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by

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Abstract

Results of air quality measurements are presented for a group of low-leakage houses located in Saskatoon, Saskatchewan. A total of 46 houses were tested for formaldehyde, nitrogen dioxide, radon, and humidity levels.

The median level of formaldehyde was 0.09 ppm, slightly lower than the guideline of 0.1 ppm. Elevated levels of formaldehyde (≥0.1 ppm) were found in 18 of 46 houses. The median level of radon was 3.0 picocuries/litre, slightly lower than the guideline of 4 pCi/L. Elevated levels of radon (≥4 pCi/L) were found in 12 out of 44 houses. The median level of nitrogen dioxide was 4.6 ppb, considerably lower than the guideline of 50 ppb. No houses were found with elevated nitrogen dioxide levels (≥50 ppb).

Introduction

In recent years, a large number of houses have been constructed in the Canadian prairie region that have been sealed to a considerably higher degree than conventional housing. A 1981 report by Dumont and Orr [1] includes pressure test values for a group of 40 houses that were specially sealed. On average, these houses had equivalent leakage area values that were 53% of those in conventional houses. (See Table 1).

As part of an ongoing research project, testing was done on the levels of selected pollutants in a group of these low-leakage houses.

A number of guidelines exist for air pollutant levels. A frequently quoted standard is the document "Ventilation for Acceptable Air Quality" produced by the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE).[2] Values for formaldehye, radon daughters, and nitrogen dioxide are presented in Table 2.

In 1982 a preliminary air quality survey of 51 houses in the Saskatoon area was undertaken to determine levels of formaldehyde and radon daughters. The survey included houses of varying ages and airtightness levels.

As shown in Figure 1, a number of the houses exhibited higher levels of formaldehyde gas. Using the ASHRAE criterion of 0.1 ppm, 8 of the 51 Saskatoon houses had elevated formaldehyde gas levels. Of particular interest in this initial survey was the relationship between formaldehyde levels and the airtightness of the structure. Figure 2 presents the relationship between formaldehyde levels and the pressure test reading for each house. It shows that houses with higher formaldehyde readings were generally among the more airtight of the sample. (It should be noted that the airtightness of the structure is not a direct measure of the air change rate, as many of the more airtight houses have controlled ventilation

systems. These systems can substantially increase the amount of ventilation compared to natural ventilation from stack and wind effects.)

In the 1982 survey, radon daughter levels were also measured using the Terradex Track-Edge Detector. The results are presented in Figure 3. Using the ASHRAE level of 0.01 working levels as a cut off, 17 of 43 houses* had elevated radon daughter levels. A plot of the radon daughter levels as a function of the pressure test readings for the houses is presented in Figure 4.

1983 Study of Saskatoon Houses

As a follow-up to the 1982 study, a survey of formaldehyde, nitrogen dioxide and radon gas levels was conducted in 1983 in a sample of 46 houses in Saskatoon. The houses chosen had all been built since 1978, and were chosen because they had a pressure test reading of less than 2.5 air changes per hour at 50 pascals. The average pressure test reading for the 46 houses was 1.33 air changes per hour at 50 pascals. This is considerably tighter than the value of 3.6 air changes per hour at 50 pascals which was reported[1] as an average for conventional houses built during the period 1960-1980 in Saskatoon.

For steady state conditions, the concentration of a pollutant within a well-mixed space may be expressed as:

$$C_s = C_o + \dot{N}/\dot{V}$$

where C_s = concentration of pollutant within the space (mass/volume)
C_o = concentration of pollutant at the source of the ventilation air, i.e., outside air (mass/volume)
$\dot{N}$ = net pollutant generation rate within the space (mass/time)
$\dot{V}$ = volume rate of air exchange (volume/time)

A high concentration of pollutant within the space may be experienced under any or all of three conditions:

- high outdoor concentration (C_o)
- high pollution generation rate ($\dot{N}$)
- low ventilation rate ($\dot{V}$)

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* Due to equipment failure etc., not all of the tests were successfully completed. For instance, in this case, although 51 tests were conducted, only 43 were successful. Throughout this paper, reference is made only to the tests that were successful.

Test Procedure for Air Quality Measurements in the 1983 Study

1. Formaldehyde

Formaldehyde tests were made in the houses using Dupont Pro-tek passive badges. A total of 2 badges, each of which was exposed for one-week periods, were placed in the living areas (generally the dining or living rooms) of each house. The badges were analyzed in a laboratory in Toronto. The measurements were taken from January 3 to January 21, 1983. During this time, the average outdoor temperature was -11°C, and the average wind speed was 13 km/h. The results of the tests for the houses are presented in Table 3.

2. Radon Gas Tests

Radon gas level tests in the houses were made using Terradex Track Etch passive detectors. The particular detector chosen has a filter which minimizes the contact of dust particles with the detector; hence only the radon gas and not the radon daughter concentration is measured. Measurements were made from January to April 1983. Results are presented in Table 3.

Appendix A presents a discussion on the consistency of the formaldehyde and radon sensor readings.

3. Nitrogen Dioxide Tests

Nitrogen dioxide tests, one per house, were made during a week in early January using a passive detector. The test badges were processed by Health and Welfare Canada. Results are presented in Table 3.

In addition to these three tests, data were gathered for each house, as follows:

- Pressure test result at a pressure difference of 50 Pa.
- Type of heating system
- Type of ventilation system used
  a. None
  b. Fresh air duct into plenum
  c. Air-to-air heat exchanger
- Type of air-to-air heat exchanger
- Number of occupants during day and night periods
- Inside temperature and relative humidity during formaldehyde tests
- Area of particle board
- Number of wood heating appliances (wood stoves or fireplaces)
- Number of cigarette or cigar smokers.

These data are contained in Table 3.

Test Results

1. The formaldehyde levels for each house are presented in Figure 5. The values shown are the average of the two readings taken. The median value for the 46 house sample was 0.09 ppm, with 18 houses having values

greater than 0.1 ppm. A plot of formaldehyde levels as a function of indoor relative humidity is shown in Figure 6. A plot of the formaldehyde levels as a function of the amount of particle board in each house is shown in Figure 7.

2. The results of the radon gas tests are shown in Figure 8. Of the 43 houses successfully tested, 12 houses had radon gas levels that exceeded 4 picocuries/litre, which is the U.S EPA remedial criterion. The median value for these 43 houses was 3.0 picocuries/litre.

3. The results of the nitrogen dioxide tests are shown in Figure 9. The median level for the 46 houses was 4.6 ppb. The houses were divided into four categories, depending on the presence or absence of wood appliances and smokers. The results were as follows:

Category	NO_2 ppb	Number of Houses
No wood appliances, no smokers	3.5	12
No wood appliances, smokers	5.3	4
Wood appliances, no smokers	5.1	21
Wood appliances, smokers	5.6	9

Discussion

1. Formaldehyde

The median formaldehyde level was 0.09 ppm, with values ranging between 0.033 and 0.24 ppm. The houses with higher formaldehyde readings tended to have higher relative humidities. Of the 8 houses with relative humidity (RH) values less than 30%, none had formaldehyde readings greater than 0.1 ppm. Of the 6 houses with RH values greater than 40%, 2 had formaldehyde readings greater than 0.1 ppm. A plot of the relationship between formaldehyde and interior relative humidity is shown in Figure 6. Assuming constant moisture generation rates in the various houses (on an equivalent volume basis), low relative humidity values are a result of higher air change rates. Thus the relationship between formaldehyde and relative humidity is not unexpected. There is a secondary effect, since the formaldehyde offgassing rate is known to increase with higher humidities.

