)² samples

Testing was conducted in 53 liter chambers; each material was tested in two chambers. The loading (m^2/m^3) for the carpet samples was 0.4; for the partition material, the loading was 1.8.

The concentrations of 4-PC and aldehydes were determined as discussed above. Based on the measured concentrations, the emissions rates of these compounds for the three materials were determined:

<u>4-PC Emission Factors</u> - Concentrations of 4-PC were measured over time for a period of two weeks. Neither the "old" carpet nor the partition material emitted measurable quantities of 4-PC. The concentrations of 4-PC for the new carpet ranged from 75 ug/m^3 to 15 ug/m^3 over the sampling period. A simple first order emission rate equation was used to analyze the chamber data:

$$EF = EF_o(e^{-kt})$$

where: EF = emission factor (ug/m^2-hr), EF_o = initial emission factor (ug/m^2-hr), k = first order rate constant (hr^{-1}), and t = time (hr). Using this equation, one can also determine the emission rate half-life (i.e., the time required for the emission factor to be reduced by 50%):

$$t(1/2) = (\ln 2)/k$$

where: t(1/2) = emission rate half-life (hr) and ln2 = natural log of 2.

Based on the chamber data, the following 4-PC emission factors and decay rates (plus half-lives) were determined:

New Carpet - EF_o = 150 ug/m^2-hr, k = 0.0036 hr^{-1}, t(1/2) = 192 hrs (8 days).

"Old" Carpet - No measurable 4-PC emissions.

Office Partition - No measurable 4-PC emissions.

Note that the 4-PC emission rate half-life of 8 days for the new carpet is consistent with results obtained by headspace analyses conducted by EMSL and with the data reported by VanErt.

Aldehyde Emission Factors - Only one set of samples was collected for analysis of aldehydes. A total of 22 compounds were analyzed for; only three were detected: formaldehyde, acetaldehyde, and acetone.

The emission factors were calculated based on an assumed constant emission rate (i.e., no decay):

$$EF = (N/L)C$$

where: EF = emission factor (ug/m^2-hr), N = air exchange rate (hr^{-1}), L = material loading (m^2/m^3), and C = concentration (ug/m^3).

The Table 1 shows the measured concentrations and calculated emission factors for the three compounds for the three materials tested:

Table 1. Aldehyde Emission Factors

Material	Compound	Chamber Concentration (ug/m^3)	Emission Factor (ug/m^2-hr)
New Carpet	Formaldehyde	3.8	9.5
	Acetaldehyde	4.0	10.0
	Acetone	17.7	44.3
"Old" Carpet	Formaldehyde	3.3	8.3
	Acetaldehyde	2.7	6.8
	Acetone	3.4	8.5
Office Partition	Formaldehyde	23.4	13.0
	Acetaldehyde	Not Detected	----
	Acetone	5.1	2.8

The formaldehyde emission factors shown in Table 1 are well below the values normally expected for particleboard and plywood.

b) Estimates of the Impact of Carpets and Partitions on Indoor Concentrations - Based on the calculated emission factors, a simple one compartment, well-mixed IAQ model was be used to estimate the contribution of the new carpet to the concentration of 4-PC inside Waterside Mall based on several assumed air exchange rates. Figure 1 shows the results of these calculations. As would be expected, increasing the air exchange rate will lower the estimated indoor concentration of 4-PC. Note that the ASHRAE ventilation guidance for IAQ corresponds to an air exchange rate of approximately 1 hr^{-1}.

Table 2 shows similar estimates for the aldehyde emissions. Note that these calculations were made assuming no decay in emission rates over time. The loadings were assumed to be 0.3 m^2/m^3 for the carpets and 0.4 m^2/m^3 for the partitions.

Table 2. Estimated Indoor Concentrations of Aldehydes (ppb)

Material	Compound	Air Exchange Rate (hr^{-1})			
		0.1	0.5	1.0	2.0
New Carpet	Formaldehyde	22	4.3	2.2	1.0
	Acetaldehyde	15	3.1	1.5	0.8
	Acetone	51	10	5.0	2.5
"Old" Carpet	Formaldehyde	19	3.7	1.9	0.9
	Acetaldehyde	10	2.1	1.0	0.5
	Acetone	10	2.0	1.0	0.5
Office Partition	Formaldehyde	39	7.5	3.9	1.9
	Acetone	4.3	0.8	0.4	0.2

Again, the low concentrations are associated with the high air exchange rates. Note that at the ASHRAE recommended air exchange rate of 1 hr^{-1} none of concentration exceed 5 ppb.

c) Estimates of the Effectiveness of Carpet Airing Out - Based on the estimated emission factor and decay rate, the simple IAQ model was used to determine how the indoor concentration would be affected by airing out the new carpet prior to installation. Figure 2 shows the results of these calculations for an air exchange rate of 1 hr^{-1}. These calculations indicate that by airing the carpet for one month prior to installation the maximum indoor concentration of 4-PC due to the carpet would be less than 1 ppb.

DISCUSSION

In evaluating the results presented above the reader is urged to consider the following factors:

1. The experimental data used to make the calculations are based on a very limited study. The 4-PC data were collected using non-standard Tenax desorption, and only one set of aldehyde samples were collected.

2. The calculations of indoor concentrations used a very simple IAQ model which did not include consideration of the complexities of the true Waterside Mall HVAC system nor the true configuration of the many office layouts at the EPA Headquarters facility. Sink effects were also not considered.

Given the limited experimental program and the many simplifying assumptions, the reader is cautioned against rigorously applying the quantitative results to a specific situation at Waterside Mall. It is felt that the results provide a reasonable qualitative "picture" and can be used to compare the impacts of the various materials on the indoor air quality at EPA Headquarters.

Enclosures

cc: Kevin Teichman (RD-672)
    Mike Berry (MD-52)
    Ross Highsmith (MD-56)

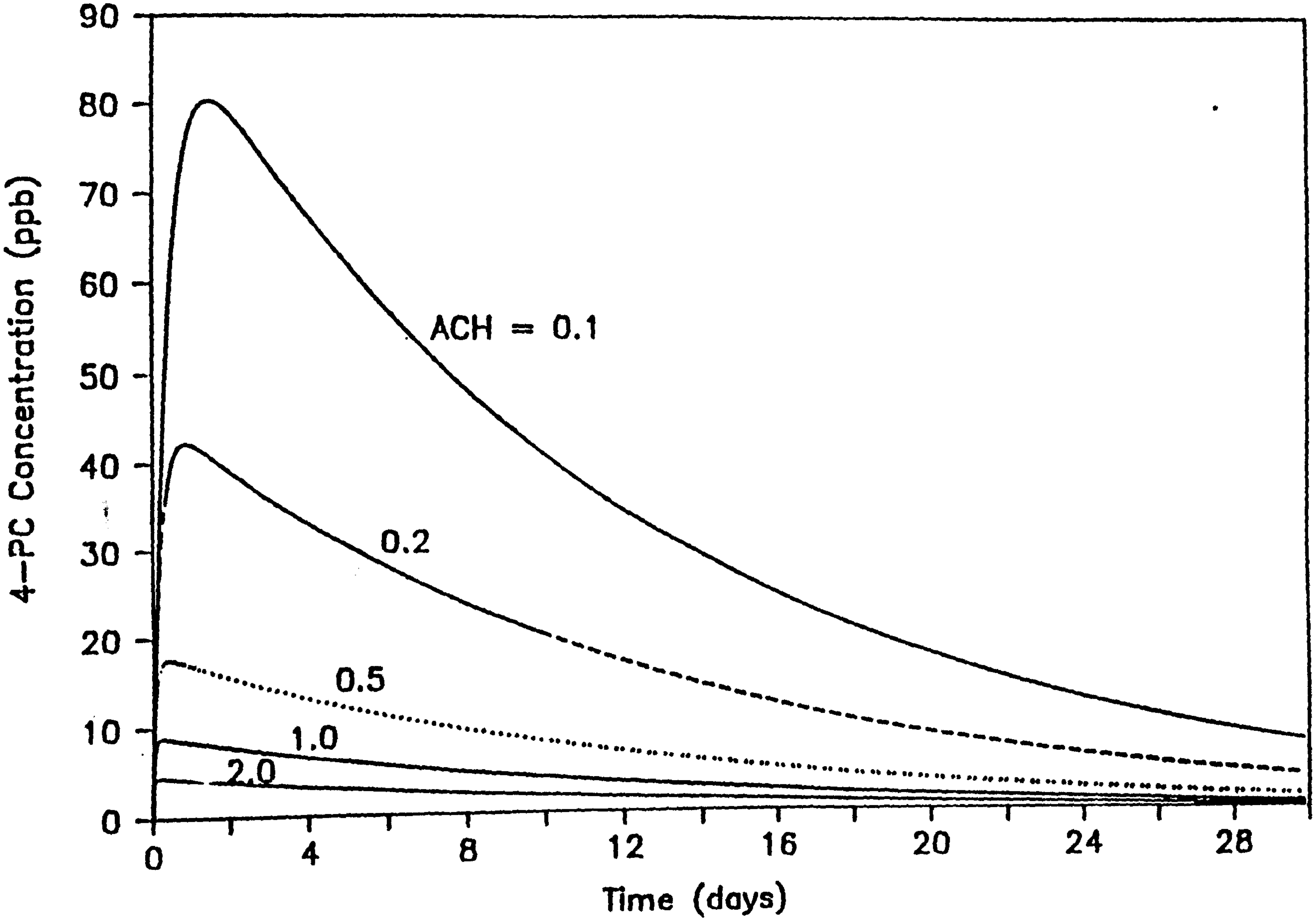

Figure 1. Effect of Air Exchange Rate (ACH) on Indoor Concentrations of 4-PC from New Carpet

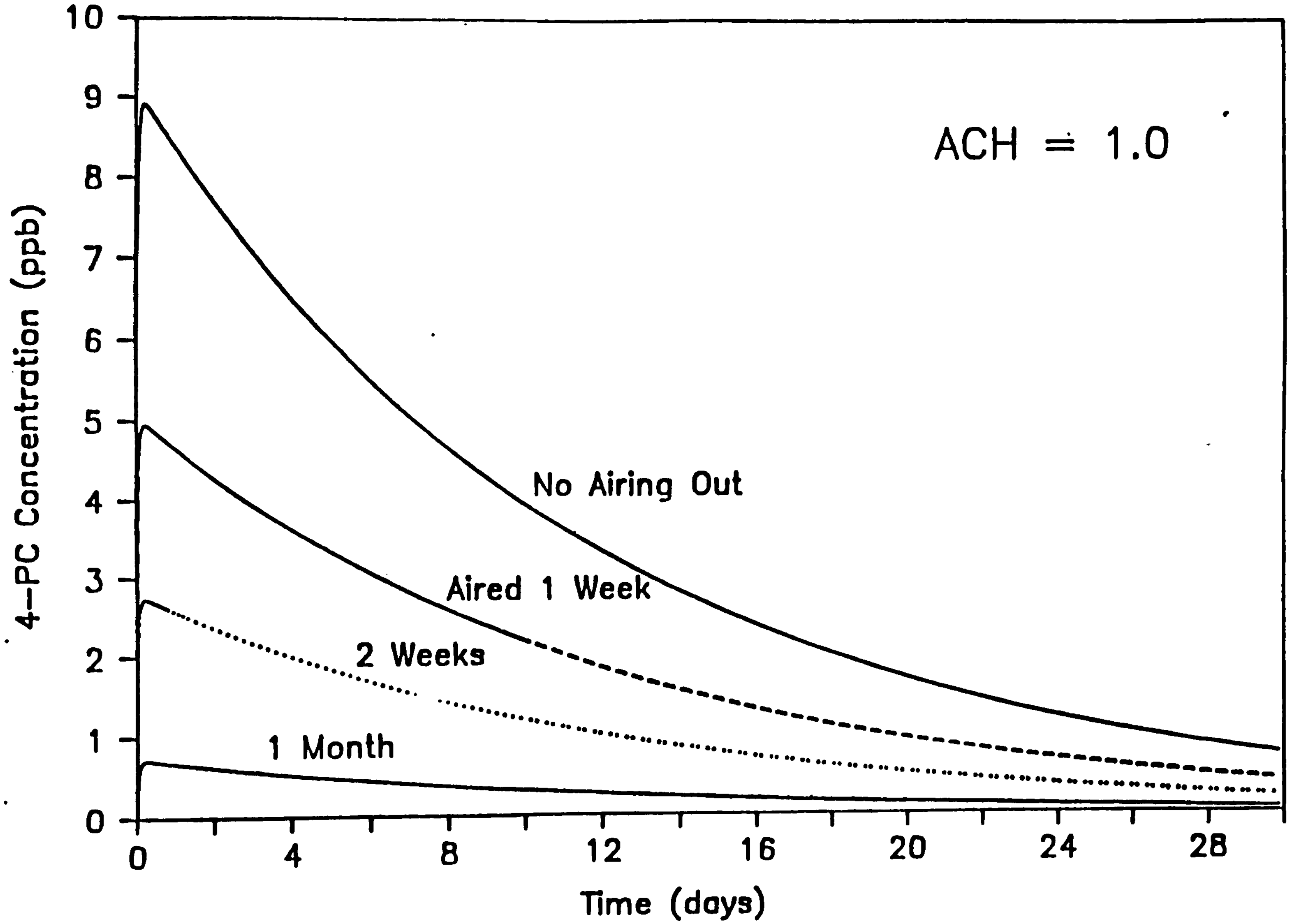

Figure 2. Effect of Carpet Airing Out Prior to Installation on the Indoor Concentrations of 4-PC

APPENDIX F

October 25, 1988, Internal EPA Report

A FINAL SUMMARY REPORT ON THE INDOOR AIR MONITORING PERFORMED AT EPA HEADQUARTERS, WASHINGTON, DC, ON MAY 24, 25, AND JUNE 6, 1988

Tenax and Charcoal data

A FINAL SUMMARY REPORT ON THE INDOOR AIR MONITORING PERFORMED AT EPA HEADQUARTERS, WASHINGTON, D.C. ON MAY 24, 25 AND JUNE 6, 1988

October 25, 1988

Prepared By:

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INTRODUCTION:

The Waterside Mall is an H-shaped structure which houses more than 6000 employees of the United States Environmental Protection Agency (USEPA), plus a shopping mall at street level, and parking garage. In October 1987, the renovation program was initiated in the EPA offices. After new carpeting and partitions were installed in some of the offices, several employees complained of nausea, headaches, skin rashes, eye irritation, and respiratory problems associated with the chemical odors. The employees suspected that the odors were coming from the newly installed carpet/partitions or the adhesive used in laying down the carpet. The USEPA Environmental Response Team (ERT), Analytical Support Section, performed a variety of sampling and analytical work for Superfund and environmental emergencies was called upon to evaluate the sources and the nature of chemicals causing these complaints.

The initial indoor air monitoring study[1] conducted in March 1988, showed the presence of low ppb level of volatile organic compounds in the EPA offices monitored. The detected volatile organic compounds normally found in cleaning products, paints, adhesives and building products. A literature search conducted by Office of Toxic Substance (OTS) revealed a recently identified compound 4-Phenylcyclohexene in the carpets by Dr. M. D. Van Ert[2] and his group at University of Arizona. According to Dr. M.D. Van Ert, 4-Phenylcyclohexene has a noxious odor with a threshold odor of 0.5ppb. In May 1988 ERT identified[3] the presence of 4-Phenylcyclohexene in the carpets stored in the warehouse at EPA headquarters by three different techniques.

In order to further investigate the presence of chemical contaminates in the EPA office building, ERT conducted extensive sampling during May 1988 at the request of the Indoor Air Task Force. The ERT coordinated sampling efforts with the Office of Administration and Resources Management (OARM), Office of Solid Waste and Emergency Response (OSWER), Environmental Health Safety Division (EHSD), Environmental Monitoring System Laboratory at Research Triangle Park and facility staff.

SAMPLING:

The sampling locations were selected at the request of EPA Headquarters employees and information available from various sources. A total of 13 sampling locations (including outside the building on the roof top, Table 1) were selected to monitor low levels of volatile organic compounds, 4-Phenylcyclohexene, and formaldehyde. Also carbon monoxide, carbon dioxide, temperature and relative humidity were measured.

Two sets of 12-16 hours time average air samples were collected in conformance with EPA and NIOSH specified methods with some modification to meet the objective of this study. The sampling instruments were fitted with a variety of absorbent material in order to trap many different types of contaminants, such as: volatile organic compounds, 4-Phenylcyclohexene and formaldehyde. The target and non-target compounds are listed in Table 2.

