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Indoor Air Quality in Commercial Buildings

Volume 2: Appendices

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Indoor Air Quality in Commercial Buildings

Volume 2: Appendices

Final Report to the Bonneville Power Administration

December 1987

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APPENDIX A.

THE EFFECT OF INTERMITTENT SAMPLING ON FORMALDEHYDE PASSIVE SAMPLER PERFORMANCE.

INTRODUCTION

Formaldehyde (HCHO) passive samplers as used in the Bonneville Power Administration (BPA) commercial building study, were developed to continuously sample residential indoor air during a one-week period (Geisling et al., 1982). For the commercial building study, the sampling technique was modified so that daily sampling periods included only the normal employee working hours for each building. The typical two-week test period included ten days of sampling and a cumulative sampling duration of approximately 90 hours. The experiment presented here was conducted to evaluate the effect of intermittent sampling upon HCHO passive sampler performance.

EXPERIMENTAL

Passive samplers were prepared by LBL Passive Sampler Method No. 110. All samplers used in this experiment were prepared together as one lot.

The samplers were deployed in a 120 l glove box chamber which allowed the samplers to be capped and uncapped without affecting the test atmosphere concentration. The HCHO test atmosphere was produced from trioxane using a generation system described by Geisling, et.al. (1982). The HCHO gas was diluted with pure air, and a continuous stream of approximately 10.8 l/min. flowed into the chamber during the test period. The chamber was maintained under slight positive pressure to prevent influx of room air.

A total of 63 samplers were grouped into six sets which were exposed intermittently or continuously for 81.5 to 221.0 hours (Table 1), and one set of unexposed blanks.

TABLE 1.

SAMPLING METHOD, EXPOSURE DURATION AND MEASURED CONCENTRATION

Method	Exposure (Hrs)											Concentration(ppb)							
	DAY	1	2	3	4	5	6	7	8	9	10	CUM.	MEAN ⁽¹⁾	N	CV% ⁽²⁾				
PASSIVE SAMPLERS	SET 1 Intermittent	7.5	10.0	9.0	9.3	9.5	9.0	11.5	10.5	10.5	8.5	95.3	131	17	3.6				
	SET 2 Continuous	-----										221.0	118	10	1.9				
	SET 3 Continuous	-----													93.3	122	8	2.5	
	SET 4 Continuous				-----								95.3	132	8	3.3			
	SET 5 Continuous				-----								96.0	132	8	5.9			
	SET 6 Continuous							-----				81.5	129	8	4.8				
BUBLER SAMPLERS	SET 7 Intermittent	7.5	10.0	9.0									26.5	112	3	5.3			
	SET 8 Intermittent				9.3	9.5	9.0									27.8	126	3	2.3
	SET 9 Intermittent							11.5	10.5	10.5					32.5	114	3	1.9	
	SET 10 Intermittent										9.0	9.0	127	3	9.0				

(1) Least significant difference = 4.77 ($t_{0.5[53]}$) between passive sampler sets (1-6)

(2) Coefficient of variation (Standard deviation/mean * 100)

At the conclusion of sampling for all test sets, the samplers were removed from the chamber, diluted with deionized water and refrigerated until analysis as per LBL Passive Sampler Method No. 111.

Concurrent with the passive sampler exposure, comparative measurements of the same experimental atmosphere were made using LBL refrigerated bubbler samplers (Fanning et al., 1981). Bubbler sets 7 - 10 sampled only when the intermittent passive samplers (set 1) were open. Each bubbler set coincided with a three-day portion of the 10-day test period except for the final set (set 10) which sampled only on the final day. A set consisted of three replicate trains of 3 bubblers with flow rates of 0.28 - 0.32 l/min. Analysis was done along with the passive samplers using the same method.

RESULTS AND DISCUSSION

The results presented in Table 1 allow comparisons between intermittent sampling and continuous sampling for equivalent exposure periods (days) and durations (hrs). Differences between passive sampler means were compared using a Student's t-Test (t_{05}) (Sokal and Rohlf, 1981).

Comparisons with continuously sampling passive sampler sets of similar exposure durations (sets 4-6) indicate that intermittent sampling (set 1) does not significantly affect sampler performance.

A fourth continuously sampling set (set 3) of similar exposure had a lower concentration than the four sets above. It is likely that the values for this set were skewed by lower concentrations of HCHO during the initial portion of the test. The bubbler sets indicate that the HCHO concentration fluctuated during the 10-day test period, and was low during the first portion of the test. The three-day average of 112 ppb for bubbler set 7 was the lowest of the bubbler sets. This corresponds to passive sampler set 3, which also sampled during the initial portion of the test and was the lowest of the 5 "short" duration passive sets at 122 ppb. The bubbler flows, as well as the flows to the HCHO generator and the chamber were quite stable throughout the test. Therefore, the observed

fluctuation can best be attributed to the trioxane diffusion tube in the HCHO generator. In addition, the concentration of HCHO may have been low at the onset of the test until the chamber atmosphere reached equilibrium with the incoming HCHO stream. Although Sets 1 and 2 also sampled during this period, this part of the test represents a small proportion of their total exposure duration.

Set 2, which continuously sampled the entire 10-day test period was significantly different ($LSD = 4.72, t_{05}$) from the intermittent set No. 1 and the continuous sets 4-6. The lower concentration measured by set 2 suggests collection efficiency of the samplers decreases with increasing exposure durations.

Measured concentrations for the four bubbler sets 7-10 ranged from 112 to 127 ppb. For comparative purposes the 10-day weighted average concentration was calculated to be 118 ppb, which is almost identical to the 221-hr passive sampler set. The 10-day intermittent passive samplers (set 1) at 131 ppb were 11.2% higher.

When individual sets are compared, passive sets consistently result in higher HCHO concentrations than corresponding bubbler sets. Passive set 3 was 9.7% higher than bubbler set 7, set 4 was 4.4% higher than set 8, and set 6 was 10.7% higher than the weighted average of sets 9 and 10 (117 ppb).

It is unclear which method is more accurate at measuring HCHO concentrations in this study. Presently, the bubbler system is considered the reference standard. Previous studies have led to the development of a 13% (passive conc. $\times 0.87$) correction factor to adjust one-week (168 hr) HCHO passive samples with comparable bubbler samples (Hodgson et al., 1982). (No such correction has been applied to HCHO values in this experiment.) If the bubbler method is assumed to be accurate, this test indicates such a correction may not be advisable for long-duration samplers. Some correction may be necessary for short-term (e.g. 90 hr) samplers. However, as it is probable the HCHO concentration fluctuated during the course of the test, the disparate values between sets could conceivably reflect the various sampling periods and average

HCHO concentrations peculiar to each set.

While these data suggest 90-hour samples will yield higher concentration values than 221-hour samples in the same test atmosphere, it is not evident which is a more accurate measure of actual concentrations. Intermittent capping and uncapping as was used in recent BPA field studies and as tested herein, should not by itself affect sampler performance.

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Hodgson, A.T., K.L. Geisling, B. Remijn and J.R. Girman (1982). Validation of a passive sampler for determining formaldehyde in residential indoor air, Lawrence Berkeley Laboratory Report LBL-144626, Berkeley, CA.

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APPENDIX B

PAH SAMPLE RETENTION

Table B summarizes results of tests to evaluate the combined effects of PAH sample retention on the teflon filter used for RSP collection and recovery efficiencies of the analytical system. A solution of 22 PAH compounds was made from NBS Standard Reference Material by the Air Industrial Hygiene Laboratory (AIHL) of the State of California Department of Health Services. Fifteen of the compounds were included in our original list of 16 PAH. Only acenaphthylene was not included. An analysis of this solution was performed by McKesson Laboratories, the contractor analyzing RSP field samples from the commercial building study, and also by the AIHL. Results are shown in the first two columns. Agreement is good for most of the compounds, although AIHL did not analyze for acenaphthene .

Four 37-mm, one-micron, teflon filters used in collecting RSP and PAH field samples were then each spiked at LBL with 250 ml of solution, fictitiously labeled, and processed along with other exposed field samples. The average of all four filters analyses is reported as "Amount Recovered". The recovery percent of these spiked field samples can be compared with recovery for internal audit samples prepared by McKesson and analyzed promptly. Obviously some mechanism, possibly volatilization, is depleting the sample of lower molecular weight PAH. This supports the findings of Galasyn, et al., that documented the loss of PAH from quartz fiber filters.

As a result, only the last seven PAH with the highest molecular weights and satisfactory retention/recovery efficiencies are included in the reporting of total PAH.

PAH Recovery and Quality Control Analysis

	PAH Solution ($\mu\text{g}/\text{mL}$)			LBL Spiked Samples ^(a)			
	As <u>Mixed</u>	Independent <u>Lab Analysis</u>	McKesson <u>Analysis</u>	Spiked Amount <u>(ng)</u>	Amount ^(b) Recovered <u>(ng)</u>	McKesson Lab ^(c)	
						Recovery <u>(%)</u>	Internal Audit <u>Recovery</u> <u>(%)</u>
NAPHTHALENE	5.00	5.16	6.10	1250	ND	0	64
ACENAPHTHYLENE ^(d)	--	ND	ND	--	ND	0	90
ACENAPHTHENE	2.50	ND	2.70	625	ND	0	77
FLUORENE	0.50	0.54	0.65	125	2.5	2	80
PHENANTHRENE	1.00	1.19	1.40	250	17	7	83
ANTHRACENE	1.00	0.94	1.10	250	15	6	78
FLUORANTHENE	0.50	0.54	0.61	125	11	9	76
PYRENE	1.00	1.45	1.70	250	38	15	83
BENZ(a)- ANTHRACENE	0.50	0.59	0.62	125	56	45	76
* CHRYSENE	0.25	0.29	0.35	63	45	72	78
* BENZO(b)- FLUORANTHENE	0.10	0.12	0.14	25	29	116	105
* BENZO(k)- FLUORANTHENE	0.10	0.10	0.11	25	22	89	110
* BENZO(a)PYRENE	0.25	0.26	0.27	63	52	83	110
* DIBENZ(a,h)- ANTHRACENE	2.00	2.54	2.50	500	560	113	95
* BENZO(g,h,i)- PERYLENE	2.00	2.60	2.40	500	520	105	95
* INDENO(1,2,3)- PYRENE	1.0	1.30	1.10	250	220	87	80

* Only compounds included in reporting of total PAH

ND = None detected

(a): 4 teflon filters were spiked at LBL with PAH solution and handled as per other field samples. Samples sent to McKesson fictitiously labeled.

(b): Average of 4 spiked samples

(c): Based on spiked samples produced in the McKesson laboratory and analyzed promptly. Samples were not exposed and handled as a field sample.

(d): PAH solution did not contain this compound

APPENDIX C

CARBON MONOXIDE - SAMPLE BAG TEST

Four-liter Tedlar gas collection bags were selected randomly from the set used during field tests to test the concentration stability of CO over a period of 21 days.

Each bag received a 2 to 2.5 liter sample of span gas (18.6 ppm CO in air) directly from a cylinder calibrated for field use.

One bag was filled each week for three weeks with the last sample collected the day before the analysis was performed. Bags with samples received no special treatment and were stored at room temperature on open shelves in a laboratory office until analysis.

On the twenty-first day all four samples were analyzed on a Model 48 Thermoelectron Bendix InfraRed Gas Filter Correlation CO Analyzer.

The concentration measured from each sample was read within 0.2 ppm of the standard value of the span gas used for the test.

CO Stability Test Results

<u>Sample #</u>	<u>Elapsed Time (days)</u>	<u>Readings (ppm)</u>
1	21	18.4 - 18.6
2	14	18.5 - 18.6
3	7	18.4 - 18.7
4	1	18.5 - 18.7

This test shows that there was undetectable loss of CO from the test bags for at least 21 days.

APPENDIX D

OUTDOOR WEATHER CONDITIONS DURING VENTILATION MEASUREMENTS

<u>Building No.</u>	<u>ACH SF₆</u>	<u>Temp(°F)</u>	<u>Outdoor Wind Dir.</u>	<u>Wind Speed(MPH)</u>
1	0.8	39	E	10
2	2.2	32	ESE	10
3	1.3	42		C
4	0.6	45	SSW	18
5	1.7	46	S	8
6	0.8	48	S	7
7	0.9	41	NW	3
8	1.1	42	WNW	3
9	0.7	48	N	5
10	0.9	48	V	3
11	3.6	43	WSW	2
12	0.3	37	V	2
13	1.5	45	NNW	3
14	4.1	51	SSE	12
15	1.7	50	SSW	12
16	2.0	51	S	3
17	2.2	54	SW	6
18	0.6	53	SSW	9
19	0.9	53	SSW	8
20	1.8	70		C
21	1.8	74	NE	7
22	2.5	66		C
23	1.0	73	E	7
24	0.4	74		C
25	1.8	66	SW	6
26	1.5	73	SSW	8
27	0.3	66	SSW	8
28	0.6	66	ENE	7
29	3.0	39	SW	10
30 ⁽¹⁾	1.3	36	SW	23
31	1.9	29	ENE	6
32	0.6	37	SW	13
33	1.6	32	SSE	6
34	1.5	32	NE	6
35	1.4	33	SW	9
36 ⁽²⁾	1.1	48	SSW	7
37	2.4	43	WSW	6
38	1.9	53	SW	8
39	2.7	49	NW	9
40	2.4	57	NW	9

(1) Second test building 17

(2) Second test building 11

Letter Codes

C Calm

V Variable wind direction

Buildings 1-7, 37-40 NSW data WSFO Portland

8-15, 36 NWS date WSO Salem

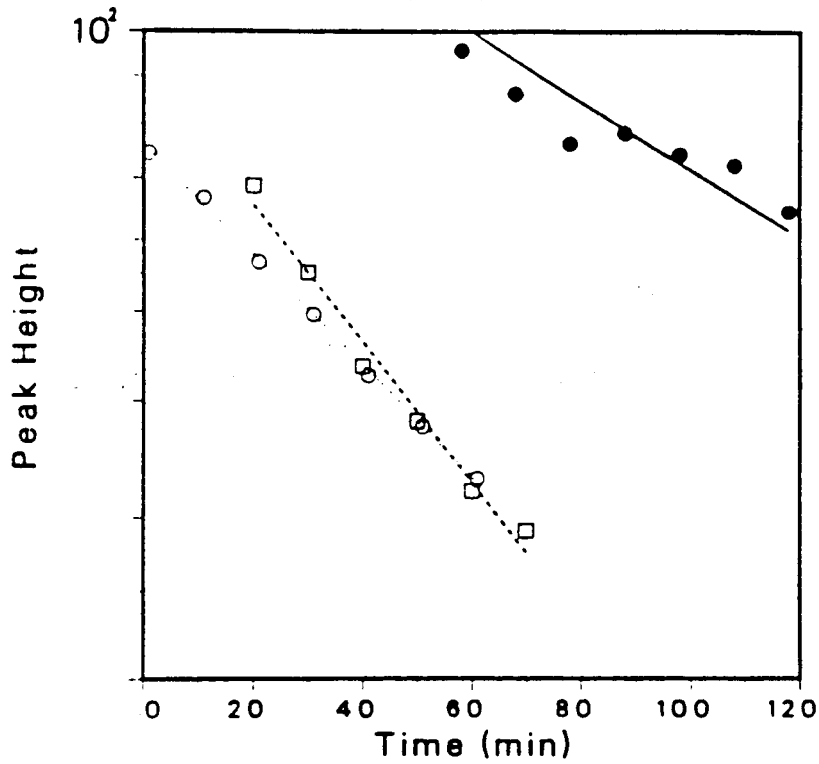
16-31, 34-35 NWS date WSFO Spokane

32, 33 EWU Physical plant Cheney

APPENDIX E

DECAY CURVES FOR THE FORTY BUILDING VENTILATION MEASUREMENTS

BUILDING 1
1/14/84

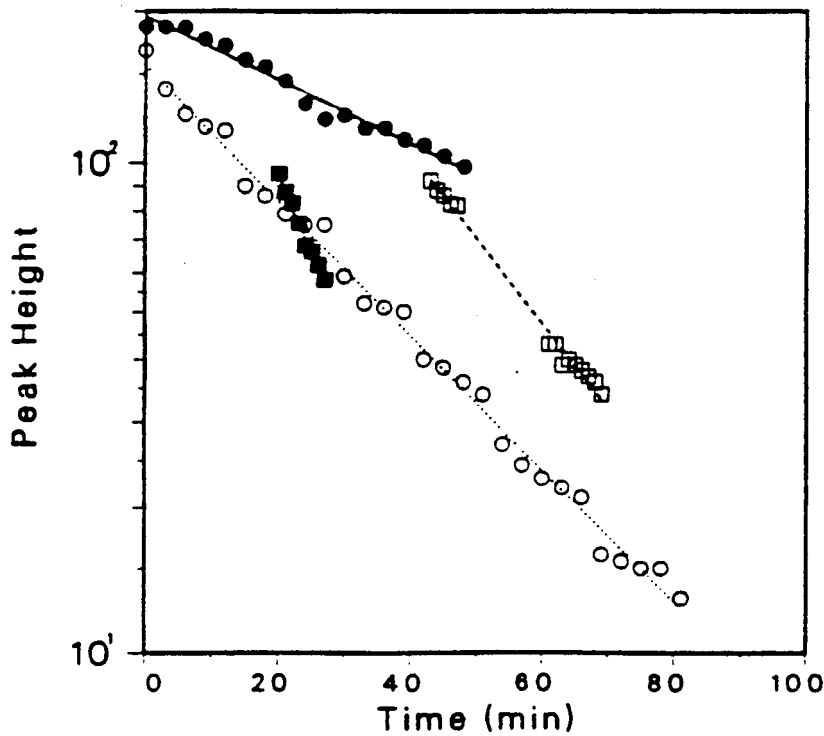


- LEGEND
- MULTIPURPOSE ROOM
0.5 ACH

 - ROOM 10
0.8 ACH

 - ROOM 7
1.0 ACH

BUILDING 2
01/19/84



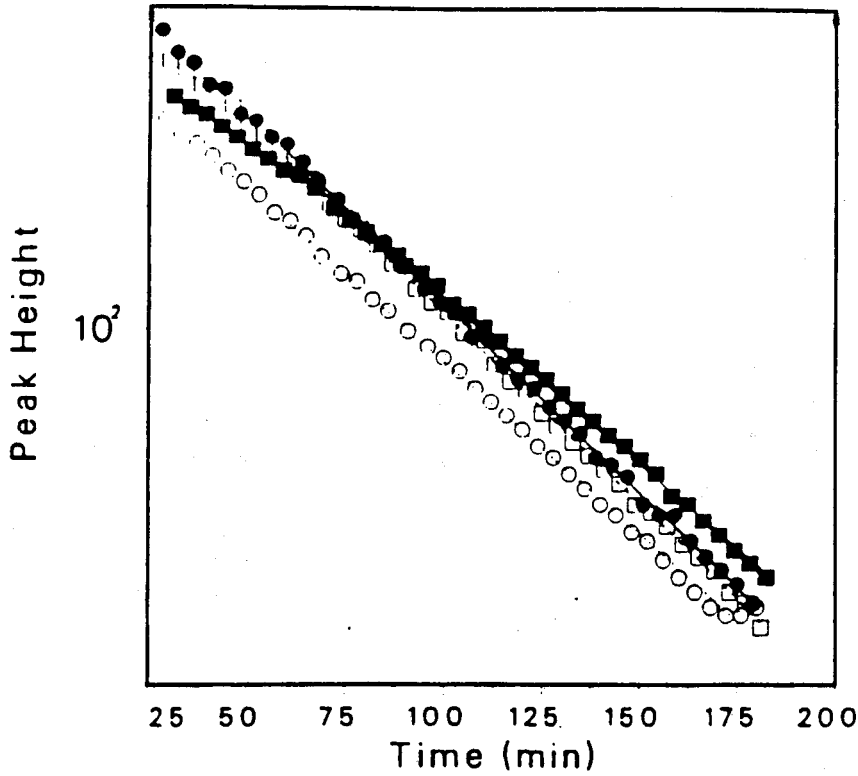
- LEGEND
- TEACHERS LOUNGE
0.9 ACH

 - ROOM 9
1.9 ACH

 - ROOM 23 TEST B
2.4 ACH

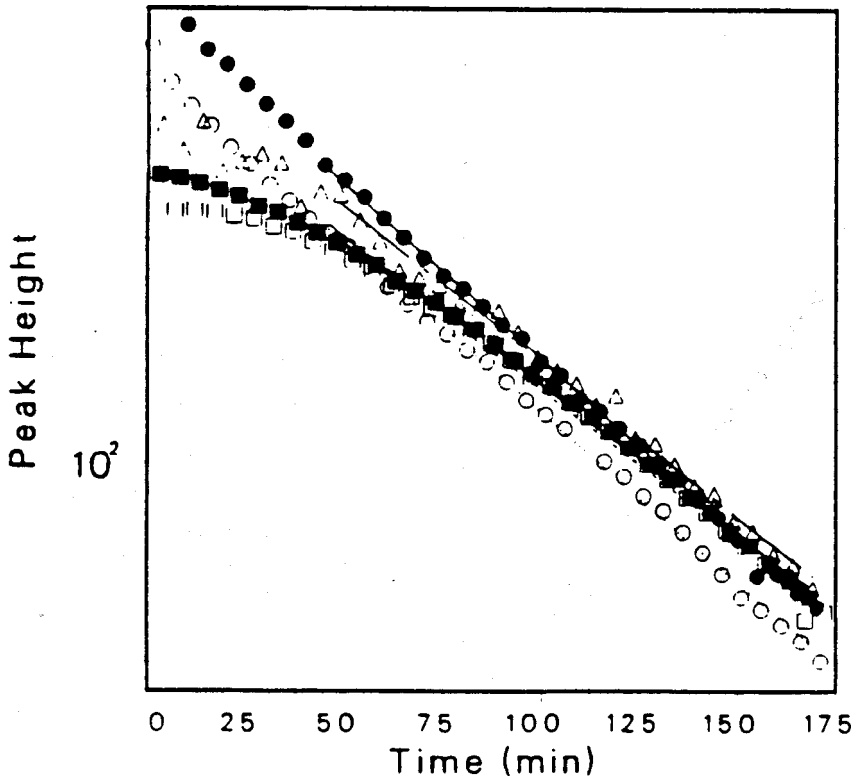
 - ROOM 23 TEST A
4.3 ACH

BUILDING 4 TEST 1
02/09/84



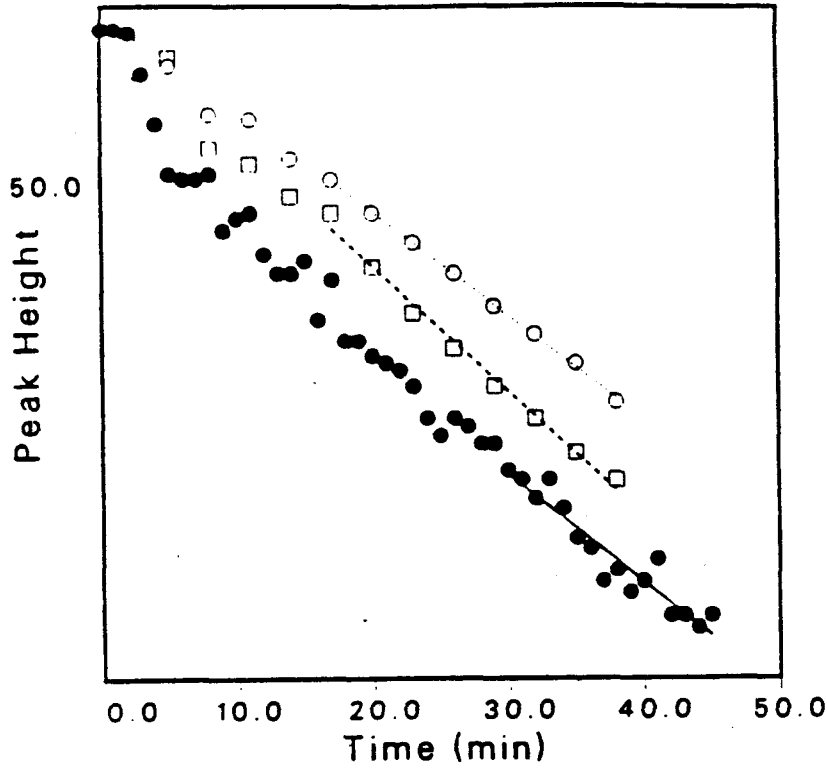
- LEGEND
- 1ST FLOOR S
0.8 ACH
 - 1ST FLOOR N
0.7 ACH
 - 2ND FLOOR N
0.8 ACH
 - BASEMENT
0.7 ACH

BUILDING 4 TEST 2
03/02/84



- LEGEND
- BASEMENT
0.6 ACH
 - NORTH MID
0.6 ACH
 - REFERENCE DESK
0.5 ACH
 - 2ND FLOOR SW
0.5 ACH
 - △ SOUTH MID
0.6 ACH