Higher formaldehyde readings were also associated with the houses that did not have a mechanical ventilation system. Fifty percent of the houses with no mechanical ventilation system showed formaldehyde levels greater than 0.1 ppm. Only 27% of those that had mechanical ventilation showed levels greater than 0.1 ppm.

As part of the survey, measurements were made of the area of particle board contained within each house. The areas of particle board are shown in Table 3. The range of particle board areas varied from 0 to 311 m^2. In addition, there were other formaldehyde-emitting sources within the houses (some carpets, permanent press fabrics, hardwood plywoods) that were not quantified. As shown in Figure 7, there was weak positive correlation

(correlation coefficient = 0.36) between the formaldehyde level and the amount of particle board in the houses. Other factors, such as the ventilation rate, the age and brand of the particle board, the type of covering on the particle board, tobacco smoke and other sources of formaldehyde are possible reasons the correlation between the formaldehyde level and the amount of particle board is not stronger.

A house can have a low formaldehyde reading by having either a low volume of formaldehyde-emitting sources or a high air change rate. Due to unavailability of equipment, air change measurements were not made during the period the formaldehyde readings were taken. It is possible to estimate the air change rate of those houses that did not have forced ventilation systems by using the pressure test data. Shaw[3] presented a correlation between the air change rate and the pressure test data, wind speed and outside air temperature. The correlation equation when the wind speed is greater than 3.5 m/s and the temperature difference is greater than 25 K, is as follows:

$$I = 4.53 \frac{C}{V}$$

where I = air change rate (h^{-1})
C = constant from pressure test ($L/(s\text{-}Pa^n)$)
V = volume of house (m^3)

Values for C, V, and I for the houses in the survey lacking forced ventilation systems are presented in Table 3. As may be seen from the table, the calculated average infiltration rate for these houses was 0.21 ac/h, and the corresponding average formaldehyde level was 0.106 ppm.

This relatively low air change rate, coupled with the high particle board loading for a number of the houses, is believed to be responsible for the elevated formaldehyde gas readings in this group of houses.

2. Radon

The median radon level for the houses was 3.0 picocuries/litre, with the values ranging between 0.82 and 9.44 pCi/L. The readings were all taken in the lowest levels of the houses, which were generally not occupied.

3. Nitrogen Dioxide

The median value for the NO_2 readings was 4.6 parts per billion, with values ranging between 0.7 and 13.3 ppb, well below the ASHRAE guideline of 50 ppb. Three of the four houses with readings above 10 ppb had either wood stoves or fireplaces. The fourth house, with a reading above 10 ppb, had 2 smokers with cigarette consumption levels of 1 pack (20 cigarettes) each per day. The houses with no wood appliances and no smokers averaged 3.5 ppb, and those with both wood appliances and smokers averaged 5.6 ppb.

Recommendations

The results of this study indicate a number of areas for further work:

- Future studies of this type should include direct measurements of the air change rates in the houses using tracer gas or other appropriate means.
- Remedial work on these houses exhibiting higher levels of pollutants should be undertaken.
- Investigations should be undertaken to determine the source of the radon gas. An area that is likely to be a strong source is the floor drain, through which radon can leak into the house via the weeping tile system.
- Offgassing rates for typical particle boards used in Canadian houses should be determined. A particular need exists for data on the offgassing rate when the board has a floor covering. Also of interest is the rate of offgassing as a function of the age of the board, the board temperature, and the relative humidity.
- Further studies should be undertaken on residences such as mobile homes, that contain large quantities of particle board.

References

1. Dumont, R.S. and Orr, H.W. "Airtightness Measurements of Detached Houses in the Saskatoon Area," National Research Council of Canada, Division of Building Research, Building Research Note 178, Ottawa, Ontario, 1981.

2. ASHRAE, "Ventilation for Acceptable Indoor Air Quality" Standard 62-1981, 1791 Tullie Circle N.E., Atlanta, Georgia, 30329, 1981.

3. Shaw, C.Y., "A Correlation between Air Infiltration and Air Tightness for Houses in a Developed Residential Area," ASHRAE Transactions, Vol. 87, Pt.2, 1981.

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Table 1. Comparison of Air Leakage Characteristics for Groups of Saskatoon Houses

Type	Leakage Area m^2	Air ch/h at 50 Pa ac/h	Number of Houses
Pre-1945	.1078	10.35	19
1946-1960	.0709	4.55	20
1961-1980	.0621	3.57	97
Special air-tight houses (1977-1980)	.0330	1.49	40

Table 2. Guidelines for generally acceptable levels of selected air contaminants.

Contaminant	Level	Reference
Formaldehyde	0.12 mg/m^3 0.1 ppm at 25°C, 101.3 kPa	ASHRAE 62-1981
Radon	4 pCi/L	U.S. EPA
Radon daughters	0.01 working levels	ASHRAE 62-1981
Nitrogen Dioxide	100 $\mu g/m^3$ 50 ppb at 25°C, 101.3 kPa	U.S. EPA

Table 3. Air Quality Data, 1983 Survey, Saskatoon

House Code	Year Built	Tightness ac/h @ 50 Pa	Press. Test No.	Formald. ppm Dupont Week 1	Formald. ppm Dupont Week 2
A2	81	1.51	319	.06	.063
A4	81	1.19	318	.099	.108
A5	81	1.7	248	.034	.038
B12	82	1.43	302	.174	.161
B11	82	2.15	313	.06	.064
B13	80	1.88	85	.103	.078
B10	81	.73	194	.108	.073
B15	82	1.49	241	.068	.072
B14	77	2.03	243	.046	.042
B3	78	1.53	140	.092	.073
AA9	81	1.39	297	.043	.03
B6	78	.99	167	.148	.134
C8	80	.54	138	.068	.071
D2	81	1.06	317	.033	.035
D3	81	.53	133	.21	.224
FF5	81	2.14	316	.043	.04
D4	79	.76	135	.048	.07
E4	81	.95	250	.156	.122
FF6	81	1.68	247	NA	.091
F8	82	1.36	296	.206	.175
F9	81	1.7	310	.086	.081
F1	80	1.57	11	.139	.133
G7	80	2.19	128	.13	.141
G4	79	.95	288	.063	.054
H6	82	1.45	320	.1	.098
H7	82	1.2	299	.077	.064
H8	81	1.09	300	.103	.095
J3	81	1.16	322	.137	.127
L10	80	.45	139	.14	.109
L11	81	1.92	245	.099	.104
G3	79	1.38	280	.05	.041
M8	80	.62	126	.073	.061
M9	81	2.34	323	.14	.13
P2	80	.87	315	.155	.166
P5	81	.84	246	.097	.086
P4	81	1.99	214	.12	NA
R3	81	1.96	314	.05	.053
R8	82	1.05	298	.06	.075
S9	82	1.26	272	.074	.069
S1	80	1.28	278	.174	.16
FF1	80	1.99	43	.035	.042
S8	82	1.41	314	.073	.074
T3	80	1.62	251	.099	.083
T4	80	.77	127	.061	.047
W7	81	.74	132	.241	.165
Y1	81	.67	207	.154	.114
AVERAGE		1.33		.100	.0919

Table 3 (cont'd)