Analytical:

Volatile Organic compounds and 4-Phenylcyclohexene:

Indoor air samples were collected on Tenax/Carbon molecular sieves (CMS) for volatile organic compounds and 4-Phenylcyclohexene. The Tenax/CMS tubes were analyzed by thermal desorption on to a cryogenic trap, followed by GC/MS analyses. A Tekmar model 5010 and Hewlett Packard 5996 GC/MS were used. These samples were spiked with bromofluorobenzene and brochloromethane as surrogate compounds prior to analysis. The Tekmar desorbing unit and GC/MS temperatures were maximize to detect volatile organic compounds and 4-Phenylcyclohexene a semi-volatile organic compound.

4-Phenylcyclohexene:

Indoor air samples were collected on SKC charcoal tube (600mg) for 4-Phenylcyclohexene for quantitation and confirmation analyses. The organic compounds absorbed on charcoal were desorbed using carbon sulfide. The carbon disulfide extract were analyzed for 4-Phenylcyclohexene using HP-5890 GC equipped with flame ionization detector (FID) and intigrator for data recording. The carbon disulfide extracts were also analyzed by GC/MS to confirm the presence of 4-Phenylcyclohexene.

Formaldehyde:

Indoor air samples were collected and analyzed using NIOSH 3500 method.

Other Parameters:

Relative humidity was measured using a sling psychometer. Levels of carbon monoxide were measured using Monotox Carbon monoxide monitor. This is passive monitor which employs an ion solution chamber and membrane with specificity for carbon monoxide. The carbon dioxide levels were measured using a portable CO_2 monitor (Gastech model 4776).

Summary of Results:

The analyses results of Tenax/CMS and charcoal are summarized in Tables 3 and 4. The Tenax/CMS analyses results showed the presence of volatile organic compounds and 4-Phenylcyclohexene at low ppb levels in the EPA offices monitored. The Tenax/CMS analyses results for 4-Phenycyclohexene were estimated using toluene response, due to diffculties experienced in preparing 4-Phenylcyclohexene standard in gas phase. However, The results were quantified and confirmed using charcoal tube analyses.

The air analyses results show 150 ppb of 2,2-dimethylhexane in Room 2827 on May 25, 1988 and was not detected on May 24, 1988.

The formaldehyde analyses results are summarized in Table 5. On May 24 and 25, 1988, 430 and 280 ppb of formaldehyde was detected in the Room 2632. A subsequent re-sampling was conducted on June 3, 1988 found less than 10 ppb of formaldehyde. The higher results on May 24 and 25 could be due to new furniture and/or from the cardboard boxes where sampling trains were placed.

The carbon dioxide, carbon monoxide, temperature and relative humidity were measured and are listed in Table 6.

Discussion:

The objective of this study was to determine the chemical contaminants present in the indoor air at EPA Headquarters offices. The results of this study shows the presence of low ppb levels of several volatile organic compounds and 4-Phenylcyclohexene. The highest concentration of 4-Phenylcyclohexene was 6.6 ppb in Room S-226 on May 24, 1988, which was reduced to 4 ppb on May 25, 1988.

In two cases (Room 2827 and 3304 on May 25, 1988), the concentration of alkanes exceeded the values reported in Table 7. Table 7 contains values reported by several researcher for indoor air concentration[4] for toluene, benzene, ethyl benzene, xylene, alkanes (pentane and lower), alkane (hexane and high molecular weight hydrocarbon), methylene chloride, trichloroethylene, tetrachloroethylene, and 1,1,1-trichloroethane.

Relative humidity, carbon dioxide, and temperature found to be normal for the office environment. The carbon dioxide levels in indoor offices (250 to 375 ppm) was slightly above the outside carbon dioxide level taken at the roof top (200 to 300 ppm) during this study.

The results from the Day Care Center air sampling showed the absence of 4-Phenylcyclohexene but the presence of low ppb levels of organic compounds.

TABLE-1

Indoor Air Monitoring Phase II

Sampling Locations (Room Number)

S-226 (New Room)
S-274
S-216 (Xerox Room)
2811
2816
2827
2807.5
2710 (Control)
2632
Roof
3241
3304 (Control)
935 East Tower)
1015 East Tower (Control)

2632 Resampled for Formaldehyde on 6/3/88
Day Care Center Outside front entrance
Day Care Center Class #3
Day Care Center Class #5

TABLE-2

INDOOR AIR MONITORING PAHSE II

LIST OF TARGET COMPOUNDS

vinylchloride	n-pentane
1,1-dichloroethene	n-hexane
trichlorofluoromethane	chloroform
methylenechloride	cyclohexane
t-1,2-dichloroethene	n-heptane
1,2-dichloroethane	1,2-dichloropropane
1,1,1-trichloroethane	methyl cyclohexane
carbon tetrachloride	n-octane
benzene	bromoform
trichloroethene	cumene
ethylbenzene	alpha-methyl styrene
o,m,p-xylene	m,p-methylstyrene
styrene	o,p-dichlorobenzene
m-ethyltoluene	benzylchloride
4-PHENYLCYCLOHEXENE	hexachloroethane
4-ter-butyl toluene	napthalene
FORMALDEHYDE	

INDOOR AIR MONITERING PHASE II

LIST OF NON TARGET COMPOUNDS

n-hexane
2,2,6-trimethyloctane
C10 alkane
alkane,>C11
phenol + C11 alkane
alkane + C10 alkene/cycloalkane
octanal
C4 alkylbenzene
n-undecane
napthalene
C4 alkane
C9 alkane + C3 alkylbenzene
2,2 dimethyl decane
C10 terpene
N-nitro-N-phenyl-benzeneamine
C6 cycloalkane
C12 alkane
2-butoxyethanol
2,2,4,6,6-pentamethylheptane
C12 alkane + limonene
2-butoxyethanol + styrene
C11 alkane + C3 alkylbenzene
alkane + ethyltoluene
2-methylbutane
n-pentane + trichlorofluoromethane
2-oxy-propanoic acid
C7 alkane
alkane + trimethylbenzene
2-furancarboxaldehyde
2-furanethanol
benzaldehyde
phenol
chloromethane
2-furanmethanol
decahydronapthalene
C12H24O3 ester (1)
C12H24O3 ester (2)
acetic acid + C8 alkane
acetic acid butyl ester
dichlorobenzene isomer
4-methyl-2,6bis(1,1-dimethylethyl)phenol
acetaldehyde
C8 alkene/cycloalkane
hexanal
n-nonane
heptanal
2-butoxyethanol
alkane
2-methylpropane
n-butane
benzaldehyde
C8 alkene/cycloalkane
C8 alkane
siloxane
C9 alkane
n-octane
limonene
n-butane + CO2
n-tridecane
C13 alkane + siloxane
n-butylether
2-butyltetrahydrofuran
C11 alkane
n-decane
C11 alkane
3-methyl-5-propylnonane
siloxane + C3 alkylbenzene
alkane + C3 alkylbenzene
nonanal
C5 alkylbenzene
n-heptane
C3 alkylbenzene
2-(2-butoxyethoxy)-ethanol
acetone
2-propanol
2,2-dimethylhexane
octanal
decanal
pentadecane
acetic acid
C16H10pah
C6 alkane

TARGET COMPOUNDS TABLE-3

INTERIOR AIR ANALYSIS BY GC/MS

SITE NAME : WATERSIDE MALL, WASHINGTON, DC.

SAMPLE LOCATION :	S-216	S-216	S-226	S-226	S-274	S-274	2811	2811	2816(a)
SAMPLE NAME/NUMBER :	217-01	507-01	217-02	507-02	217-03	507-03	217-04	507-04	507-05
DATE SAMPLED :	5/24/88	5/25/88	5/24/88	5/25/88	5/24/88	5/25/88	5/24/88	5/25/88	5/25/88
DATE ANALYZED :	5/27/88	6/06/88	5/28/88	6/06/88	5/28/88	6/06/88	5/28/88	6/06/88	6/06/88
FRN :	B0030	B0098	B0041	B0100	B0042	B0101	B0043	B0102	B0103
parameter	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
vinyl chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-dichloroethene	ND	ND	ND	0.76(B)	ND	ND	ND	0.21(B)	ND
trichlorofluoromethane	ND	2.10	1.09(B)	ND	0.55(B)	ND	0.19(B)	1.60	ND
methylene chloride	0.04*(B)	1.74	4.86	2.13	1.12	ND	ND	4.21	0.15
trans-1,2-dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-trichloroethane	0.16(B)	6.30	1.06	5.76	0.53(B)	2.90(B)	0.21(B)	0.85(B)	2.56(B)
carbon tetrachloride	ND	0.10	0.03	0.12	ND	0.15	ND	0.12	0.05
benzene	0.09(B)	0.80	0.61	0.55(B)	0.25	0.51(B)	0.25	0.79	0.20(B)
trichloroethylene	ND	ND	0.08	0.07*	0.06	ND	ND	0.06	ND
toluene	1.20	2.94	11.11	4.90	5.91	4.26	7.39	3.35	2.52
tetrachloroethylene	0.15	0.52	0.90	0.57	0.76	0.71	0.63	0.54	2.86
ethyl benzene	0.18	0.53	0.46	0.43	0.71	0.48	0.92	0.30	0.33
m-xylene	0.56	1.42	1.19	1.31	2.21	1.50	3.06	0.76	1.03
o-xylene	0.20	0.53	0.35	0.55	0.81	0.63	0.99	0.23	0.38
styrene	0.2(B)	0.94	0.21(B)	0.34	0.61	0.45	1.58	0.42	0.40
meta ethyltoluene	0.12	0.10	0.44	0.11	1.06	0.59	1.08	0.23	0.16
4-phenylcyclohexene **	0.06	0.16	5.15	2.65	0.89	0.48	2.58	0.78	NA
total	3.02	18.18	27.54	20.25	15.45	12.74	18.86	14.37	10.60

(a). Only sampled on 5/25/88.

NA. Not Analyzed for; scan terminated before compound elution.

*: Estimated concentration below limit of quantitation.

**: Not a target compound; results are estimates.

(B): Amounts were not significantly above background levels.

COMBINED NON-TARGET COMPOUNDS

TABLE-3

INTERIOR AIR ANALYSIS BY GC/MS

SITE NAME : WATERSIDE MALL, WASHINGTON, DC.

SAMPLE LOCATION :	8-216	8-216	8-226	8-226	8-274	8-274	2811	2811	2816(a)
SAMPLE NAME/NUMBER :	217-01	507-01	217-02	507-02	217-03	507-03	217-04	507-04	507-05
DATE SAMPLED :	5/24/88	5/25/88	5/24/88	5/25/88	5/24/88	5/25/88	5/24/88	5/25/88	5/25/88
DATE ANALYZED :	5/27/88	6/06/88	5/28/88	6/06/88	5/28/88	6/06/88	5/28/88	6/06/88	6/06/88
FRN :	B0030	B0098	B0041	B0100	B0042	B0101	B0043	B0102	B0103
parameter	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
alkanes	1.07	8.60	21.60	9.10	27.00	22.60	5.30	7.70	2.70
alkenes/cycloalkanes	0.20	1.10	1.00	1.90	----	----	----	0.50	0.50
alkylbenzenes, C3-C5	0.10	----	2.90	----	1.60	0.90	4.60	1.00	2.30
polyaromatic hydrocarbons (PAH)	----	----	----	----	----	----	----	----	----
acetaldehyde #	0.20	0.70	----	----	----	----	----	0.90	----
benzaldehyde	0.10	0.50	2.90	----	----	----	----	0.60	----
other aldehydes	0.50	----	3.10	0.90	2.70	----	1.50	----	0.90
alcohols	0.20	1.10	----	----	----	----	0.90	0.50	1.20
phenols	----	----	----	----	----	----	----	----	----
limonene	----	----	1.60	----	2.60	1.90	2.60	0.50	2.70
dichlorobenzene isomers	----	----	----	----	----	----	----	----	----
chloromethane	----	----	----	----	----	----	----	----	----
siloxane	0.20	3.10	2.40	9.80	10.70	12.90	11.60	3.80	2.90
acetone	0.08	1.60	----	----	----	----	----	1.10	----
acetic acid	----	----	----	----	----	----	----	----	----
acetic acid butyl ester	0.10	----	----	----	----	----	----	0.70	----
N-nitro-N-phenyl-benzenamine	----	----	----	----	----	----	----	----	----
C12H24O3 ester (1)	0.20	2.80	14.00	9.80	11.00	5.00	4.20	1.20	----
C12H24O3 ester (2)	1.60	4.90	20.00	16.00	1.70	7.00	5.40	1.80	----
other organics	----	0.80	2.20	1.40	----	----	----	----	----
total	4.55	25.20	71.70	48.90	57.30	50.30	36.10	20.30	13.20

(a) Only sampled on 5/25/88.

(1) Propanoic acid, 2 methyl-2,2-dimethyl-1-(2-hydroxy-1-methylethyl)propyl ester.

(2) Propanoic acid, 2 methyl-3-hydroxy-2,4,4-trimethylpentyl ester.

Known Tenax contaminant.

TARGET COMPOUNDS   TABLE-3(CONT'D)

INTERIOR AIR ANALYSIS BY GC/MS

SITE NAME : WATERSIDE MALL, WASHINGTON, DC.

SAMPLE LOCATION :	2827	2827	2708.5	2708.5	2710	2710	2632	2632
SAMPLE NAME/NUMBER :	217-05	507-06	217-06	507-07	217-07	507-08	217-08	507-09
DATE SAMPLED :	5/24/88	5/25/88	5/24/88	5/25/88	5/24/88	5/25/88	5/24/88	5/25/88
DATE ANALYZED :	5/28/88	6/07/88	5/28/88	6/07/88	5/31/88	6/07/88	5/31/88	6/07/88
FRN :	B0044	B0113	B0039	B0114	B0050	B0115	B0051	B0117
parameter	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
vinyl chloride	ND	ND	ND	ND	ND	ND	ND	ND
1,1-dichloroethene	ND	0.98(B)	ND	1.51(a)(B)	ND	ND	ND	ND
trichlorofluoromethane	0.45(a)(B)	2.20	0.20(B)	1.32(a)	0.64(a)(B)	1.09	0.11(B)	ND
methylene chloride	1.16(B)	6.26	1.94	2.09(a)	0.32(a)(B)	0.34	ND	0.42
trans-1,2-dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND
1,1-dichloroethane	ND	ND	0.02*	ND	ND	ND	ND	ND
1,2-dichloroethane	ND	ND	ND	ND(1)	ND	ND	ND	ND
1,1,1-trichloroethane	0.47(B)	3.01(B)	0.17(B)	1.04(B)	0.30(B)	2.27(B)	0.33(B)	1.55(B)
carbon tetrachloride	0.06	ND	ND	0.09	ND	ND	ND	ND
benzene	0.26	0.77	0.15	ND(1)	0.15	0.06(B)	0.10	0.05(B)
trichloroethylene	ND	ND	ND	0.10	ND	ND	ND	ND
toluene	8.13	3.09	6.72	2.99	10.46	0.27	14.08	6.86
tetrachloroethylene	0.61	0.46	0.95	5.28	1.34	5.00	1.13	4.30
ethyl benzene	0.80	0.38	0.67	0.27	0.75	0.38	1.05	0.65
m-xylene	2.35	1.15	2.08	0.76	1.97	1.23	3.34	2.12
o-xylene	0.84	0.46	0.68	0.28	0.54	0.46	1.29	0.77
styrene	0.43	0.38	0.52	0.22	0.28(B)	0.47	0.98	0.71
meta ethyltoluene	0.46	0.59	0.59	0.22	0.08(B)	0.30	0.93	0.60
4-phenylcyclohexene **	0.84	1.10	2.20	1.26	0.07	0.03	0.19	0.18
total	16.86	20.83	16.89	17.43	16.90	11.90	23.53	18.21

(a). Split peak, added integration peaks.

(1). Compound maybe present, spectrum was overshadowed by a hydrocarbon peak.

*; Estimated concentration below limit of quantitation.

**; Not a target compound; results are estimates.

(B): Amounts were not significantly above background levels.

COMBINED NON-TARGET COMPOUNDS

TABLE-3(CONT'D)

INTERIOR AIR ANALYSIS BY GC/MS

SITE NAME : WATERSIDE MALL, WASHINGTON, DC.