BUILDING 3
02/06/84

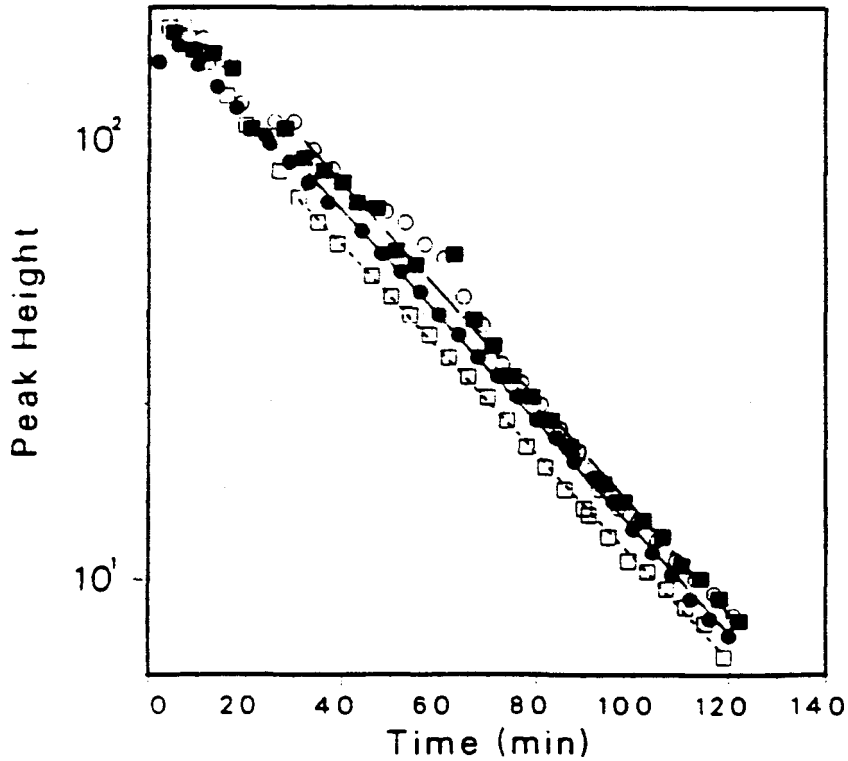


- LEGEND
- CONTROL ROOM
1.2 ACH

 - RECEPTION ROOM
1.1 ACH

 - 3RD FLOOR OFFIC
1.4 ACH

BUILDING 5
02/10/84



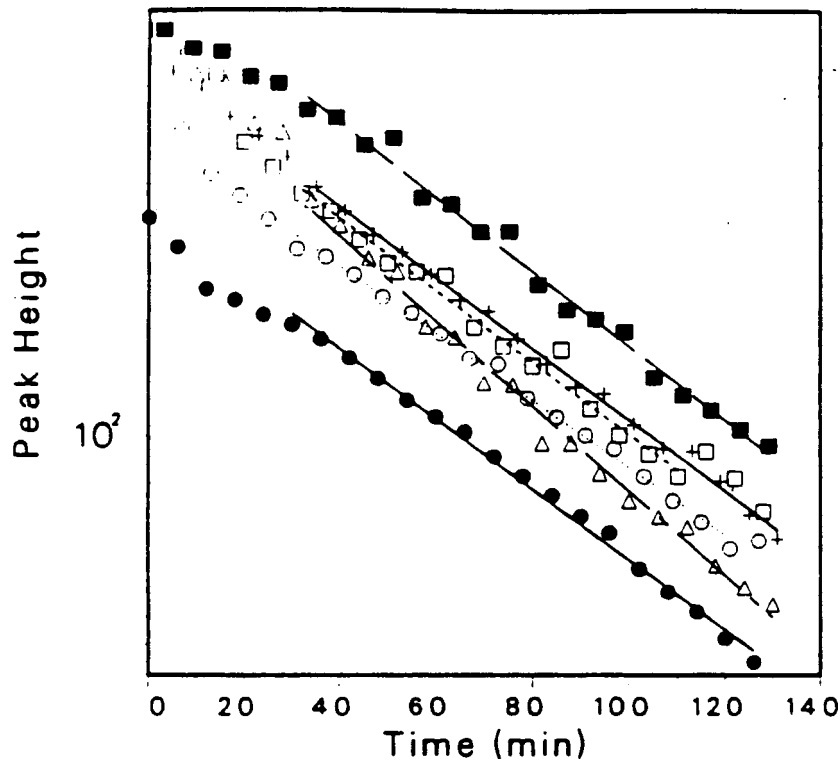
- LEGEND
- DOWNSTAIRS ANNE
1.7 ACH

 - UPSTAIRS ANNEX
1.7 ACH

 - UPSTAIRS MAIN
1.6 ACH

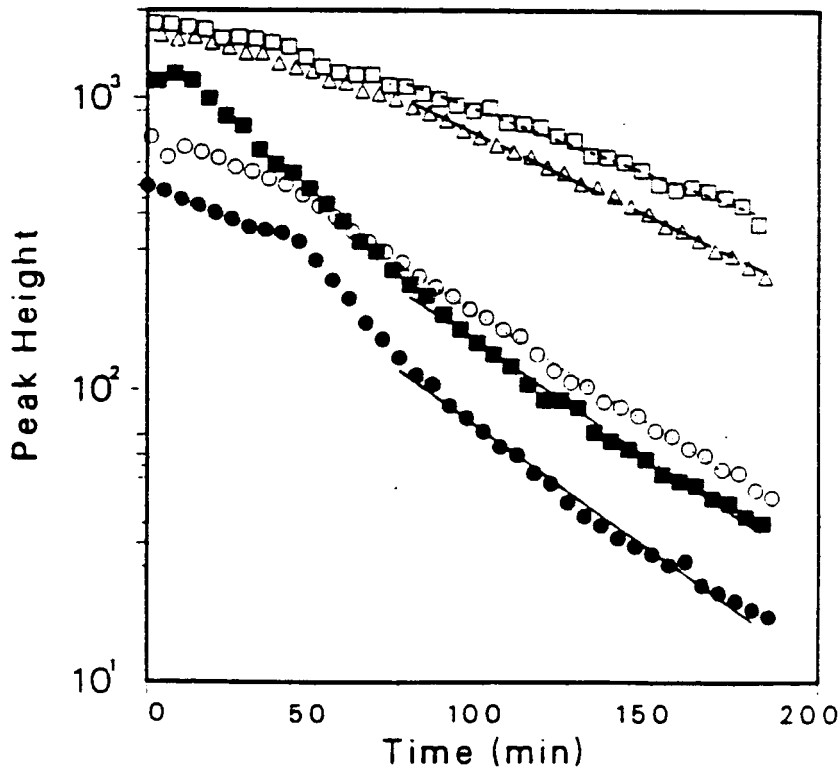
 - DOWNSTAIRS MAIN
1.7 ACH

BUILDING 6
03/01/84



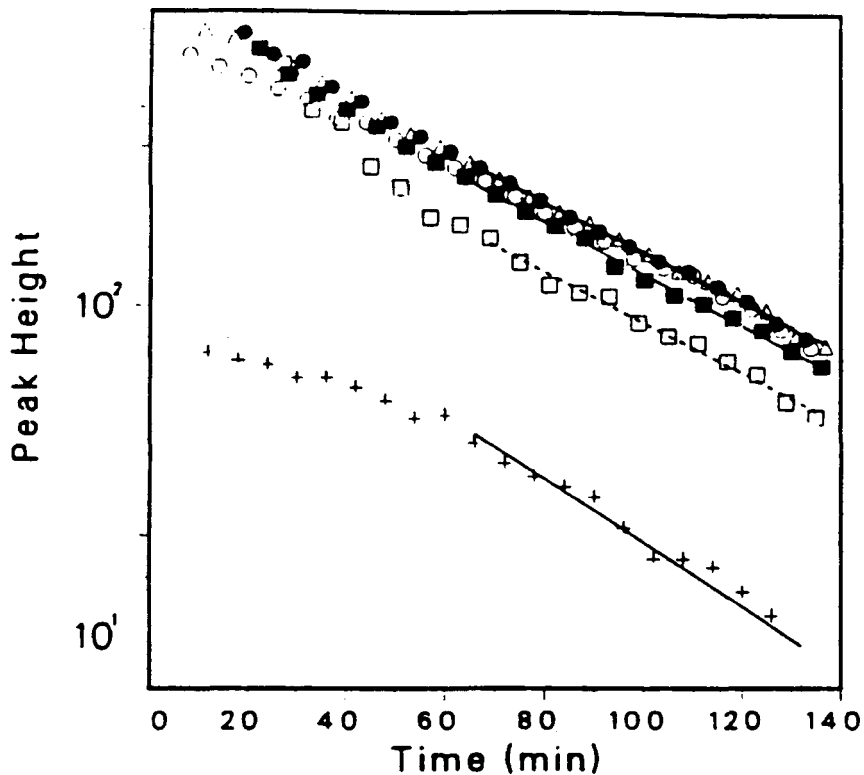
- LEGEND
- 3 EAST MID
0.8 ACH
 - 3 SW
0.8 ACH
 - 5 SE
0.8 ACH
 - 5 NW
0.8 ACH
 - △ 7 NW
1.0 ACH
 - + 7 SE
0.8 ACH

BUILDING 7
03/03/84



- LEGEND
- BASEMENT
1.1 ACH
 - 2ND FLOOR
1.0 ACH
 - 3RD FLOOR
0.6 ACH
 - 4TH FLOOR
1.1 ACH
 - △ 2ND FLOOR
0.8 ACH

BUILDING 8
03/27/84



LEGEND

- 2-B
1.1 ACH

- 2-A
1.0 ACH

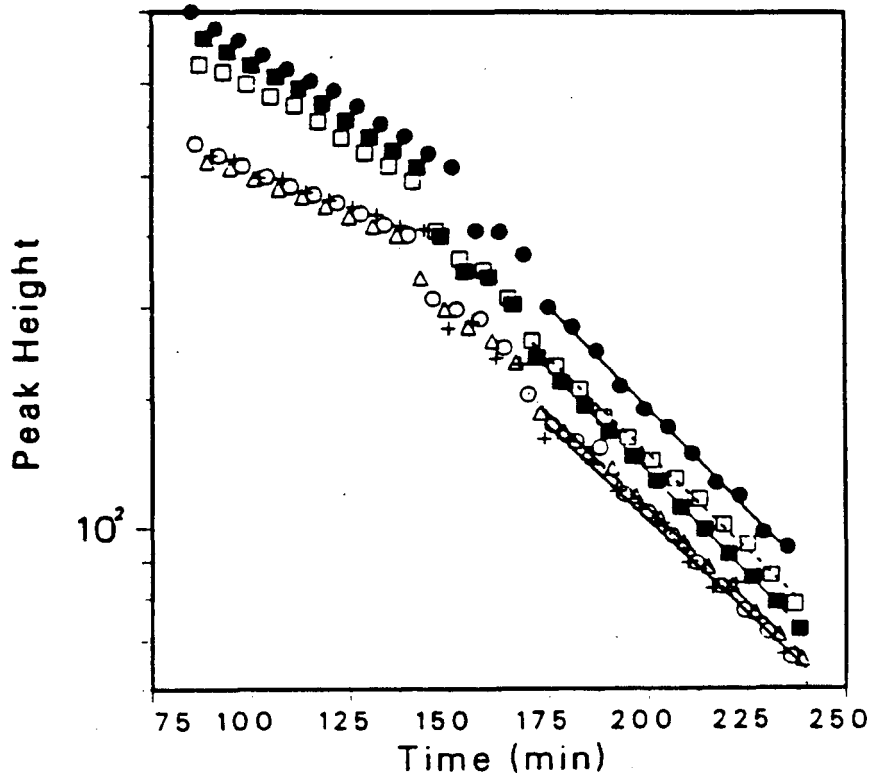
- B-1
1.1 ACH

- ROOM 103
1.1 ACH

- △ PERSONNEL 1ST FL
1.0 ACH

- + LAB 2ND FLOOR
1.3 ACH

BUILDING 9
03/28/84



LEGEND

- 3RD NW
0.8 ACH

- 3RD SE
0.8 ACH

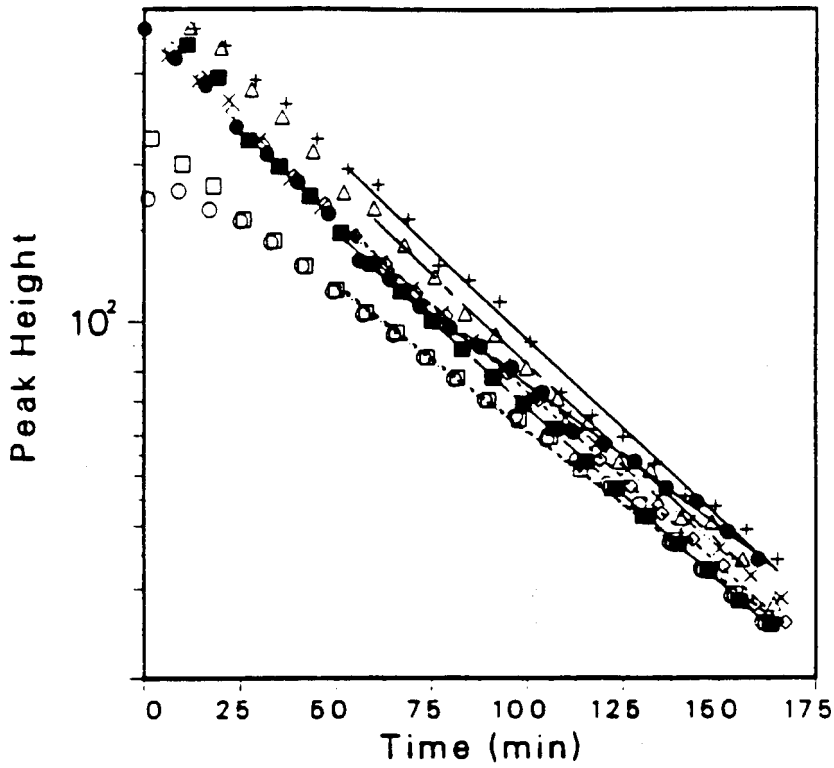
- 5TH NW
0.7 ACH

- 2ND NW
0.8 ACH

- △ 2ND SE
0.7 ACH

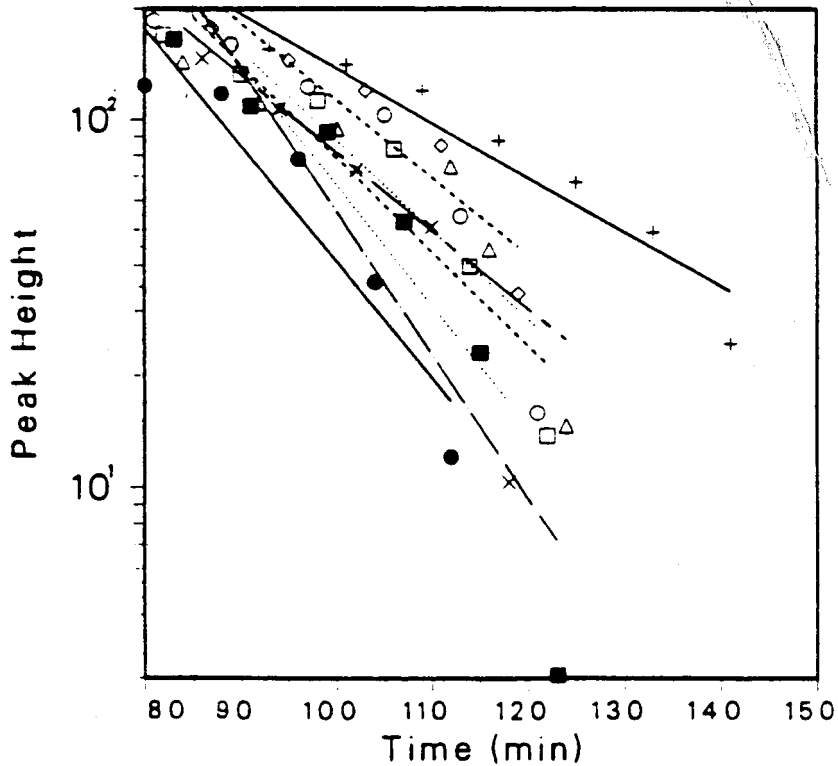
- + 1ST SE
0.7 ACH

BUILDING 10
05/02/84



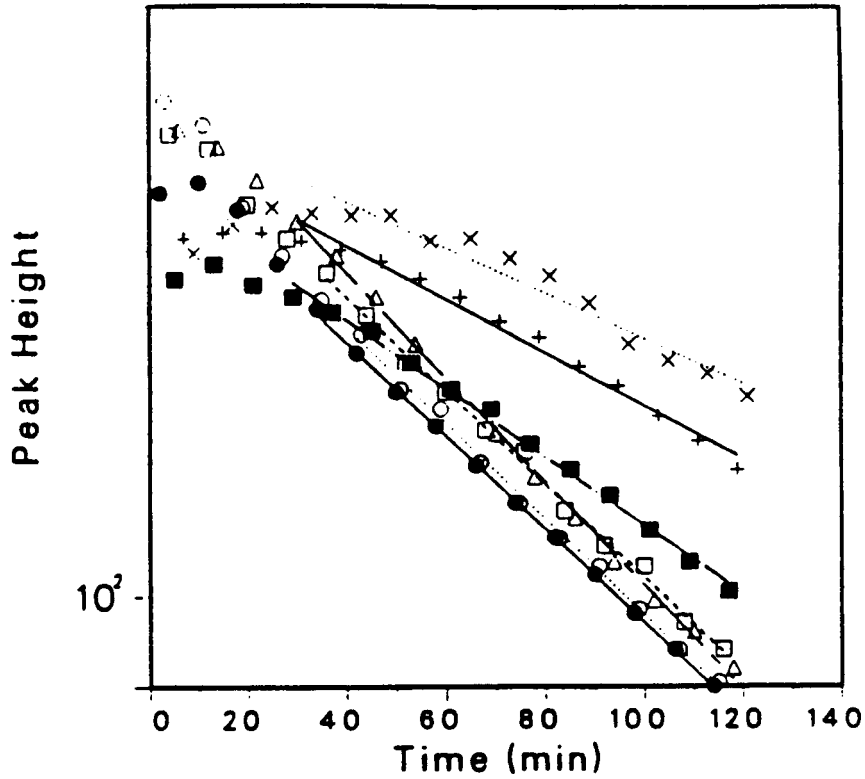
- LEGEND
- 3-A
0.8 ACH
 - 3-B
0.8 ACH
 - 3-B
0.8 ACH
 - 5TH FL NW
0.9 ACH
 - △ 5-A
1.0 ACH
 - + 5-C, D, E
1.0 ACH
 - × 1-A
0.9 ACH
 - ◇ 1-B
0.9 ACH

BUILDING 11
03/28/84



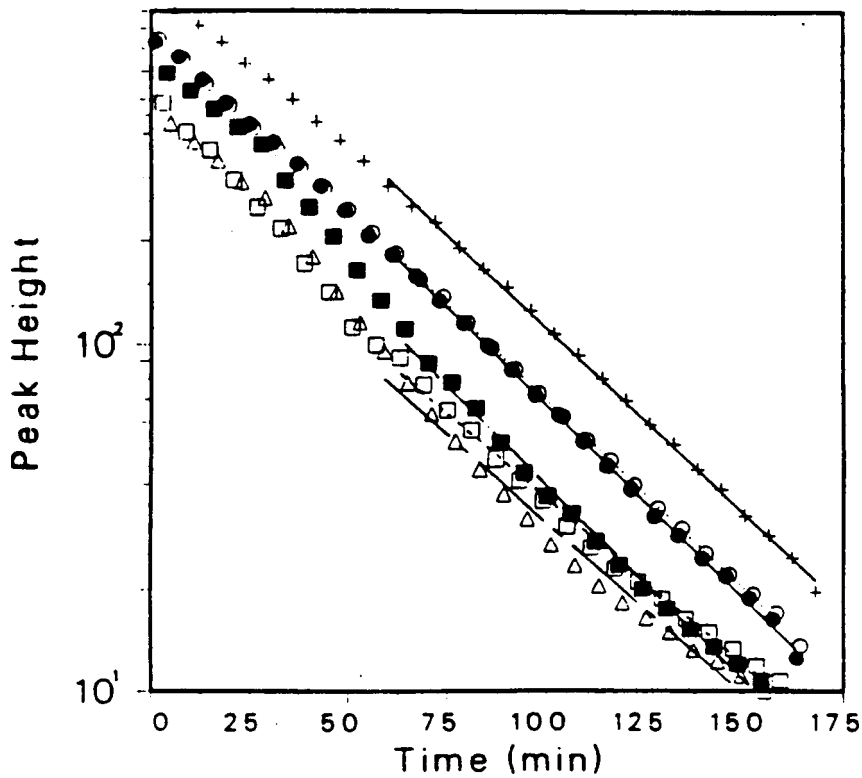
- LEGEND
- 2ND INSIDE OFFICE
4.4 ACH
 - 2-D
3.4 ACH
 - 1ST S CENTRAL OFF
3.5 ACH
 - B-1
5.4 ACH
 - △ 3-A
2.9 ACH
 - + 4-A
2.1 ACH
 - × 4-B
4.6 ACH
 - ◇ 3-C
2.9 ACH

BUILDING 12
03/30/84



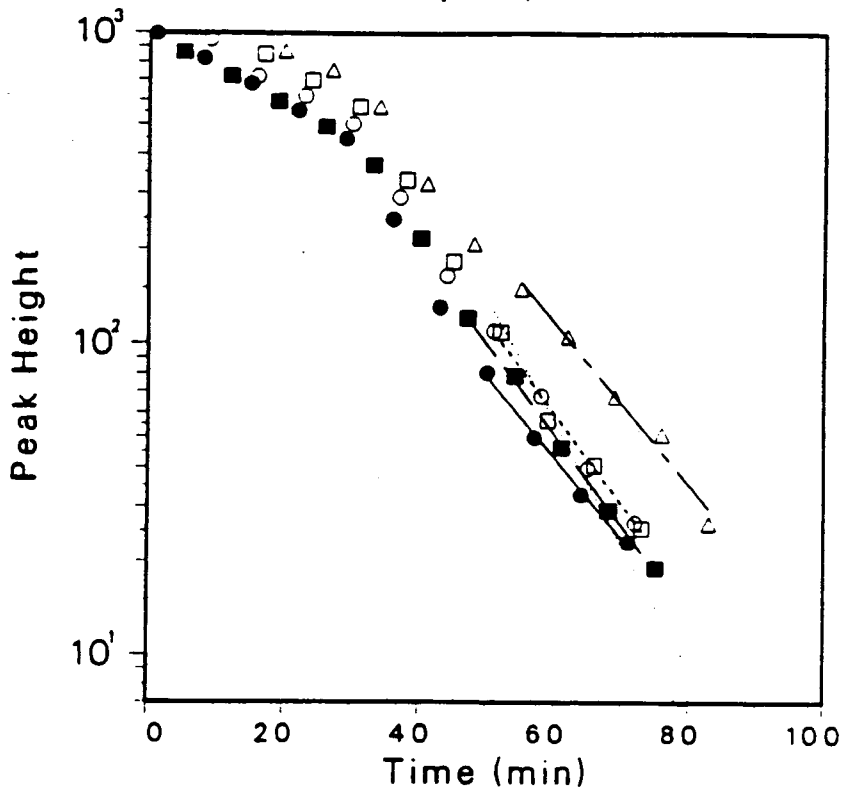
- LEGEND
- EXH/RET
0.3 ACH
 - 3D W
0.3 ACH
 - BASE W
0.3 ACH
 - 1 NORTH
0.2 ACH
 - △ 2 SOUTH
0.4 ACH
 - + 2-A
0.2 ACH
 - × 4TH
0.2 ACH

BUILDING 13
05/03/84



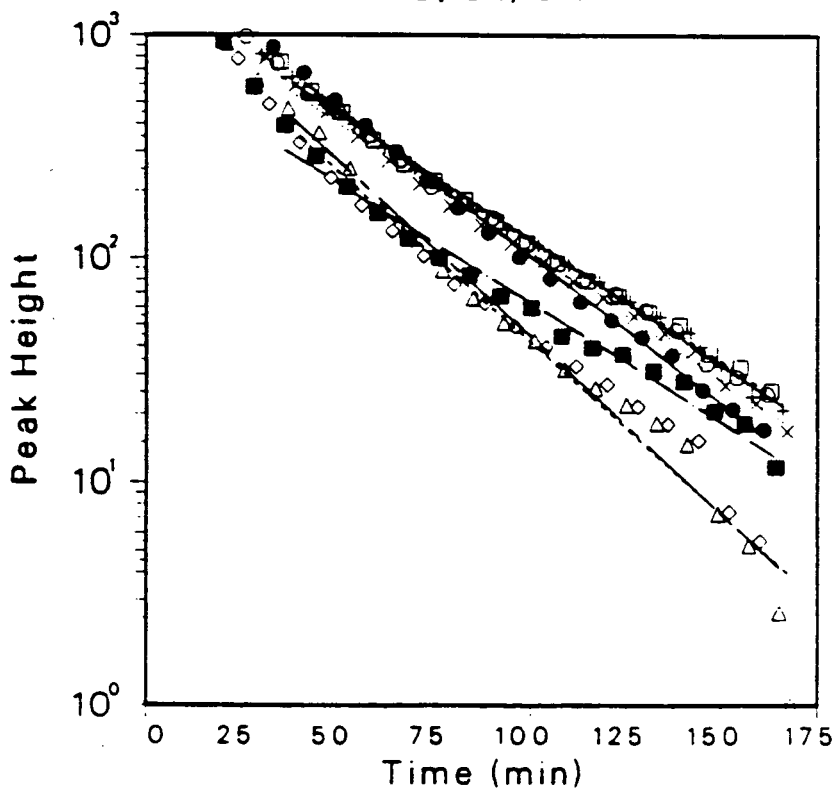
- LEGEND
- 2 EAST
1.5 ACH
 - 2 SOUTH
1.5 ACH
 - 1-A
1.3 ACH
 - 1 WEST CEN
1.6 ACH
 - △ 1 EAST CEN
1.4 ACH
 - + 2 WEST
1.5 ACH