House Code	House Volume (m^3)	Total Particle Board Area (m^2)	NO_2 ppb	# of Wood Appl	# of Smokers	Radon (pCi/L)
A2	784.2	195	1.5	1	0	1.91
A4	549.7	55	3.1	0	0	2.46
A5	753.7	49.7	10.7	2	0	2.03
B12	832	232.7	4.5	1	0	2.1
B11	630.2	204.3	6.9	1	0	3.01
B13	419	130.5	6.1	1	1	2.09
B10	900	266.2	4.6	1	0	9.44
B15	600	55.7	1.5	0	0	3.67
B14	369	96.8	1.5	0	2	1.7
B3	737	141.3	6.1	1	1	6.81
AA9	425.5	131.7	1.5	0	0	2.05
B6	658.5	261.3	3	1	2	6.66
C8	490.4	109.6	7.6	0	0	1.36
D2	620.2	0	1.5	1	0	2.27
D3	466.5	129	3.1	0	0	3.56
FF5	711.8	236.1	6.1	1	0	.85
D4	570.5	147.3	1.5	0	0	3.11
E4	704	183.7	.7	1	0	3.8
FF6	758.3	244.5	3.1	1	2	2.12
F8	490.5	189	9.4	1	0	
F9	612	123.6	1.4	1	0	3.16
F1	733.6	175.3	3.1	1	0	4.9
G7	541	209.7	3	1	0	2.17
G4	759	181.9	6.1	1	0	7.17
H6	489	118.4	6.2	0	2	4.87
H7	420.2	131.6	13.3	1	0	.82
H8	553.4	154.9	1.3	1	2	
J3	520	148.6	4.7	0	0	9.43
L10	457	147.2	8.2	1	1	3.45
L11	552	191.1	6.9	1	2	1.88
G3	618	170.6	2.3	0	0	2.17
M8	472	130.7	10.4	0	2	2.89
M9	657	311.6	1.5	1	0	1.53
P2	835.1	173.7	6	0	0	4.03
P5	659.2	56.3	3	0	0	2.26
P4	607	158.1	3.1	1	0	6
R3	666	187.8	10.7	1	0	2.97
R8	700	164.2	5.5	1	0	1.33
S9	543	159.3	4.6	1	0	3.2
S1	462	121.5	3	0	1	5.68
FF1	499.6	122.4	6.4	0	0	4.46
S8	428	155.3	9.1	1	1	1.99
T3	721		3.2	1	0	3.53
T4	461.7	182.9	6	1	0	
W7	494.7	136.9	1.5	0	0	6.92
Y1	521	159.9	6.9	1	1	5.2
	596.8	156.2	4.8			3.56

Table 3 (cont'd)

House Code	Heating System Type	Number of Chimneys	Ventil System Type	A/A Heat Exchanger Type	A/A Est On Time Hrs.	Problems Moisture/ Odour?
A2	GAS	2	A TO A	P & P	24	NO
A4	GAS	1	A TO A	MITSUB	24	NO
A5	GAS	3	A TO A	VAN EE 200	24	NO
B12	GAS	2	FR. AIR DUCT	------	NA	NO
B11	GAS	2	FR. AIR DUCT	------	NA	
B13	GAS	2	NONE	------	NA	YES/NO
B10	GAS	2	A TO A	MITSUB	24	NO
B15	GAS	1	A TO A	P & P	4	YES/NO
B14	GAS	1	NONE	------	NA	YES/NO
B3	GAS	2	A TO A	P & P	24	NO
AA9	EL. BASE.	0	A TO A	PASS. SOLAR	20	YES/NO
B6	EL. BASE.	1	A TO A	P & P	12	NO
C8	GAS	1	A to A	VAN EE 200	3	NO
D2	GAS	2	A TO A	P & P		NO
D3	GAS	1	A TO A	P & P	0	YES/NO
FF5	GAS	2	FR. AIR DUCT	-------	NA	YES/NO
D4	GAS	2	A TO A	MITSUB	24	NO
E4	GAS	2	FR. AIR DUCT	-------	NA	NO
FF6	GAS	2	NONE	-------	NA	NO
F8	GAS	2	FR. AIR DUCT	-------	NA	YES/NO
F9	GAS	2	FR. AIR DUCT	-------	NA	NO
F1	GAS	3	NONE	-------	NA	
G7	HOT WATER	1	A TO A	P & P		NO
G4	EL. BASE.	2	A TO A	P & P	1	NO
H6	GAS	1	A TO A	VAN EE 200	24	YES/NO
H7	GAS	3	A TO A	VAN EE 200	4	NO
H8	GAS	2	A TO A	P & P	4	NO
J3	GAS	2	A TO A	OTHER	4	YES/NO
L10	GAS	2	A TO A	VAN EE 200	22	NO
L11	GAS	2	FR. AIR DUCT	-------	NA	YES/NO
G3	GAS	2	FR. AIR DUCT	-------	NA	NO
M8	GAS	1	A TO A	MITSUB		YES/NO
M9	GAS	2	FR. AIR DUCT	-------	NA	NO
P2	BOILER	1	FR. AIR DUCT	-------	NA	NO
P5	EL. FURNACE	0	A TO A	VAN EE 200	24	
P4	GAS	2	NONE	-------	NA	YES/NO
R3	GAS	3	A TO A	PASS. SOLAR	24	NO
R8	GAS	2	A TP A	VAN EE 200		NO
S9	GAS	2	A TO A	VAN EE 200	6	NO
S1	EL. BASE.	1	A TO A	P & P	2.75	YES/NO
FF1	GAS	2	A TO A	P & P	4	NO
S8	GAS	2	FR. AIR DUCT	--------	NA	NO/YES
T3	GAS	2	A TP A	OTHER	24	YES/NO
T4	GAS	2	A TO A	VAN EE 200	8	NO
W7	GAS	1	A TO A	DC2	24	YES/NO
Y1	GAS	2	A TO A	PASS. SOLAR	24	YES/NO

Table 3 (cont'd)

House Code	Daytime Adults/ Children	Nightime Adults/ Children	In. Temp Deg (C) Week 1	In. Temp Deg (C) Week 2	Rel Hum Percent Week 1	Rel Hum Percent Week 2
A2	1/1	2/4	20	21	NA	29
A4	1/2	2/2	21	21	39	36
A5	3/2	4/2	20	20	32	34
B12	1/2	2/3	20	20	33	33
B11	1/2	2/2	18	18	24	22
B13	1/2	2/2	19	19	36	34
B10	0	2/0	20.5	20.5	27	28
B15	0	2/0	17	17	NA	36
B14	1/2	2/2	19.5	19.5	42	37
B3	1/0	3/0	19	19	NA	29
AA9	2/1	2/1	22	21	35	38
B6	0	3/0	19.5	19.5	34	38
C8	1/0	2/0	20	20	26	24
D2	0	2/4	18.5	18.5	38	29.5
D3	.5/0	2/2	21	20.5	46	42
FF5	1/0	2/2	17.5	17	28	24
D4	0	4/1	17.5	17.5	40	36
E4	0/0	2/0	20	20	38	36
FF6	0/0	3/3	18.5	18.5	35	30
F8	1/0	2/3	16.5	16.5	44	40
F9	0/0	2/0	21	21	36	29
F1	0/0	3/0	21	21	34	27
G7	1/0	2/0	20	20	35	30
G4			19.5	19.5	38	37
H6	0	2/0	17.5	17.5	35	28
H7	1/0	1/0	20	20	28	18
H8	0/0	2/0	21	20.5	36	28
J3	2/0	2/0	18	18	38	36
L10	.5/0	2/2	18	18	35	38
L11	1/1	2/3	20	20	40	36
G3	0	2/0	21.5	21.5	32	25
M8	0/1	2/2	19.5	19.5	38	42
M9	2/3	2/3	21	21	38	29
P2	2/0	2/0	18.5	18.5	36	32
P5	2/1	2/1	20	20	42	44
P4			20	20	37	33
R3	2/0	3/2	20	20	32	26
R8	0	2/0	19.5	19.5	24	22
S9	0	2/0	17.5	17.5	29	28
S1	2/0	2/0	18.5	18.5	46	45
FF1	1/1	2/1	17.5	17.5	45	52
S8	1/0	2/1	17.5	17.5	30	32
T3	4/1	4/1	21	21	42	30
T4	1/1.5	2/2	21	20.5	31	30
W7	1/0	2/2	23	23	NA	33
Y1	1/1	2/2	21	20	40	38
			19.5	19.5	35.6	32.7