SAMPLE LOCATION	:	2827	2827	2708.5	2708.5	2710	2710	2632	2632
SAMPLE NAME/NUMBER	:	217-05	507-06	217-06	507-07	217-07	507-08	217-08	507-09
DATE SAMPLED	:	5/24/88	5/25/88	5/24/88	5/25/88	5/24/88	5/25/88	5/24/88	5/25/88
DATE ANALYZED	:	5/28/88	6/07/88	5/28/88	6/07/88	5/31/88	6/07/88	5/31/88	6/07/88
FRN	:	80044	80113	80039	80114	80050	80115	80051	80117
parameter		ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
alkanes		1.80	143.20*	23.00	44.10	5.10	8.20	10.90	49.70
alkenes/cycloalkanes		----	----	----	----	----	----	----	----
alkylbenzenes, C3-C5		1.60	4.60	0.80	----	1.40	1.50	3.80	----
polyaromatic hydrocarbons (PAH)		----	----	2.30	----	----	----	----	----
acetaldehyde #		----	----	2.30	----	----	----	1.40	----
benzaldehyde		----	2.40	1.60	0.60	----	----	----	----
other aldehydes		2.60	14.60	----	----	0.50	----	1.80	----
alcohols		2.00	4.90	----	----	0.50	0.50	----	----
phenols		0.90	----	----	----	0.80	0.80	----	----
limonene		1.00	----	0.90	0.60	1.50	0.60	1.70	2.30
dichlorobenzene isomers		----	----	----	----	0.50	0.80	1.10	1.60
chloromethane		----	----	----	----	----	----	----	----
siloxane		5.20	9.90	3.10	4.00	2.50	2.50	6.00	6.70
acetone		3.60	2.50	----	----	----	----	----	----
acetic acid		----	----	1.30	0.60	0.60	0.50	----	----
acetic acid butyl ester		0.90	----	----	1.10	0.40	----	1.00	----
N-nitro-N-phenyl-benzenamine		----	2.30	----	----	----	0.50	----	----
C12H24O3 ester (1)		1.30	----	6.20	1.30	1.30	0.70	3.40	3.90
C12H24O3 ester (2)		2.20	----	9.60	2.50	1.90	1.00	5.10	5.50
other organics		1.30	----	----	----	----	----	----	----
total		24.40	204.40	51.10	54.80	17.00	17.60	36.20	69.70

(1) Propanoic acid, 2 methyl-2,2-dimethyl-1-(2-hydroxy-1-methylethyl)propyl ester.

(2) Propanoic acid, 2 methyl-3-hydroxy-2,4,4-trimethylpentyl ester.

* Includes 150 ppb of 2,2 dimethylhexane.

Kno[illegible] Tenax contaminant.

07/22/88

TARGET COMPOUNDS TABLE-3(CONT'D)

INTERIOR AIR ANALYSIS BY GC/MS

SITE NAME : WATERSIDE MALL, WASHINGTON, DC.

SAMPLE LOCATION :	ROOF	ROOF	3241	3241	3304	3304	935#	935#
SAMPLE NAME/NUMBER :	217-09	507-10	217-10	507-11	217-11	507-12	217-12	507-13
DATE SAMPLED :	5/24/88	5/25/88	5/24/88	5/25/88	5/24/88	5/25/88	5/24/88	5/25/88
DATE ANALYZED :	5/31/88	6/07/88	5/31/88	6/08/88	5/31/88	6/08/88	5/31/88	6/08/88
FRN :	80052	80118	80053	80122	80054	80126	80055	80124
parameter	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
vinyl chloride	ND	ND	ND	ND	ND	ND	ND	ND
1,1-dichloroethene	ND	ND	ND	ND	0.33	0.18(B)	ND	ND
trichlorofluoromethane	0.05(B)	1.39	0.92(s)(B)	1.95	4.09	2.21	0.97(B)	0.05(B)
methylene chloride	0.08(B)	0.29	1.28	0.40	1.38	2.56	0.58	ND
trans-1,2-dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND
1,1-dichloroethane	ND	ND	ND	ND	0.03*	ND	ND	ND
1,2-dichloroethane	ND	ND	ND	ND	ND	0.08	ND	ND
1,1,1-trichloroethane	0.09(B)	0.20(B)	5.10	0.27(B)	11.70	1.7(B)	0.34(B)	0.24(B)
carbon tetrachloride	ND	ND	1.05	ND	0.06	0.14	ND	ND
benzene	0.10(B)	0.08(B)	0.19	0.05(B)	0.33	0.76	0.07(B)	0.02*(B)
trichloroethylene	ND	ND	0.05	ND	0.03	0.13	ND	ND
toluene	5.96	0.13	8.91	0.63	8.66	4.99	5.69	5.79
tetrachloroethylene	0.77	0.27	0.10	1.45	12.52	1.24	0.83	0.83
ethyl benzene	0.73	0.23	0.80	0.57	0.50	0.48	0.82	0.50
m-xylene	2.58	0.83	2.01	1.88	1.54	1.65	2.45	1.43
o-xylene	1.08	0.32	0.72	0.60	0.54	0.59	0.88	0.44
styrene	ND	0.12	0.46	0.55	0.26(B)	0.33	0.51	0.48
meta ethyltoluene	1.14	0.02	0.60	0.41	0.40	0.26	0.46	0.20
4-phenylcyclohexene **	ND	ND	2.10	1.10	0.17	0.03	0.87	0.63
total	12.58	3.88	24.29	9.86	42.74	17.33	14.39	10.61

#. East Tower sample.
(s). Split peak, added integration peaks.
*; Estimated concentration below limit of quantitation.
**; Not a target compound; results are estimates.
(B): Amounts were not significantly above background levels.

COMBINED NON-TARGET COMPOUNDS

TABLE-3(CONT'D)

INTERIOR AIR ANALYSIS BY GC/MS

SITE NAME : WATERSIDE MALL, WASHINGTON, DC.

SAMPLE LOCATION :	ROOF	ROOF	3241	3241	3304	3304	9350	9350
SAMPLE NAME/NUMBER :	217-09	507-10	217-10	507-11	217-11	507-12	217-12	507-13
DATE SAMPLED :	5/24/88	5/25/88	5/24/88	5/25/88	5/24/88	5/25/88	5/24/88	5/25/88
DATE ANALYZED :	5/31/88	6/07/88	5/31/88	6/08/88	5/31/88	6/08/88	5/31/88	6/08/88
FRN :	B0052	B0118	B0053	B0122	B0054	B0126	B0055	B0124
parameter	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
alkanes	2.00	4.60	28.00	17.60	88.70	213.90	30.00	60.10
alkenes/cycloalkanes	0.50	1.20	----	----	2.00	----	----	----
alkylbenzenes, C3-C5	5.60	0.80	2.30	----	----	----	----	----
polyaromatic hydrocarbons (PAH)	0.80	1.60	----	----	----	----	----	----
acetaldehyde ##	----	----	----	----	----	----	----	----
benzaldehyde	----	2.10	----	----	----	----	----	----
other aldehydes	2.00	4.10	3.30	----	----	----	----	----
alcohols	----	0.40	4.80	1.20	2.90	16.00	7.60	2.20
phenols	----	----	2.90	0.90	2.00	----	1.30	----
limonene	----	----	1.50	4.20	----	----	1.50	2.30
dichlorobenzene isomers	----	0.50	1.40	1.20	2.00	4.50	0.90	1.70
chloromethane	----	----	----	----	----	----	----	----
siloxane	2.10	3.20	5.30	2.90	----	3.90	5.00	2.90
acetone	----	----	----	----	----	----	----	----
acetic acid	1.20	----	----	----	----	----	1.30	----
acetic acid butyl ester	----	----	----	----	----	----	----	----
N-nitro-N-phenyl-benzenamine	----	----	----	1.60	----	----	----	----
C12H24O3 ester (1)	----	0.60	4.50	4.30	2.80	----	2.30	1.70
C12H24O3 ester (2)	----	----	7.40	6.40	4.30	----	4.10	----
other organics	----	----	----	----	----	----	----	----
total	15.00	19.10	61.40	40.30	104.70	238.30	54.80	70.90

East Tower sample.

(1) Propanoic acid, 2 methyl-2,2-dimethyl-1-(2-hydroxy-1-methylethyl)propyl ester.

(2) Propanoic acid, 2 methyl-3-hydroxy-2,4,4-trimethylpentyl ester.

Known Tenax contaminant.

07/22/88

TARGET COMPOUNDS   TABLE-3(CONT'D)

****

INTERIOR AIR ANALYSIS BY GC/MS

****

SITE NAME : WATERSIDE MALL, WASHINGTON, DC.

SAMPLE LOCATION	:	1015#	1015#	NURSERY(1)	NURSERY(2)	NURSERY(3)
SAMPLE NAME/NUMBER	:	217-13	507-16	514-01	514-02	514-03
DATE SAMPLED	:	5/24/88	5/25/88	6/03/88	6/03/88	6/03/88
DATE ANALYZED	:	5/31/88	6/08/88	6/08/88	6/08/88	6/08/88
FRN	:	B0056	B0125	B0128	B0129	B0130
parameter		ppb	ppb	ppb	ppb	ppb
vinyl chloride		ND	ND	ND	ND	ND
1,1-dichloroethene		ND	0.92(B)	ND	0.11	0.21
trichlorofluoromethane		ND	4.51	ND	7.33	15.44
methylene chloride		0.30(B)	9.12	ND	0.81(B)	ND
trans-1,2-dichloroethene		ND	ND	ND	ND	ND
1,1-dichloroethane		ND	ND	ND	ND	ND
1,2-dichloroethane		ND	ND	ND	ND	ND
1,1,1-trichloroethane		0.33(B)	3.99	0.07	0.52	0.46
carbon tetrachloride		ND	0.15	ND	0.10	0.11
benzene		0.08(B)	0.89	0.18	0.40	0.65
trichloroethylene		ND	0.32	ND	0.12	0.10
toluene		0.65	4.67	5.99	2.67	2.56
tetrachloroethylene		0.69	0.79	0.36	0.39	0.42
ethyl benzene		0.60	0.34	0.77	0.13	0.20
m-xylene		1.79	0.87	2.35	0.17	0.53
o-xylene		0.77	0.19	0.92	0.07	0.19
styrene		0.44	0.13	ND	0.05*(B)	0.15
meta ethyltoluene		0.73	0.03*	0.50	ND	0.10
4-phenylcyclohexene **		0.25	0.03	ND	ND	ND
total		6.63	26.95	11.14	12.87	21.12

#. East Tower sample.

(1). Outside. (2). Class No.3. (3). Class No.5.

*: Estimated concentration below limit of quantitation.

**: Not a target compound; results are estimates.

(B): Amounts were not significantly above background levels.

COMBINED NON-TARGET COMPOUNDS

INTERIOR AIR ANALYSIS BY GC/MS

TABLE-3(CONT'D)

SITE NAME : WATERSIDE MALL, WASHINGTON, DC.

SAMPLE LOCATION :	10150	10150	NURSERY(1)	NURSERY(2)	NURSERY(3)
SAMPLE NAME/NUMBER :	217-13	507-14	514-01	514-02	514-03
DATE SAMPLED :	5/24/88	5/25/88	6/03/88	6/03/88	6/03/88
DATE ANALYZED :	5/31/88	6/08/88	6/08/88	6/08/88	6/08/88
FRN :	B0056	B0125	B0128	B0129	B0130
parameter	ppb	ppb	ppb	ppb	ppb
alkanes	53.20	16.10	26.90	9.80	34.20
alkenes/cycloalkanes	----	----	----	0.30	----
alkylbenzenes, C3-C5	----	----	7.80	----	----
polyaromatic hydrocarbons (PAH)	----	----	----	----	----
acetaldehyde	----	----	0.60	1.20	1.30
benzaldehyde	----	----	----	----	----
other aldehydes	----	----	0.60	----	----
alcohols	----	----	----	0.70	----
phenols	----	----	----	----	----
limonene	1.60	----	0.50	0.30	3.20
dichlorobenzene isomers	----	----	0.70	----	----
chloromethane	----	----	----	----	----
siloxane	3.10	0.60	1.30	0.70	2.00
acetone	----	1.10	----	3.70	1.70
acetic acid	----	----	----	0.60	----
acetic acid butyl ester	----	1.20	----	----	----
N-nitro-N-phenyl-benzenamine	----	----	----	----	----
C12H24O3 ester (4)	2.70	----	----	----	----
C12H24O3 ester (5)	3.50	----	----	----	----
other organics	----	0.70	----	0.60	----
total	64.10	19.70	38.40	17.90	42.40

(1) Outside.

(2) Class No. 3.

(3) Class No. 5

(4) Propanoic acid, 2 methyl-2,2-dimethyl-1-(2-hydroxy-1-methylethyl)propyl ester.

(5) Prop[illegible] acid, 2 methyl-3-hydroxy-2 [illegible] 4-trimethylpentyl ester

TARGET COMPOUNDS TABLE-3(CONT'D)

INTERIOR AIR ANALYSIS BY GC/MS

SITE NAME : WATERSIDE MALL, WASHINGTON, DC.

SAMPLE LOCATION	:	LOT BLANK	TRIP BLANK	TRIP BLANK	LOT BLANK	TRIP BLANK
SAMPLE NAME/NUMBER	:	217-LB(1)	217-TB(1)	507-TBA(1)	507-LBA(1)	514-TB(2)
DATE SAMPLED	:	5/24/88	5/24/88	5/25/88	5/25/88	6/03/88
DATE ANALYZED	:	5/27/88	5/31/88	6/06/88	6/6/88	6/08/88
FRN	:	80028	80049	80096	80097	80127
parameter		ppb	ppb	ppb	ppb	ppb
vinyl chloride		ND	ND	ND	ND	ND
1,1-dichloroethene		ND	ND	1.42	ND	ND
trichlorofluoromethane		ND	0.85	0.16	ND	1.12
methylene chloride		0.11	0.15	ND	0.14	0.96
trans-1,2-dichloroethene		ND	ND	ND	ND	ND
1,1-dichloroethane		ND	ND	ND	ND	ND
1,2-dichloroethane		ND	ND	ND	ND	ND
1,1,1-trichloroethane		ND	0.29	1.42	ND	ND
carbon tetrachloride		ND	ND	ND	ND	ND
benzene		ND	0.04*	0.25	0.03*	0.04*
trichloroethylene		ND	ND	ND	ND	ND
toluene		ND	0.20	0.05	0.09	0.09
tetrachloroethylene		ND	0.02*	ND	ND	ND
ethyl benzene		ND	0.04*	0.01*	ND	0.03*
m-xylene		ND	0.12	0.03*	ND	0.03*
o-xylene		ND	0.05	ND	ND	ND
styrene		ND	0.12	0.03*	ND	0.02*
meta ethyltoluene		ND	0.04*	ND	ND	ND
4-phenylcyclohexene **		ND	ND	ND	ND	ND
total		0.11	1.92	3.37	0.26	2.29

(1): Concentrations equivalent to a 18.0 liter sample volum

(2): Concentrations equivalent to a 14.7 liter sample.

*: Estimated concentration below limit of quantitation.

**: Not a target compound; results are estimates.

COMBINED NON-TARGET COMPOUNDS

TABLE-3(CONT'D)

INTERIOR AIR ANALYSIS BY GC/MS

SITE NAME	:	WATERSIDE MALL, WASHINGTON, DC.

SAMPLE LOCATION :	LOT BLANK	TRIP BLANK	TRIP BLANK	LOT BLANK	TRIP BLANK
SAMPLE NAME/NUMBER :	217-LB(1)	217-TB(1)	507-TBA(1)	507-LBA(1)	514-TB(2)
DATE SAMPLED :	5/24/88	5/24/88	5/25/88	5/25/88	6/03/88
DATE ANALYZED :	5/27/88	5/31/88	6/06/88	6/6/88	6/08/88
FRN :	80028	80049	80096	80097	80127
parameter	ppb	ppb	ppb	ppb	ppb
alkanes	0.20	0.10	0.79	0.16	0.76
alkenes/cycloalkanes	0.07	----	0.17	0.07	0.29
alkylbenzenes, C3-C5	----	0.30	0.70	0.30	0.20
polyaromatic hydrocarbons (PAH)	----	----	0.07	----	0.20
acetaldehyde ##	0.08	0.20	1.20	0.30	0.60
benzaldehyde	----	----	0.20	0.10	0.20
other aldehydes	----	0.40	2.26	0.69	0.30
alcohols	----	----	0.19	0.40	0.10
phenols	----	0.20	0.20	0.10	0.08
limonene	----	----	0.08	----	----
dichlorobenzene isomers	----	0.20	----	----	0.09
chloromethane	----	----	----	----	0.09
siloxane	0.10	2.20	1.47	0.70	0.40
acetone	----	----	0.30	0.07	0.10
acetic acid	----	----	----	----	0.30
acetic acid butyl ester	----	----	----	----	----
N-nitro-N-phenyl-benzenamine	----	0.20	0.40	0.10	----
C12H24O3 ester (3)	----	----	0.10	----	0.10
C12H24O3 ester (4)	----	----	----	----	----
other organics	----	0.30	----	0.10	----
total	0.45	4.10	8.13	3.09	3.81

(1) Concentrations equivalent to a 18.0 liter sample volume.

(2) Concentrations equivalent to a 14.7 liter sample.

(3) Propanoic acid, 2 methyl-2,2-dimethyl-1-(2-hydroxy-1-methylethyl)propyl ester.