BUILDING 14
04/30/84



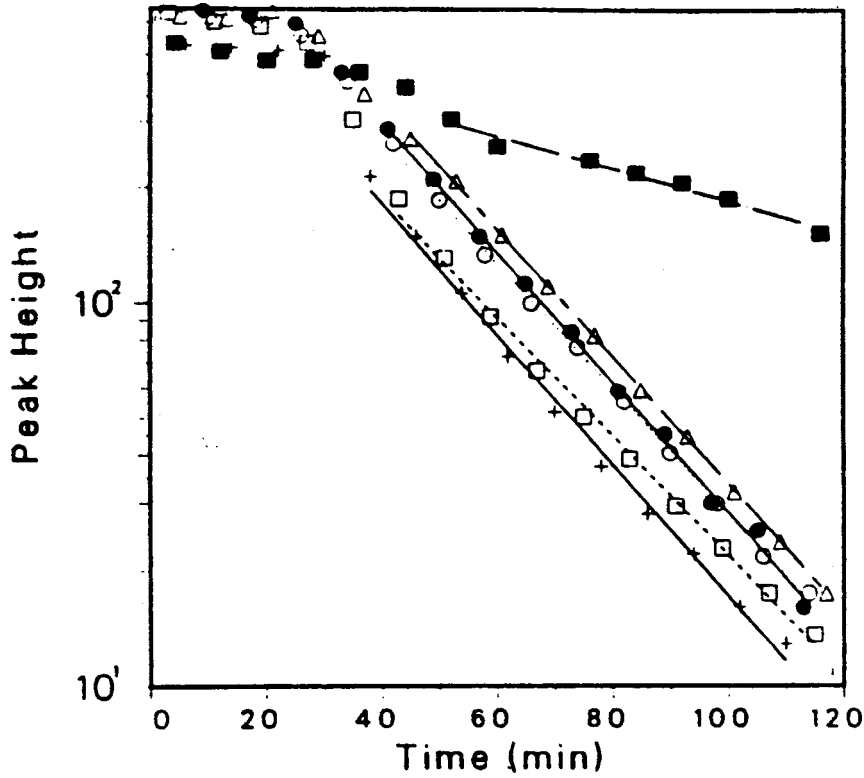
- LEGEND
- 1-A
3.6 ACH
 - 2 WEST
5.4 ACH
 - BASEMENT SE
4.0 ACH
 - BASEMENT W
4.0 ACH
 - △ 1-B
3.6 ACH

BUILDING 15
05/01/84



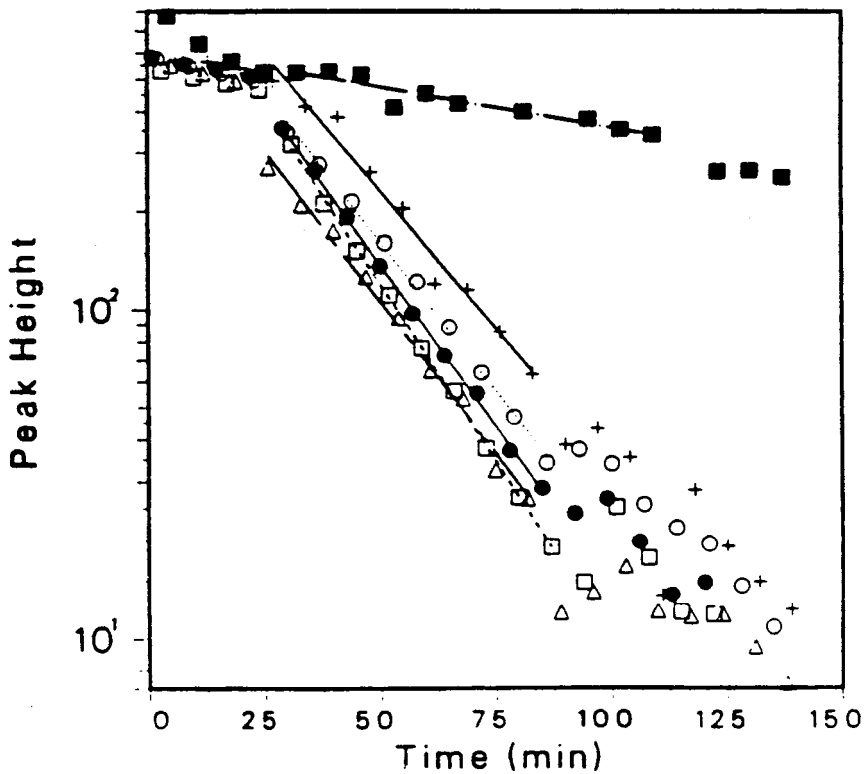
- LEGEND
- BASEMENT
1.8 ACH
 - 4 SOUTH
1.5 ACH
 - 2 S CENT HI
1.5 ACH
 - 4 NORTH
1.5 ACH
 - △ 1-C
2.2 ACH
 - + 2 S CENT BL
1.6 ACH
 - x 2-A
1.6 ACH
 - ◇ 1 NW
2.1 ACH

BUILDING 16
06/06/84



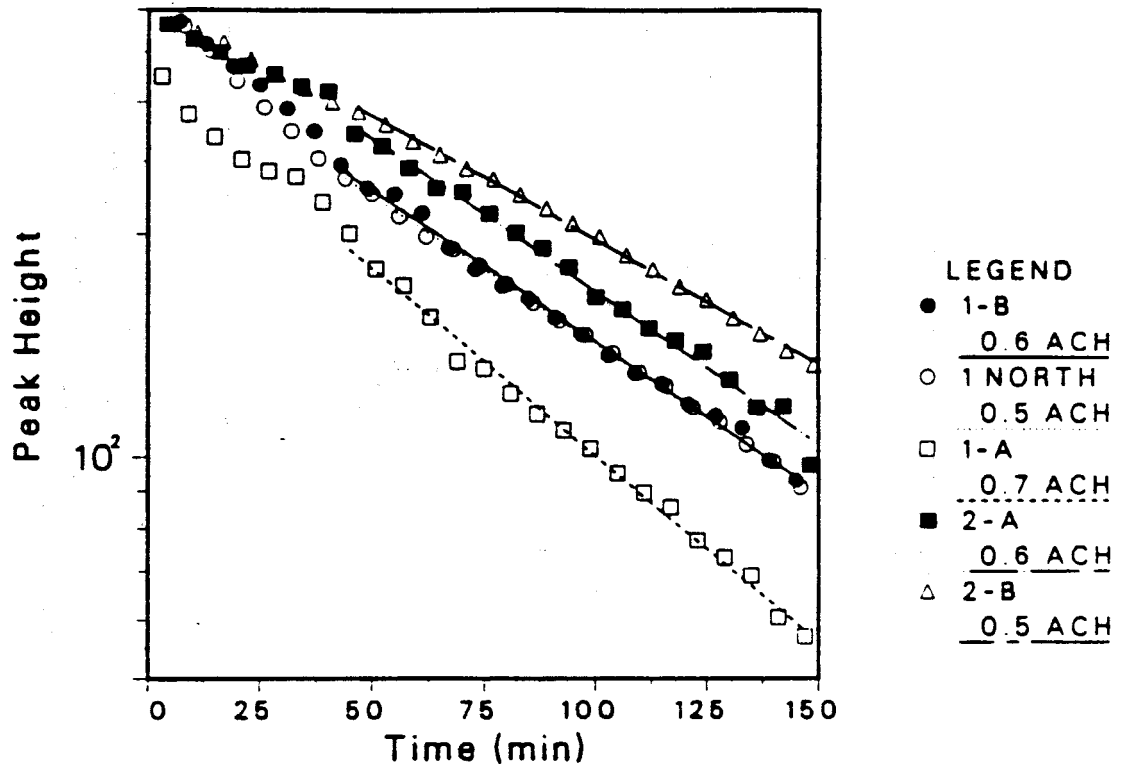
- LEGEND
- 1 NORTH
2.4 ACH
 - 1-C
2.3 ACH
 - 2 NORTH EAST
2.2 ACH
 - 1-E
0.6 ACH
 - △ 2-A
2.3 ACH
 - + 1 SOUTH CENT
2.4 ACH

BUILDING 17
06/07/84

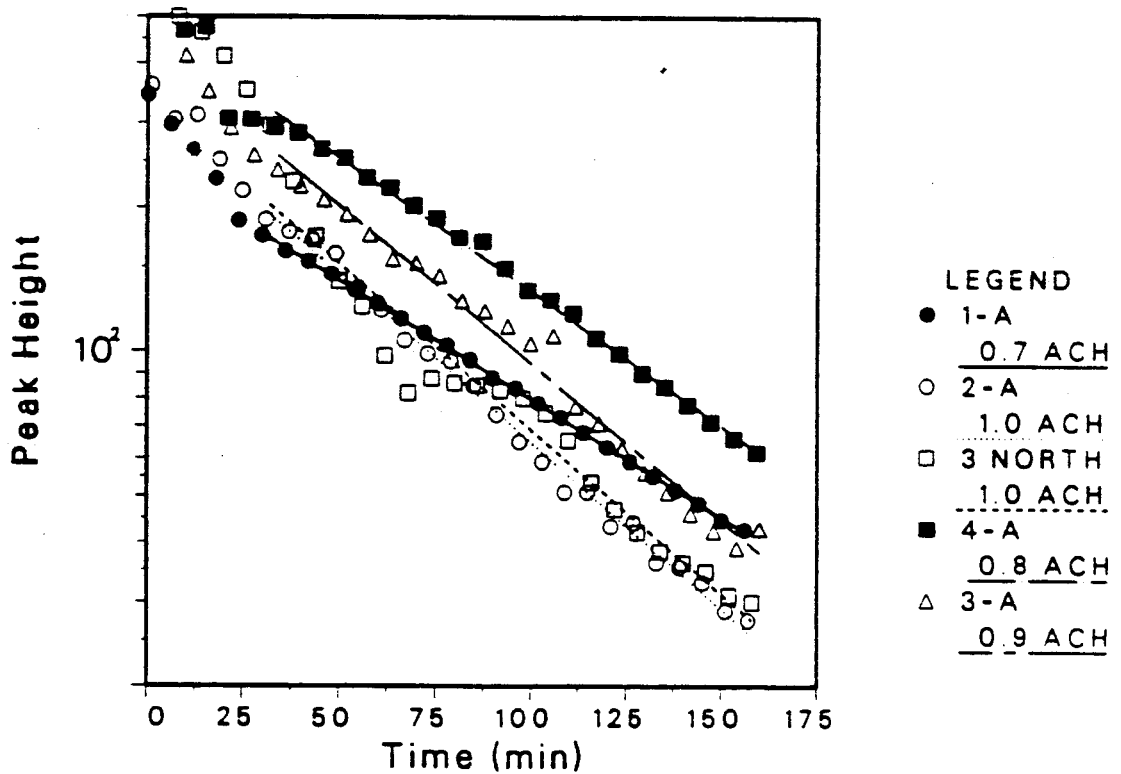


- LEGEND
- 1-A
2.7 ACH
 - WEST CENT
2.5 ACH
 - 2-A
3.0 ACH
 - S WING WEST
0.3 ACH
 - △ SUPPLY
2.6 ACH
 - + RETURN
2.3 ACH

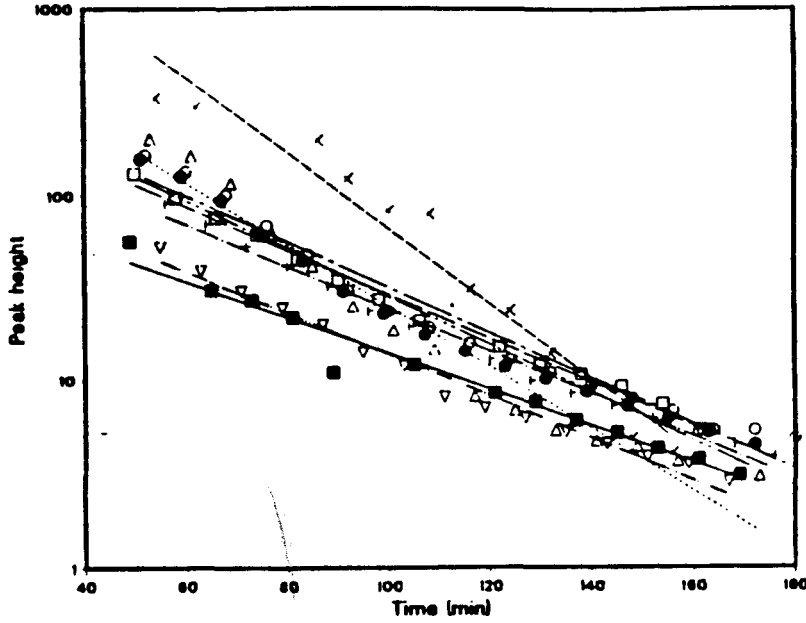
BUILDING 18
06/04/84



BUILDING 19
06/05/84



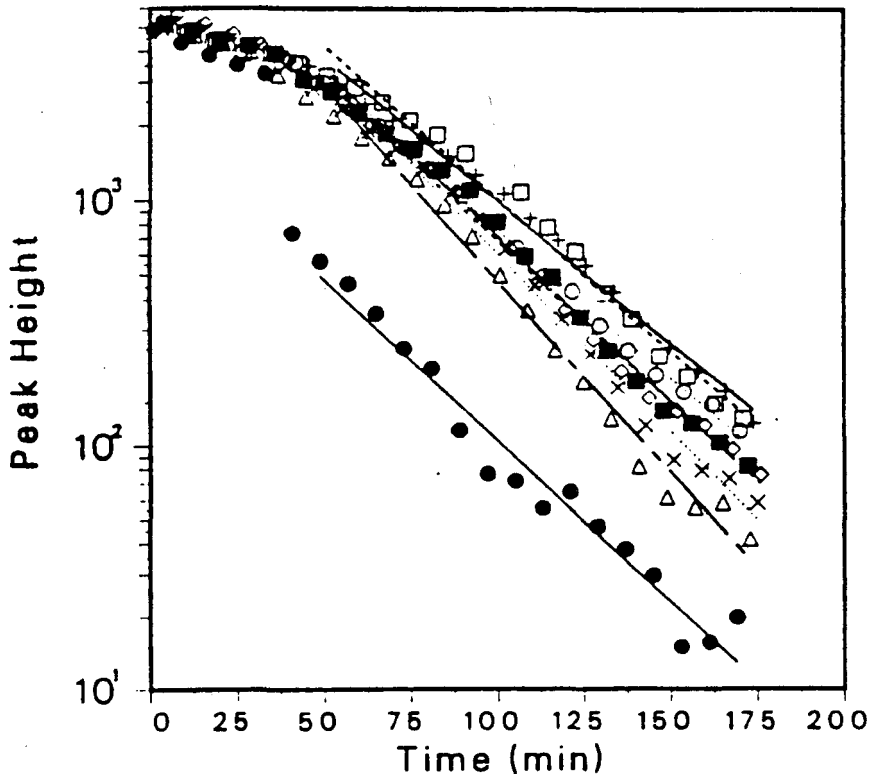
BUILDING 20
1 AUGUST 1984
SPOKANE, WA



- Main supply
1.36 ACH
- Main return
1.65 ACH
- 1st floor A
1.80 ACH
- 1st floor B
1.71 ACH
- △ Cafeteria
2.30 ACH
- ∨ Auditorium
2.80 ACH
- ▽ 2nd floor A
1.57 ACH
- ⋈ 2nd floor B
1.59 ACH

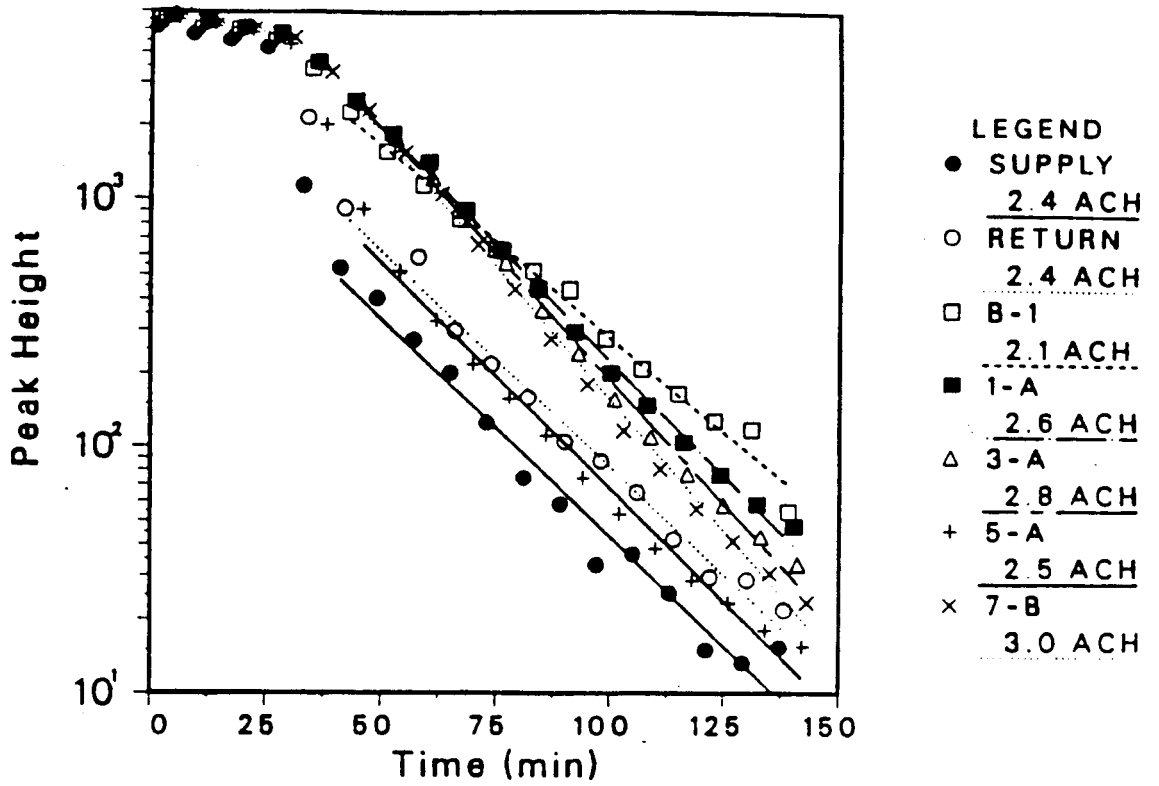
10L 851-954

BUILDING 21
08/03/84

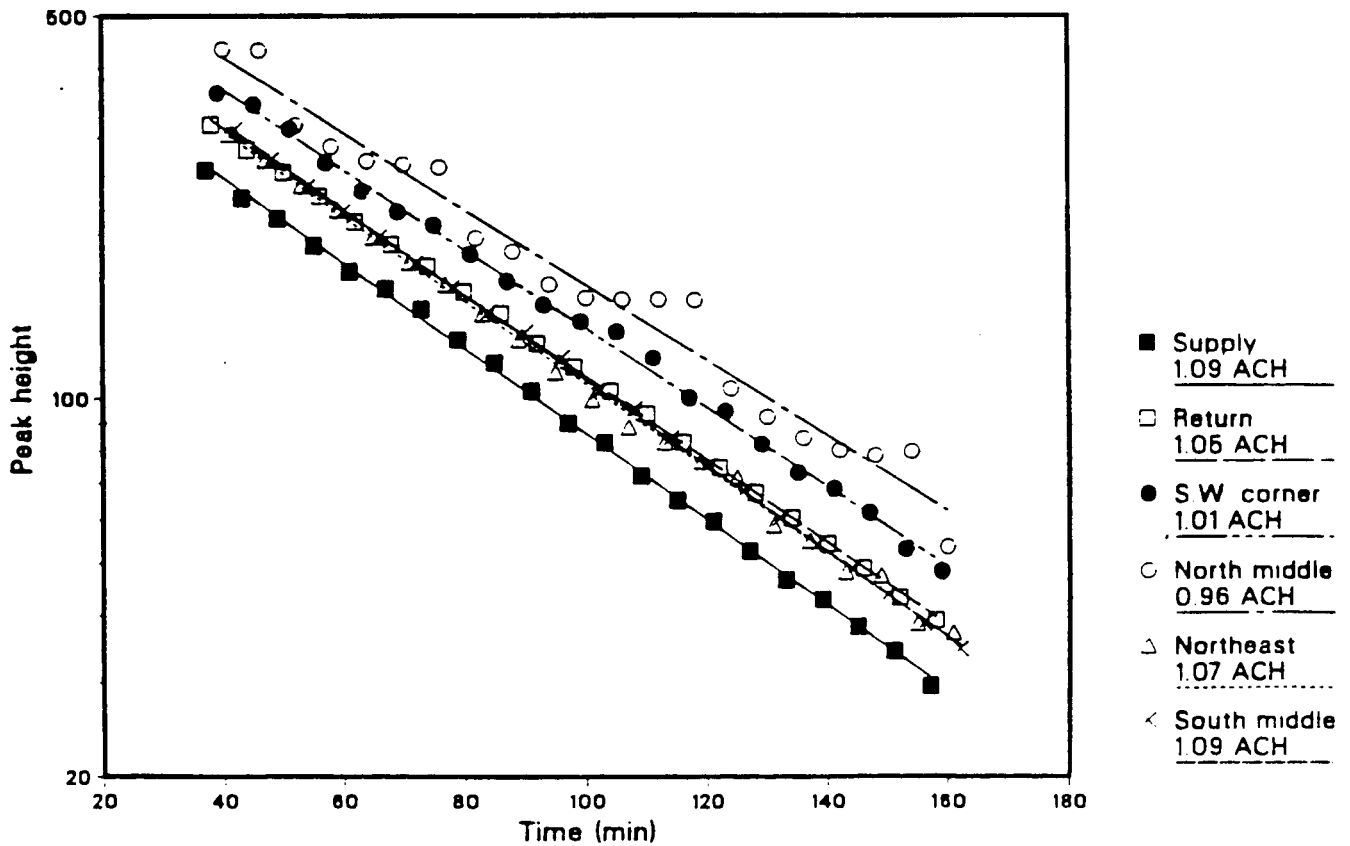


- LEGEND
- SW SUPPLY
1.8 ACH
 - SW RETURN
1.7 ACH
 - 1-A
1.7 ACH
 - 1-B
1.9 ACH
 - △ 2 NORTH WEST
2.2 ACH
 - + 2-B
1.6 ACH
 - × 3-A
2.0 ACH
 - ◇ 3-B
1.8 ACH

