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AIR TIGHTNESS MEASUREMENTS OF DETACHED HOUSES IN THE SASKATOON AREA

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The purpose of this study was to identify the air tightness levels of a group of houses in the Saskatoon area. Included in the tests were houses of different ages, construction styles, and methods of achieving air tightness.

A 1979 report by Beach[1] presents the results of air tightness tests on a group of new houses in the Ottawa area. The Saskatoon study included a sample of new houses comparable in number to the Ottawa sample and thus enabled comparison between the two studies.

The total number of houses tested in the Saskatoon Group was 176. Categorized according to age, the number of conventionally constructed houses in each group was as follows:

	No. of Houses
Pre 1945	19
1946 - 1960	20
1961 - 1980	97

In addition to the houses constructed using conventional air tightness measures, a sample of 40 houses in which the builders had made efforts to improve the air tightness level was included. The techniques used in the majority of these special houses are detailed in the booklet "Energy Efficient Housing: A Prairie Approach,"[2] Which was written in collaboration with members of the Division of Building Research of the National Research Council.

In addition to categorization by age and air tightness levels, the houses tested were also classified according to the construction style and the contractor.

The pressure test procedure and the apparatus used are described in "An Exhaust Fan Apparatus for Assessing the Air Leakage Characteristics of Houses."[3]

The test can be done on a house in a relatively short time. Typically, in an 8-hour day, two persons could pressure test about 5 houses provided the travel time between houses was not greater than about 20 minutes

All tests reported in this Note were conducted with all vents and chimneys in the houses blocked. The fan was positioned so as to cause a negative pressure in the house relative to the outdoor pressure.

About ten data points were taken for each house. The volume flow and pressure difference across the house were used to determine C and n in the equation:

$$Q = C\ (\Delta P)^n$$

where Q = volume flow (m^3/s);

C = constant ($m^3/(s\text{-}Pa^n)$);

ΔP = pressure difference (Pa);

n = dimensionless number.

A number of figures of merit have been used by various authors to rate the air tightness level of houses. These criteria have generally been of the following form:

(1) equivalent orifice area;

(2) air flow at a reference pressure difference;

(3) air flow per unit volume at a reference pressure difference; and

(4) air flow per unit exposed above grade area at a reference pressure difference.

As all of the above criteria have some merit, a decision had to be made as to the criterion used in this note. The choice used in this note for averaging the data was the air flow per unit volume at a pressure difference of 50 Pa. This will be referred to as the n_{50} rating, following the Swedish[4] and Norwegian[5] terminology. To assist those more familiar with different units, however, the values of the volume, external area above grade, the constants C and the exponent n are also presented for each of the houses, along with the air flow per unit exposed surface area at a pressure difference of 10 Pa, and the air flow at 10 Pa.

DESCRIPTION OF THE HOUSES TESTED

The 176 houses tested and the pressure test results are described in Table I. The n_{50} values range from a low of 0.37 to a high of 33.3. A selection of the results is presented in histogram form in Figures 1 and 2.

Test Results

1. Age of houses

The age of the house had a marked effect on the pressure test results. For ease of categorization, the conventionally constructed houses were divided into three age categories:

(1) Pre 1945;

(2) 1946 - 1960;

(3) 1961 - 1980;

The reason for using the three age groups was as follows. Prior to 1945, vapour barriers in sheet form were not used in houses. Following 1945, vapour barriers in the form of waxed paper were introduced. From 1960 onward, the use of polyethylene sheets for vapour barriers became a common practice in Canada.

The test results for the three age categories are presented in Table 2.

In the 1961 - 1980 sample, those houses which were in the low-energy house category were excluded. Only those houses using conventional air tightness techniques are in this sample.

2. Low-Energy Houses

The low-energy house sample includes houses built over the period 1977 to 1980. Of the 40 houses, 35 were built by contractors, and the remainder by individuals on a "do-it-yourself" basis. Houses 20 to 33 were in a special project built on one street in a new area of Saskatoon. The test results are presented in Table 3.

The low-energy houses were further subdivided into categories based on the type of wall system used (single stud or double stud) and on the location of the wall vapour barrier (conventional or vapour barrier sandwiched). The results are presented in Table 4.

3. Effect of Contractor

Included in the test sample were houses built by different contractors. With the exception of contractor A, all the contractors were building conventional houses that did not incorporate special air tightness techniques.

As already mentioned, there was a group of 14 low-energy houses built for a special project. Because these houses incorporated special air tightness techniques, these houses are excluded from the contractor sample. The results for the contractors are presented in Table 5.

4. Construction Style

To determine the effect of construction style on the pressure test results, the conventional houses of the 1961 to 1980 category were sorted according to the following division of construction styles: bungalow, bi-level, split level, 1½ storey and 2 storey. The pressure test results are presented in Table 6.

5. Comparison with Ottawa House Sample

A 1979 report by Beach[1] presented pressure test results on a sample of 63 new houses built by contractors. A comparison is presented in Table 7 between the results found for the Ottawa sample and for a similar group of houses in Saskatoon. Because contractor A in Saskatoon was using special air tightness measures, his houses were excluded from the Saskatoon sample for this comparison.