Table 4. Calculated air change rates for houses lacking forced ventilation

House Code	C $m^3/(s\text{-}Pa^n)$	n	V (m^3)	I Ac/h	Formaldehyde ppm 2 wk Average
B12	.0327	.668	832	.178	.1675
B11	.0295	.651	630.2	.212	.062
B13	.0211	.666	419	.228	.0905
FF5	.0208	.785	711.8	.132	.0415
E4	.0498	.543	704	.320	.139
F8	.0341	.617	490.5	.314	.1905
F9	.0142	.769	612	.105	.0835
F1	.0273	.698	733.6	.168	.136
L11	.0238	.771	552	.195	.1015
G3	.023	.665	618	.168	.0455
M9	.0235	.754	657	.162	.135
P2	.0164	.759	835.1	.088	.1605
P4	.0199	.792	607	.148	.12
S8	.0461	.518	428	.487	.0735
FF6	.0351	.693	758.3	.209	.0455
AVERAGE	.02782	.689	639.2	.208	.106

Appendix A

Consistency of the Radon and Formaldehyde Sensors

During the air quality measurements, a number of cross-checks were made with the radon and formaldehyde sensors. These checks were primarily taken to ensure that the companies supplying the sensors and doing the analyses were providing consistent readings.

Radon

During the course of the experiment, groups of 5 sensors were placed side-by-side in two locations. The first location for the side-by-side check was in a crawl space area that was known to have elevated radon levels. The results for the five sensors, all of which were placed side by side, were as follows, when read at the 1.0 pCi/L-month sensitivity level.

Sensor No.	Radon reading (pCi/L)
D91	5.48
D92	5.73
D93	6.43
D94	4.90
D95	5.40
Average =	5.59
Std. Dev. =	0.56

A second check, again using 5 sensors placed side-by-side, was performed in a well-ventilated laboratory. The results for this comparison are shown below:

Sensor No.	Radon reading (pCi/L)
D96	0.27
D97	0.14
D98	0.22
D99	0.12
D100	0.17
Average =	0.18
Std. Dev. =	0.06

Formaldehyde

A side-by-side check was performed on the DuPont sensors. A total of 4 sensors were placed side-by-side in one house for a one week period. The readings were as follows:

Sensor no.	Formaldehyde level (ppm)
1	0.071
2	0.076
3	0.078
4	0.088
Average =	0.078
St. Dev. =	0.007