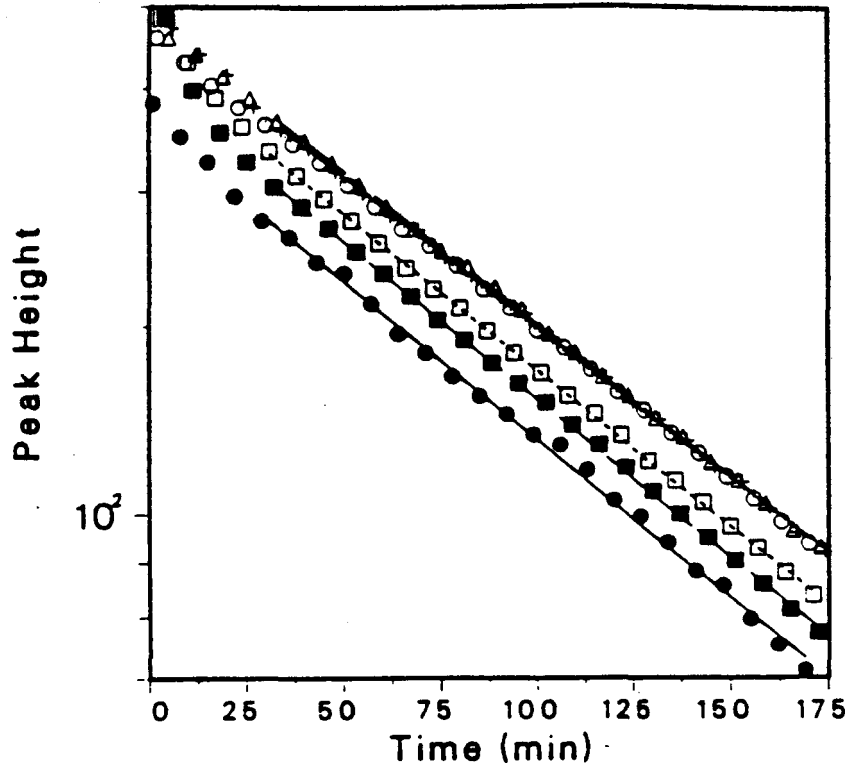
BUILDING 22
07/31/84



BUILDING 23
30 JULY 1984
SPOKANE, WA

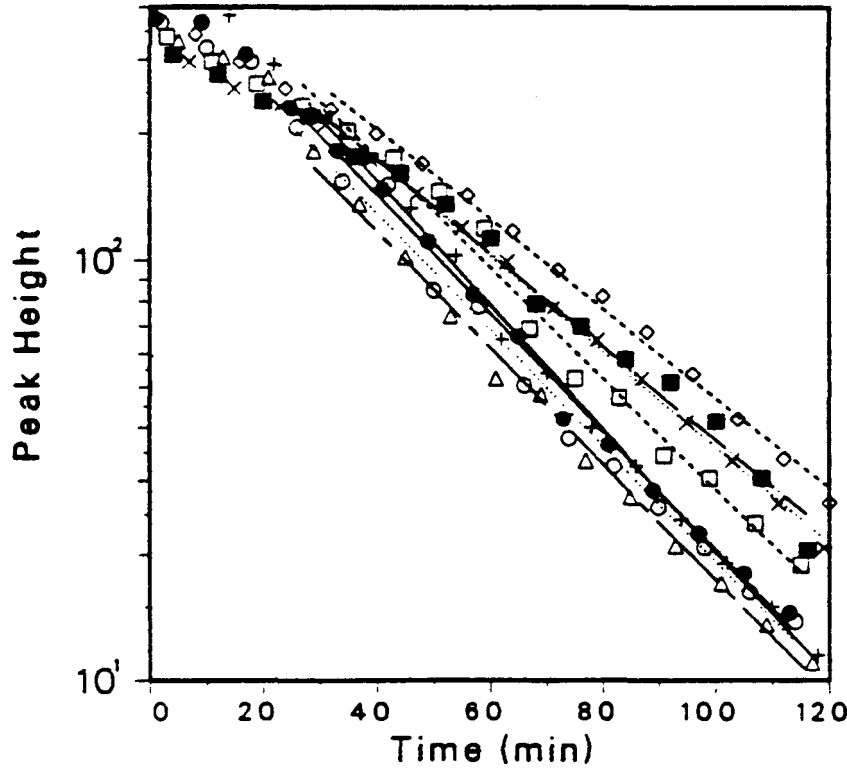


BUILDING 24
08/03/84



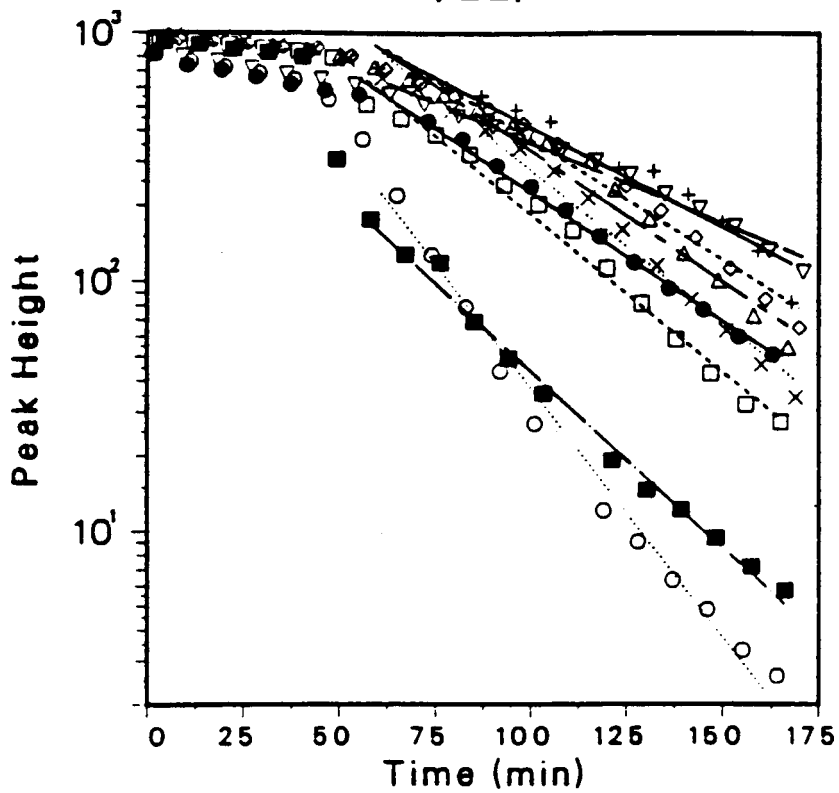
- LEGEND
- SUPPLY
0.4 ACH
 - RETURN N.
0.4 ACH
 - RETURN S.
0.4 ACH
 - 1-A
0.4 ACH
 - △ 1-B
0.4 ACH
 - + 1-C
0.4 ACH

BUILDING 25
08/20/84



- LEGEND
- SYSTEM 1 SUPPLY
1.9 ACH
 - SYSTEM 1 RETURN
1.9 ACH
 - SYSTEM 2 SUPPLY
1.8 ACH
 - SYSTEM 2 RETURN
1.5 ACH
 - △ FIRST FLOOR S.
1.9 ACH
 - + 1-B
2.0 ACH
 - × 2-C
1.6 ACH
 - ◇ 2-B
1.5 ACH

BUILDING 26
08/22/84



- LEGEND
- B-1
1.4 ACH

 - 2-C
2.8 ACH
 - 4TH CORE SUPPLY
1.7 ACH

 - 4TH PERIM SUPPLY
1.9 ACH

 - △ COMMON RETURN
1.5 ACH

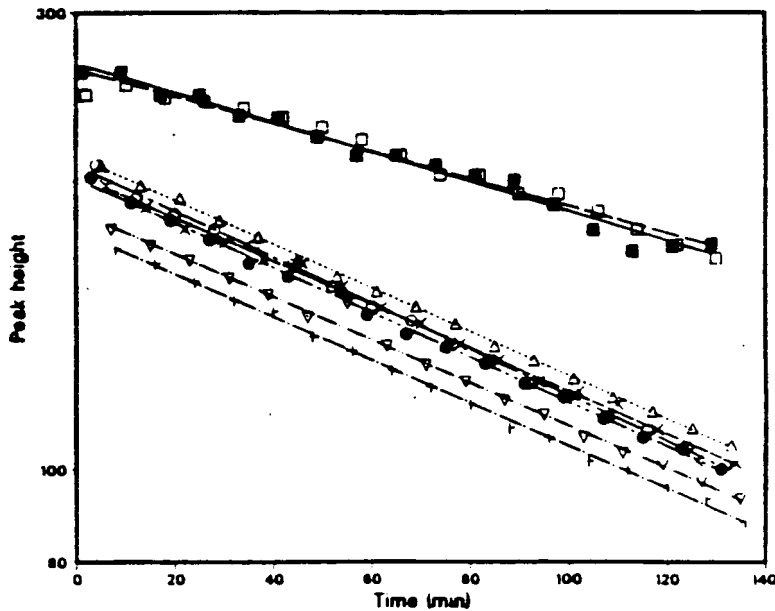
 - + 4-A
1.1 ACH

 - × 4-C
1.7 ACH

 - ◇ 6-C
1.3 ACH

 - ▽ 9-B
0.9 ACH

BUILDING 27
23 AUGUST 1984
SPOKANE, WA



- Basement 2
0.21 ACH

- Basement 3
0.20 ACH

- 2nd A
0.32 ACH

- 2nd B
0.33 ACH

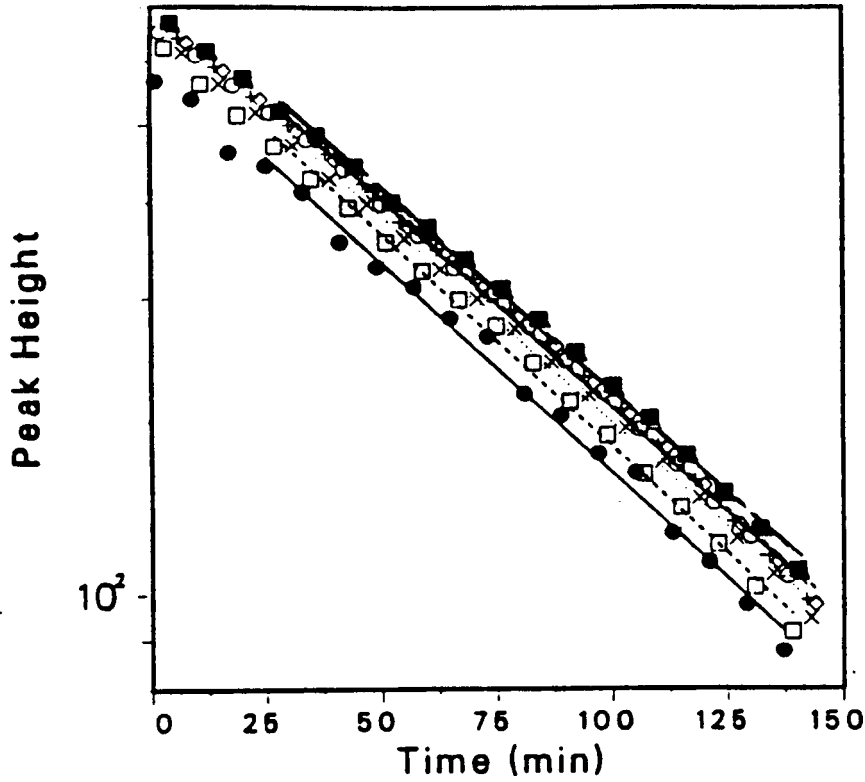
- △ 3rd
0.32 ACH

- ▽ 4th
0.31 ACH

- ▽ Supply roof
0.31 ACH

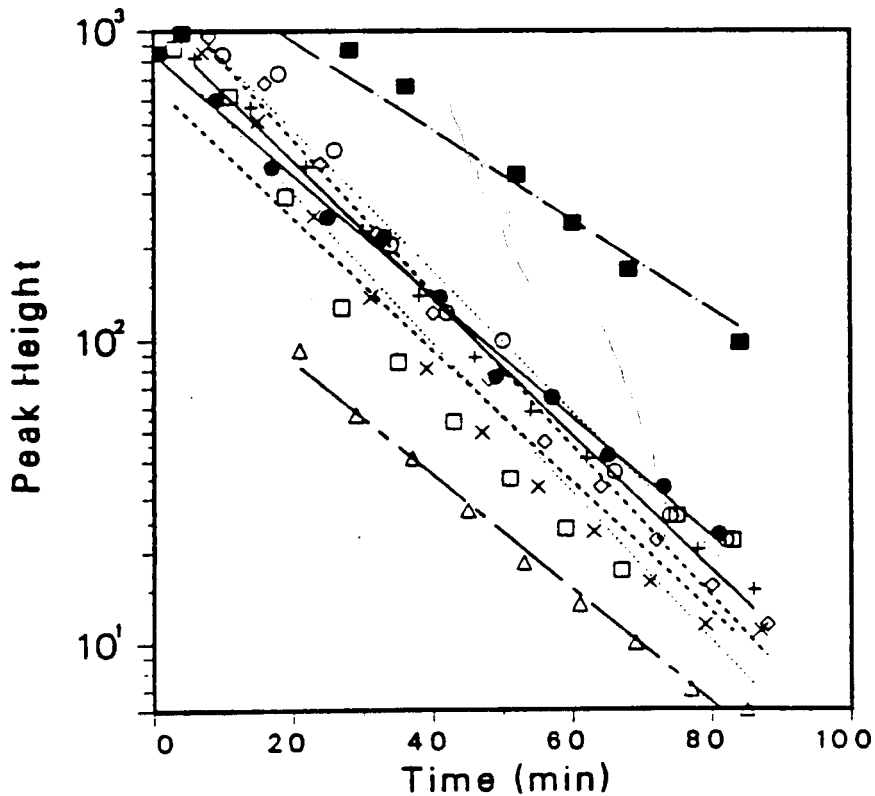
- ▽ Return roof
0.31 ACH

BUILDING 28
08/21/84



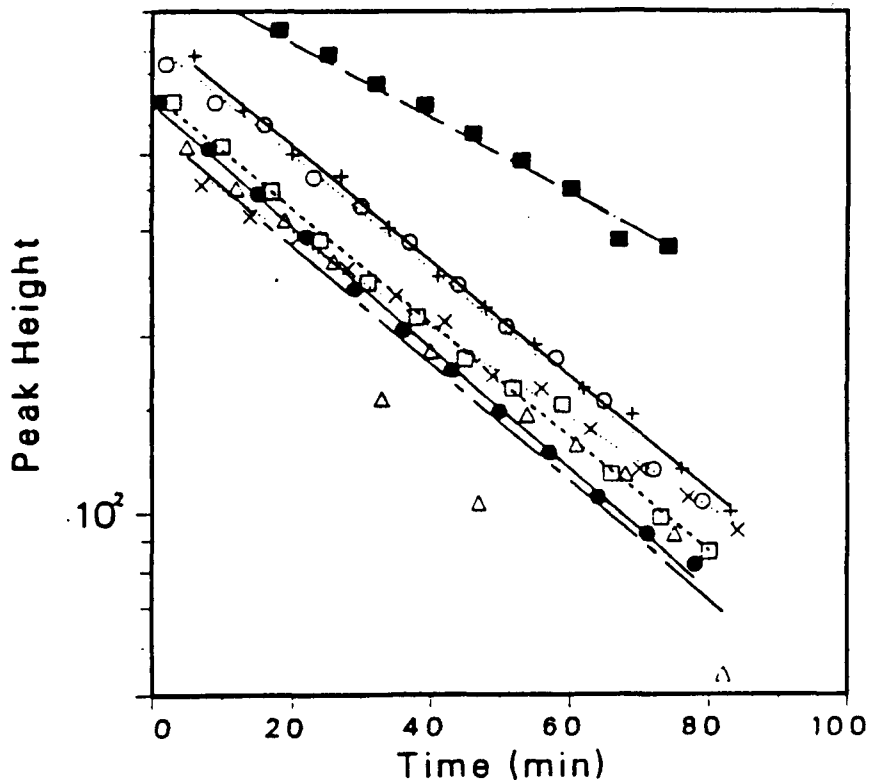
- LEGEND
- system supply
0.6 ACH
 - system return
0.6 ACH
 - B-1
0.6 ACH
 - 1-A
0.6 ACH
 - △ 2-A
0.6 ACH
 - + 2-B
0.6 ACH
 - × 4-A
0.6 ACH
 - ◇ 4-B
0.6 ACH

BUILDING 29
2/12/85



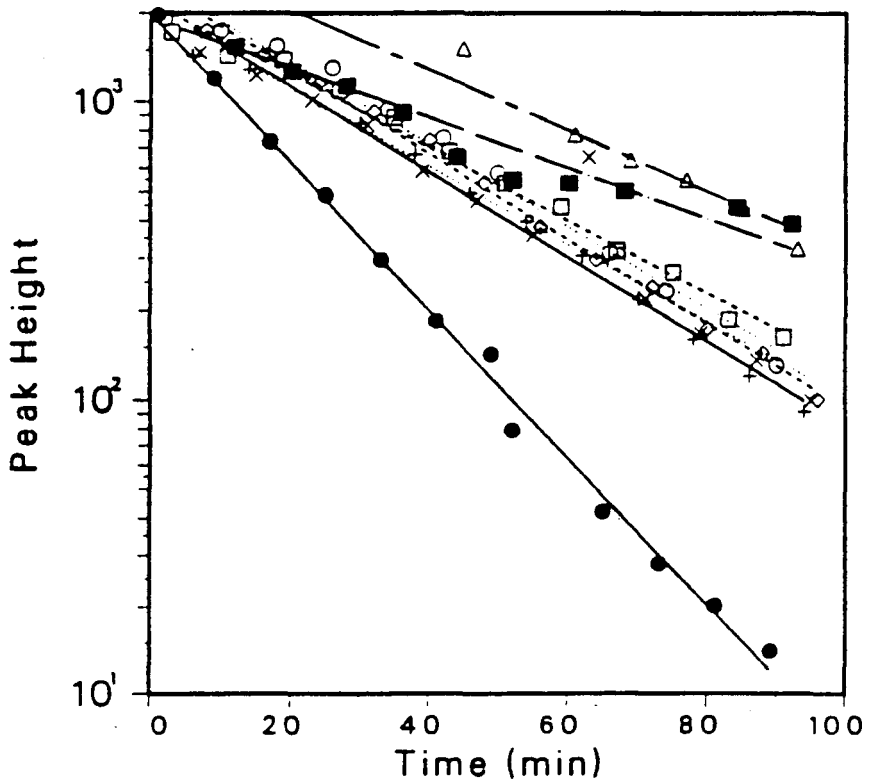
- LEGEND
- 1-A
2.7 ACH
 - 1-F
3.2 ACH
 - 3-A
3.0 ACH
 - G-1
2.0 ACH
 - △ SUPPLY
2.6 ACH
 - + RETURN
3.1 ACH
 - × 2-A
3.4 ACH
 - ◇ 2-C
3.4 ACH

BUILDING 30
2/11/85



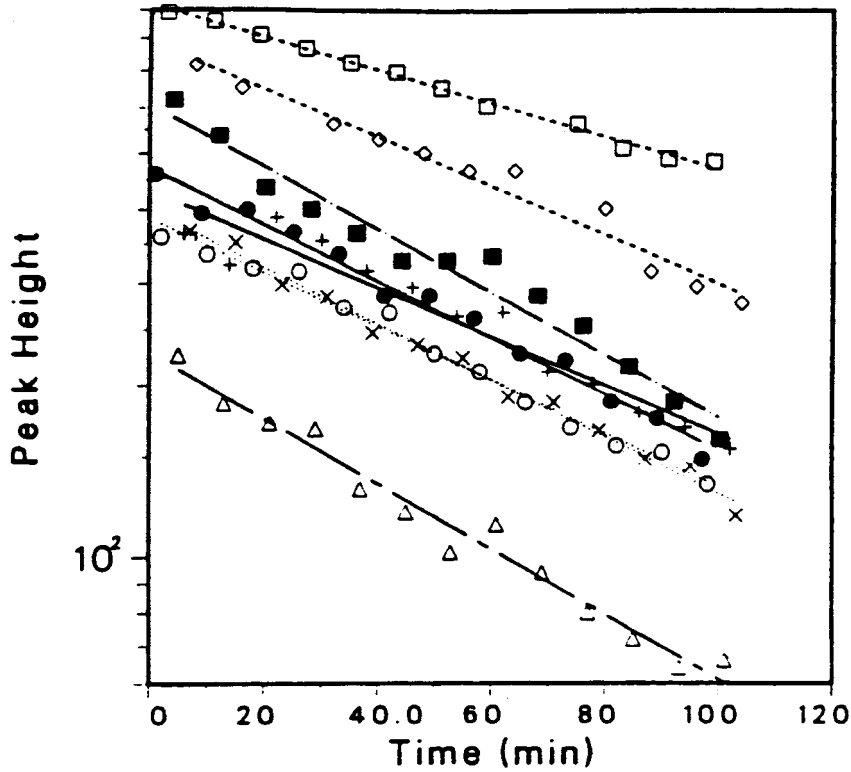
- LEGEND
- ROOM 190
1.4 ACH
 - S-1
1.3 ACH
 - 2-A
1.3 ACH
 - 6-A
0.9 ACH
 - △ SUPPLY
1.4 ACH
 - + RETURN
1.3 ACH
 - × G-1
1.1 ACH

BUILDING 31
2/13/85



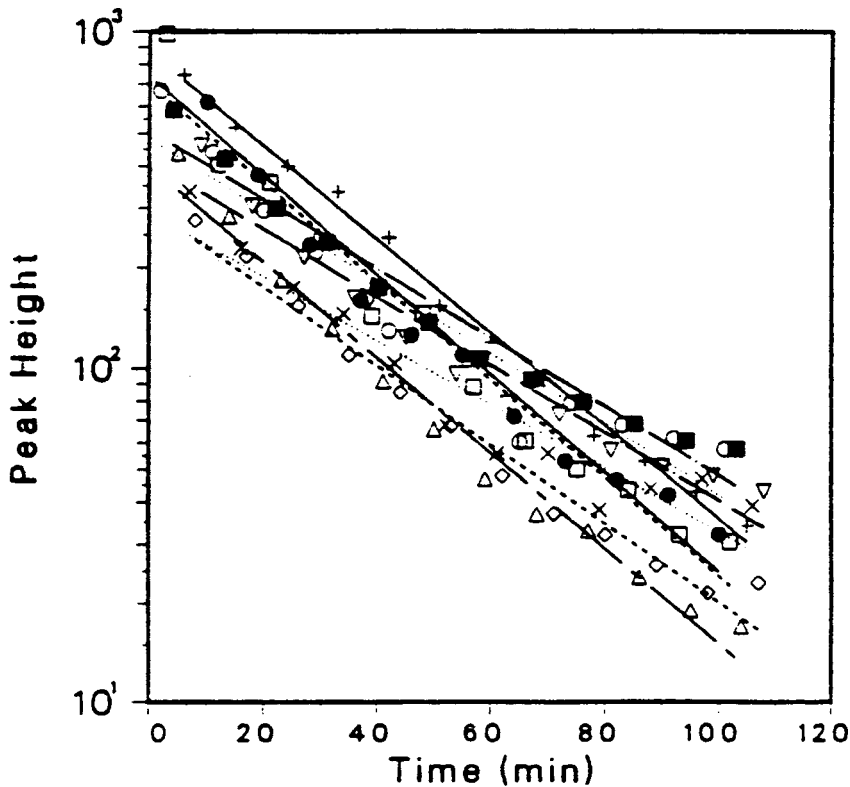
- LEGEND
- 1-C
3.4 ACH
 - 1-D
1.9 ACH
 - 1-E
1.7 ACH
 - 1-F
1.2 ACH
 - △ 1-G
1.4 ACH
 - + 1-B
2.0 ACH
 - × BOWLING ALLEY
1.8 ACH
 - ◇ BOOK STORE
2.0 ACH

BUILDING 32
2/15/85



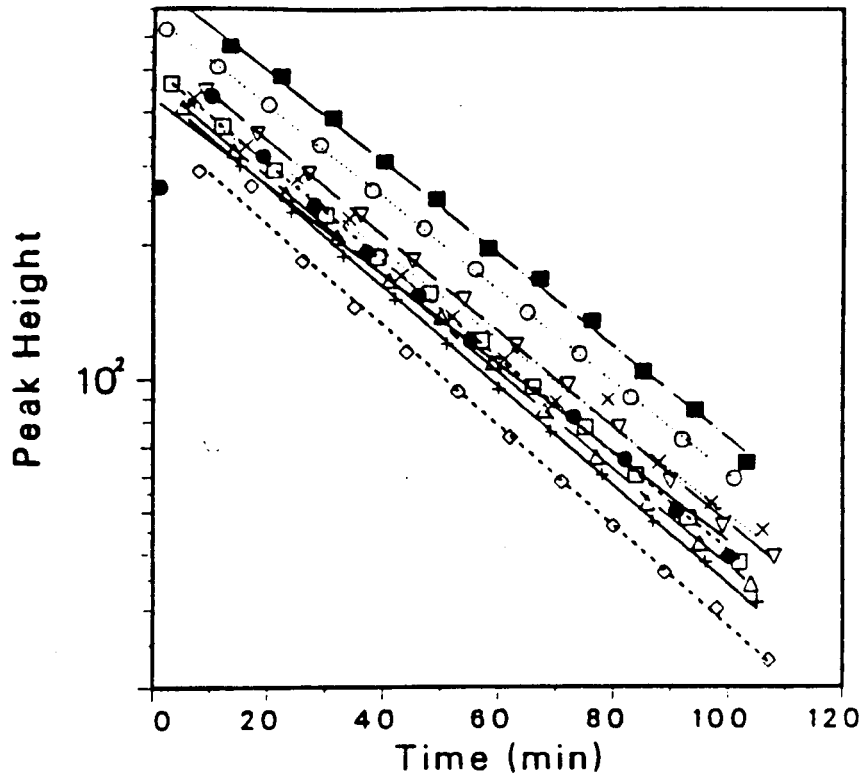
- LEGEND
- B-1
0.7 ACH
 - 1-A
0.6 ACH
 - 1-C
0.4 ACH
 - 2-A
0.7 ACH
 - △ 2-B
0.8 ACH
 - + 3-C
0.6 ACH
 - × SUPPLY
0.7 ACH
 - ◇ RETURN
0.6 ACH