(4) Propanoic acid, 2 methyl-3-hydroxy-2,4,4-trimethylpentyl ester.

Kn[illegible] Tenax contaminant.

[illegible]2/88

TABLE-4

ANALYSIS RESULTS

4-PHENYLCYCLOHEXENE

SAMPLE LOCATIONS	5/24/88	5/25/88
S-226 (NEW ROOM)	6.65	3.70
S-274	1.30	0.67
2811	2.78	1.70
2827	0.44	0.41
2708.5	3.86	2.63
2710	0.13J	ND
2632	0.37	0.26J
3241	1.86	1.69
3304	0.21J	ND
935	1.19	1.27
1015	0.44	NA
ROOF	ND	ND
2816	*	0.28J

CONC. UNITS PPB.
ND: NOT DETECTED
NA: NOT ANALYZED
* SAMPLE WAS NOT COLLECTED ON 5/24/88

Table 5 (Cont'd)

Formaldehyde Analysis Results

Conc. Units ppb

Location	6/3/88
2632-1	ND
2632-2	ND
2632-3	ND
2632-4	ND
2632-5	ND
2632-6	9.0 J
2710	ND
Day Care Center (Outside)	9.0 J
Day Care Center (Class #3)	ND
Day Care Center (Class #5)	ND

ND - Not Detected (Detection Limit 10 ppb)
J - Detected Below Detection Limits

Table 5

Formaldehyde Analysis Results

Conc. Units ppb

Location	5/24/88	5/25/88
New Room (S-226)	ND	ND
S-274	48.9	7.3 J
2811	9.0 J	ND
2816	NS	ND
2827	46.4	ND
2708.5	ND	36.6
2710	58.7	ND
2632	429.0	284.0
Roof	ND	9.0 J
3241	58.7	5.7 J
3304	ND	ND
935	ND	ND
1015	ND	ND

ND - Not Detected (Detection Limit 10 ppb)
J - Detected Below Detection Limits
NS - Not sampled on 5/24/88

Table 6

May 24, 1988

Analysis Results

Room No.	CO (PPM)	CO_2 (PPM)	% RH	Room Temp (°F)	Time
S-216	7	400	61	75.7	4:30 pm
S-226	8	400	69	74.8	4:35 "
S-274	8	400	59	74.9	4:37 "
2811	7	400	51	71.4	4:42 "
2827	8	400	68	69.9	4:45 "
2708 1/2	7	400	60	77.8	4:50 "
2710 C	7	375	61	72.0	4:55 "
2632	7	400	61	72.8	4:59 "
3241	7	400	50	78.0	5:10 "
3304 C	7	350	60	74.0	5:15 "
935	7	400	52	77.0	5:25 "
1015 C	8	400	49	76.7	5:30 "
Roof	8	300	71	85.0	5:12 "

Table 6 (Cont'd)

May 25, 1988

Analysis Results

Room No.	CO (PPM)	CO_2 (PPM)	% RH	Room Temp (°F)	Time
S-216	7	250	59	79.0	8:40 am
	4	275	63	77.0	11:15 am
	5	500	67	76.5	2:30 pm
S-226	7	300	60	78.5	8:27 am
	5	300	60	75.0	11:00 am
	5	350	62	73.9	2:35 pm
S-274	6	325	52	77.0	8:34 am
	4	300	61	75.0	11:54 am
	5	375	51	72.2	2:40 pm
2811	6	300	59	72.0	8:45 am
	5	275	55	73.0	11:09 am
	5	275	59	70.0	2:50 pm
2827	5	275	65	71.0	8:48 am
	5	375	60	68.1	11:13 am
	5	275	61	72.0	3:00 pm
2708 1/2	5	275	61	72.0	8:53 am
	5	300	61	74.0	11:18 am
	5	425	60	71.7	3:05 pm
2710 C	5	275	69	69.0	8:52 am
	5	275	69	68.0	11:20 am
	5	450	65	70.0	3:08 pm
2632	5	275	60	73.0	9:04 am
	5	275	59	71.0	11:24 pm
	5	525	67	73.0	3:17 pm
3241	5	350	50	76.0	9:20 am
	5	300	59	77.0	11:30 am
	4	375	52	75.0	3:54 pm
3304 C	5	300	61	73.0	9:30 am
	6	275	61	73.0	11:40 am
	4	375	52	72.0	3:26 pm

(Cont'd) - Table 6 (May 25, 1988)

Room No.	CO (PPM)	CO_2 (PPM)	% RH	Room Temp (°F)	Time
935	5	350	60	76.0	9:36 am
	6	325	65	75.0	11:55 am
	4	350	43	74.0	3:45 pm
1015 C	5	350	60	77.0	9:45 am
	5	350	59	77.0	11:50 am
	5	-	56	76.0	3:50 pm
Roof	5	200	79	59.0	9:07 am
	4	275	84	62.0	11:08 am
	3	300	86	65.5	3:25 pm

TABLE 7.

TYPICAL INDOOR CONCENTRATIONS OF SELECTED COMPOUNDS

Compound	Concentration (ppb)	Common Sources
Toluene	3 - 160 (1) 33.7 (3), 14.6 (4) 2.4 (5)	Petroleum based cleaning solvents, Paints & paint removers, spray deodorants, Nail basecoat & polish, Furniture polish; silicon caulking
Benzene	3 - 16 (1) 9.4 (2) 16.3 (3), 3.1 (4) 4.7 (6a & 6d), 1.4 (6e & 6f) 3.4 (6g)	Same sources as toluene with exception of nail basecoat and polish; cigeratte smokers in household; Additional source -particle board
Ethyl benzene	1 - 9 (1) 1.5 (2 & 6a), 9.3 (3) 1.2 (4 & 6c), 1.1 (6b) 1.8 (6d), 0.6 (6e & 6h) 0.4 (6f), 0.5(6g)	Same sources as benzene with exception of particle board
Xylenes	3 - 29 (1) 1.2 - 3.7 (2) 2.0 - 28.8 (6) 28.8 (3), 4.8 (4)	Same sources as ethyl benzene
Alkanes (pentane and lower)	no data in ppb	Same sources as toluene plus general cleaning solvents, floor waxes, lower MW alkanes also occassionally used as spray propellents

TABLE 7 (cont.)

TYPICAL INDOOR CONCENTRATIONS OF SELECTED COMPOUNDS

Compound	Concentration (ppb)	Common Sources
Alkane (hexane and higher molecular weight hydrocarbons)	1.4 - 122 (1)	Some glass cleaners, room deodorizers, floor polishes, wood stains, and furniture polish
(basically pentane and hexane will be found in any substance containing petroleum distillates or kerosene)		
Methylene Chloride	372 (3) 6 (*)	Tar removers & tire patch, paint strippers, some mothballs, car engine cleaners & common spray can propellant
(* value found in detached table w/ no reference)		
Trichloroethylene	.4 - 13 (1) 0.5 (2), 3.5 (3) 0.3 (4 & 6c), 0.4 (6a) 0.5 (6b), 0.2 (6d & 6g) 0.1 (6e & 6), <0.1 (6f)	General cleaning solvents, metal cleaners, tire patches, & degreasers
Tetrachloroethane	0.6 - 29 (1) 0.3 - 1.2 (6) 2.5 (3), 0.6 (4) 0.9 (5)	Latex paints, residual dry cleaning solvents in clothing, metal degreasers, dewaxing and stripping solvents, upholstery cleaners, general household cleaning solvents.
1,1,1-Trichloroethane (Methyl Chloroform)	1.7 (2) 2.7 - 53 (1) 4.0 (3), 3.1 (6a) 2.2 (6b), 3.3 (6c) 4.8 (6d), 1.3 (6e) 0.8 (6f), 4.8 (6g) 6.8 (6h)	General cleaning solvents, dry cleaning solvents, non-caustic drain cleaners, carpet & upholstery cleaners, metal cleaners, auto engine cleaners, and degreaser compounds.

TABLE 7 (cont.)

TYPICAL INDOOR CONCENTRATIONS OF SELECTED COMPOUNDS (REFERENCES)

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(2) <u>Environment International</u>, Vol. 12, 369, 1986; "Total Exposure Assessment Methodology (TEAM) Study: Personal Exposures, Indoor-Outdoor Relationships, and Breath Levels of Volatile Organic Compounds in New Jersey"; Wallace, L.A., et. al. (concentrations are the reported Geometric Mean of overnight personal air values)

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(4) "Proceedings of the 3rd International Conference on Indoor Air Quality and Climate"; B. Berglund, T. Lindvall, & J. Sundell, ed.; Liber Tryck AB, Stockholm, 1984; "Volatile Hydrocarbons in Dutch Homes", E. Lebret, et. al.; pp. 169-174.

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Project Participants

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3. Singhvi, R.; Burchette, S.M.; Rodney, T. 1988. Final report on the Sampling and Analyses of Carpet and Harter partition off gases collected at the Warehouse and Navy yard at USEPA HQ., Washington, DC. on May 6,1988. Environmental Response Branch, USEPA, Edison, N.J. 08837.

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APPENDIX G

February 17, 1989, Internal EPA Report

A FINAL SUMMARY REPORT ON THE INDOOR AIR MONITORING PERFORMED AT USEPA HEADQUARTERS, WASHINGTON, DC ON NOVEMBER 6-8, 1988

A FINAL SUMMARY REPORT ON THE INDOOR AIR MONITORING PERFORMED AT USEPA HEADQUATERS, WASHINGTON, D.C. ON NOVEMBER 6-8, 1988

February 17, 1989

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Indoor Air Quality Monitoring
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Introduction:

During November 6 through November 8, 1988, the Environmental Response Team (ERT), assisted by the Response Engineering Analytical Contract (REAC), conducted an Indoor Air Quality (IAQ) Survey at EPA Headquarters in Waterside Mall. This survey was undertaken at the request of the Director, Hazardous Site Control Division (HSCD), to determine whether indoor airborne contaminants were present, since a number of employee health complaints had been received, from the South East section of the Mall. In addition, concerns were still being expressed over the air quality in the day care center, and it too was resampled.

Sampling:

The sampling locations were selected in consultation with several concerned employees and in consideration of the operating schedule of the ventilation system and the real-time carbon dioxide concentrations, which indicate areas of low air circulation. The sampling locations in the day care center were selected based on a previous study (1). The eight locations selected for the IAQ Survey were Offices 2123, SE-274D, 2827, 2710, day care center classrooms 2 and 5, and the south entrance of the day care center, and the Roof for outdoor ambient air.

Indoor air samples were collected on November 6 and 7, 1988, for volatile organic compounds, formaldehyde/acrolein and 4-Phenylcyclohexene (4PC). The purpose of the Sunday (November 6) monitoring was to collect data when the ventilation system was off and poential off-gasing products could accumulate in the offices. The Monday (November 7) monitoring was conducted to determine the level of various compounds during normal office activities (ventilation turned on). The air supply vents were operating in the day care center on both days of the indoor air monitoring.

On November 7, 1988, indoor air samples were also collected for volatile organic compounds in the evening in the absence of normal office work activities. Microbial monitoring was conducted by the Environmental Health and Saftey Division (EHSD) and performed on November 8, 1988, by EHSD'S contract (Science Applications International Corporation (SAIC), Virginia).

ANALYTICAL:

The volatile organic compounds were collected on Tenax/CMS tubes for a five hour period and analyzed by Gas Chromatography/Mass Spectroscopy (GC/MS) quantitatively for several target compounds and semiquantitatively (relative to the toluene response) for the non-target compounds. The 4PC samples were collected on 600 mg charcoal tubes for ten hours and analyzed using Gas Chromatography/Flame Ionization Detector (GC/FID). Selected samples were confirmed by GC/MS. The details of these collection procedures are shown in Table 1. Also, GC/FID results were used for fingerprinting purposes. The formaldehyde/acrolein samples were collected on Orbo tubes supplied by Galson Laboratories and analyzed by Gas Chromatography/Nitrogen Phosphrous Detector (GC/NPD) using OSHA Method 52.

Quality Assurance/Quality Control:

Each type of analysis conformed with standard methods with some modification to meet the objective of this study. In almost all cases, the quality control checks were within the accepted limits for the particular analysis performed.

Summary of Results:

The analytical results of the IAQ Survey are summarized in Appendix A. Low ppb levels of organic compounds were found in all the offices monitored and in the day care center on all two days. The concentration of trichlorofluoromethane was in the range of 6.72 to 43.19 ppb, with an average of 19 ppb and a standard deviation of 12.9 ppb. In the previous studies, the highest concentration of trichlorofluoromethane found was 4 ppb. This compound, however, is a common laboratory contaminant, and the results are suspect. Formaldehyde was detected at 40 ppb in the outside air. This value is significantly above the normal ambient level found in the U.S., and the data are questionable. Also, on Sunday (November 6) in office S-274D, 20 ppb of formaldehyde was detected, but it was not detected on Monday (November 7). Acrolein was not detected at any location. The 4PC, one of the main off-gas components of the carpets was detected on Sunday in two offices at the 0.1 ppb level. No significant differences were observed between this study and the previous ERT studies (1-3) conducted at Waterside Mall for volatile organic compounds.

Indoor air samples collected for a ten-hour period on charcoal tubes and analyzed by GC/FID were used to compare the indoor air quality for Sunday and Monday monitoring. The day care center fingerprinting comparisons are presented in appendix B Figures 1, 2 and 3. The estimated organic concentration in the day care

INDOOR AIR MONITORING, USEPA, HQ. (Nov. 6 through Nov. 8, 1988.)

TABLE-1

SAMPLING AND ANALYSES :

PARAMETER	ANALYTICAL METHOD	TOTAL SAMPLE VOLUME LITERS	SAMPLING TIME HOURS	SAMPLING MEDIA	INSTRUMENTS USED
VOLATILE ORGANIC COMPOUNDS	MODIFIED EPA TO-1	6	5	TENAX/CMS	GC/MS
4-PHENYLCYCLOHEXENE	ERT-10	1200	10	CHARCOAL	GC/FID CONFIRMED BY GC/MS
FORMALDEHYDE/ACROLEIN *	OSHA 52	30	5	ORBO TUBE	GC/NPD

* ANALYSES BY GALSON LABORATORIES.

center on Sunday (November 6) was in the range 2 to 5 ppb and on Monday (November 7) 10 to 36 ppb. The GC/MS analyses shows the presence of hydrocarbons at low ppb levels. The hydrocarbon presence could be attributed to the parking garage. Further investigation would be necessary to identify the source. The EPA Headquarters fingerprinting comparison are presented in appendix B Figures 4, 5, 6, 7 and 8. The fingerprinting pattern in office 2710 is similiar to the day care center, 3 ppb on Sunday, and 10 ppb on Monday. In other offices, there were no significant differences in volatile organic compound concentrations between the two days.

There was not enough information available on the ventilation system to evaluate its contribution to the problem. However, the following observations were made: Office 2123 air supply vents were disconnected; Day care center air supply vents were operating on both days; air supply vents were Off on Sunday and were operating on Monday in Offices 2710, 2827 and SE-274D. The carbon dioxide, carbon monoxide, percent relative humdity and temperatures were found to be normal for office environments.

Conclusions:

The low ppb levels of organic compounds found in this study are the same as those found in the Waterside Mall, EPA offices indoor air in the previous EPA studies (1-3). The only compound that was found at different concentrations during the last ten month period was 4PC. In general 4PC decreased from 6.65 ppb (May 24, 88) to 0.12 ppb (November 6, 88). The results are listed in Table 2.

APPENDIX A

:REFERENCES:

1. Singhvi, R.; Burchette, S.M.; Turpin, R.D. 1988 (Oct. 25). A Final Summary Report on the Indoor Air Monitoring Performed at USEPA Headquaters, Washington, D.C. on May 24, 25 and June 6, 1988. Environmental Response Branch, USEPA, Edison, N.J. 08837.

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TABLE-2

ANALYSES RESULTS

4-Phenylcyclohexene
(Conc. in ppb)

Sample Location	5/24/88	5/25/88	6/29/88	8/11/88	11/6/88	11/7/88
SE-274	1.30	0.67	NS	NS	0.07	ND(0.07)
SE-226	6.65	3.70	0.76	0.22	NS	NS
2708.5	3.86	2.63	0.56	NS	NS	NS
2710	ND(0.30)	ND(0.30)	0.21 *	ND(0.20)	ND(0.06)	ND(0.06)
3241	1.84	1.69	ND(0.15)	NS	NS	NS
2827	0.44	0.41	NS	NS	0.12	ND(0.10)

* GC/MS analysis does not confirm the presence of 4PC.
ND: not detected.
( ): denotes sample conc. below limit of quantification.
NS: not sampled.