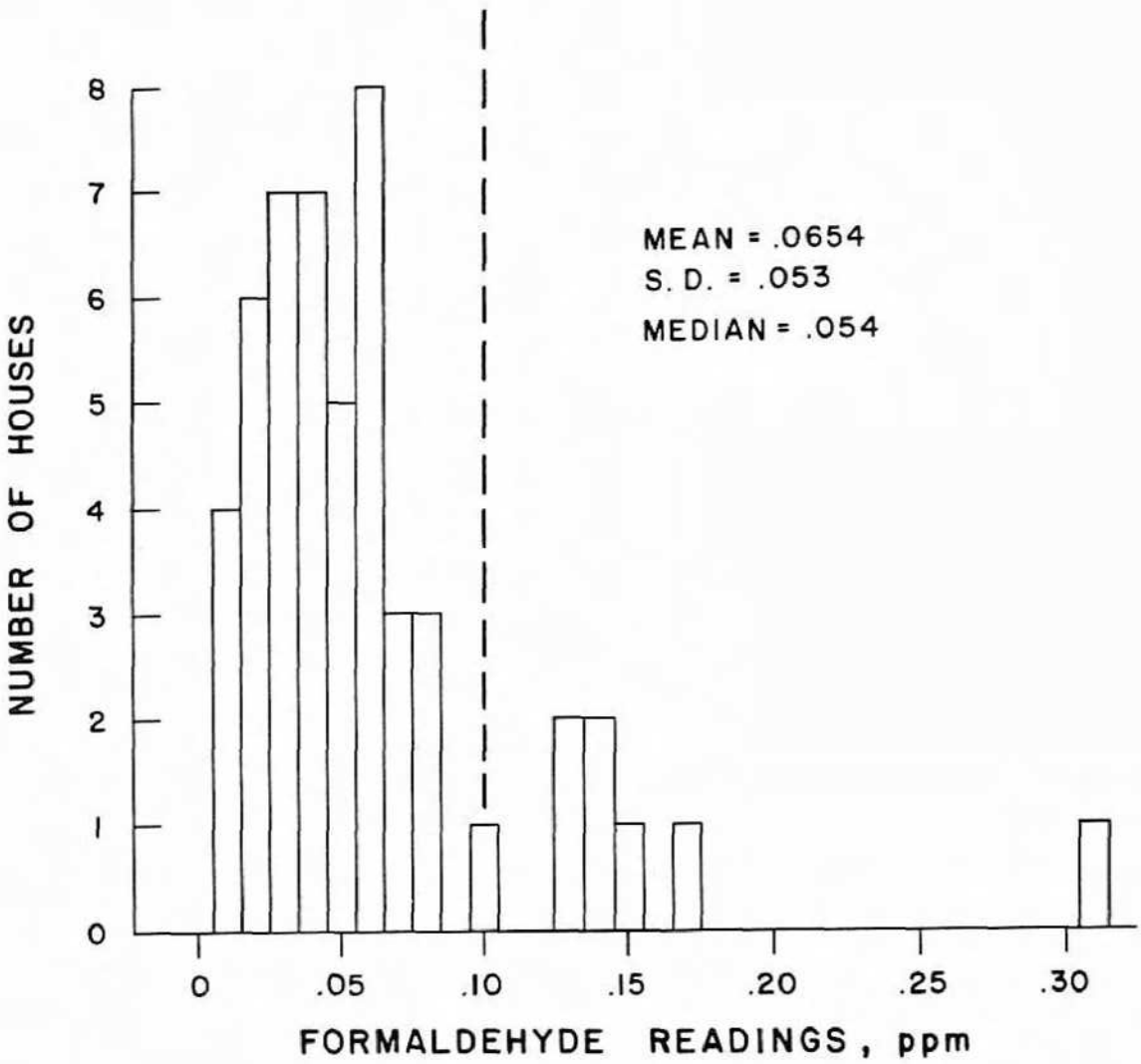

Figure 1

Formaldehyde readings, 1982 study

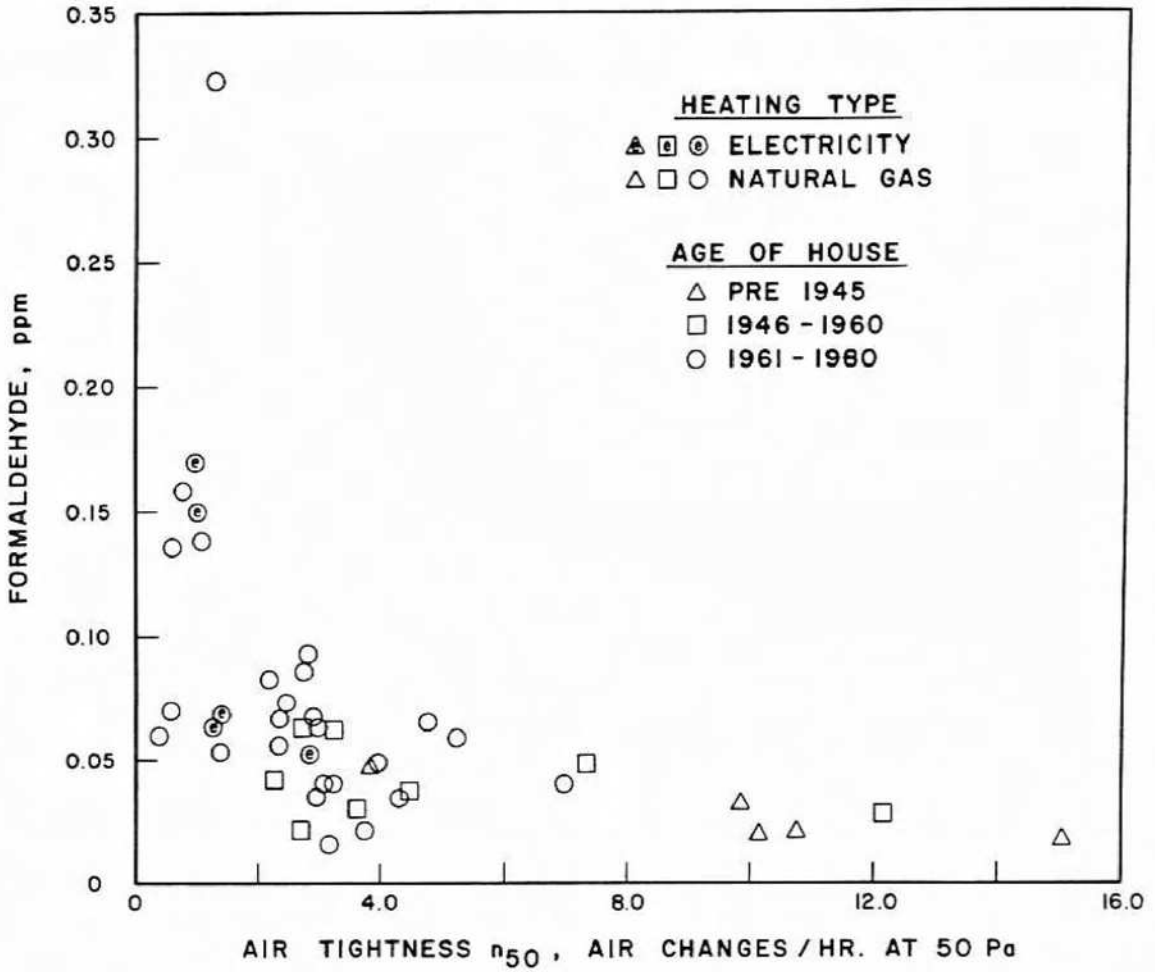

Figure 2

Formaldehyde readings as a function of air tightness, 1982 study

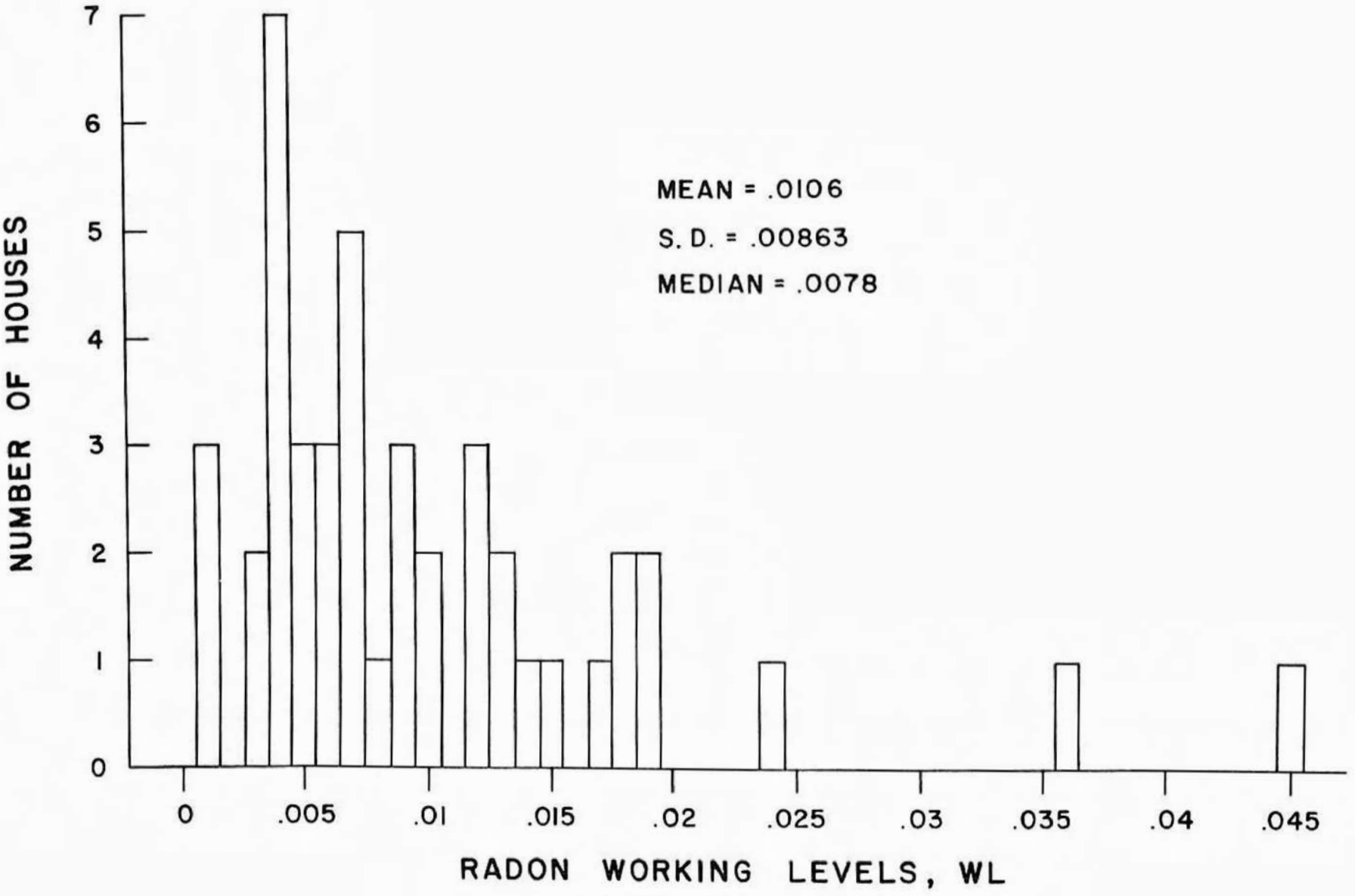