BUILDING 33
2/17/85



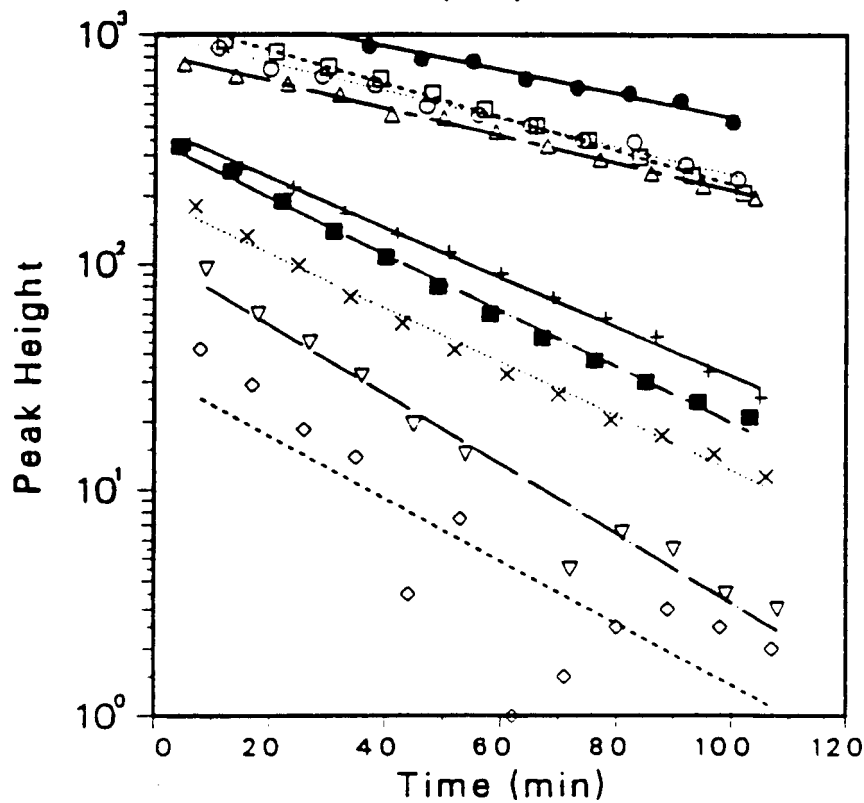
- LEGEND
- 3-C
2.0 ACH
 - 3-A
1.5 ACH
 - 2-C
2.0 ACH
 - 2-A
1.4 ACH
 - △ 1-C
2.0 ACH
 - + 1-B
1.9 ACH
 - × 1-A
1.3 ACH
 - ◇ AH-2 SUPPLY
1.6 ACH
 - ▽ AH-1,2,3 RETURN
1.4 ACH

BUILDING 34
2/18/85



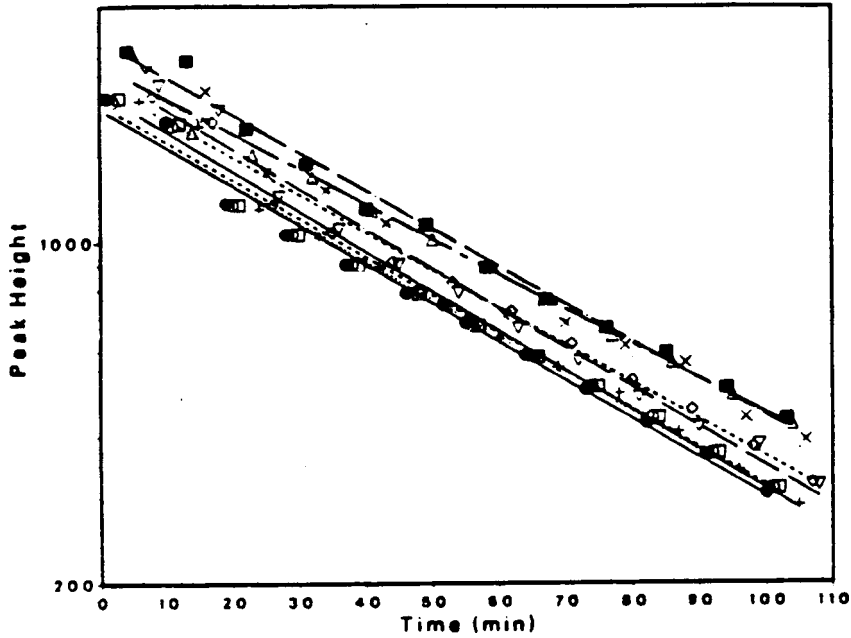
- LEGEND
- B-2
1.4 ACH
 - 1-C
1.4 ACH
 - 2-C
1.5 ACH
 - 3-B
1.4 ACH
 - △ 5-A
1.5 ACH
 - + 10-A
1.5 ACH
 - × 12-B
1.4 ACH
 - ◇ SUPPLY
1.6 ACH
 - ▽ RETURN
1.5 ACH

BUILDING 35
2/19/85



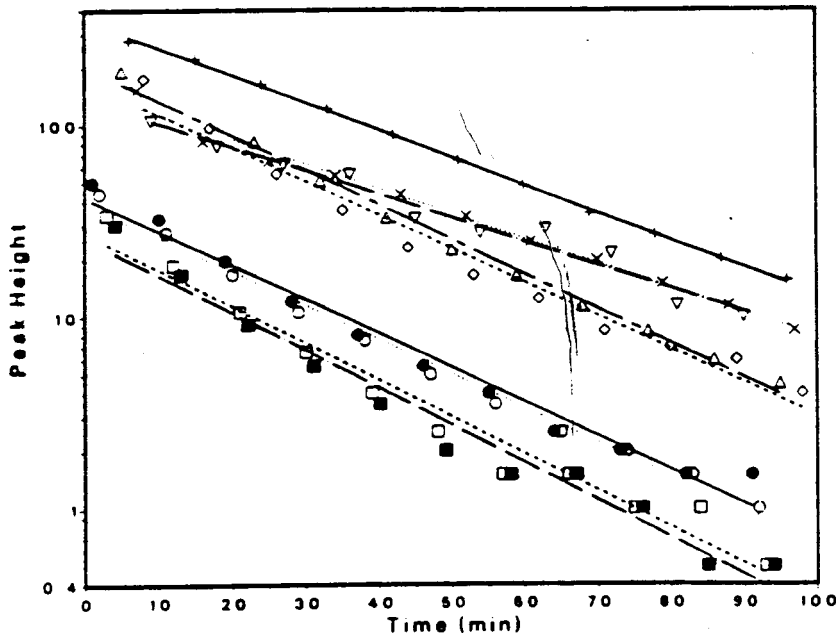
- LEGEND
- 15-A
0.7 ACH
 - 13 FLOOR
0.8 ACH
 - 9-A
1.0 ACH
 - 7-A
1.7 ACH
 - △ 6-A
0.8 ACH
 - + 3-A
1.5 ACH
 - × 2-A
1.7 ACH
 - ◇ M-2
1.9 ACH
 - ▽ B-1
2.1 ACH

BUILDING 36
17 APRIL 1985
SALEM, OR



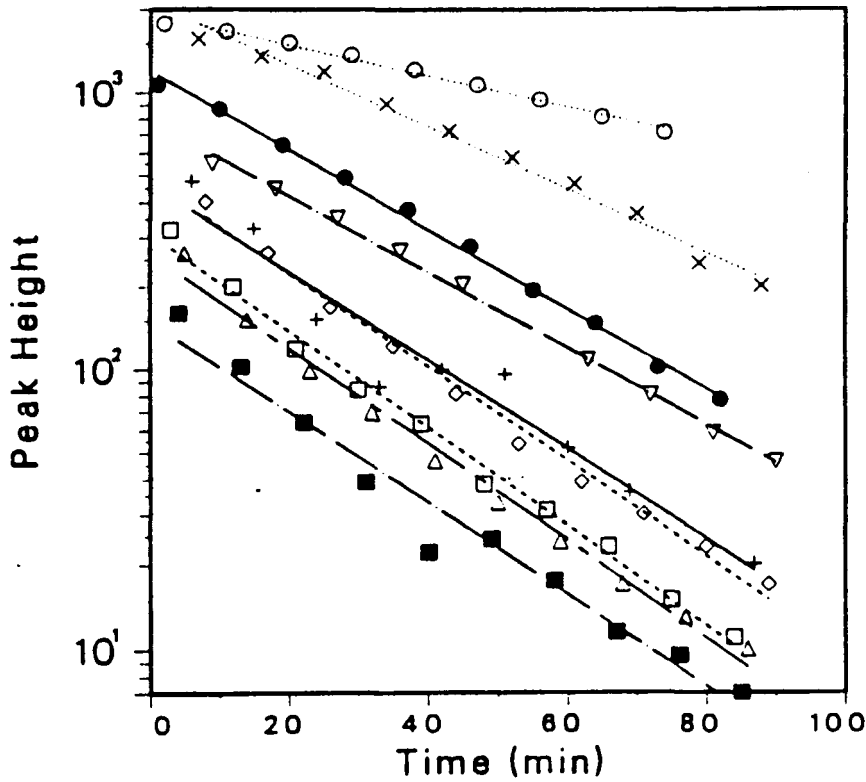
- SUPPLY AH-2
1.1 ACH
- RETURN AH-2
1.1 ACH
- 4-B
1.1 ACH
- ROOM 208 1-FT.
1.1 ACH
- △ ROOM 208 6-FT.
1.0 ACH
- + 1-A
1.1 ACH
- × B-1
1.0 ACH
- ◇ 3-D
1.1 ACH
- ▽ 3-A
1.1 ACH

BUILDING 37
18 APRIL 1985
PORTLAND, OR



- WEST RETURN
2.5 ACH
- EAST RETURN
2.5 ACH
- 8-A
2.7 ACH
- 4-B
2.7 ACH
- △ 2-A
2.5 ACH
- + A-4
2.0 ACH
- × CAFETERIA
1.8 ACH
- ◇ 1-B
2.4 ACH
- ▽ REPRO SERV
1.7 ACH

BUILDING 38
4/15/85



- LEGEND
- B-2
2.0 ACH

 - 1-B
0.8 ACH

 - 3-B
2.4 ACH

 - 3RD SOUTH SUPPLY
2.2 ACH

 - △ 3RD SOUTH RETURN
2.4 ACH

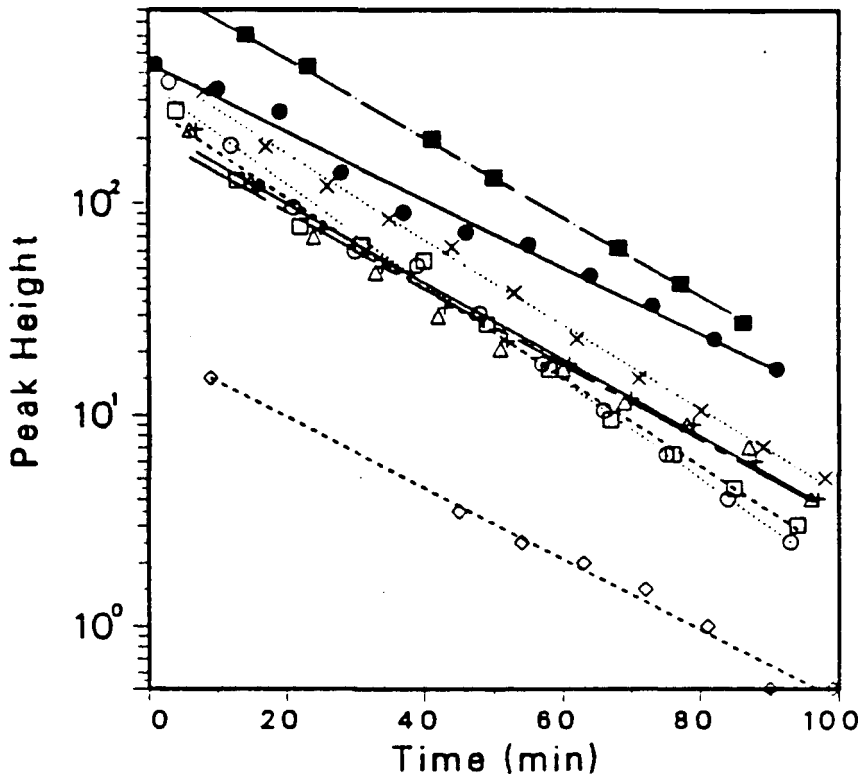
 - + 5TH HALL
2.2 ACH

 - × 7-A
1.6 ACH

 - ◇ 9-A
2.3 ACH

 - ▽ 10-B
1.9 ACH

BUILDING 39
4/16/85



- LEGEND
- P1-1
2.2 ACH

 - B-1
3.2 ACH

 - 3-A
2.9 ACH

 - 3-B
2.5 ACH

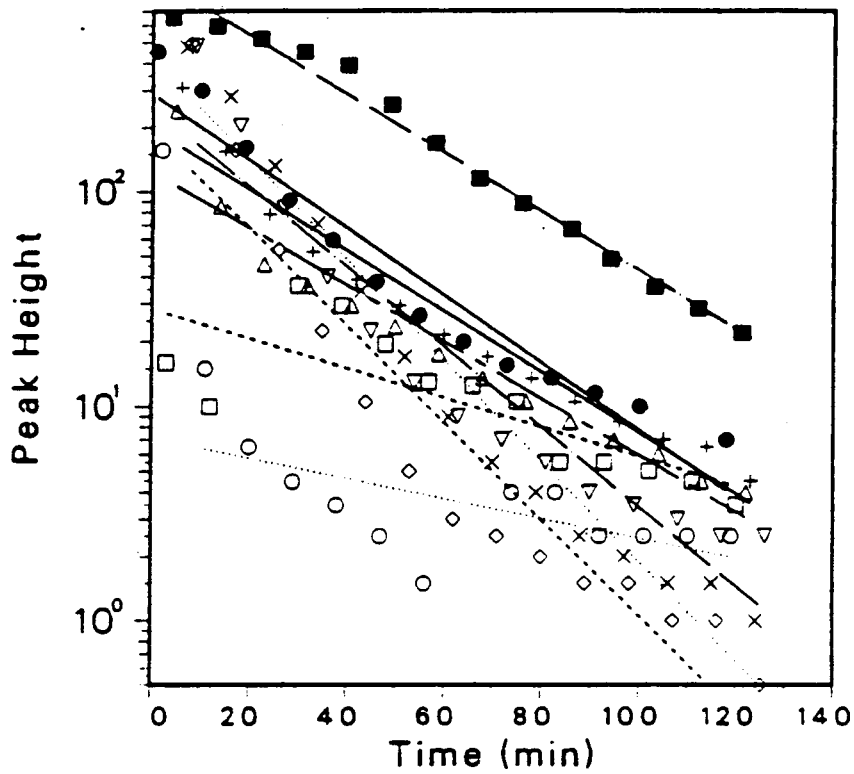
 - △ 4-A
2.5 ACH

 - + 5-A
2.5 ACH

 - × 108 RETURN
2.8 ACH

 - ◇ 109 SUPPLY
2.3 ACH

BUILDING 40
4/14/85



- LEGEND
- BASEMENT RETURN
2.2 ACH
 - AH-201 SUPPLY
0.6 ACH
 - AH-202 SUPPLY
0.9 ACH
 - P1-1
1.9 ACH
 - △ 3-A
1.8 ACH
 - + 8-A
2.0 ACH
 - × 13-A
3.2 ACH
 - ◇ 16-B
3.1 ACH
 - ▽ ROOF RETURN
2.6 ACH

APPENDIX F

SUMMARY OF BUILDING POLLUTANT CONCENTRATIONS AND VENTILATION RATES

BUILDING POLLUTANT CONCENTRATIONS & VENTILATION RATES

	HCHO ⁽¹⁾ (ppb)			H ₂ O ⁽¹⁾ (g H ₂ O/kg air)			RADON ⁽²⁾ (pCi/l)		RSP ⁽¹⁾ (μg/m ³)			CO ₂ ⁽³⁾ (ppm)		CO ⁽⁴⁾ (ppm)		NO ₂ ⁽¹⁾ (ppb)			VENTILATION RATE ⁽⁵⁾ SF ₆ (ACH)	
	AVE	RANGE	OUT	AVE	RANGE	OUT	AVE	RANGE	AVE	RANGE	OUT	AVE	RANGE	RANGE	OUT	AVE	RANGE	OUT	AVE	RANGE
1	34	24-53	---	6.6	6.0-7.1	---	0.8	0.8	25	19-36	---	840	307-1290	---	---	---	---	---	0.8	0.5-1.0
2	B.D.	10-36	---	5.5	5.1-6.2	---	1.0	0.6-1.8	19	15-21	---	510	320-690	---	---	---	---	---	2.2	1.9-3.3
3	All	B.D.	---	4.9	4.6-5.1	---	0.9	0.5-1.4	20	16-25	---	420	340-480	---	---	---	---	---	1.3	1.2-1.4
4	56	38-75	---	6.1	5.6-6.3	---	0.3	0.2-0.5	7	6-8	8	440	400-480	---	---	---	---	---	0.7	0.7-0.8
																			0.6	0.5-0.6
5	38	30-44	---	6.5	5.8-7.2	---	1.5	0.4-2.9	13	13-14	B.D.	490	340-690	---	---	---	---	---	1.7	1.6-1.7
6	32	B.D.-46	---	6.1	5.4-6.6	---	0.7	0.2-1.9	28	11-59	35	496	402-650	< 2-7	---	43*	38-53	---	0.8	0.8-1.0
7	30	B.D.-42	---	6.4	6.1-6.7	---	0.7	0.4-1.3	38	32-44	35	514	458-598	3	---	---	---	---	0.9	0.6-1.1
8	B.D.	B.D.-24	---	7.5	6.8-10.2	---	0.2	0.1-0.4	7	7-8	8	420	360-500	< 2	---	---	---	---	1.1	1.0-1.3
9	B.D.	B.D.-25	---	7.3	6.9-7.6	---	0.3	0.0-1.1	15	11-20	8	420	320-510	< 2-3	---	19	16-23	---	0.7	0.7-0.8
10	32	B.D.-52	---	5.9	5.3-6.7	---	0.3	0.0-0.7	86	53-127	9	---	---	---	---	12	B.D.-29	---	0.9	0.8-1.0
11	B.D.	B.D.-41	---	5.9	5.2-6.2	---	0.3	0.0-0.6	63	9-209	8	467	400-540	≤ 2	---	15	9-19	---	3.6	2.1-5.4
12	23	B.D.-35	---	6.8	5.6-7.7	---	0.5	0.0-0.9	36	10-63	---	520	460-644	---	---	80	---	---	0.3	0.2-0.4 ⁽⁷⁾
13	25	B.D.-34	---	6.1	5.4-7.2	---	0.3	0.3	5	5-6	10	600	520-680	< 2	---	18	17-19	---	1.5	1.3-1.6
14	22	B.D.-29	---	6.1	4.2-10.1	---	0.5	0.0-1.5	30	26-34	6	420	330-500	< 2	---	25	23-28	---	4.1	3.6-5.5
15	B.D.	B.D.-31	---	6.0	5.3-7.3	---	0.6	0.2-1.6	11	7-14	B.D.	370	350-430	< 2	---	12	9-14	---	1.7	1.5-2.2
16	20	B.D.-34	---	6.5	6.1-7.0	---	1.1	0.8-1.4	31	8-73	10	530	410-700	---	---	10	8-12	---	2.0	0.6-2.4
17	All	B.D.	---	6.6	6.0-7.1	---	2.2	1.9-2.5	40	10-105	7	520	340-670	< 2	---	80	7	---	2.2	0.3-3.0 ⁽⁷⁾
18	All	B.D.	---	6.8	6.6-7.1	---	1.8	0.4-3.3	19	19	7	390	320-450	< 2	---	17	17	---	0.6	0.5-0.7

BUILDING POLLUTANT CONCENTRATIONS & VENTILATION RATES

	HCHO ⁽¹⁾ (ppb)			H ₂ O ⁽¹⁾ (g H ₂ O/kg air)			RADON ⁽²⁾ (pCi/l)		RSP ⁽¹⁾ (μg/m ³)			CO ₂ ⁽³⁾ (ppm)		CO ⁽⁴⁾ (ppm)		NO ₂ ⁽¹⁾ (ppb)			VENTILATION RATE ⁽⁵⁾ SF ₆ (ACH)	
	AVE	RANGE	OUT	AVE	RANGE	OUT	AVE	RANGE	AVE	RANGE	OUT	AVE	RANGE	RANGE	OUT	AVE	RANGE	OUT	AVE	RANGE
19	B.D.	B.D.-28	---	6.5	6.3-6.8	---	1.7	1.7	20	11-29	7	490	350-660	< 2	---	19	15-23	---	0.9	0.7-1.0
20	42	B.D.-192	---	8.2	7.9-8.7	---	2.1	1.5-2.6	11	10-11	18	400	330-460	< 2	< 2	17	12-21	---	1.8	1.4-2.8
21	20	B.D.-40	---	8.2	7.5-9.3	---	1.0	1.0	11	9-12	17	410	340-530	< 2	---	15	12-18	---	1.8	1.6-2.2 ⁽⁷⁾
22	28	B.D.-39	---	8.4	7.6-9.2	---	1.0	1.0	50	18-165	20	510	410-630	< 2	---	19	17-21	---	2.5	2.1-3.0 ⁽⁷⁾
23	32	B.D.-57	---	9.4	8.2-12.0	---	1.3	1.3	9	B.D.-20	11	394	335-470	< 2	---	11	11	---	1.0	1.0-1.1 ⁽⁷⁾
24	35	32-39	---	9.8	9.5-10.0	---	1.5	1.5	37	10-77	11	585	340-685	< 2	---	13	13	---	0.4	0.4-0.4 ⁽⁷⁾
25	29	B.D.-49	---	9.8	9.5-10.2	---	0.9	0.8-1.1	60	32-109	68	470	375-535	< 2	---	14	12-15	---	1.8	1.5-2.0 ⁽⁷⁾
26	B.D.	B.D.-27	35	8.0	7.1-9.3	8.6	0.8	0.5-1.2	67	20-123	32	400	370-480	< 2	< 2	27	16-37	21	1.5	0.7-3.5 ⁽⁷⁾
27	36	B.D.-62	34	8.3	7.5-9.4	9.1	0.9	0.5-1.4	48	33-89	52	460	390-640	< 2-3	5	16	14-19	20	0.3	0.2-0.3 ⁽⁷⁾
28	B.D.	B.D.-20	47	8.7	7.9-10.2	9.9	0.3	0.3	24	B.D.-43	65	511	480-540	< 2	3	24	23-25	23	0.6	0.6-0.6 ⁽⁷⁾
29	B.D.	ALL B.D.	21	3.4	3.1-3.7	3.2	1.2	1.0-1.3	32	8-144	29	571	480-707	< 2-4	---	16	13-19	21	3.0	2.0-3.4 ⁽⁷⁾
30	22	B.D.-46	80	4.2	3.5-4.8	2.1	1.9	1.6-2.3	37	20-113	33	641	374-863	< 2-4	---	13	12-16	15	1.3	0.9-1.4 ⁽⁷⁾
	(#17 Test 2)																			
31	B.D.	B.D.-62	21	4.1	3.8-4.5	4.8	1.2	0.6-1.5	64	8-268	13	610	384-790	< 2	< 2	14	9-20	10	1.9	1.2-3.4
32	B.D.	ALL B.D.	80	5.4	4.2-6.6	3.0	7.4	3.3-9.2	21	10-52	ND	579	520-673	< 2	---	5	B.D.-8	5	0.6	0.4-0.8 ⁽⁷⁾
33	B.D.	B.D.-30	(6)	4.8	3.7-6.1	(6)	0.8	0.5-1.2	29	12-74	ND	642	456-806	< 2	< 2	10	7-14	(6)	1.6	1.3-2.0 ⁽⁷⁾
34	25	B.D.-34	45	4.0	3.6-4.7	4.0	0.9	0.3-2.5	28	10-117	16	407	365-477	< 2-6	< 2	18	10-29	26	1.5	1.4-1.6 ⁽⁷⁾
35	24	B.D.-32	24	4.8	4.2-6.0	6.3	1.1	0.2-5.7	23	6-50	18	458	426-505	< 2-4	---	22	9-58	25	1.4	0.7-2.1

L-3

BUILDING POLLUTANT CONCENTRATIONS & VENTILATION RATES

	HCHO ⁽¹⁾ (ppb)			H ₂ O ⁽¹⁾ (g H ₂ O/kg air)			RADON ⁽²⁾ (pCi/l)		RSP ⁽¹⁾ (µg/m ³)			CO ₂ ⁽³⁾ (ppm)		CO ⁽⁴⁾ (ppm)		NO ₂ ⁽¹⁾ (ppb)			VENTILATION RATE ⁽⁵⁾ SF ₆ (ACH)		
	AVE	RANGE	OUT	AVE	RANGE	OUT	AVE	RANGE	AVE	RANGE	OUT	AVE	RANGE	RANGE	OUT	AVE	RANGE	OUT	AVE	RANGE	
36	B.D.	B.D.-23	B.D.	6.2	5.4-7.1	6.0	0.2	0.1-0.4	28	9-127	20	604	424-878	≤2	2	18	15-22	17	1.1	1.0-1.1 ⁽⁷⁾	
	(#11 test 2)																				
37	B.D.	B.D.-47	20	5.3	4.7-6.0	6.5	0.3	0.1-1.1	25	11-62	19	395	323-482	< 3	---	31	26-38	40	2.4	1.7-2.7 ⁽⁷⁾	
38	26	B.D.-76	B.D.	7.1	6.7-8.8	8.5	0.9	0.2-1.8	46	B.D.-308	14	691	476-889	< 2	< 2	27	17-32	37	1.9	0.8-2.4	
39	B.D.	B.D.-30	35	7.3	6.6-11.8	8.6	0.3	0.1-1.0	11	8-14	11	337	306-363	< 2	< 2	33	27-40	37	2.7	2.2-3.2	
40	B.D.	B.D.-31	--	7.1	6.1-7.5	--	0.3	0.2-0.6	15	8-40	11	517	383-645	≤2	< 2	31	24-37	37	2.4	0.6-3.2 ⁽⁷⁾	

Footnotes:

1. Results for passive samplers deployed in a variety of building locations for 10 days. (Water vapor corresponds to a range of 30-70% RH at an assumed average indoor temperature of 68°F).
2. Results for passive samplers deployed in a variety of building locations for approximately 3 months.
3. Measurements were taken continuously over an eight hour period at one building location. Data for buildings 6 and 9 represent two building sampling locations.
4. CO 8-hour integrated samples were taken at from one to six indoor locations.
5. Results of measurements taken during a single tracer SF₆ decay test for a variety of building locations. HVAC systems operated under conditions observed during air quality measurements. (Data for building #4 indicates tests run on separate dates.)
6. Samplers damaged - data missing.
7. Building average ventilation rate includes decay rate measured in return air.