TABLE-1A

4-Phenylcyclohexene
(Conc. in ppb)

Sample Location	11/6/88	11/7/88
Roof(outside air)	ND(0.064)	ND(0.075)
2123 $	ND(0.064)	ND(0.064)
✓SE-274D #	0.074	ND(0.087)
✓2827 #	0.122	ND(0.100)
2710 #	ND(0.064)	ND(0.064)
South Entrance(Day Care)	ND(0.064)	ND(0.120)
Day Care Class #2*	ND(0.064)	ND(0.090)
Day Care Class #5*	ND(0.064)	ND(0.064)

ND: denotes not detected.
( ): denotes sample conc. below limit of quantification.
* air supply vents on both days.
\# air supply vents OFF on 11/6/88 and ON on 11/7/88.
$ air supply vents disconnected.

TABLE-2A

Acrolein
(Conc. in ppb)

Sample Location	11/6/88	11/7/88
Roof(outside air)	ND(20)	ND(20)
2123 $	ND(20)	ND(20)
SE-2740 #	ND(20)	ND(20)
2827 #	ND(20)	ND(20)
2710 #	ND(20)	ND(20)
South Entrance(Day Care) *	ND(20)	ND(20)
Day Care Class #2*	ND(20)	ND(20)
Day Care Class #5*	ND(20)	ND(20)

ND: denotes not detected.
( ): denotes sample detection limits.
* air supply vents on both days
# air supply vents OFF on 11/6/88 and ON 11/7/88.
$ air supply vents disconnected.

INDOOR AIR MONITORING USEPA, HQ.

TABLE-3A

Formaldehyde
(Conc. in ppb)

Sample Location	11/6/88	11/7/88
Roof(outside air)	40	30
2123 $	ND(8)	ND(8)
SE-2740 #	20	ND(8)
2827 #	ND(8)	ND(8)
2710 #	ND(8)	ND(8)
South Entrance(Day Care) *	ND(8)	ND(8)
Day Care Class #2*	ND(8)	ND(8)
Day Care Class #5*	ND(8)	ND(8)

ND: denotes not detected.
( ): denotes sample detection limits.
* air supply vents on both days
# air supply vents OFF on 11/6/88 and ON on 11/7/88
$ air supply vents disconnected.

TARGET COMPOUNDS TABLE-4A-1

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INDOOR AIR ANALYSIS BY GC/MS

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SITE NAME :WATERSIDE MALL - 11/6/88

SAMPLE NAME/NUMBER	:TRAVEL	7322-A	7322-B	7322-C	7336-A	7336-B	7336-C	7205-A	7205-B	DUP 7205-B	7205-C	3412-A	3412-B	DUP 3412-B	3412-C	7342-A	DUP 7342-A	7342-B	7342-C
SAMPLING LOCATION	:BLK	ROOF	ROOF	ROOF	2827	2827	2827	2710	2710	2710	2710	2123	2123	2123	2123	S-274	S-274	S-274	S-274
DATE ANALYZED	:11/18	11/21	11/23	11/30	11/21	11/23	11/29	11/21	11/23	11/23	11/29	11/21	11/23	11/23	11/29	11/18	11/21	11/23	11/29
DATE SAMPLED	:11/6	11/6	11/7	11/8	11/6	11/7	11/8	11/6	11/7	11/7	11/8	11/6	11/7	11/7	11/8	11/6	11/6	11/7	11/8
FRN	:B1005	B1021	B1051	B1087	B1023	B1046	B1075	B1025	B1043	B1044	B1067	B1026	B1049	B1050	B1072	B2006	B1027	B1047	B1077
parameter	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
vinyl chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trichlorofluoromethane *	6.72	11.54	14.29	28.08	32.77	41.19	1.82	9.70	43.19	26.28	2.47	30.03	10.72	26.17	7.83	14.16	25.14	14.55	BLOQ
1,1-dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	BLOQ	ND	ND	ND
methylene chloride	0.56	2.29	1.52	5.06	8.92	7.53	1.50	1.27	8.04	4.31	0.85	7.41	1.39	5.82	3.24	2.24	4.45	1.29	0.94
trans-1,2-dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-trichloroethane	0.46	0.84	BLOQ	1.87	1.67	0.33	0.90	1.01	0.96	0.90	0.54	1.09	0.34	0.33	1.78	1.87	1.77	0.31	0.73
carbon tetrachloride	ND	BLOQ	ND	0.33	0.27	BLOQ	ND	BLOQ	0.18	0.20	ND	0.25	ND	0.18	ND	BLOQ	0.28	ND	BLOQ
benzene	5.27	0.59	0.43	1.67	0.55	0.67	0.74	0.67	0.74	0.62	1.12	0.53	0.45	0.73	1.42	0.97	0.49	0.74	1.15
1,2-dichloroethane	ND	0.19	ND	0.69	0.74	0.47	ND	BLOQ	0.62	0.58	ND	0.64	0.45	0.56	BLOQ	0.35	0.26	ND	BLOQ
trichloroethylene	ND	ND	ND	0.41	0.37	0.23	ND	ND	0.28	0.27	ND	0.32	0.22	0.25	BLOQ	0.27	0.17	ND	BLOQ
toluene	0.24	1.05	0.93	6.65	2.97	2.79	1.83	1.30	2.97	2.70	2.10	4.31	3.19	3.73	5.45	4.32	2.18	1.71	2.11
tetrachloroethylene	BLOQ	ND	BLOQ	0.41	0.91	0.28	BLOQ	0.26	0.36	0.35	BLOQ	1.18	BLOQ	0.29	0.41	1.16	0.79	0.29	ND
ethyl benzene	BLOQ	0.18	BLOQ	0.91	0.53	0.35	0.24	BLOQ	0.41	0.40	0.32	0.49	0.36	0.44	0.64	0.74	0.38	0.24	0.34
m-xylene	BLOQ	0.42	0.32	1.49	0.98	0.67	0.84	0.43	0.73	0.69	1.05	0.96	0.79	1.05	1.95	1.74	0.93	0.73	0.94
o-xylene	ND	0.25	BLOQ	0.68	0.50	0.37	0.28	0.19	0.36	0.41	0.40	0.43	0.35	0.51	0.76	0.78	0.20	0.31	0.35
styrene	BLOQ	ND	BLOQ	BLOQ	ND	BLOQ	BLOQ	BLOQ	0.30	0.28	0.18	0.30	BLOQ	0.33	0.33	0.87	0.39	BLOQ	0.29
meta-ethyltoluene	ND	0.27	ND	0.32	0.32	0.26	0.32	BLOQ	0.32	0.28	0.52	0.23	0.18	0.43	0.81	0.80	0.37	0.29	0.42
total (targets)	13.3	17.6	17.5	48.6	51.5	55.1	8.5	14.8	59.5	38.3	9.6	48.2	18.4	40.8	24.6	30.3	37.8	20.5	7.3
total non targets #	9.9	20.8	5.0	23.4	40.9	33.9	13.5	12.6	36.7	49.2	31.2	26.4	25.0	48.2	58.3	62.6	35.7	23.0	32.5
TOTAL VOC	23.2	38.4	22.5	72.0	92.4	89.0	22.0	27.4	96.2	87.5	40.8	74.6	43.4	89.0	82.9	92.9	73.5	43.5	39.8
Limit of Quantitation (in ppb) @	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.167

ND. Not Detected.

BLOQ. Below Limit of Quantitation.

* possible lab contamination

Non target total from page 2 of Table 4A-1.

@ Calculated Limit of Quantitation = (Lowest Calibration Volume)x(Standard Concentration) / Sample Volume

COMBINED NON-TARGET COMPOUNDS TABLE-4A-1

INDOOR AIR ANALYSIS BY GC/MS

SITE NAME :WATERSIDE MALL - 11/6/88

SAMPLE NAME/NUMBER	:TRAVEL	7322-A	7322-B	7322-C	7336-A	7336-B	7336-C	7205-A	7205-B	DUP 7205-B	7205-C	3412-A	3412-B	DUP 3412-B	3412-C	7342-A	DUP 7342-A	7342-B	7342-C
SAMPLING LOCATION	:BLK	ROOF	ROOF	ROOF	2827	2827	2827	2710	2710	2710	2710	2123	2123	2123	2123	S-274	S-274	S-274	S-274
DATE ANALYZED	:11/18	11/21	11/23	11/29	11/21	11/23	11/29	11/21	11/23	11/23	11/29	11/21	11/23	11/23	11/29	11/18	11/21	11/23	11/29
DATE SAMPLED	:11/6	11/6	11/7	11/8	11/6	11/7	11/8	11/6	11/7	11/7	11/8	11/6	11/7	11/7	11/8	11/6	11/6	11/7	11/8
FRN	:B1005	B1021	B1051	B1087	B1023	B1046	B1075	B1025	B1043	B1044	B1067	B1026	B1049	B1050	B1072	B2006	B1027	B1047	B1077
parameter	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	pbb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
alkanes	1.3	1.8	1.1	9.0	9.9	7.4	4.6	5.6	17.0	21.4	16.1	11.0	7.9	22.4	41.9	25.9	14.1	8.6	18.2
alkenes/cycloalkanes	ND	0.3	ND	2.4	ND	0.3	ND	ND	ND	0.3	ND	0.4	0.6	0.8	0.8	ND	0.3	1.3	ND
alkybenzenes,C3-C5	ND	0.2	ND	0.7	0.5	ND	1.3	ND	0.4	ND	0.8	ND	ND	0.5	1.3	0.9	1.5	1.1	0.3
polyaromatic hydrocarbons	ND	ND	ND	0.4	0.7	0.4	ND	ND	ND	0.4	ND	ND	ND	1.8	ND	1.4	ND	ND	ND
acetaldehyde #	1.1	1.2	0.6	ND	1.0	0.7	0.8	0.6	1.2	0.9	0.8	1.3	1.3	1.3	0.7	1.8	0.9	0.7	1.5
benzaldehyde	0.3	5.1	0.2	ND	1.4	1.3	ND	0.8	ND	ND	1.3	ND	ND	2.8	ND	2.1	ND	ND	ND
other aldehydes	0.4	1.0	ND	0.4	1.4	0.3	ND	0.3	0.3	0.3	0.6	0.5	1.2	ND	ND	2.8	0.7	ND	0.3
alcohols	0.6	0.6	1.0	ND	8.0	9.1	0.3	ND	2.6	10.4	0.7	ND	2.7	2.3	2.8	12.1	4.1	0.9	ND
phenols	ND	0.4	ND	ND	0.8	0.7	ND	0.3	ND	ND	ND	ND	ND	0.6	ND	ND	ND	ND	ND
limonene	ND	ND	ND	ND	0.5	ND	ND	ND	0.5	ND	0.6	ND	ND	ND	1.5	ND	1.0	0.2	0.5
dichlorobenzene isomers	ND	1.1	ND	ND	1.0	0.4	ND	ND	0.7	0.7	ND	ND	ND	1.0	ND	1.1	0.8	ND	ND
chloromethane	ND	ND	0.2	7.2	0.6	0.3	ND	ND	0.4	ND	ND	3.5	0.3	ND	ND	ND	ND	ND	ND
siloxane *	4.4	4.2	0.7	3.3	8.9	9.5	5.1	3.1	10.1	11.0	8.4	3.7	3.9	9.4	7.2	10.3	7.4	8.7	10.3
acetone	0.4	3.7	1.2	ND	5.2	2.7	1.1	ND	3.1	3.8	1.9	5.8	7.1	3.8	2.1	4.2	3.7	1.5	1.2
acetic acid	0.7	0.4	ND	ND	1.0	0.8	0.3	1.6	0.4	ND	ND	0.2	ND	1.5	ND	ND	1.2	ND	0.2
acetic acid butyl ester	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
N.P.B.A. (3)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C12H24O3 ester (1)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C12H24O3 ester (2)	0.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
other organics	0.4	0.8	ND	ND	ND	ND	ND	0.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
total	9.9	20.8	5.0	23.4	40.9	33.9	13.5	12.6	36.7	49.2	31.2	26.4	25.0	48.2	58.3	62.6	35.7	23.0	32.5

ND: Not Detected

(1) Propanoic acid, 2 methyl-2,2-dimethyl-1-(2-hydroxy-1-methylethyl)propyl ester.

(2) Propanoic acid, 2 methyl-3-hydroxy-2,4,4-trimethylpentyl ester.

(3) N-nitro-N-phenyl-benzenamine

* system contamination

\# known [redacted] contamination

TARGET COMPOUNDS   TABLE-4A-2

INDOOR AIR ANALYSIS BY GC/MS

SITE NAME : WATERSIDE MALL - 11/6/88

SAMPLE NAME/NUMBER	TRAVEL	7322-A	7322-B	7322-C	7327-A	7327-B $	7327-C	3413-A	3413-B	3413-C	DUP 3413-C	7167-A	7167-B	7167-C
SAMPLING LOCATION	BLK	ROOF	ROOF	ROOF	S.ENTRANCE	S.ENTRANCE	S.ENTRANCE	DAYCARE #2	DAYCARE #2	DAYCARE #2	DAYCARE #2	DAYCARE #5	DAYCARE #5	DAYCARE #5
DATE ANALYZED	11/18	11/21	11/23	11/30	11/21	11/23	11/29	11/21	11/23	11/29	11/29	11/18	11/23	11/29
DATE SAMPLED	11/6	11/6	11/7	11/8	11/6	11/7	11/8	11/6	11/7	11/8	11/8	11/6	11/7	11/8
FRN	B1005	B1021	B1051	B1087	B1022	B1052	B1068	B1024	B1045	B1069	B1071	B1007	B1048	B1073
parameter	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
vinyl chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trichlorofluoromethane *	6.72	11.54	14.29	28.08	41.25	7.31	19.17	10.30	14.21	38.15	37.15	11.87	3.24	20.96
1,1-dichloroethene	ND	ND	ND	ND	ND	BLOQ	ND	ND	ND	ND	ND	BLOQ	ND	ND
methylene chloride	0.56	2.29	1.52	5.06	6.98	1.73	3.29	1.75	2.68	7.59	9.81	2.40	1.00	2.41
trans-1,2-dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-trichloroethane	0.46	0.84	BLOQ	1.87	0.78	BLOQ	2.43	0.85	0.54	1.29	1.18	0.80	0.33	0.80
carbon tetrachloride	ND	BLOQ	ND	0.33	0.22	ND	ND	BLOQ	BLOQ	0.35	0.35	BLOQ	ND	ND
benzene	5.27	0.59	0.43	1.67	0.51	2.67	1.90	0.29	0.68	1.33	1.33	0.67	0.51	1.10
1,2-dichloroethane	ND	0.19	ND	0.69	0.54	BLOQ	ND	ND	0.26	0.84	0.81	0.22	ND	ND
trichloroethylene	ND	ND	ND	0.41	0.30	ND	ND	ND	ND	0.40	0.39	BLOQ	ND	ND
toluene	0.24	1.05	0.93	6.65	2.76	0.20	4.69	1.06	2.95	4.15	4.86	1.97	2.41	2.45
tetrachloroethylene	BLOQ	ND	BLOQ	0.41	0.67	BLOQ	BLOQ	0.26	0.43	0.38	0.54	0.33	0.30	0.26
ethyl benzene	BLOQ	0.18	BLOQ	0.91	0.37	BLOQ	BLOQ	BLOQ	0.33	BLOQ	0.71	0.37	0.17	0.34
m-xylene	BLOQ	0.42	0.32	1.49	0.68	BLOQ	1.98	0.43	0.85	BLOQ	1.31	1.00	0.54	1.09
o-xylene	ND	0.25	BLOQ	0.68	0.36	BLOQ	BLOQ	BLOQ	0.40	ND	0.71	0.44	0.23	0.46
styrene	BLOQ	ND	BLOQ	BLOQ	0.30	BLOQ	BLOQ	ND	0.25	ND	0.51	0.27	ND	0.18
meta-ethyltoluene	ND	0.27	ND	0.32	0.25	ND	ND	ND	0.38	ND	0.43	0.29	0.22	0.39
total (targets)	13.3	17.6	17.5	48.6	56.0	11.9	33.5	14.9	24.0	54.5	60.1	20.6	9.0	30.4
total non targets #	9.9	20.8	5.0	23.4	30.5	5.6	26.5	9.3	129.5	13.8	44.7	21.8	30.8	20.0
TOTAL VOC	23.2	38.4	22.5	72.0	86.5	17.5	60.0	24.2	153.5	68.3	104.8	42.4	39.8	50.4
Limit of Quantitation (in ppb) @	0.167	0.167	0.167	0.167	0.167	0.167	1.04	0.167	0.167	0.167	0.167	0.167	0.167	0.167

ND. Not Detected.
BLOQ. Below Limit of Quantitation.
* possible lab contamination
$ low surrogate recoveries, data rejected.