Figure 3

Radon readings, 1982 study

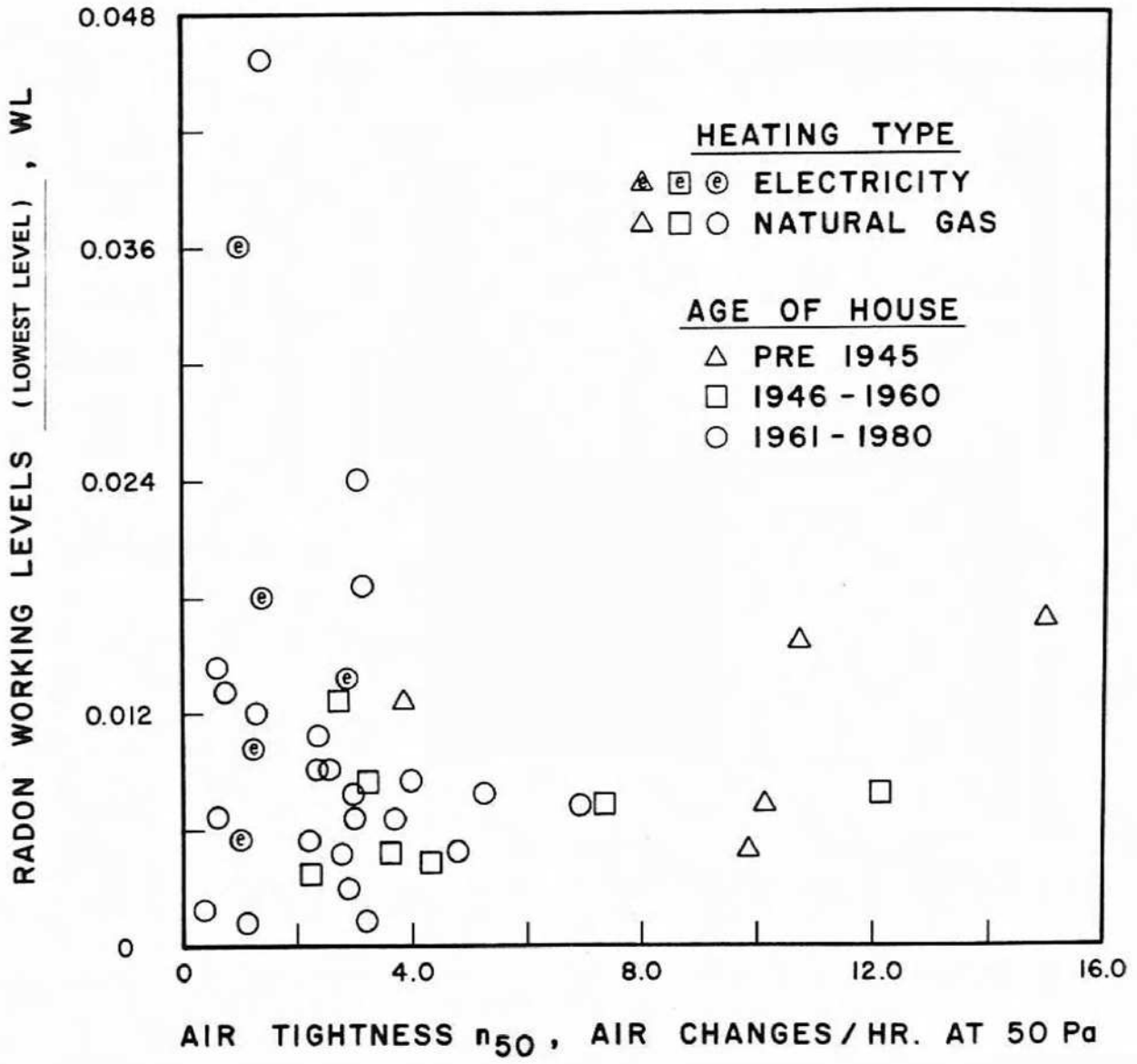

Figure 4

Radon readings as a function of air tightness, 1982 study

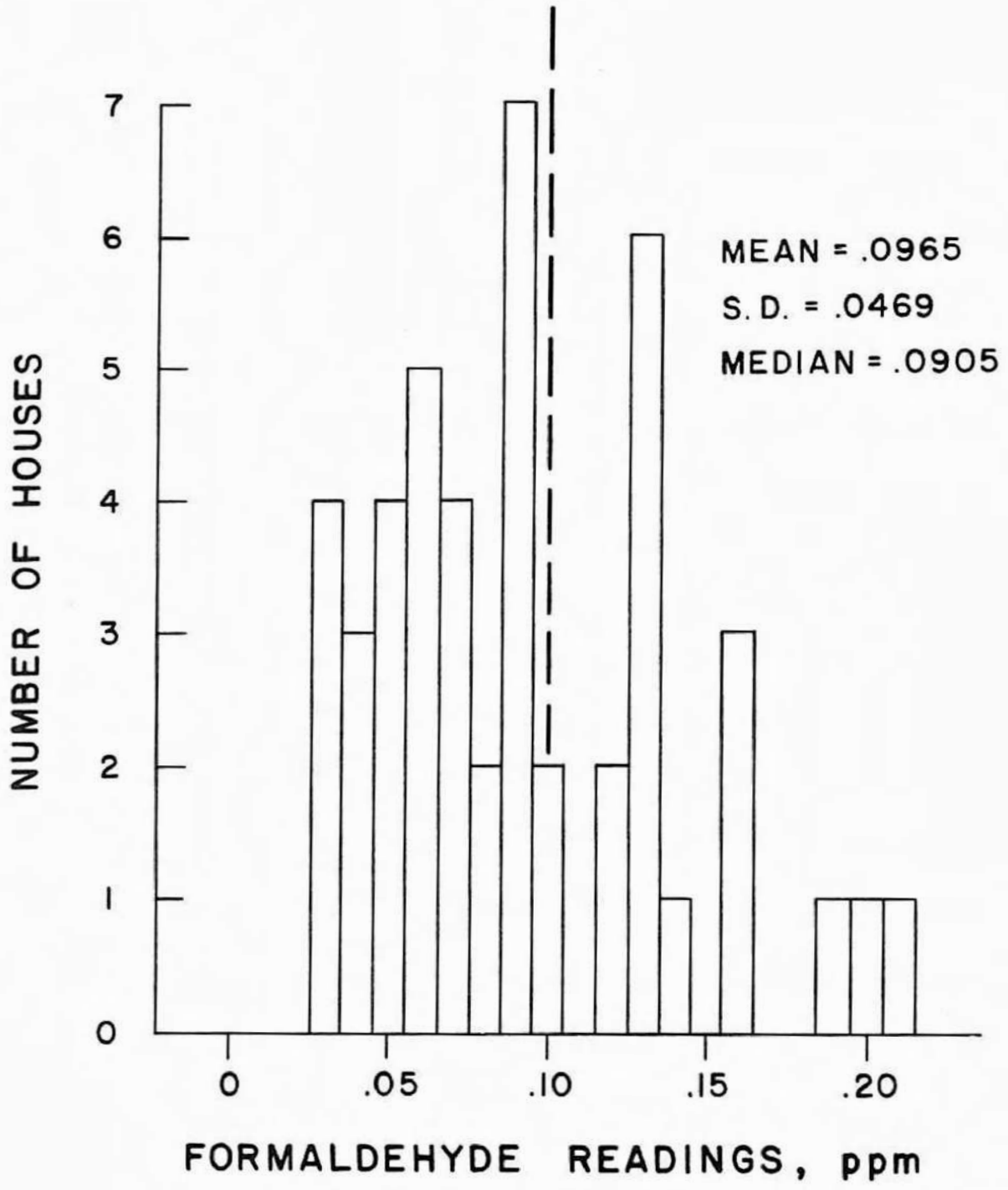

Figure 5