B.D. = Below detection limits

APPENDIX G

LOCATION OF ODEQ - SCAPCA MONITORING SITE RELATIVE TO BPA/COMMERCIAL BUILDINGS

In the four cities where buildings were monitored, outdoor air pollution measurements are made by local or state agencies. The siting of pollution measuring devices relative to the buildings being tested in each city is of interest for comparative purposes. In Salem and Portland the Oregon Department of Environmental Quality (ODEQ) and Oregon Department of Transportation (ODOT) maintain monitoring facilities. In Spokane and Cheney the Spokane County Air Pollution Control Authority (SCAPCA) monitors airborne pollutants. Table G.1 lists measurements of outdoor air pollutants measured by these agencies during the period when tests were being conducted in the nearby buildings. As can be seen, only Total Suspended Particles (TSP) measured using a high volume sampler are available in all four cities. Fine fraction suspended particulate matter, with a cut-off size of $2.5 \mu\text{m}$ was monitored by air pollution agencies concurrent with 20 building test periods. Since this BPA study measured respirable suspended particles (RSP), with a 50% cut point at $3.0 \mu\text{m}$, for RSP, only an approximate comparison with agency measurements is possible. For other pollutants, CO and NO_2 , the coverage is less complete. Nitrogen dioxide in particular was measured during the test period for only the last four buildings near downtown Portland, Oregon.

In Cheney, WA, TSP was the only pollutant measured by the SCAPCA for comparison to Buildings #32 and #33. The TSP values for the Cheney City Hall site were used. The SCAPCA TSP measurements were taken at seven-day intervals. The data presented in Table G.1 is an arithmetic average for all the measurements which occurred from two days before to two days after the RSP measurement of this study. Since RSP measurements at the buildings were taken for ten working days usually two or three measurements by SCAPCA were available for comparison to each building.

In Spokane proper, 16 monitoring sites are maintained by SCAPCA. Sites for comparison to outdoor pollutant measurements at the buildings were selected on the basis of their proximity to the buildings and dependent upon the pollutant to be measured, since most SCAPCA sites measure only one pollutant. The buildings in this study were also monitored in groups of two or three at one time so identical readings may apply to more than one building where the nearest relevant SCAPCA site was used for comparison (e.g.; Building #16 and #17). Only one SCAPCA site measures fine fraction particles and is more than 2 miles distant from 14 of the 18 buildings. Buildings #31 and #29 are 5.2 and 3.8 miles respectively from this site. Building #31 is in a sparsely populated suburban area whereas the SCAPCA site is in an urban setting so that its measurement of fine fraction is not necessarily representative of that occurring at Building #31. This is the most glaring example of the nonrepresentativeness of sites. For the other pollutants (CO and TSP) and most buildings (#18 - 28, 34, and 35), the nearest pollutant measuring site is less than one mile distant and similarly sited with respect to surrounding level of urban development. Buildings #16, 17, 29, and 30 are somewhat more distant (less than 2.5 miles) but similar in their environmental setting to the nearest SCAPCA pollutant measuring site. (Table G.1).

Only TSP and CO are monitored in Salem, OR. One site monitors TSP near central Salem, less than one mile from all buildings (#8-#15 and #36). Carbon monoxide is measured at two sites one of which is also located quite close to the sample buildings.

For buildings in the metropolitan Portland area, the Table gives the relevant distances to the monitoring station for each measured pollutant.

Distances from monitoring sites are generally greater for the buildings in the Portland metropolitan area than those from the other two cities. However, the five downtown buildings (#6, 7, 38, 39, 40) are quite close to the ODEQ - ODOT sites and are found in the same surroundings. Information from these sites should correspond quite well with the building measurement. Agency measurements of NO₂ and CO are made hourly each day, and were averaged for the hours of the entire ten day sampling period (maximum of 80 hourly values).

Total suspended particles was measured every seven days. Values from two days before or after the building sampling period were used to give two or three measurements to average for comparison.

The fine fraction (<2.5 μm) ratio to the TSP values shown in Table H.1 are interesting in that the spring-summer samples for buildings #16 - #28 show a much smaller ratio of fine to TSP (0.05 to 0.11) than do the winter samples buildings #31, #34, and #35 (0.31-0.56). Winter-spring measurement values in Portland fall into the same range (0.39-0.44) as those in Spokane but there are no summer measurements for Portland.

Values of pollutant concentrations, measured by these air pollution control groups, are discussed relative to building site specific measurements where they occur in the textual discussion of specific pollutants.

OUTDOOR POLLUTANT LEVELS - MONITORING AGENCY REPORTS (1)

Building	CO(ppm)		NO ₂ (ppb)		HV TSP (μgm ⁻³)		FINE FRACTION ⁽²⁾		FINE +
		-(mi) ⁽³⁾		-(mi)		-(mi)	(μgm ⁻³)	-(mi)	TSP
1	NA		NA		56	0.7	NA		
2	NA		NA		68	0.7	NA		
3	NA		NA		29	1.1	NA		
4	NA		NA		38	1.1	NA		
5	NA		NA		28	0.6	NA		
6	2	0.4	NA		NA		NA		
7	5	0.4	NA		NA		NA		
8	1		NA		23		NA		
9	1		NA		23		NA		
10	2		NA		23		NA		
11	1		NA		23		NA		
12	NA		NA		23		NA		
13	1		NA		23		NA		
14	1		NA		18		NA		
15	1		NA		18		NA		
16	NA		NA		84	2.4	5	2.4	0.06
17	NA		NA		84	2.4	5	2.4	0.06
18	NA		NA		92	0.2	5	3.2	0.05
19	NA		NA		87	0.2	5	3.3	0.06
20	2	0.6	NA		140	0.8	9	2.9	0.06
21	4	0.3	NA		140		10	3.2	0.07
22	3	0.2	NA		140	0.4	9	1.6	0.06
23	NA		NA		155	0.8	10	0.8	0.06
24	1	1.7	NA		155	0.8	10	0.8	0.06
25	2	1.7	NA		155	0.8	10	0.8	0.06
26	3	0.1	NA		141	0.3	14	3.1	0.10
27	5	0.6	NA		133	0.5	14	2.6	0.11
28	NA		NA		141	0.5	14	3.2	0.10
29	2	2.0	NA		173	1.8	NA	3.8	NA
30	4	1.9	NA		173	2.4	NA	2.4	NA
31	3	1.8	NA		45	2.0	25	5.2	0.56
32	NA		NA		29	1.0	NA		NA
33	NA		NA		29	1.0	NA		NA
34	3	0.2	NA		109	0.5	34	2.8	0.31
35	3	0.3	NA		109	0.5	34	2.8	0.31
36	2		NA		77		NA		NA
37	3	1.4	22	4.0	113	1.2	44	1.2	0.39
38	4	0.4	16	3.8	63	0.8	28	0.8	0.44
39	3	0.2	15	3.6	63	0.4	28	0.4	0.44
40	3	0.2	17	3.6	69	0.4	28	0.4	0.41

(1) Mean value for all readings for nearest monitoring site for period of BPA outside sampling.

(2) ≤2.5μm

(3) Distance to nearest relevant other agency site, in map measured straight line miles

BUILDINGS: 1-15 and 36-40 OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY
16-35 SPOKANE COUNTY AIR POLLUTION CONTROL AUTHORITY

APPENDIX H

CONCENTRATIONS OF 7 POLYCYCLIC AROMATIC HYDROCARBONS
IN INDOOR AND OUTDOOR AIR

Outdoor Concentrations of 7 Polycyclic Aromatic Hydrocarbons

BLOG	CHRY SENE (ng/m ³)	BENZO-B FLUORAN THENE (ng/m ³)	BENZO-K FLUORAN THENE (ng/m ³)	BENZO-A PYRENE (ng/m ³)	DIBENZ A-N ANTHRA CENE (ng/m ³)	BENZO G-H-I PERY LENE (ng/m ³)	INDENO 1-2-3 CD PYRENE (ng/m ³)	TOTAL PAN
08	0.18	0.56	0.25	0.22	0.43	0.91	0.33	2.89
09	0.27	0.71	0.32	0.27	0.47	1.00	0.40	3.44
10	0.04	0.26	0.08	0.04	0.14	0.67	0.29	1.53
11	0.24	0.32	0.13	0.09	0.12	0.70	0.32	1.92
15	0.27	0.81	0.34	0.34	0.60	0.90	0.12	3.38
20	0.13	0.15	0.09	0.09	0.11	0.30	0.80	1.67
21	0.11	0.13	0.08	0.08	0.09	0.26	0.68	1.42
23	0.10	0.52	0.15	0.11	0.08	0.16	0.62	1.75
25	0.11	0.58	0.17	0.12	0.09	0.18	0.69	1.94
26	ND	ND	ND	0.29	ND	ND	ND	ND
27	0.13	0.17	0.10	0.38	0.12	0.23	0.90	2.03
28	0.08	0.10	0.06	0.23	0.07	0.56	0.54	1.63
29	ND	ND	ND	1.75	ND	ND	ND	ND
30	4.23	3.72	1.83	2.84	0.44	4.26	2.33	19.66
31	0.62	0.90	0.37	0.58	0.20	1.61	1.36	5.64
34	1.03	2.01	0.79	0.73	0.23	2.39	3.14	10.32
35	1.35	2.49	1.03	1.25	0.38	3.08	5.28	14.85
36	0.45	1.20	0.52	0.40	0.20	1.42	0.66	4.85
37	0.72	1.41	0.55	0.42	0.21	2.19	0.75	6.26
39	0.44	1.09	0.47	0.47	0.06	0.27	0.23	3.04

ND - Data not available for that compound

Building Average

Indoor Concentrations of 7 Polycyclic Aromatic Hydrocarbons

BLDG	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	TOTAL
	CHRY SENE (ng/m ³)	BENZO-B FLUORAN THENE (ng/m ³)	BENZO-K FLUORAN THENE (ng/m ³)	BENZO-A PYRENE (ng/m ³)	DIBENZ A-H ANIHRA CENE (ng/m ³)	BENZO G-H-I PERT LENE (ng/m ³)	INDENO 1-2-3 CD PYRENE (ng/m ³)	PAH (ng/m ³)	
08	0.17	0.43	0.20	0.18	0.31	0.97	0.40	2.67	
09	0.37	0.70	0.29	0.31	0.29	0.98	0.22	3.16	
10	0.61	1.13	0.38	0.87	0.43	1.58	0.46	5.45	
11	0.66	0.99	0.35	0.73	0.64	1.42	0.22	5.00	
12	0.21	0.24	0.07	0.10	0.12	0.79	0.29	1.83	
13	0.08	0.23	0.09	0.10	0.15	0.44	0.11	1.20	
14	0.35	0.90	0.24	0.54	0.38	1.20	0.36	3.97	
15	0.24	0.48	0.18	0.20	0.30	0.92	0.34	2.66	
16	1.02	0.61	0.17	0.70	0.09	0.69	0.69	3.98	
17	0.52	0.66	0.20	0.78	0.09	0.46	1.00	3.71	
18	0.35	0.35	0.06	0.06	0.17	0.22	0.58	1.80	
19	0.38	0.28	0.08	0.08	0.09	0.27	0.71	1.89	
22	0.32	0.30	0.16	0.36	0.08	0.51	0.75	2.48	
23	0.09	0.47	0.13	0.10	0.07	0.14	0.55	1.56	
24	0.09	0.48	0.14	0.10	0.08	0.15	0.57	1.60	
25	0.75	0.47	0.14	0.15	0.07	0.14	0.56	2.28	
26	0.43	0.30	0.12	0.43	0.09	0.94	0.55	2.86	
27	0.38	0.35	0.08	0.26	0.09	0.17	0.68	2.00	
28	0.08	0.10	0.06	0.29	0.07	0.30	0.46	1.36	
29	1.87	1.20	0.50	0.86	0.21	1.50	1.28	7.43	
30	2.98	2.33	0.99	1.36	0.68	2.94	1.26	12.54	
31	7.50	4.53	1.50	1.36	0.52	2.81	3.28	21.52	
32	ND	ND	ND	0.36	ND	ND	0.00	ND	
33	1.09	1.00	0.32	0.29	0.23	0.81	1.37	5.12	
34	2.72	2.59	0.98	0.72	0.39	1.68	1.94	11.03	
35	1.01	1.11	0.69	1.22	0.34	2.71	1.18	8.26	
36	2.25	2.88	1.77	0.69	0.06	1.79	2.31	11.76	
37	1.09	2.43	1.14	0.81	0.06	1.59	1.55	8.67	
38	10.01	18.76	8.29	4.91	0.19	1.25	2.19	45.60	
39	ND	ND	ND	0.12	ND	ND	ND	ND	
40	0.62	1.37	0.60	0.30	0.06	0.29	0.25	3.49	

ND - Data not available for that compound

CONCENTRATIONS OF 7 POLYCYCLIC AROMATIC HYDROCARBONS: INDOOR AIR (ng/m3)

Portland-Salem-Spokane-Cheney

BUILDING #	LOCATION	SMOKING	VOLUME (m3)	RSP (ug/m3)	Chrysene	Benzo (b)-Fluoranthene	Benzo (k)-Fluoranthene	Benzo (a)-Pyrene	Dibenz (a,h)-Anthracene	Benzo (g,h,i)-Perylene	Indeno (1,2,3-cd)-Pyrene
8	1A	N	8.61	7.55	0.13	0.34	0.17	0.13	0.19	1.03	0.55
8	2C	N	8.67	6.92	0.21	0.52	0.22	0.22	0.44	0.92	0.26
8	OUTSIDE		8.67	8.42	0.18	0.56	0.25	0.22	0.43	0.91	0.33
9	1A	Y	6.17	13.93	0.64	1.21	0.55	0.57	0.4	0.95	0.16
9	2A	Y	6.51	12.59	0.55	0.84	0.37	0.38	0.26	1.07	0.15
9	3C	Y	6.88	18.6	0.11	0.41	0.12	0.14	0.13	0.96	0.15
9	4A	Y	6.83	19.64	0.44	0.77	0.33	0.39	0.56	1.21	0.31
9	B1	N	6.94	10.81	0.09	0.24	0.06	0.09	0.11	0.73	0.35
9	OUTSIDE-1		6.85	8.03	0.27	0.71	0.32	0.27	0.47	1	0.4
10	1A	?	7.62	66.3	0.3	0.84	0.22	0.37	0.29	0.97	0.43
10	2A	N	7.59	52.97	0.5	1.2	0.49	0.56	0.86	1.41	0.41
10	3B	Y	7.99	66.5	0.5	1.15	0.44	1.16	0.24	1.65	0.5
10	4C	Y	7.99	91.17	0.4	0.58	0.15	0.42	0.15	1.21	0.23
10	B2	Y	7.90	126.83	1.36	1.87	0.62	1.85	0.6	2.63	0.72
10	O1		7.05	8.79	0.04	0.26	0.08	0.04	0.14	0.67	0.29
11	1A	N	7.00	10.58	0.21	0.51	0.2	0.21	0.26	0.8	0.14
11	2C	?	7.00	38.32	0.12	0.32	0.11	0.11	0.06	0.57	0.14
11	3A	Y	7.11	209.5	1.63	2.76	0.94	2.45	2.07	3.94	0.44
11	4B	N	7.00	9.29	0.69	0.37	0.14	0.13	0.15	0.36	0.14
11	O1		13.20	7.96	0.24	0.32	0.13	0.09	0.12	0.7	0.32
12	2C	N	6.91	9.84	0.26	0.12	0.03	0.04	0.06	0.14	0.14
12	3A	Y	5.92	62.86	0.17	0.36	0.11	0.17	0.18	1.44	0.43
13	1C	N	15.18	5.73	0.05	0.14	0.05	0.06	0.09	0.38	0.15
13	2A	N	14.16	4.8	0.1	0.32	0.12	0.14	0.22	0.51	0.07
14	2A	Y	7.93	33.55	0.38	0.63	0.03	0.26	0.05	0.61	0.13
14	B1	Y	7.96	26.39	0.31	1.16	0.45	0.83	0.71	1.79	0.59
15	1C	Y	7.90	12.15	0.35	0.85	0.33	0.35	0.53	1.19	0.35
15	3B	N	8.21	7.43	0.12	0.26	0.11	0.13	0.21	0.62	0.29
15	B2	N	7.84	13.9	0.26	0.33	0.1	0.13	0.15	0.94	0.37
15	ROOF		8.04	5.47	0.27	0.81	0.34	0.34	0.6	0.9	0.12
16	2B	Y	6.54	72.92	1.02	0.61	0.17	0.7	0.09	0.69	0.69
17	5A	N	6.91	13.17	0.11	0.12	0.07	0.07	0.09	0.25	0.65
17	S1	Y	6.91	104.79	0.93	1.2	0.33	1.49	0.09	0.67	1.35
18	2B	Y	7.73	18.76	0.35	0.35	0.06	0.06	0.17	0.22	0.58
19	2A	Y	6.34	29.17	0.38	0.28	0.08	0.08	0.09	0.27	0.71
20	0A	OUTSIDE	5.64	18.46	0.13	0.15	0.09	0.09	0.11	0.3	0.8
21	0A	OUTSIDE	6.63	17.05	0.11	0.13	0.08	0.08	0.09	0.26	0.68
22	1A	Y	7.36	22	0.1	0.12	0.07	0.07	0.08	0.23	0.61
22	3B	Y	7.22	165.08	0.9	1.05	0.51	1.43	0.08	1.11	1.27
22	7A	Y	7.25	35.87	0.37	0.12	0.07	0.18	0.08	0.51	0.62
22	B1	Y	7.34	30.68	0.1	0.12	0.07	0.07	0.08	0.48	0.61
22	B2	N	7.36	18.34	0.1	0.12	0.07	0.07	0.08	0.23	0.61
23	1A	N	8.16	19.86	0.09	0.47	0.13	0.1	0.07	0.14	0.55
23	1B	N	8.16	3.92	ND	ND	ND	0.1	ND	ND	ND
23	1D	N	8.16	2.58	ND	ND	ND	0.1	ND	ND	ND
23	OUTSIDE		7.25	11.04	0.1	0.52	0.15	0.11	0.08	0.16	0.62

CONCENTRATIONS OF 7 POLYCYCLIC AROMATIC HYDROCARBONS: INDOOR AIR (ng/m3) - continued

Portland-Salem-Spokane-Cheney

SMOKE #	LOCATION	SMOKING	VOLUME (m3)	RSP (ug/m3)	Chrysene	Benzo (b)-Fluoranthene	Benzo (k)-Fluoranthene	Benzo (a)-Pyrene	Dibenz (a,h)-Anthracene	Benzo (g,h,i)-Perylene	Indeno (1,2,3-cd)-Pyrene
24	1A	Y	7.93	24.22	ND	ND	ND	0.1	ND	ND	ND
24	1C	N	7.93	77.31	0.09	0.48	0.14	0.1	0.08	0.15	0.57
24	1D	N	7.93	10.34	ND	ND	ND	0.1	ND	ND	ND
25	1A	Y	8.04	109.43	0.75	0.47	0.14	0.25	0.07	0.14	0.56
25	2A	N	8.13	37.78	ND	ND	ND	0.1	ND	ND	ND
25	2B	N	8.24	31.67	ND	ND	ND	0.1	ND	ND	ND
25	OUTSIDE		6.54	67.72	0.11	0.58	0.17	0.12	0.09	0.18	0.69
25	2C	Y	8.16	54.57	0.63	0.69	0.23	0.65	0.07	1.72	0.55
25	4A	Y	8.21	122.75	0.93	0.32	0.13	0.83	0.13	0.14	0.55
26	6B	N	8.27	19.59	ND	ND	ND	0.23	ND	ND	ND
26	9B	N	8.35	70.27	0.08	0.1	0.06	0.23	0.07	0.42	0.54
26	82	Y	8.18	70.02	0.08	0.1	0.06	0.23	0.07	1.47	0.55
26	OUTSIDE		6.66	32.46	ND	ND	ND	0.29	ND	ND	ND
27	2A	Y	6.63	89.04	0.38	0.35	0.08	0.29	0.09	0.17	0.68
27	3A	Y	8.33	33.15	ND	ND	ND	0.23	ND	ND	ND
27	4A	N	8.27	33.26	ND	ND	ND	0.23	ND	ND	ND
27	81	N	6.80	38.11	ND	ND	ND	0.28	ND	ND	ND
27	OUTSIDE		5.01	52.27	0.13	0.17	0.1	0.38	0.12	0.23	0.9
28	2A	N	8.33	29.31	0.08	0.1	0.06	0.23	0.07	0.3	0.46
28	4A	N	5.32	42.64	ND	ND	ND	0.36	ND	ND	ND
28	81	Y	6.80	5.44	ND	ND	ND	0.28	ND	ND	ND
28	OUTSIDE		8.41	65.4	0.08	0.1	0.06	0.23	0.07	0.56	0.54
29	01		7.00	28.59	ND	ND	ND	1.75	ND	ND	ND
30	4A	N	8.16	25.14	ND	ND	ND	1.5	ND	ND	ND
30	4B	N	3.82	30.34	ND	ND	ND	1.4	ND	ND	ND
30	5A	N	8.16	23.18	ND	ND	ND	1.23	ND	ND	ND
30	5B	N	7.93	25.1	ND	ND	ND	1.76	ND	ND	ND
30	6A	N	9.71	19.56	ND	ND	ND	0.9	ND	ND	ND
30	61	N	7.05	23.26	ND	ND	ND	1.3	ND	ND	ND
30	01		11.61	33.08	4.23	3.72	1.83	2.84	0.44	4.26	2.33
30	81	Y	8.04	113.28	2.98	2.33	0.99	1.44	0.68	2.94	1.26
31	1C	Y	6.40	268.14	7.5	4.53	1.5	3.6	0.52	2.81	3.28
31	1F	N	8.18	17.72	ND	ND	ND	0.26	ND	ND	ND
31	1G	N	8.16	13.12	ND	ND	ND	0.23	ND	ND	ND
31	0-1		8.10	13.34	0.62	0.9	0.37	0.58	0.2	1.61	1.36
32	2A	N	7.53	16.6	ND	ND	ND	0.27	ND	ND	ND
32	2B	N	7.65	14.26	ND	ND	ND	0.26	ND	ND	ND
32	3C	Y	7.34	21.13	ND	ND	ND	0.2	ND	ND	ND
32	8-1	Y	6.17	51.68	ND	ND	ND	0.7	ND	ND	0