@ Calculated Limit of Quantitation = (Lowest Calibration Volume)x(Standard Concentration) / Sample Volume

COMBINED NON-TARGET COMPOUNDS TABLE-4A-2

INDOOR AIR ANALYSIS BY GC/MS

SITE NAME	: WATERSIDE MALL - 11/6/88													
SAMPLE NAME/NUMBER	: TRAVEL	7322-A	7322-B	7322-C	7327-A	7327-B S	7327-C	3413-A	3413-B	3413-C	DUP 3413-C	7167-A	7167-B	7167-C
SAMPLING LOCATION	: BLK	ROOF	ROOF	ROOF	S.ENTRANCE	S.ENTRANCE	S.ENTRANCE	DAYCARE #2	DAYCARE #2	DAYCARE #2	DAYCARE #2	DAYCARE #5	DAYCARE #5	DAYCARE #5
DATE ANALYZED	: 11/18	11/21	11/23	11/30	11/21	11/23	11/29	11/21	11/23	11/29	11/29	11/18	11/23	11/29
DATE SAMPLED	: 11/6	11/6	11/7	11/8	11/6	11/7	11/8	11/6	11/7	11/8	11/8	11/6	11/7	11/8
FRN	: B1005	B1021	B1051	B1087	B1022	B1052	B1068	B1024	B1045	B1069	B1071	B1007	B1048	B1073
parameter	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
alkanes	1.3	1.8	1.1	9.0	6.2	1.0	14.5	1.6	96.9	7.4	27.3	6.2	20.2	12.3
alkenes/cycloalkanes	ND	0.3	ND	2.4	ND	ND	ND	ND	ND	0.4	0.9	ND	ND	ND
alkybenzenes,C3-C5	ND	0.2	ND	0.7	0.3	ND	ND	ND	ND	ND	ND	0.2	ND	0.6
polyaromatic hydrocarbons	ND	ND	ND	0.4	0.3	ND	ND	ND	3.6	ND	ND	ND	ND	ND
acetaldehyde #	1.1	1.2	0.6	ND	0.8	0.4	1.3	0.5	1.7	0.7	0.6	1.3	0.9	0.7
benzaldehyde	0.3	5.1	0.2	ND	1.4	ND	ND	0.6	ND	ND	ND	ND	ND	ND
other aldehydes	0.4	1.0	ND	0.4	1.0	ND	ND	0.3	ND	ND	ND	2.4	ND	ND
alcohols	0.6	0.6	1.0	ND	9.6	0.9	3.8	1.1	7.6	0.3	7.4	3.6	1.4	1.1
phenols	ND	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
limonene	ND	ND	ND	ND	0.3	ND	ND	ND	ND	ND	ND	ND	0.8	ND
dichlorobenzene isomers	ND	1.1	ND	ND	0.6	ND	ND	ND	ND	ND	ND	0.4	ND	ND
chloromethane	ND	ND	0.2	7.2	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND
siloxane *	4.4	4.2	0.7	3.3	6.0	1.8	5.7	2.9	11.3	0.7	4.3	4.5	5.1	3.8
acetone	0.4	3.7	1.2	ND	3.6	1.2	1.2	0.8	6.0	4.3	4.2	3.2	1.8	1.5
acetic acid	0.7	0.4	ND	ND	ND	0.3	ND	0.7	ND	ND	ND	ND	ND	ND
acetic acid butyl ester	ND	ND	ND	ND	ND	ND	ND	ND	2.4	ND	ND	ND	0.6	ND
N.P.B.A. (3)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C12H24O3 ester (1)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C12H24O3 ester (2)	0.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
other organics	0.4	0.8	ND	ND	ND	ND	ND	0.8	ND	ND	ND	ND	ND	ND
total	9.9	20.8	5.0	23.4	30.5	5.6	26.5	9.3	129.5	13.8	44.7	21.8	30.8	20.0

ND: Not Detected

(1) Propanoic acid, 2 methyl-2,2-dimethyl-1-(2-hydroxy-1-methylethyl)propyl ester.

(2) Propanoic acid, 2 methyl-3-hydroxy-2,4,4-trimethylpentyl ester.

(3) N-nitro-N-phenyl-benzeneamine

* system contamination

known [redacted] contamination

APPENDIX B

INDOOR AIR MONITORING, USEPA, HQ.

TABLE-18

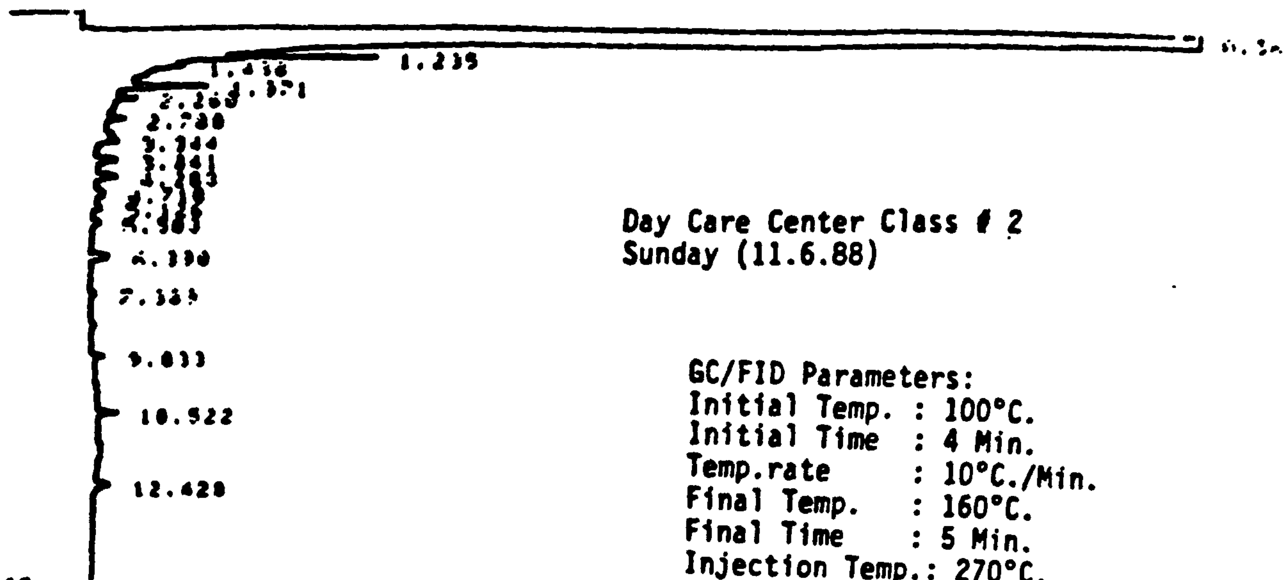
TOTAL VOLATILE ORGANIC ESTIMATED CONC. IN PPB**

SAMPLING LOCATIONS	SUNDAY(11.6.88)	MONDAY(11.7.88)
DAY CARE CENTER #2 *	5	33
DAY CARE CENTER #5 *	2	10
DAY CARE CENTER SOUTH ENTRANCE *	3	36
2710 #	3	10
2123 $	12	16
2827 #	7	5
SE-2740 #	10	8
ROOF	2	4

* air supply vents on both days.
# air supply vents OFF on 11/6/88 and ON 11/7/88.
$ air supply vents disconnected.

** CHARCOAL TUBE ANALYSES (ORGANIC COMPOUND FOUND ARE INCLUDED IN TABLE-4)
Calculated with respect to 4PC GC/FID response.
Results used for comparison purpose only.

RUN # 68 NOV 10, 1988
START



STOP

Day Care Center Class # 2
Sunday (11.6.88)

GC/FID Parameters:
Initial Temp. : 100°C.
Initial Time : 4 Min.
Temp.rate : 10°C./Min.
Final Temp. : 160°C.
Final Time : 5 Min.
Injection Temp.: 270°C.
Detector Temp. : 225°C.
DB-624 Megabore column

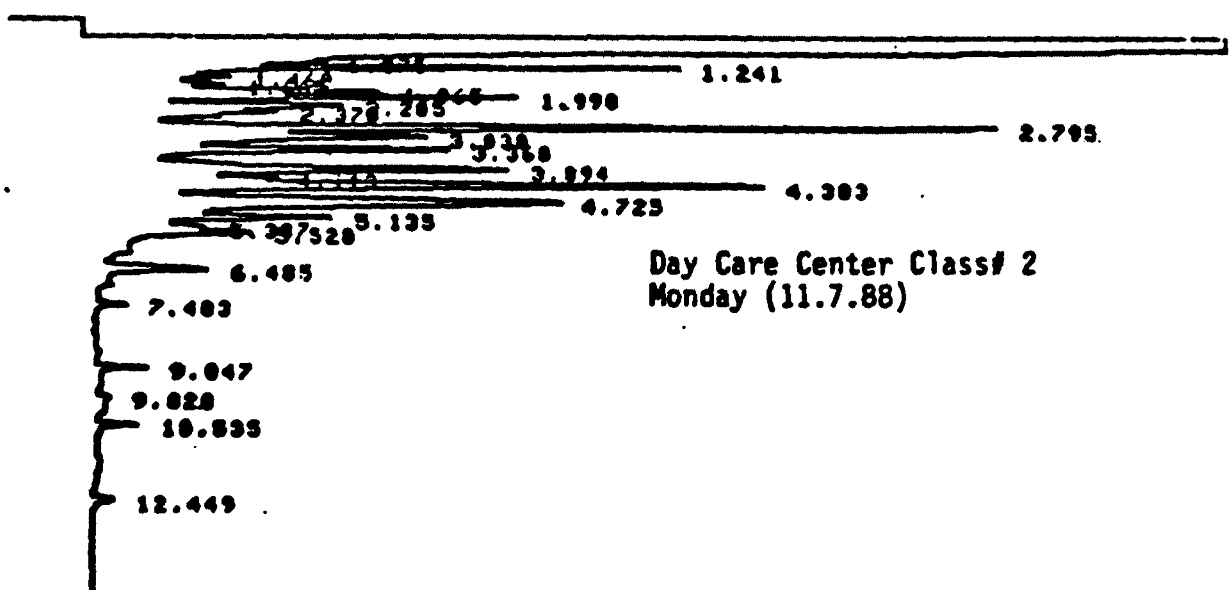
Closing signal file A:07642731.BNC

RUN# 68 NOV 10, 1988 05:35:44

SAMPLE NAME: 7324A FRONT SAMPLE# 31
METHOD NAME: N:PCH_4.MET

RUN # 47-083

RUN # 48 NOV 9, 1988 23:09:07
START



STOP

Day Care Center Class# 2
Monday (11.7.88)

Closing signal file A:0763CC94.BNC

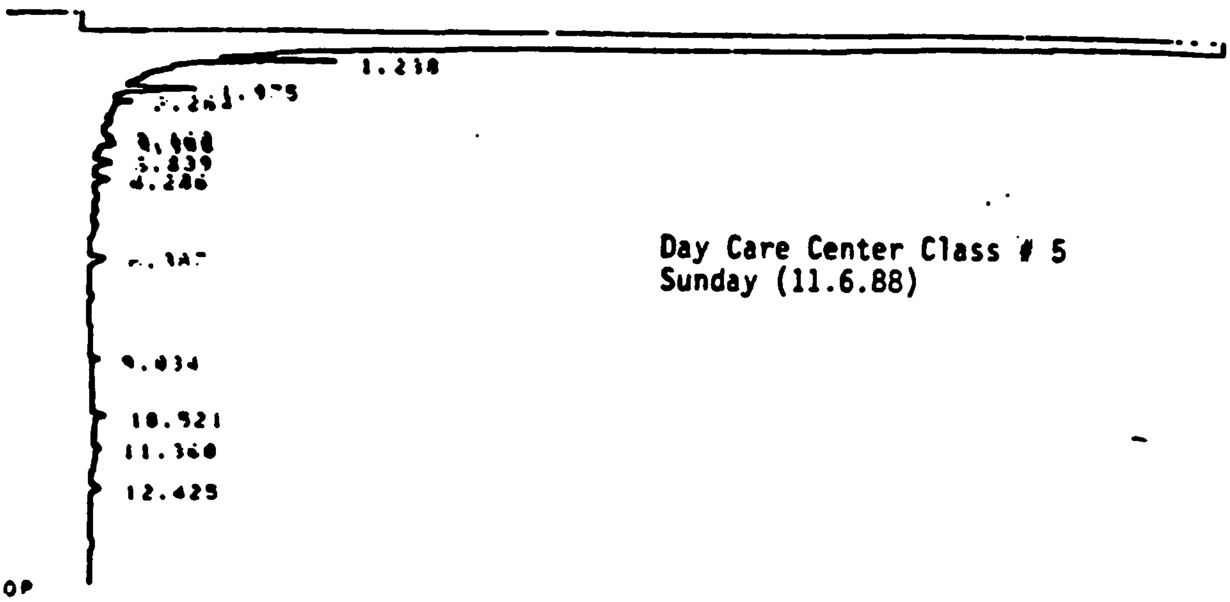
RUN# 48 NOV 9, 1988 23:09:07

SAMPLE NAME: 7324B FRONT SAMPLE# 11
METHOD NAME: N:PCH_4.MET
DAY CARE #2

SIGNAL FILE: A:0763CC94.BNC

Fig.-2

RUN # 70 NOV 10. 1988 0611
START



Day Care Center Class # 5
Sunday (11.6.88)

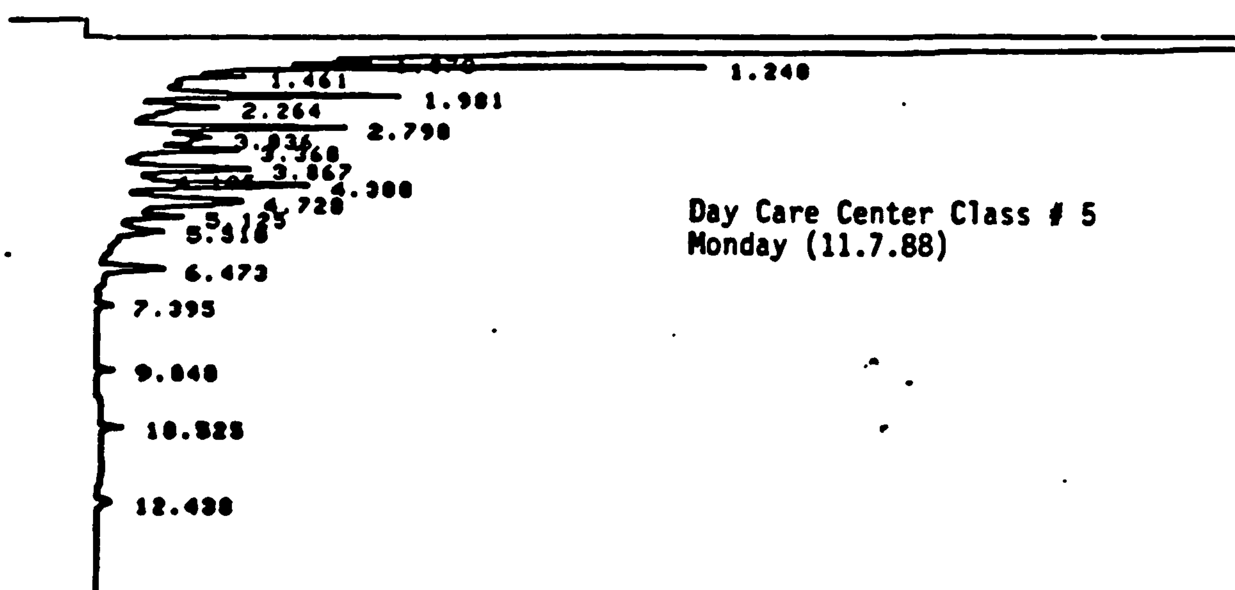
STOP

Closing signal file A:07643030.BNC

RUN# 70 NOV 10. 1988 06:14:20

SAMPLE NAME: 3409A FRONT SAMPLE# 33
METHOD NAME: M:PCH_4.MET
DAY CARE 05

RUN # 60 NOV 10. 1988 03:01:12
START



Day Care Center Class # 5
Monday (11.7.88)