Formaldehyde readings, 1983 study

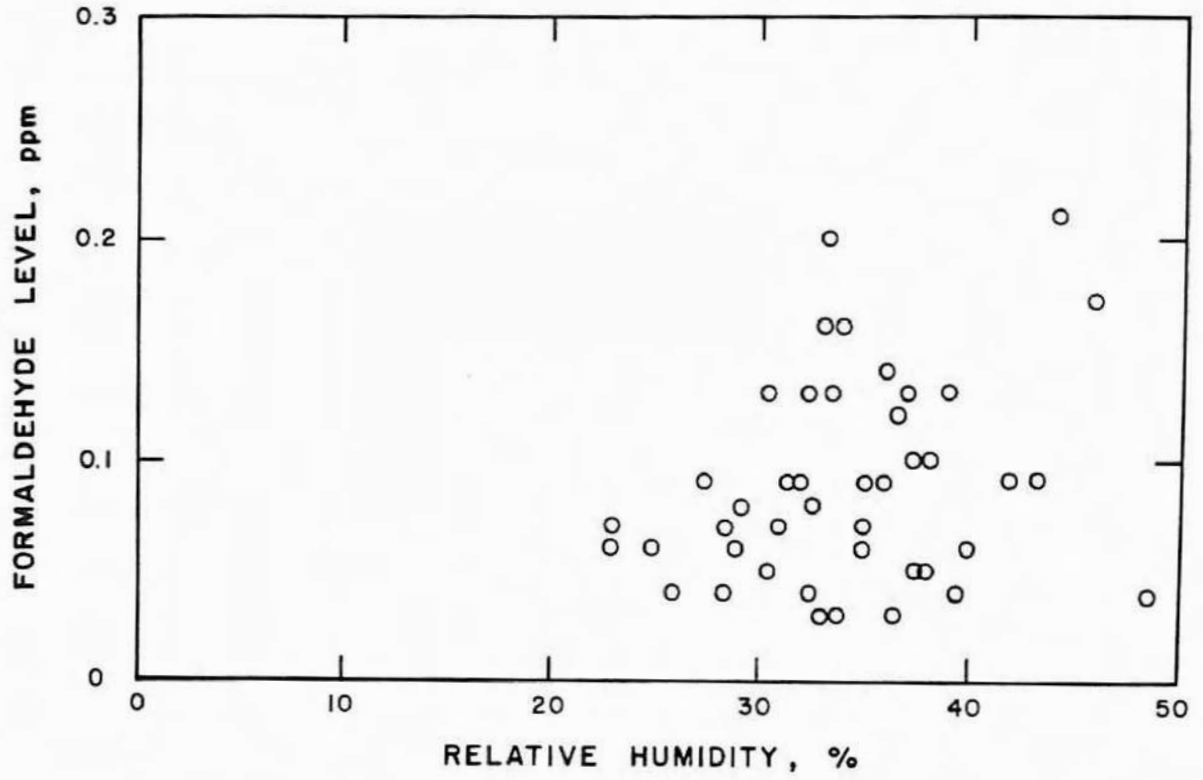

Figure 6

Formaldehyde readings as a function of indoor relative humidity, 1983 study

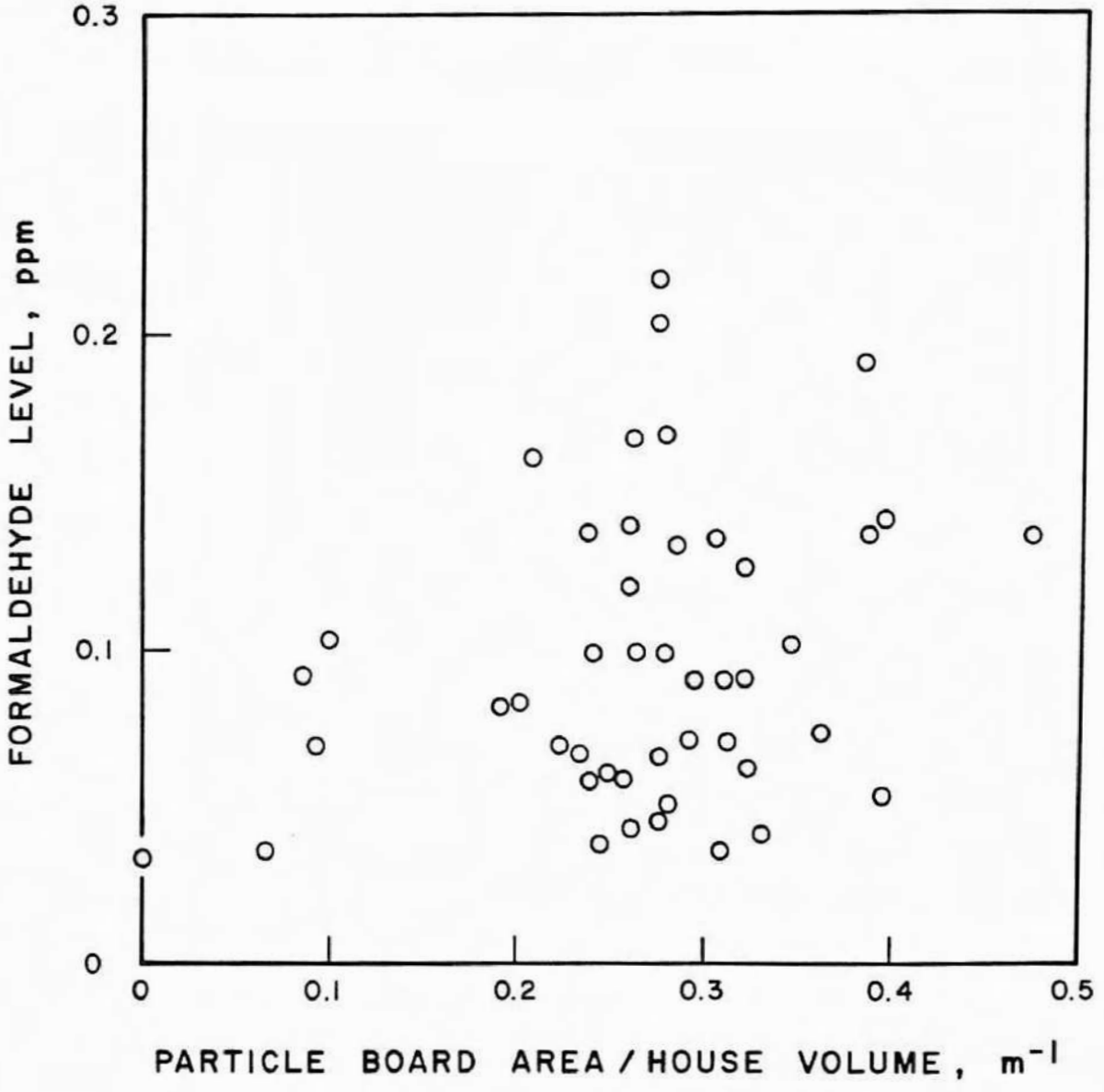

Figure 7