CONCENTRATIONS OF 7 POLYCYCLIC AROMATIC HYDROCARBONS: INDOOR AIR (ng/m3) - continue

Portland-Salem-Spokane-Cheney

BUILDING #	LOCATION	SMOKING	VOLUME (m3)	RSP (ug/m3)	Chrysene	Benzo (b)-Fluoranthene	Benzo (k)-Fluoranthene	Benzo (a)-Pyrene	Dibenz (a,h)-Anthracene	Benzo (g,h,i)-Perylene	Indeno (1,2,3-cd)-Pyrene
33	1C	Y	7.14	74.27	1.09	1	0.32	0.69	0.23	0.81	1.37
33	2A	Y	7.34	15.13	ND	ND	ND	0.18	ND	ND	ND
33	2C	Y	7.36	24.04	ND	ND	ND	0.26	ND	ND	ND
33	3C	Y	11.10	12.43	ND	ND	ND	0.1	ND	ND	ND
34	10-A	Y	7.39	31.53	ND	ND	ND	0.95	ND	ND	ND
34	12-B	N	7.87	16.39	ND	ND	ND	0.19	ND	ND	ND
34	2-C	N	8.16	12.88	ND	ND	ND	0.37	ND	ND	ND
34	3-B	N	7.87	13.21	ND	ND	ND	0.17	ND	ND	ND
34	5-A	Y	7.73	116.55	2.72	2.59	0.98	1.94	0.39	1.68	1.94
34	0-1		7.96	16.34	1.03	2.01	0.79	0.73	0.23	2.39	3.14
35	11-C	N	7.36	35.31	ND	ND	ND	0.87	ND	ND	ND
35	15-A	Y	8.50	50.26	1.01	1.11	0.69	1.65	0.34	2.71	1.18
35	2-A	N	8.04	31.83	ND	ND	ND	2.36	ND	ND	ND
35	3-A	N	8.21	18.75	ND	ND	ND	0.74	ND	ND	ND
35	9-A	N	8.24	20.63	ND	ND	ND	0.45	ND	ND	ND
35	0-1		6.83	18.44	1.35	2.49	1.03	1.25	0.38	3.08	5.28
36	1-A	N	7.99	18.03	ND	ND	ND	0.17	ND	ND	ND
36	1-C	N	7.96	18.22	ND	ND	ND	0.15	ND	ND	ND
36	2-D	Y	8.07	17.1	ND	ND	ND	0.25	ND	ND	ND
36	3-A	Y	8.33	126.72	2.25	2.88	1.77	2.62	0.06	1.79	2.31
36	B-1	N	7.87	16.26	ND	ND	ND	0.25	ND	ND	ND
36	0-1		8.27	20.32	0.45	1.2	0.52	0.4	0.2	1.42	0.66
37	1-B	N	7.65	16.22	ND	ND	ND	0.19	ND	ND	ND
37	2-A	N	8.50	12.24	ND	ND	ND	0.26	ND	ND	ND
37	4-A	Y	7.39	22.33	ND	ND	ND	0.19	ND	ND	ND
37	4-B	Y	8.30	15.43	ND	ND	ND	0.18	ND	ND	ND
37	8-A	N	7.90	23.29	ND	ND	ND	0.35	ND	ND	ND
37	A-2	Y	8.64	61.6	1.34	2.55	1.22	1.38	0.06	1.6	1.67
37	A-4	Y	7.39	35.45	0.83	2.3	1.05	1.18	0.07	1.58	1.43
37	B-1	Y	8.52	22.17	ND	ND	ND	0.44	ND	ND	ND
37	B-3	N	6.40	32.03	ND	ND	ND	3.1	ND	ND	ND
37	0-1		7.79	19.01	0.72	1.41	0.55	0.42	0.21	2.19	0.75
38	7-A	Y	6.40	307.99	10.01	18.76	8.29	9.69	0.19	1.25	2.19
38	B-2	N	9.66	9.22	ND	ND	ND	0.13	ND	ND	ND
39	4-A	Y	8.72	12.73	ND	ND	ND	0.09	ND	ND	ND
39	B-1	Y	8.75	14.06	ND	ND	ND	0.11	ND	ND	ND
39	0-1		8.55	10.76	0.44	1.09	0.47	0.47	0.06	0.27	0.23
39	P1-1	Y	7.56	13.76	ND	ND	ND	0.15	ND	ND	ND
40	13-A	N	8.69	11.62	ND	ND	ND	0.09	ND	ND	ND
40	3-A	Y	8.04	39.92	0.62	1.37	0.6	0.72	0.06	0.29	0.25
40	8-A	Y	8.24	12.14	ND	ND	ND	0.08	ND	ND	ND

APPENDIX I

VENTILATION SYSTEMS SYNOPSIS

<u>Building No.</u>	<u>HVAC System Description</u>
1.	Adjacent classrooms share small HVAC system with thermostatically-controlled outdoor air/recirculation ratio. Separate larger systems for gymnasium and offices.
2.	Each classroom has separate outdoor air intake, return air is shared among three rooms. Individual thermostatically-controlled outside air dampers. Exhaust air very close to outside air intakes. No outside air for offices and lounge.
3.	HVAC system with one supply and two exhaust fans. Extra recirculation in computer rooms. Room thermostats control local air distribution. Supply and return completely ducted.
4.	Four ventilation systems each with partial recirculation. Substantial mixing between zones. New systems, dampers did not appear to respond to controls. Supply air delivered at ceiling level, return vents in floor.
5.	Building in two sections. Old section ventilated by one boiler-type system with plenum ducted to five zones. Outside air dampers always closed. New section ventilated by four residential-type forced air furnaces. Outside air dampers manually fixed.
6.	Three HVAC systems, one smaller system for basement and floors 1-3, two large systems each ventilate approximately 1/2 of floors 4-16. All energy-miser systems, computer controlled. Systems react to return air temperature. VAV boxes have two settings. Substantial mixing between zones on floors 4-16.

7. One small ventilation/cooling system for 4th floor only. All others naturally ventilated, steam heat.
8. Two HVAC systems, one each for office section and laboratory. Economizer system for office, laboratory always on full outside air. Office thermostats control mixing of hot and cold ducts, return air through grills at windows.
9. Two large systems ventilate north and south sides of building. Substantial mixing between zones. Return air through open ceiling, VAV boxes for supply air. Outside air intakes at ground level.
10. Two large older systems ventilate north and south halves of building. Supply air through non-modulating vents, four return vents in central hall on each floor. Outside air intakes on roof, fans in basement.
11. Two supply fans, one each for interior and perimeter zones respectively, one exhaust fan for all return air. Return air through ceiling plenum. Interior and perimeter zones well mixed. Outside air intake at sub-ground level. Third system supplies computer room on 4th floor and part of basement. Fourth system ventilates most of auditorium.
12. One main system ventilates floors 1-3. System renovated to include outside air, however, dampers always closed. Supply and return vents poorly placed. Penthouse ventilated separately with rooftop AC unit.
13. Three systems: 2 remodeled units on first and second floor, one older system in basement. HVAC systems "revised as built" 6/83. Combination of delivery and return systems through floors, walls, and ceilings. No local ventilation modulation is apparent.
14. Two rooftop systems supply 10 building zones (4 for one system, 6 for the other zones). Defined vertically through 3 floors. Each zone has a separate thermostat that modulates system dampers. Supply diffusers and returns in

ceiling. Each branch duct has a manual volume damper. Good mixing on 2nd and 3rd floors.

15. Two large systems for north and south halves of building. Each system has two supply fans (perimeter and core) and one return. Hot and cold supply streams mixed before diffusers. Return air through open ceiling plenum. Supply and return diffusers close together. Significant mixing between all ventilation system zones.
16. Four small HVAC systems, some mixing between zones. No return air for kitchen system. Supply and return diffusers close to each other. Outside air intakes and system exhaust grills close together at second floor level.
17. One large system for classrooms. Supply and return air through grills, no local adjustments for amount of supply air delivered. All return air mixed. Three small systems with fixed recirculation for gymnasium. Two small systems with modulating dampers for music rooms.
18. No mechanical ventilation.
19. No mechanical ventilation.
20. Four moderate size systems, little mixing between zones. All systems have economizer controls. Above 75°F, minimum outside air. One system ventilates gymnasium, another the theater only.
21. Two large systems for each half of building. Almost complete mixing between zones due to central atrium through building core. Hot and cold supply air streams mixed at diffusers. Return air through open ceiling plenum. Economizer controls. Above 80°F, minimum outside air. Outside air intakes at ground level. Mechanical rooms adjacent to parking garage.
22. One main system. Supply air through VAV boxes, return through open ceiling plenum. Outside air intake at ground level near parking lot. New system currently being balanced.

23. One ventilation system feeds fourteen local heating and cooling units. Return air common for building. Zone thermostats control local units. Separate TV studio system.
24. One moderate size system for ventilation and cooling. Separate radiant heating. Return air common through heated ceiling duct. Outside air dampers always closed.
25. Two systems, one for each floor. First floor system has hot and cold decks with economizer controls (below 70°F). Second floor system only cold deck (separate radiant heat). Air flows controlled by multizone dampers and thermostats.
26. Four large HVAC systems. Zones separated by floors, only slight mixing. Systems supply air to perimeter and core separately, however return air is mixed in ceiling plenum. Systems never balanced. Outside air intake on east side of building extremely close to another structure, therefore little air flow. Three auxiliary systems for cafeteria and courtrooms.
27. One large system for floor 1-4. Thermostats control VAV boxes. Return air through ceiling plenum. Outside air intake on roof. Separate basement system has one outside air intake, at ground level near parking lot, which feeds three heating and cooling units. Only return air dampers operable.
28. One large HVAC system. Hot and cold decks with mixing at supply grills. Return intakes at perimeter. System runs 0% outside air when chiller is on.
29. Two systems. Gymnasium system is recirculation only, but receives some supply from main system. Main system ventilates remainder of building through ceiling grill supplies and returns through light fixtures into ceiling plenum. Local thermostat control for temperature.
30. Same building as #17. Energy management system recently installed.

31. Ten rooftop systems of various sizes ventilating different zones in building. Each under local thermostat control. Outside air and return air mixed on roof before delivery through variety of diffusers. Kitchen-cafeteria system has heat exchanger on 100% O.A. Cafeteria has large exhaust fan near smoking section.
32. Two systems. Old main system pulls return air through halls and stairwells and supplies through undampened ducting. Outside air dampers essentially shut, but "outside air" is drawn through basement cracks and particularly through long network (3 mi.) of campus wide service tunnels. Outside and return air mix in basement that has broken concrete and open soil floor. Separate theater system on roof that supplies through ceiling and returns below stage. No dampers are modulated.
33. Four air handlers with systems AH1, 2, 3 having a large common return into basement. AH4 ventilates only the kitchen. AH1 serves multipurpose room, AH3 ventilates attached 2nd floor lounge and 3rd floor offices. Outside air for AH3 opens into City Bus loading platform. AH2 serves remainder of building. Supply typically through linear diffusers in ceiling and return into ceiling. All dampers modulated by central campus computer that monitors interior temperatures and meteorological conditions.
34. One large main system on roof serves entire building. Supply (controlled by VAV boxes in core; passes through heat coils in perimeter) through ceiling linear diffusers. Return air into ceiling plenum. System must interact with skywalk system (covered walkways connecting downtown buildings). Also, one system solely for exhausting restrooms and basement lunchroom. Up to 45°F outside air temperature-dampers modulate to maintain mixed air temperature of 55°F; from 45°F - 78°F system goes to full outside air, above 78°F - system shuts to 10% outside air.
35. Old naturally ventilated building "renovated" with 11 HVAC systems in 1963. Complicated arrangement serves various areas in building through combination of diffusers and return grilles. Building operators unsure of damper control mechanism. Suspect that outside air and exhaust air use an

abandoned service chase (going the full height of the building) as a common plenum. Two systems heat or cool air and recirculate only.

36. Same building as #11.
37. Fifteen systems, five that ventilate an annex addition. Six systems in penthouse supply air to floors 1-8 through ceiling tiles and return through ceiling grilles to penthouse as a common return. No local damper control. Building has four small air conditioning units for local cooling.
38. Except for basement, first floor, and cafeteria - two identical systems per floor for a total of 23. Air delivered through ceiling terminal units. Three cafeteria systems only supply outside air. Basement and first floor served by two large units.
39. Eleven systems. Two large high pressure systems on roof deliver supply air through VAV boxes to majority of office space. Good mixing in open office areas. Separate systems handle computer room, dispatch center, and street and parking level rooms. Central computer controlled. Lower level systems pull outside air from roof.
40. Nine systems total serving 18 floors. Four main high pressure systems supply air through VAV boxes to ceiling diffusers (2 above and 2 below floor 10). Return air collected in ceiling plenum and brought together in 2 vertical return air shafts. Remaining systems ventilate smaller spaces on street and parking levels. Outside air drawn in from roof and street. Central computer controlled.

APPENDIX J

ASHRAE 62-1981

VENTILATION FOR ACCEPTABLE INDOOR AIR QUALITY

SELECTED GUIDELINES FROM

TABLE 3 - OUTDOOR AIR REQUIREMENTS FOR VENTILATION

3.1 COMMERCIAL FACILITIES

	<u>Outdoor Air Requirements (cfm/person)</u>	
	<u>Smoking</u>	<u>Nonsmoking</u>
<u>OFFICES</u>		
Office Space	20	7
Meeting & Waiting Space	35	7
<u>PUBLIC SPACES</u>		
Corridors and Utility Rooms	0.02	0.02
<u>SPORTS AND AMUSEMENT FACILITIES</u>		
Bowling Alleys (seating areas)	35	7
Playing Floors (e.g., gymnasiums, ice arenas)	--	20 ^(a)
<u>THEATER</u>		
Lobbies, foyers, lounges and auditoriums in motion picture theaters, lecture, concert and opera halls	35	7
<u>EDUCATIONAL FACILITIES</u>		
Classrooms	25	5
Laboratories	--	10 ^(a)
Training Shops	35	7
Music Rooms	35	7
Libraries	--	5

(-) indicates that smoking (or non-smoking) in a space should not occur.

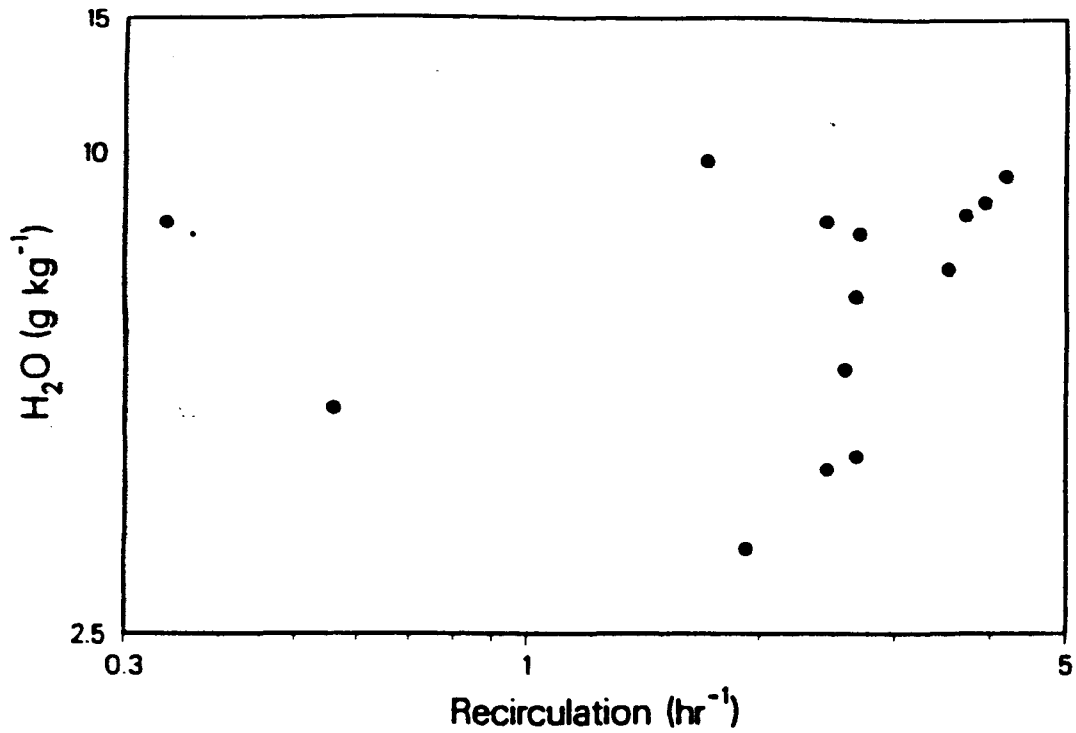
(a) special ventilation may be required for certain activities and processes.

APPENDIX K

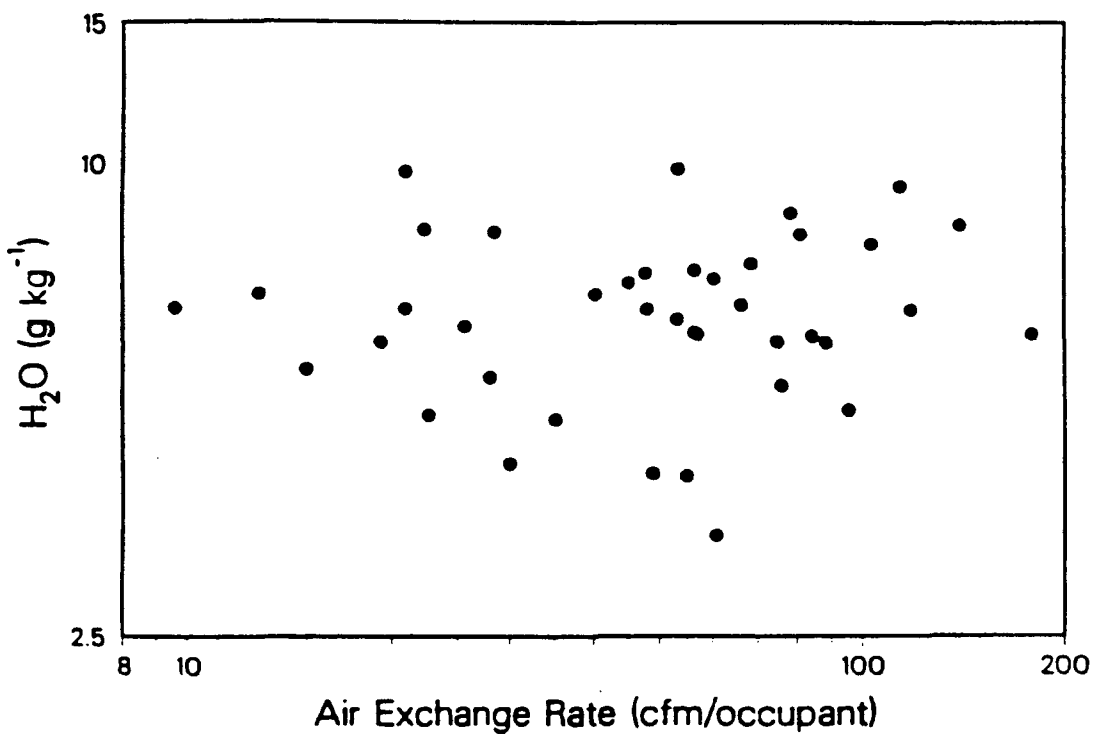
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POLLUTANT CONCENTRATIONS AS A FUNCTION OF BUILDING PARAMETERS

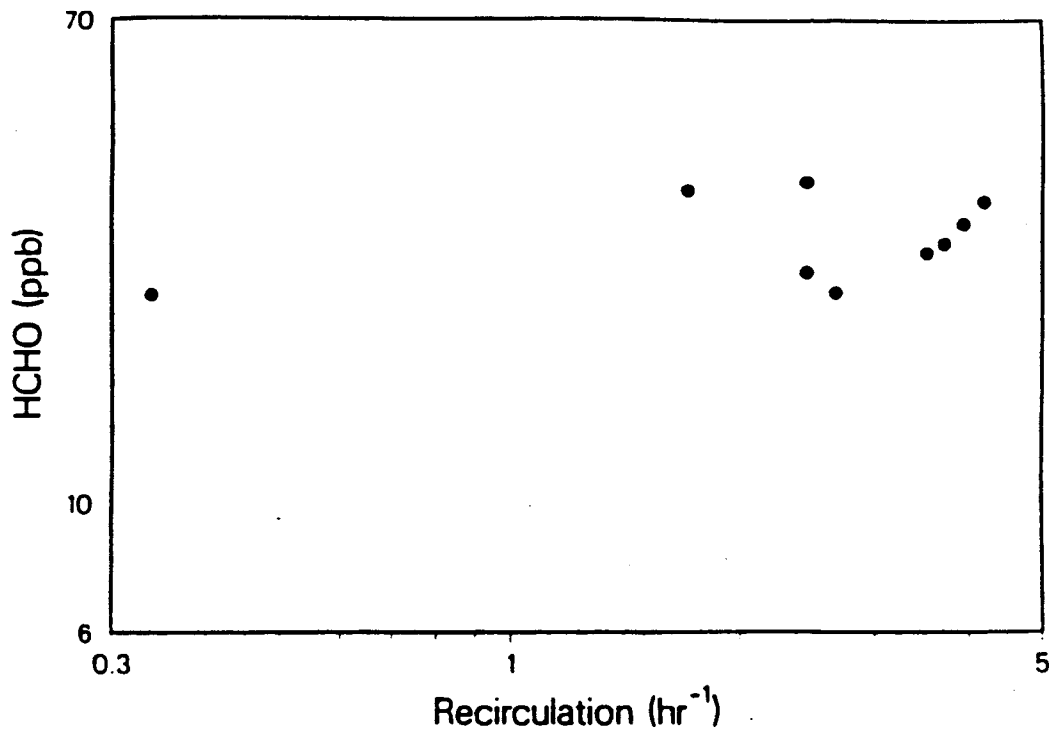
COMMERCIAL BUILDING STUDY - WATER VAPOR
(14 BUILDINGS)



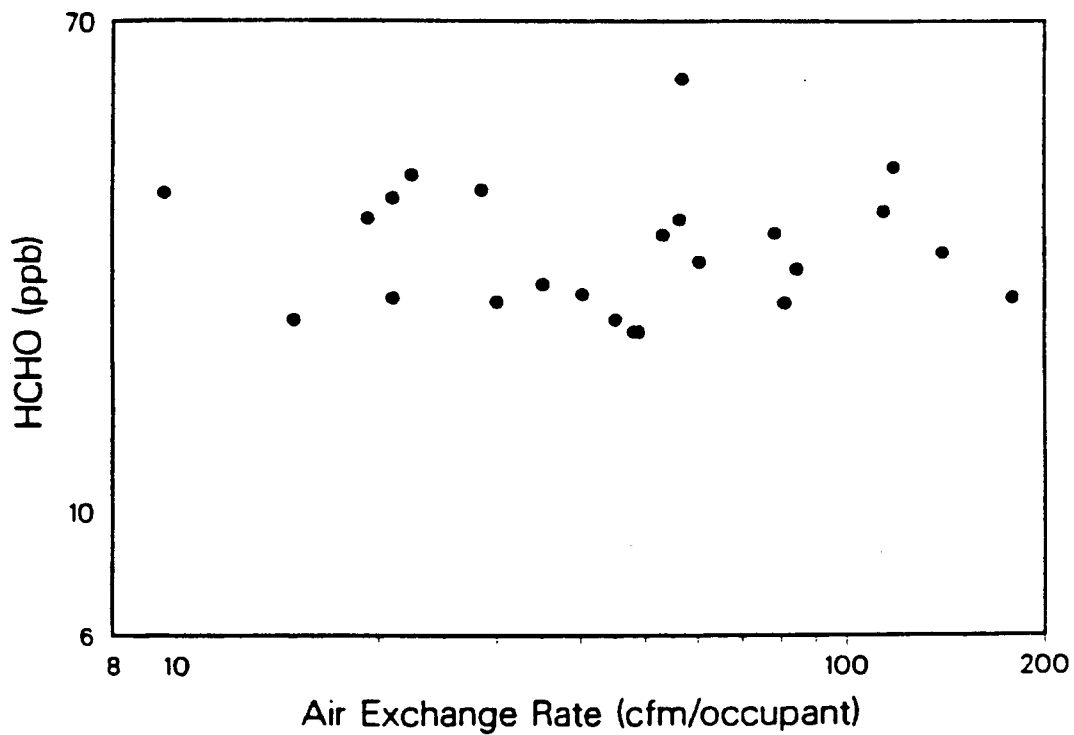
COMMERCIAL BUILDING STUDY - WATER VAPOR
(40 BUILDINGS)



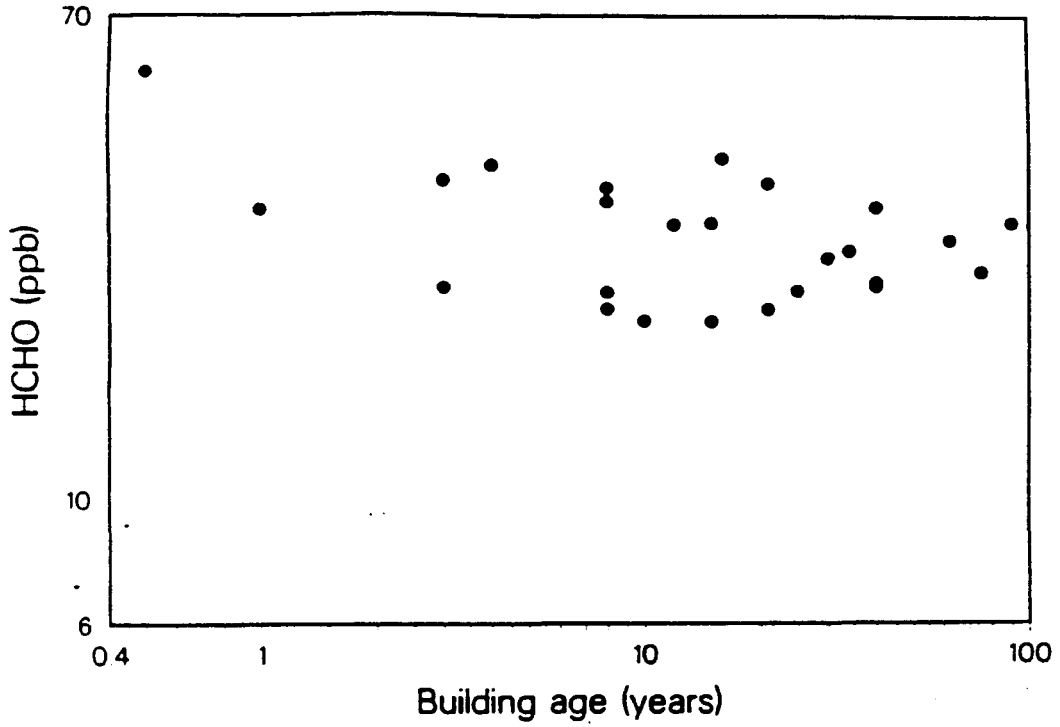
COMMERCIAL BUILDING STUDY - FORMALDEHYDE
(14 BUILDINGS)