STOP

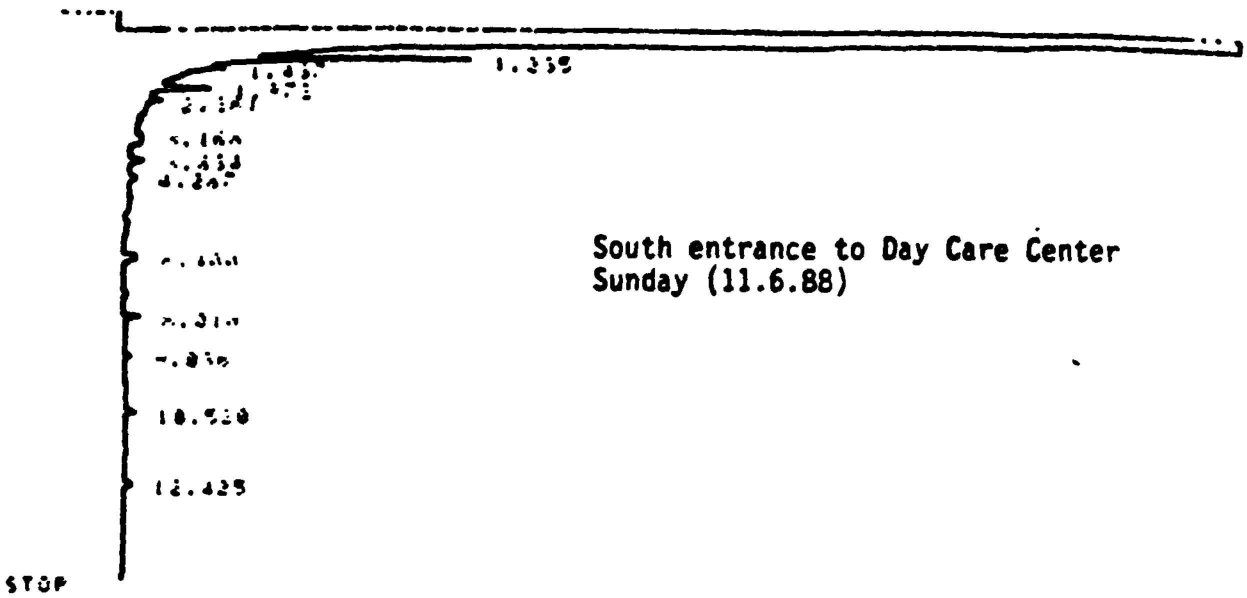
Closing signal file A:076402F9.BNC

RUN# 60 NOV 10. 1988 03:01:12

SAMPLE NAME: 3409B FRONT SAMPLE# 23
METHOD NAME: M:PCH_4.MET
DAY CARE 05

SIGNAL FILE: A:076402F9.BNC

Fig.-3



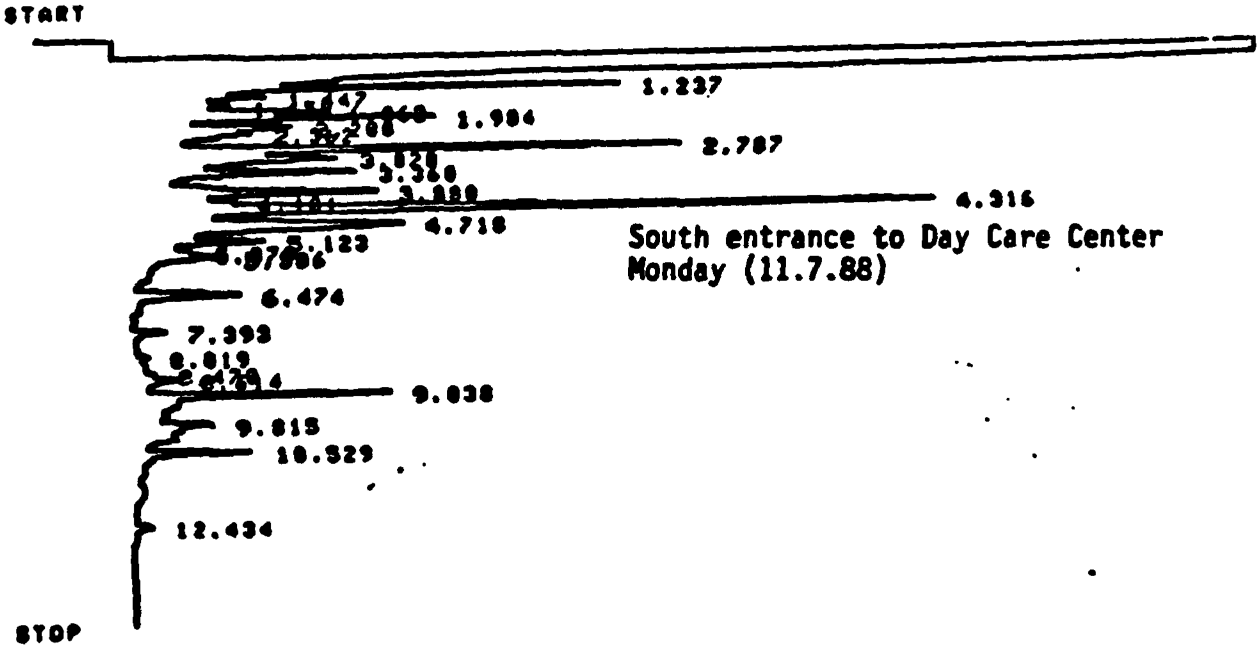
Closing signal file ...

RUN # 76 NOV 10, 1988 03:10:11

SAMPLE NAME: 2178W FRONT SAMPLE# 39
METHOD NAME: MIPCH_4.MET
S. ENTERANCE

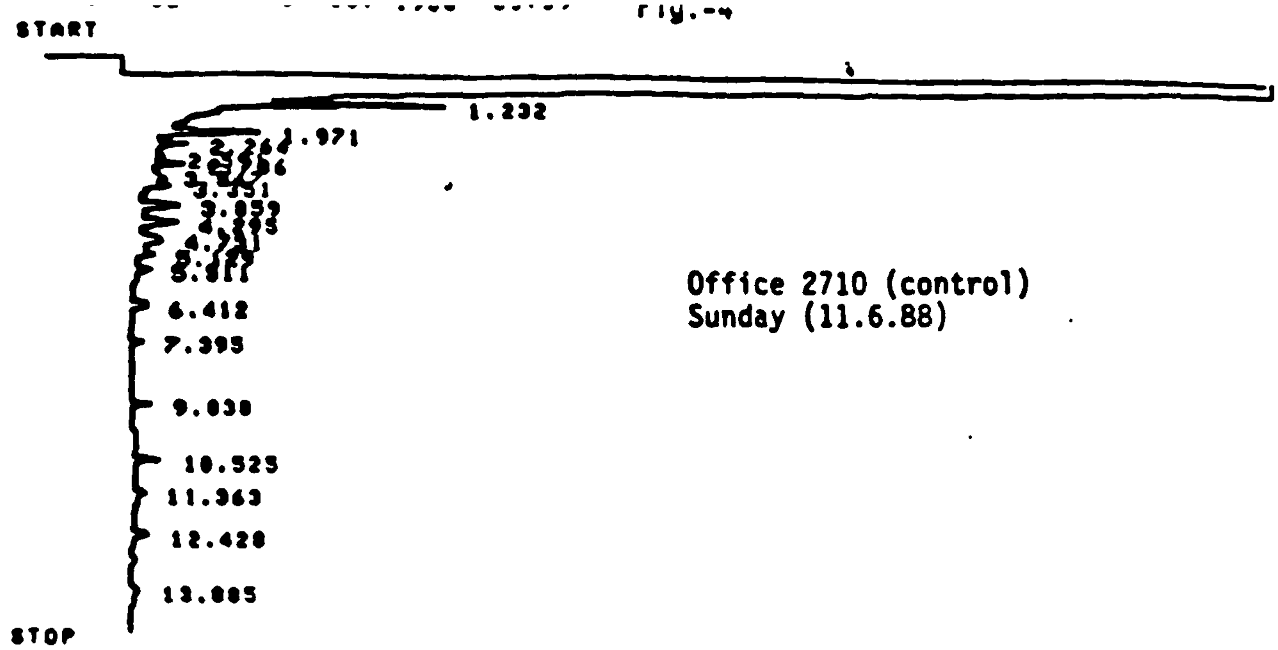
RUN # 57-003

RUN # 58 NOV 10, 1988 02:22:33
START



Closing signal file A:0763F9EB.BNC

Fig.-4



Office 2710 (control)
Sunday (11.6.88)

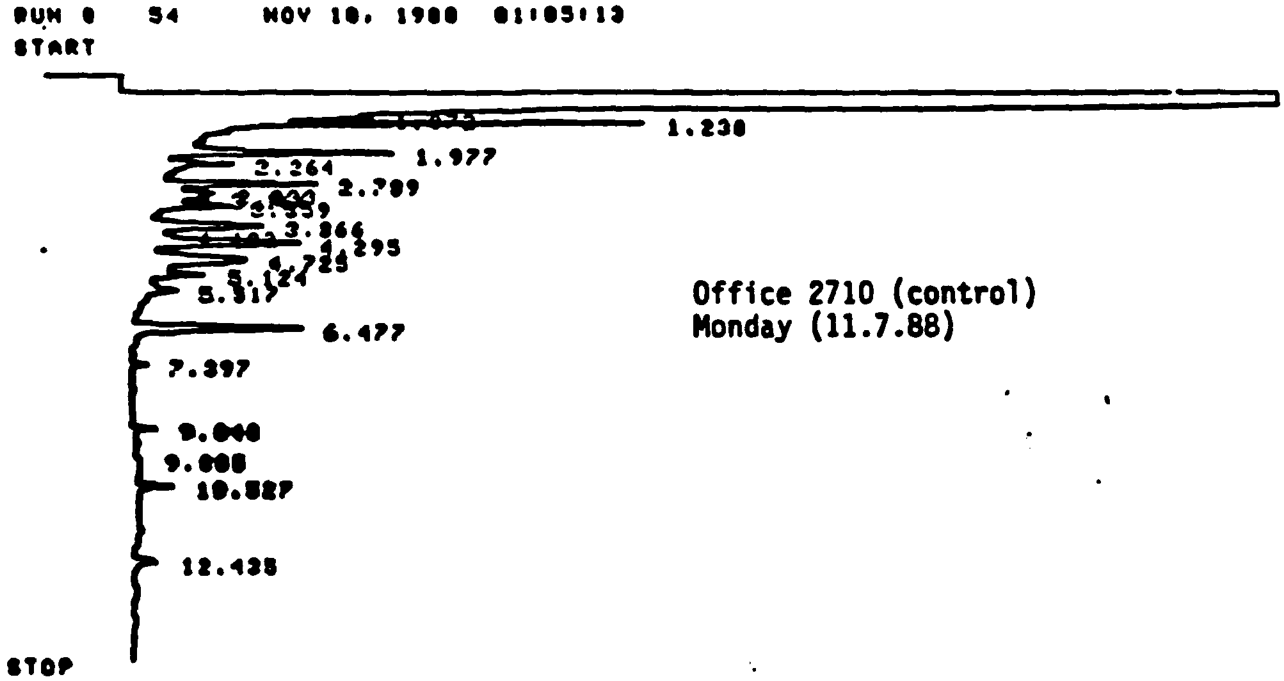
Closing signal file A:07640C06.BNC

RUN# 62 NOV 10, 1988 03:39:49

SAMPLE NAME: 73 A FRONT SAMPLE# 25
METHOD NAME: CH_4.MET
T. FIELD O 2710

RUN # 53-003

RUN # 54 NOV 10, 1988 01:05:13



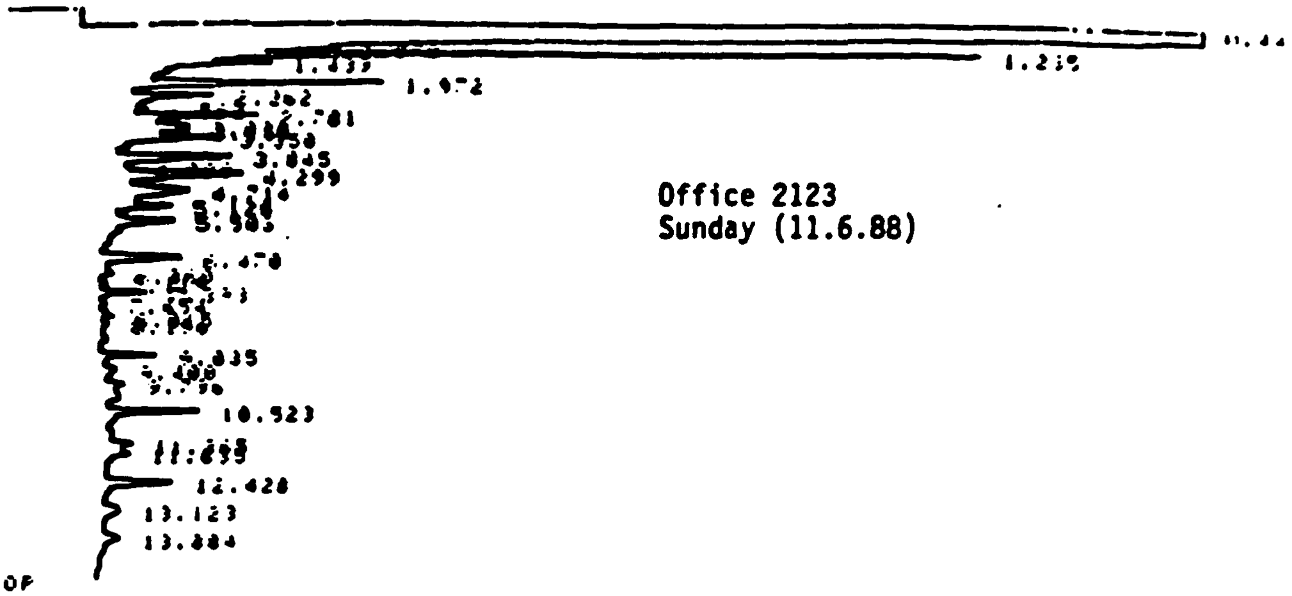
Office 2710 (control)
Monday (11.7.88)