Formaldehyde readings as a function of the amount of particle board, 1983 study

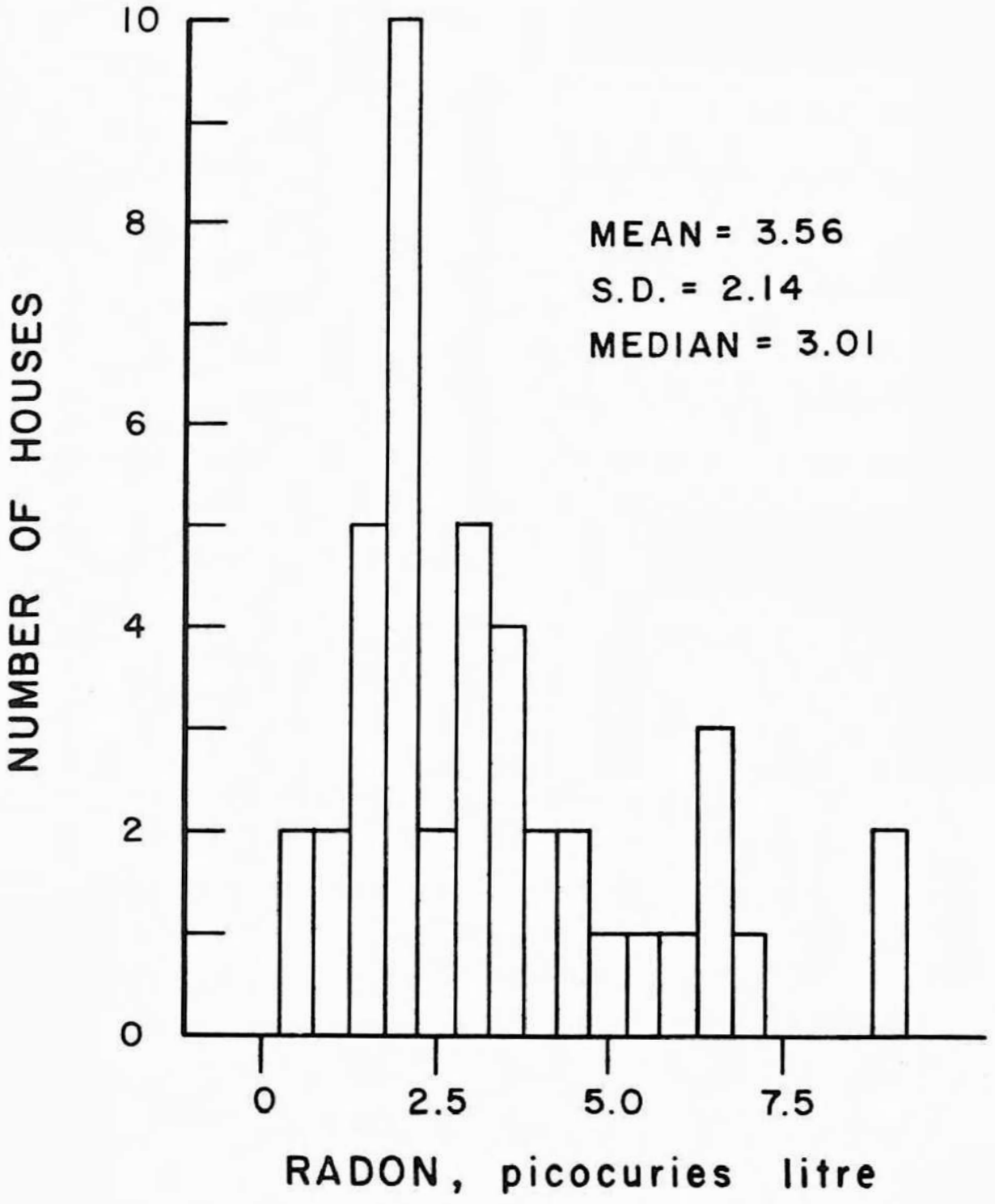

Figure 8

Radon readings, 1983 study

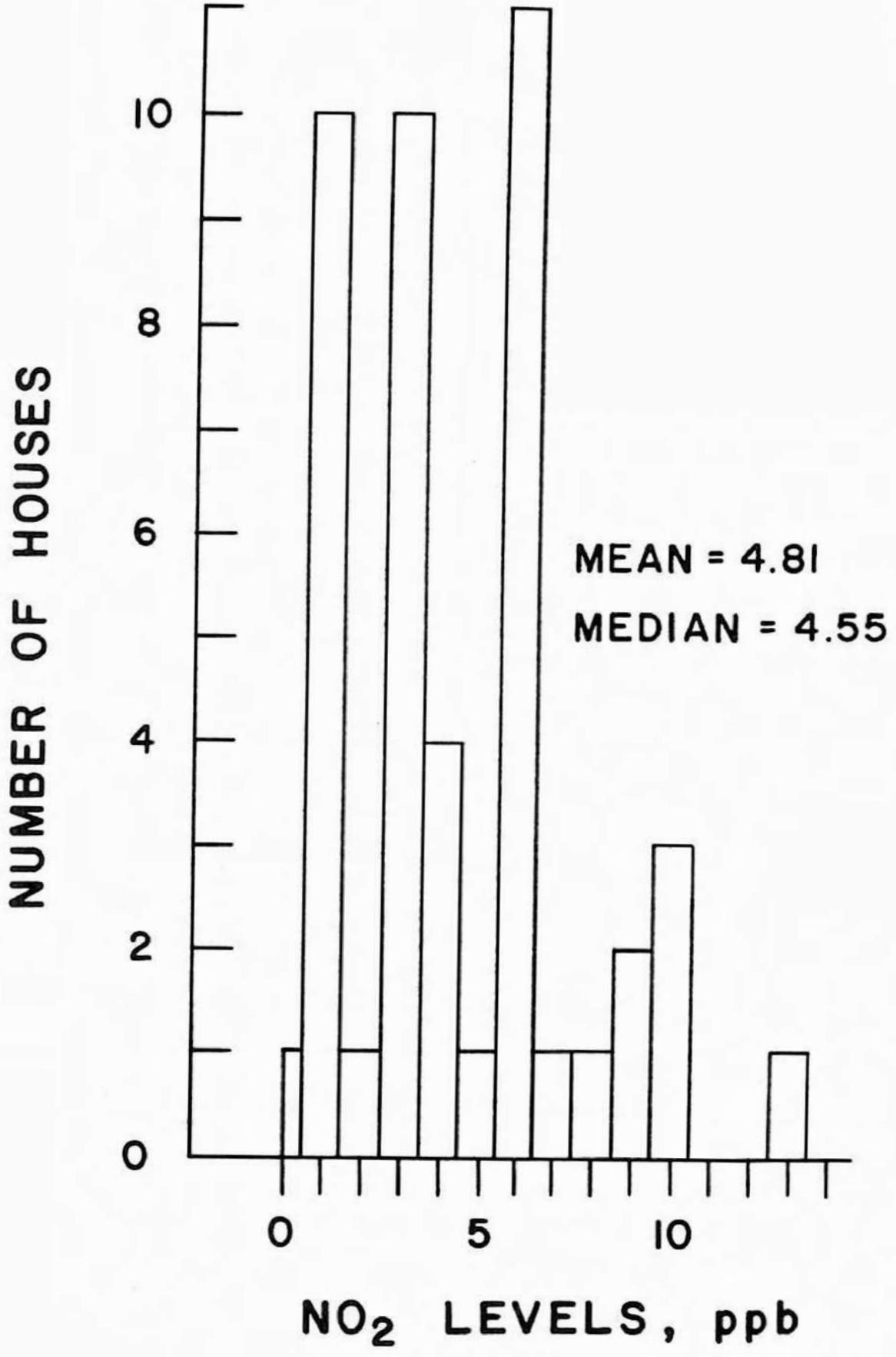

Figure 9

Nitrogen dioxide readings, 1983 study