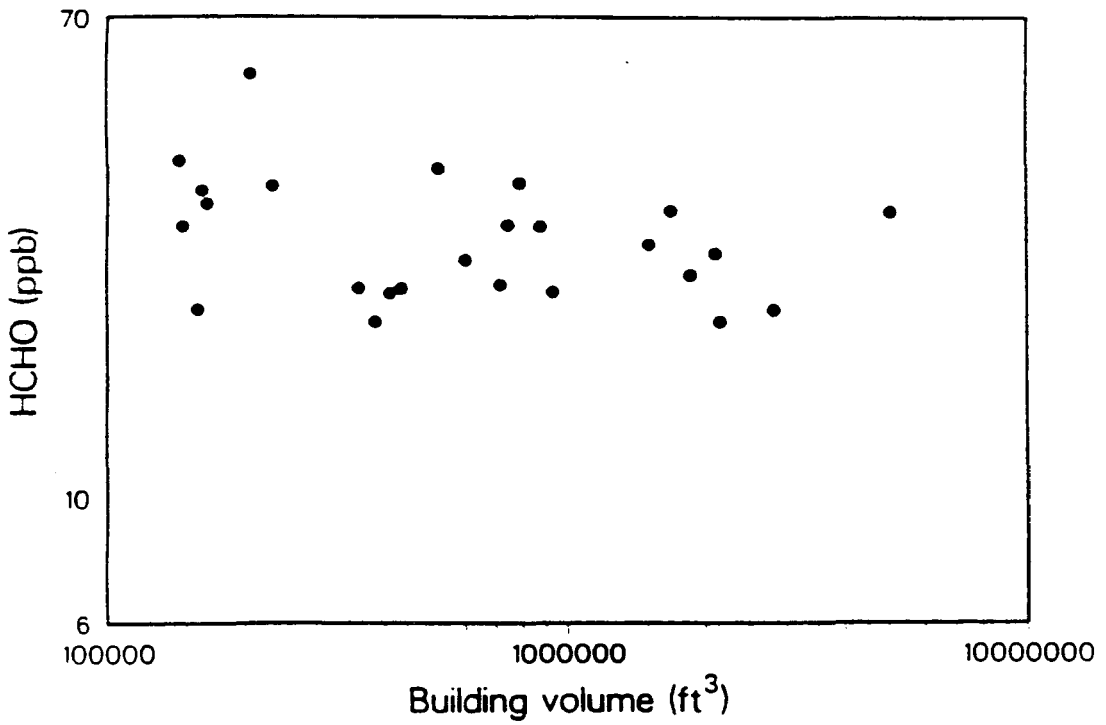
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(40 BUILDINGS)



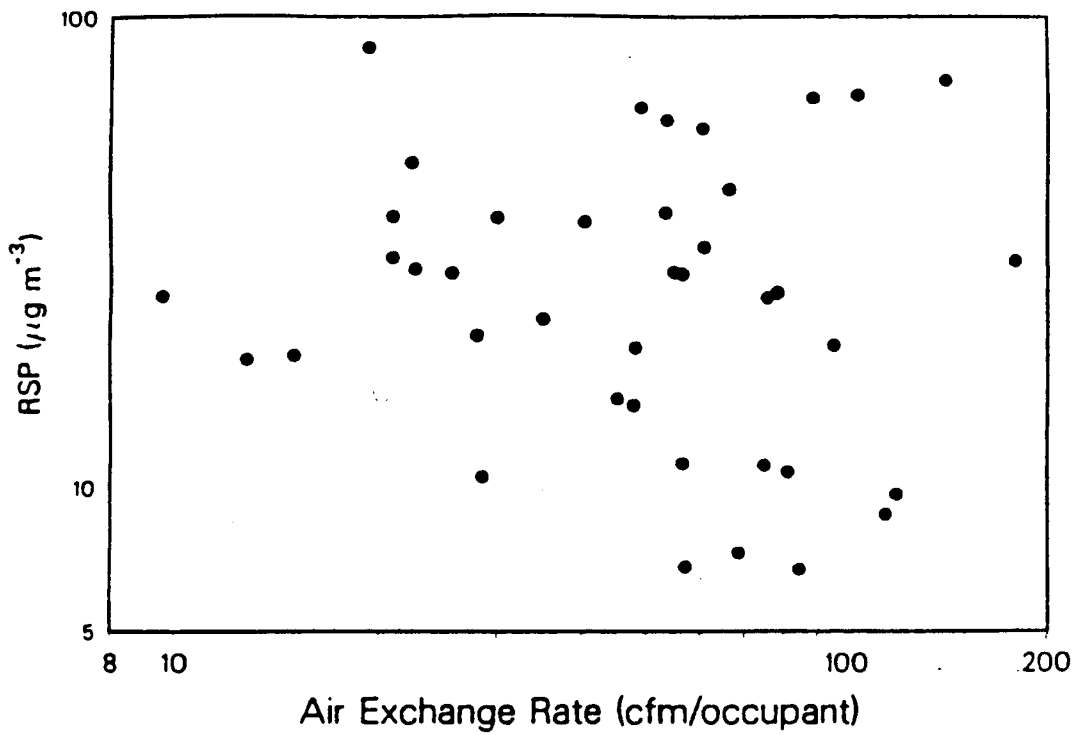
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(40 BUILDINGS)



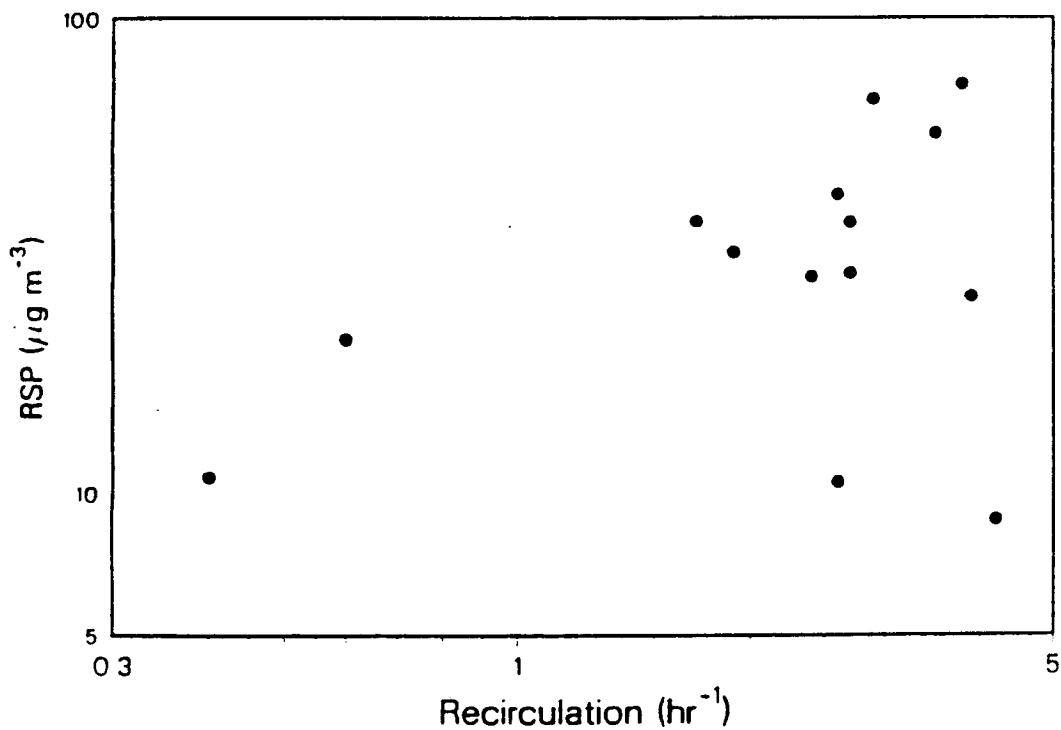
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(40 BUILDINGS)



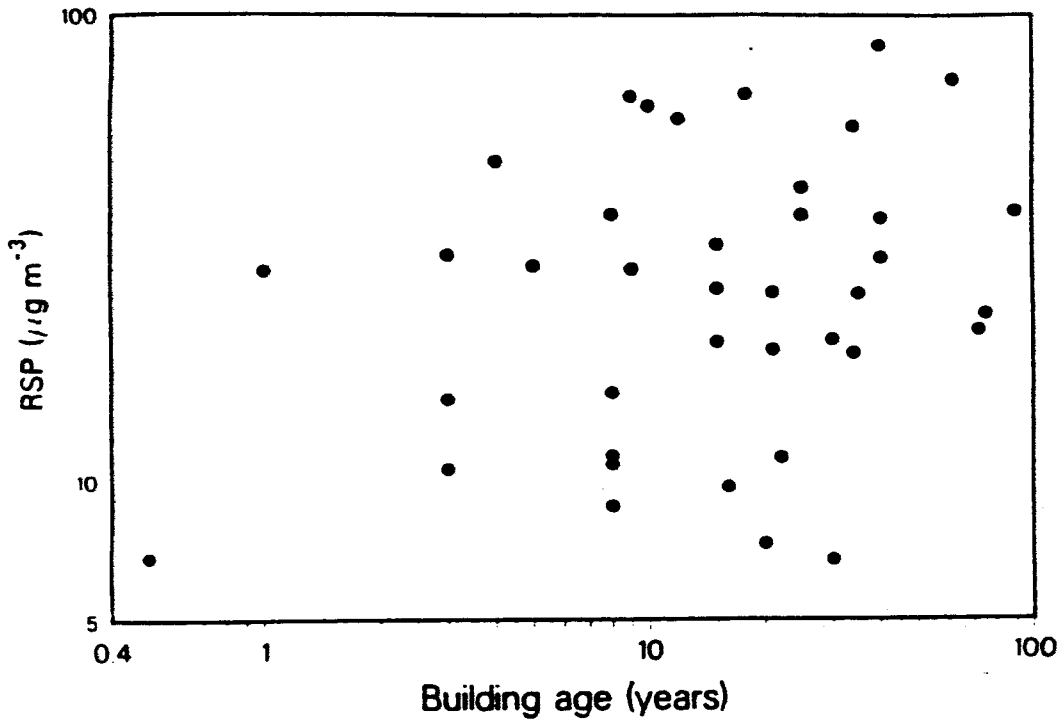
COMMERCIAL BUILDING STUDY - RESPIRABLE PARTICLES (40 BUILDINGS)



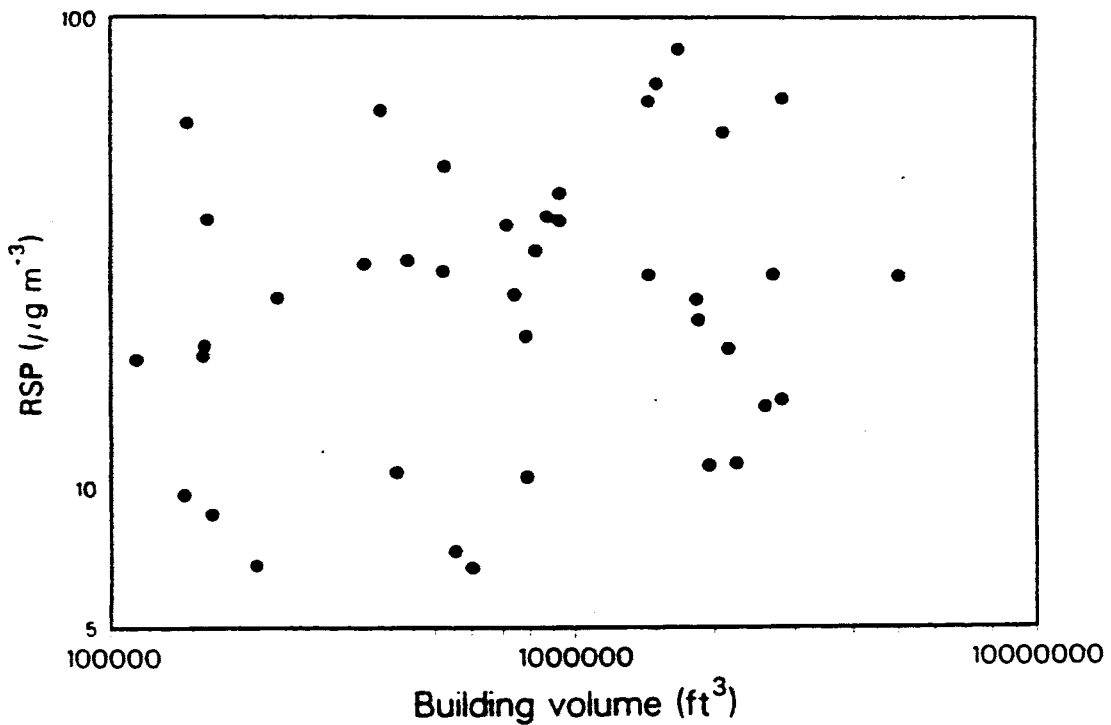
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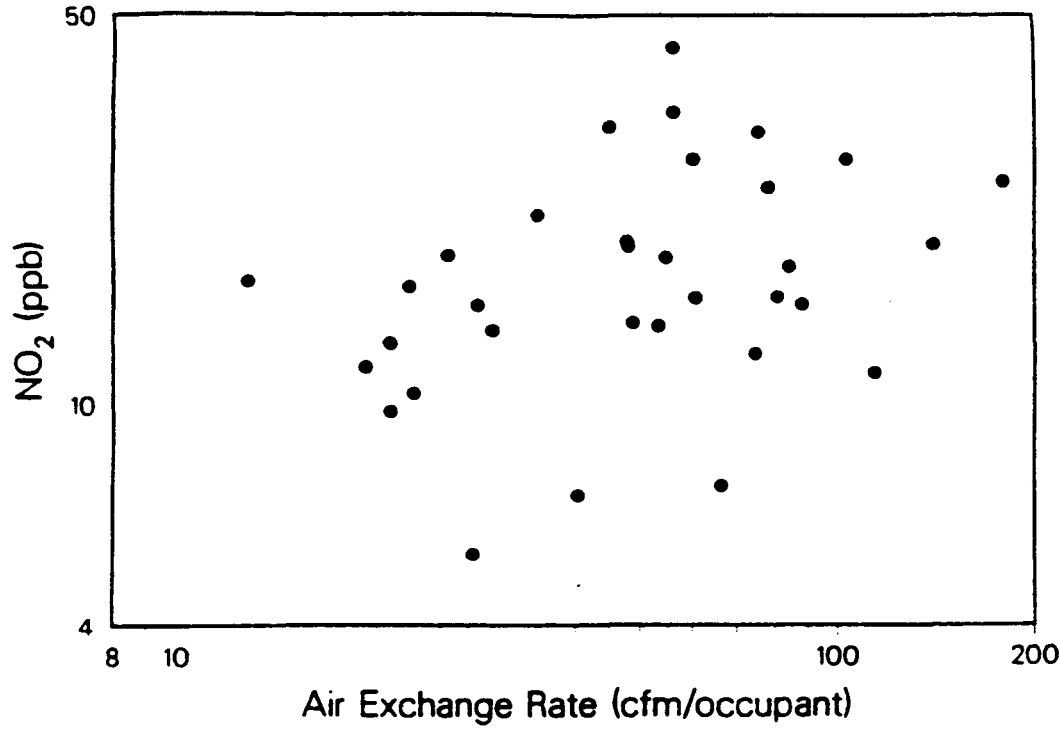
COMMERCIAL BUILDING STUDY - RESPIRABLE PARTICLES (40 BUILDINGS)



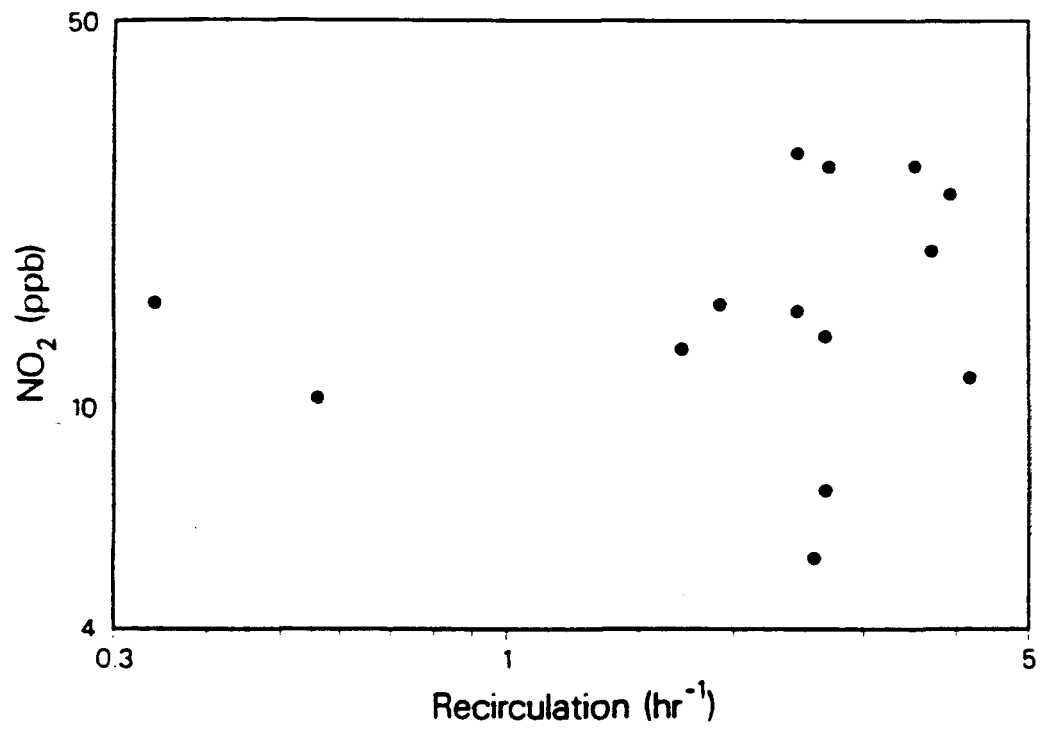
COMMERCIAL BUILDING STUDY - RESPIRABLE PARTICLES (40 BUILDINGS)



COMMERCIAL BUILDING STUDY - NO₂
(33 BUILDINGS)



COMMERCIAL BUILDING STUDY - NO₂
(14 BUILDINGS)



APPENDIX L

CLIMATOLOGICAL COMPARISON PORTLAND OR - SPOKANE WA

Portland, Oregon has a mild, humid, summer dry climate with 88% of the yearly mean precipitation falling between October and May. Only five days per year on average have measurable snow fall. For the period 1931 - 1960 Portland averaged eight days per year with a maximum temperature above 90°F. Generally, winds in the winter blow from the southeast.

By comparison Spokane, Washington has a mild, arid summer and cold coastal winter climate with 70% of the yearly mean precipitation falling between October and March, half of which falls as snow. During the thirty years 1931 - 1960 Spokane averaged 16 days per year with a maximum above 90°F and 116 days per year with a minimum below 32°F.

The climate of Spokane imposes much greater heating requirements on buildings than does that of Portland. For the period 1951 - 1980, Portland averaged 4691 heating degree days per year (based on 65°F) whereas 6882 heating degree days were the annual average in Spokane. As can be seen, the climate of Spokane shows greater variation between winter and summer temperatures than does Portland. An index of this variability is given by the Johansen Index of Continentality where Portland has a value of 0.20 and Spokane 0.35 in which a key component of the is the annual temperature range. An additional climatologic element which could affect heating requirements during the autumn and winter months, October through March, is the mean percent of possible sunshine. However, the difference is small, 33% in Portland, 37% in Spokane. Since their mean temperature difference is only 4.3°F (Portland 52.5°F and Spokane 48.2°F) it is the distribution of colder weather and greater temperature variation that causes Spokane to have the larger heating and cooling load than Portland.

CLIMATIC COMPARISON

	<u>PORTLAND</u>	<u>SALEM</u>	<u>SPOKANE</u>
Heating Degree Days	4691	4974	6882
Cooling Degree Days	300	232	388
Freeze Free (days)	279	197	175
Max >90°F (days)	8	16	16
Min <32°F (days)	22	60	116
Annual mean RH			
@ Time =	1000	55%	62%
	1600	48%	50%
Continentality			
	0.20		0.35
Possible Annual Sunshine			
	48%		58%

APPENDIX M

THE BPA DATABASE

The BPA database consists of data stored in disk files on a Digital VAX-11/8600 computer system. Data which is recorded by hand on the basis of laboratory analysis or questionnaire is entered into individual files, each with a record structure designed for the particular application, using an entry program written locally; Datatrieve, the Digital data management program, is then used for calculations, selection, averaging, and report writing. Data which is recorded automatically by a locally produced data logger is written to a single file whose records consist of a code representing the collection location, a date and time, and a field for the output of each sensor. A separate file contains descriptive information keyed to the first field of the data file. A locally written program reads the data logger modules, transforms the output to usable data, analyzes the data, and produces graphic output. Data on tracer gas decay is handled by a distinct locally written program, which calculates air exchange rates and produces graphic output.

The following files contain the raw data:

BLDG	Basic information on commercial buildings
HOUSE	Basic information on residential buildings
HCHO, CHCHO	Residential and commercial formaldehyde
H2O, CH2O	Residential and commercial water vapor
NO2, CNO2	Residential and commercial nitrogen dioxide
RSP, CRSP	Residential and commercial respirable particles
CO	Carbon monoxide
CO2	Carbon dioxide
RADON	Radon, based on track-etch measurements
R_ORG, C_ORG,	Residential and commercial organics
ACH	Commercial air exchange and circulation rates
EHS	All data collected by data logger
EHSHDR	Descriptive information keyed to EHS

All filenames use the extension ".DAT", e.g., radon data is stored in RADON.DAT. Data on tracer gas decay is stored in individual files for each building, with the building code as the filename and ".INF" as the extension. The file EHS.DAT characteristically contains data from a continuous radon monitor and, in many cases, a weather station.

Reports on data contained in a single file are produced by the use of Datatrieve or by locally produced programs, as described above. Each of the files other than those for organics, EHS, and infiltration, includes a field "SITE", containing the building code, and where appropriate, a field "LOCATION", containing a code for the sampling point within the building. The organics files are connected to the site and location by the lot and sample numbers common to this data and the respirable particle data. The codes used in the EHS data file are connected to the site and location by a table. Hence, a set of procedures written in the language of the Datatrieve interpreter allows the analyst to find data of any type for a given site and location. The results of these procedures may then be used for additional statistical analysis and tabular and graphic output.

APPENDIX N

DETECTION LIMITS FOR L B L PASSIVE SAMPLERS USED IN BPA FIELD STUDIES

Passive sampler detection limits are obtained by finding analytical absorbances (HCHO, NO₂) or weight differences (H₂O) which are significantly different from those obtained from representative unexposed sampler blanks. From these values the detection limit for a given exposure duration can be calculated using the sampling rate and correction factors established for each sampler type.

After completion of testing in 1984 and 1985, theoretical detection limits were determined using analysis data from BPA field samples. These detection limits have been selected as the criterion for evaluating and reporting all BPA field study passive sampler results.

The detection limits represent single variates which are significantly different ($P \leq 0.05$) from given populations of field blanks by application of a one-tailed Student's t-test (Sokal and Rohlf, 1981).

Formaldehyde Detection Limits:

Detection Limit (ppb)		Mean Blank Absorbance	Mean Inverse Slope	Mean Intercept
168 Hr	90 Hr			
11	20	0.0136	4.3099	-.0008

These figures were calculated from the absorbances of 337 field blanks and 65 formaldehyde analyses performed in 1984 and 1985. The limits correspond to a sample concentration of 0.15 $\mu\text{g}/\text{cc}$, an absorbance of 0.036, and a sampling rate of 240 cc/hr.

Nitrogen Dioxide Detection Limits

Detection Limit (ppb)		Mean Blank Absorbance	Mean Inverse Slope	Mean Intercept
168 Hr	90 Hr			
2	4	0.0166	44.159	-0.0024

These figures were calculated from the absorbances of 303 field blanks and 47 nitrogen dioxide analyses performed in 1984 and 1985. The limits correspond to a sample concentration of 1.33 nM NO₂, an absorbance of 0.030, and a sampling rate of 60 cc/hr.

Water Vapor Detection Limits:

Detection Limit (g H ₂ O/kg AIR)		Mean Blank
160 Hr.	90 Hr.	
0.3	0.5	0.031g

These figures were calculated using the net weight increases of 275 field blanks weighed as part of water vapor analyses during 1984 and 1985. The limits correspond to a sampling rate of 102 cc/hr.