Closing signal file A:0763E7CA.BNC

RUN# 54 NOV 10, 1988 01:05:13

SAMPLE NAME: 73358 FRONT SAMPLE# 17
METHOD NAME: A:PCH_1.MET
FIELDS

RUN # 64 NOV 10, 1988 04:18:29
START



STOP

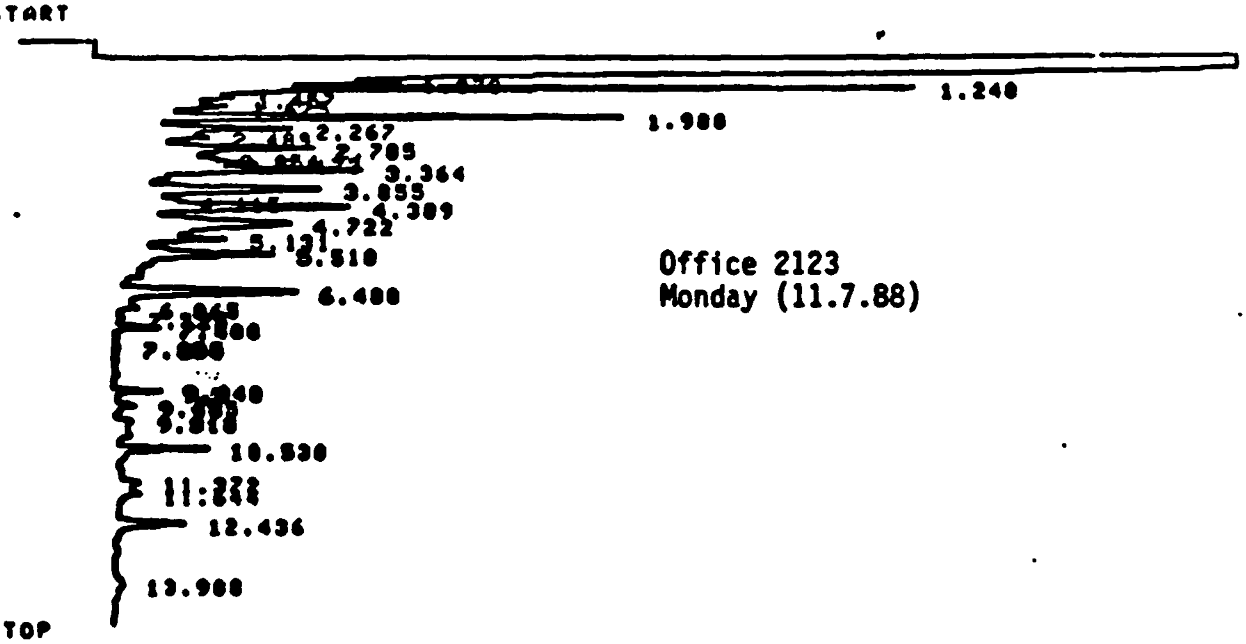
Closing signal file M:0764151G.BNC

RUN# 64 NOV 10, 1988 04:18:29

SAMPLE NAME: 7340A FRONT SAMPLE# 27
METHOD NAME: M:PCM_4.MET
BIGS OFFICE

RUN # 51-003

RUN # 52 NOV 10, 1988 08:26:31
START



STOP

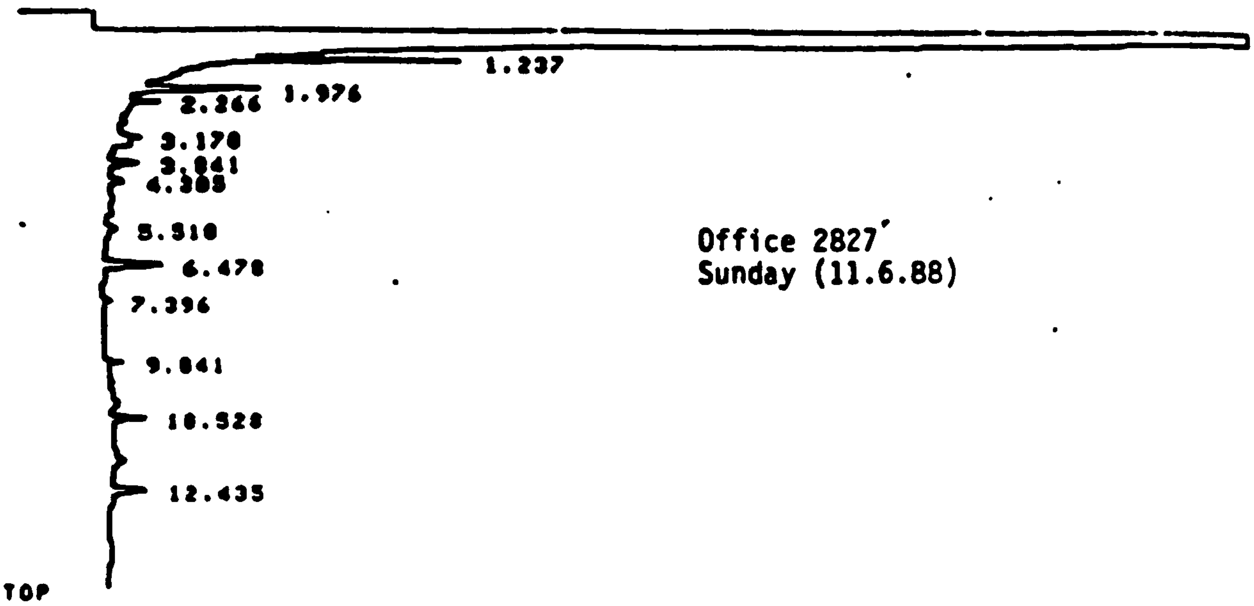
Closing signal file A:0763DE08.BNC

RUN# 52 NOV 10, 1988 08:26:31

SAMPLE NAME: 7340B FRONT SAMPLE# 15
METHOD NAME: M:PCM_4.MET

RUN # 56 NOV 10. 1988 01:43:51

START



Office 2827
Sunday (11.6.88)

STOP

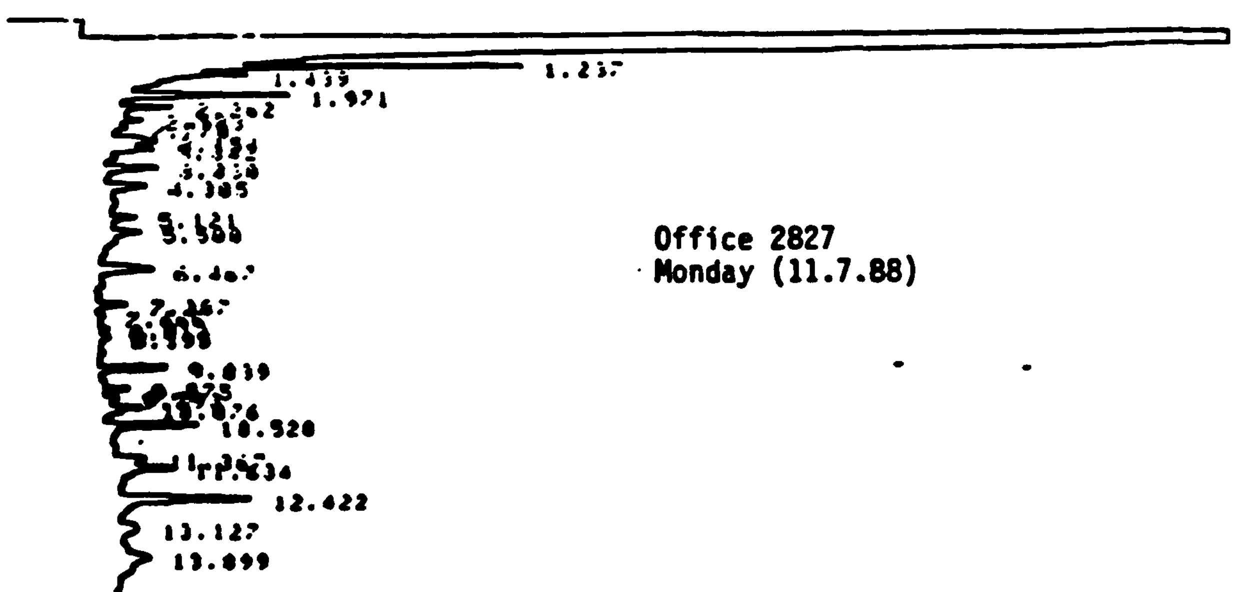
Closing signal file A:Q763F8D9.BNC

RUN# 56 NOV 10. 1988 01:43:51

SAMPLE NAME: 7338B FRONT SAMPLE# 19
METHOD NAME: M:PCH_4.MET
ROOM 2827

RUN # 72 NOV 10. 1988 06:52:55

START



Office 2827
Monday (11.7.88)

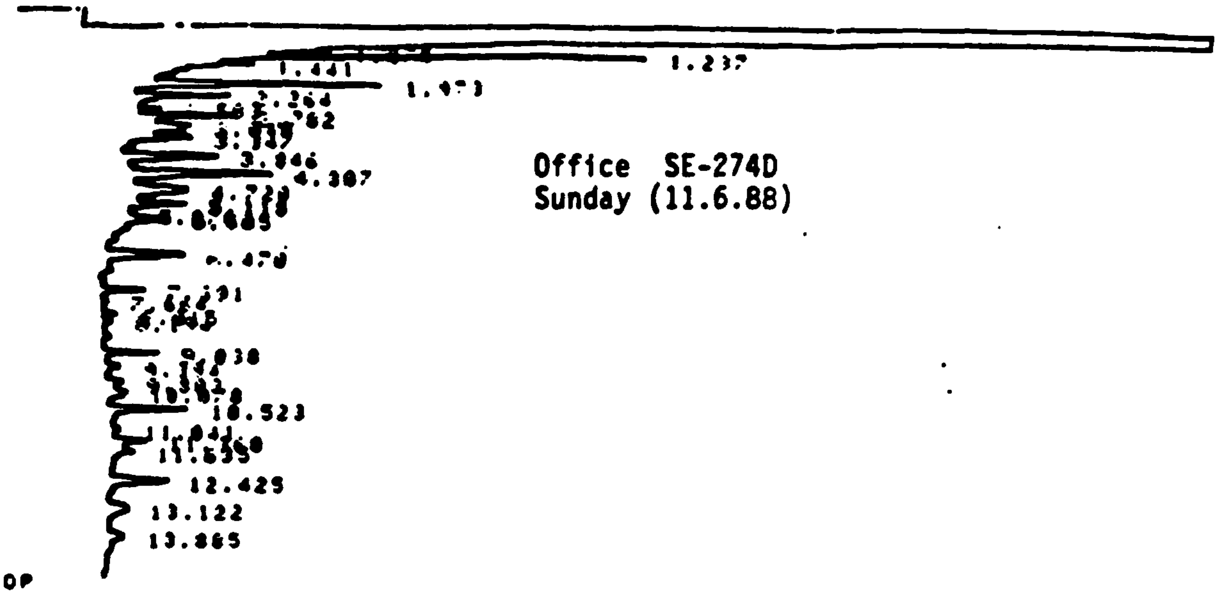
STOP

Closing signal file A:Q7643949.BNC

RUN# 72 NOV 10. 1988 06:52:55

SAMPLE NAME: 7338M FRONT SAMPLE# 35
METHOD NAME: M:PCH_4.MET
ROOM 2827

RUN # 66 NOV 10, 1988 0
START



Office SE-274D
Sunday (11.6.88)

STOP

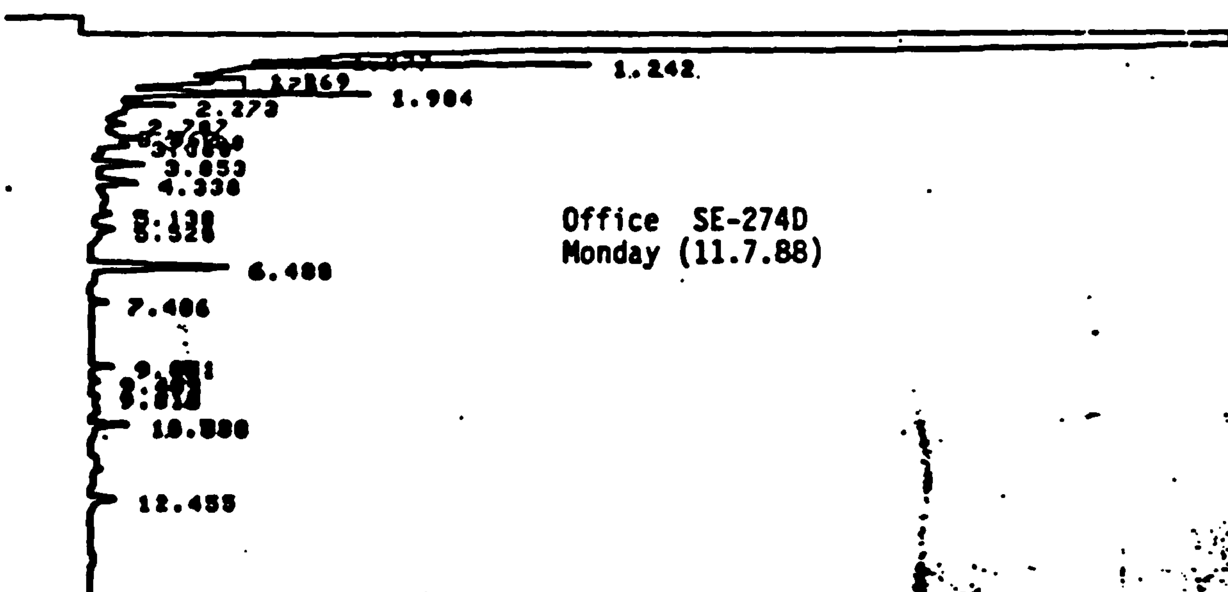
Closing signal file A:Q7641E21.BNC

RUN# 66 NOV 10, 1988 04:57:04

SAMPLE NAME: 7173A FRONT SAMPLE# 29
METHOD NAME: A:PCH_4.MET
RUSS WYER Rm S274

RUN # 45-003

RUN # 46 NOV 9, 1988 22:38:21
START



Office SE-274D
Monday (11.7.88)

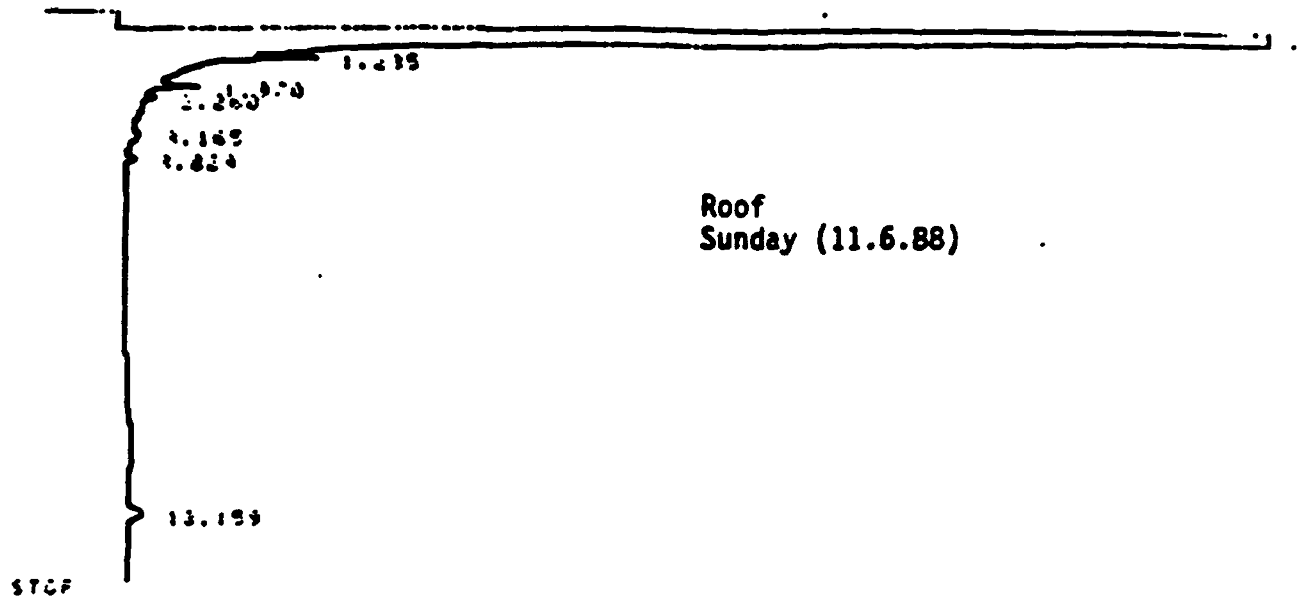
STOP

Closing signal file A:Q763C37E.BNC

RUN# 46 NOV 9, 1988 22:38:21

SAMPLE NAME: 7173B FRONT SAMPLE# 9
METHOD NAME: A:PCH_4.MET
RUSS WYER S274

START



STOP

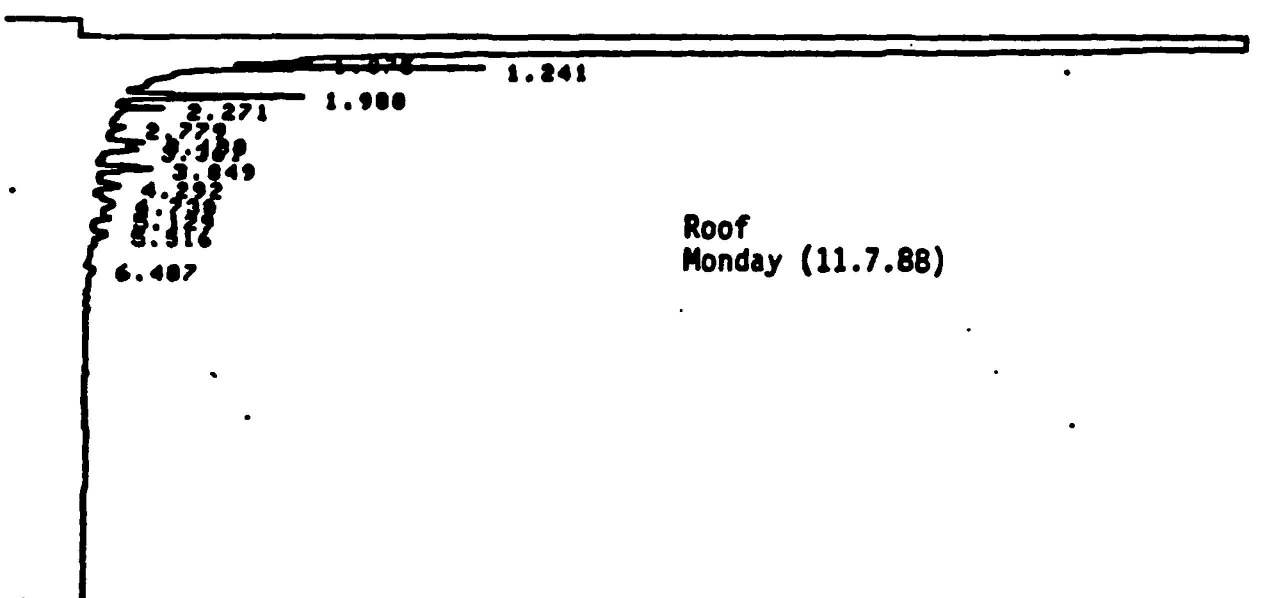
Closing signal file M:07644258.BNC

RUN# 74 NOV 10, 1988 07:31:35

SAMPLE NAME: 7325W FRONT SAMPLE# 37
METHOD NAME: M:PCH_4.MET
ROOF

RUN # 49-083

RUN # 50 NOV 9, 1988 23:47:49
START



STOP

Closing signal file A:0763D5A6.BNC

RUN# 50 NOV 9, 1988 23:47:49

SAMPLE NAME: 7325B FRONT SAMPLE# 13
METHOD NAME: M:PCH_4.MET
ROOF