DISCUSSION

A number of observations can be made concerning the data presented in this Note. The effect of age, air tightness measures used, contractor and construction style are discussed in turn.

1. Age of Houses

Of all the variables that influenced the air tightness of the houses tested, it was the age of the house that was most significant. The age of the house had a marked effect on the type of vapour barrier used, which in turn affected the pressure test results. As can be seen from Table 2, the houses in the pre 1945 sample (n_{50} = 10.35) were approximately 2.2 times as leaky as the sample built between 1946 and 1960 (n_{50} = 4.55). There was a slight improvement in air tightness in the post 1960 sample (n_{50} = 3.57) compared with the 1946 - 1960 sample.

2. Low-Energy Houses

Those houses using special air tightness measures had pressure tests with an average value of n_{50} = 1.49. This represents a reduction of 58% over the values for conventional 1961 - 1980 houses not incorporating the special air tightness measures. The placement of the vapour barrier in the wall appears to have had an influence on the air tightness level achieved. Those houses using a sandwich technique for the vapour barrier, i.e., placing the vapour barrier part way through the wall,[6] exhibited considerably lower air leakage values (n_{50} = 1.16 single stud wall; n_{50} = 0.93 double stud wall) as compared with those low energy houses using a conventional location for the vapour barrier (n_{50} = 1.72 single stud wall; n_{50} = 1.91 double stud wall).

3. Effect of Contractor

With the exception of contractor A, all of the contractors were using conventional air tightness measures, which consist of 50μm thick polyethylene as the vapour barrier on the ceiling and walls of the house. In the conventional installation, there is some attempt to achieve continuity of the vapour barrier, but there are numerous locations where this goal was not achieved. As can be seen from Table 5, a variation of approximately 2.2 to 1 existed between the contractor with the lowest n_{50} value (2.13) and the contractor with the highest n_{50} value (4.69). The present Swedish standard[4] for new houses is 3 air changes/hour at 50 pascals. Of the 9 contractors surveyed, only 2 of the Saskatoon contractors would have met the Swedish standard.

4. Construction Style

The bungalow and bi-level designs, with n_{50} values of 3.04 and 3.37, were found to be measurably tighter than the 1½-storey, 2-storey and split level designs, which had n_{50} values of 4.35, 4.38 and 4.49.

With the latter group of houses, the greater surface area above grade is likely the major reason for the greater air leakage.

5. Comparison between Saskatoon and Ottawa Contractor-Built Houses

The Ottawa houses (n_{50} = 4.41) had greater air leakage values than the Saskatoon sample (n_{50} = 3.60). As Saskatoon is located in a colder climate area, it is not unexpected that the houses in the Saskatoon sample were tighter.

References

1 Beach, R.K. Relative Tightness of New Housing in the Ottawa Area, National Research Council of Canada, Division of Building Research, BR Note No. 149, Ottawa, 1979

2 Energy Efficient Housing: A Prairie Approach, Office of Energy Conservation, Government of Saskatchewan, 1914 Hamilton Street, Regina, Saskatchewan, Canada.

3 Orr, H.W. and Figley, D.A. An Exhaust Fan Apparatus for Assessing the Air Leakage Characteristics of Houses, National Research Council of Canada, Division of Building Research, BR Note No. 156, Ottawa, 1980.

[4] Carlsson, B, Elmroth, A. and Engrall, P. Airtightness and Thermal Insulation: Building Design Solutions, Swedish Council for Building Research, Stockholm, Sweden, 1980.

[5] Brunsell, J.T. and Urslkk, S. The airtightness of Houses, (Boligers Lufhetthet) Norwegian Building Research Institute Report No. 31, 1980.

[6] Orr, H.W., Design and Construction of Low Energy Houses in the Prairies. In preparation.

TABLE I. HOUSE CHARACTERISTICS

Symbols:

Construction Style

B - Bungalow

BL - Bi-level

2S - Two Storey

1½S - One and one-half storey

3L - Three level split

4L - Four level split

5L - Five level split

SL - Slab on grade

Wall Type

A - 38 x 89 mm stud

B - 38 x 140

C - 38 x 190

D - 38 x 89 + polystyrene sheathing

E - 38 x 140 + polystyrene sheathing

F - Double stud (FS sandwiched vapour barrier)

G - (38 x 64) + (38 x 89) + polystyrene sheathing

H - 2nd skin retrofit

I - Wood truss

J - Log construction

Heating System

G - Gas fired, forced air

O - Oil fired, forced air

E - Electric, baseboard

Domestic Water Heating

G - Gas

E - Electric

TABLE I (p.2)

PRE-1945 HOUSES

HOUSE NO.	HOUSE CODE	CONST. STYLE	WALL TYPE	HEATED VOL., m^3	AIR BARRIER AREA m^2	HEATING SYSTEM	DOMESTIC HOT WATER	FIREPLACE OR WOOD HEATER	Q/A @ 10 Pa, L/s m^2	Q @ 10 Pa, L/s	Q/V @ 50 Pa, h^{-1}	C $m^3/s\ Pa^n$	n
1	181	1½S	A	283	172	G	G	1	1.66	286	10.75	0.0607	0.673
2	182	1½S	A	386	211	G	G	N	1.80	380	9.14	0.0973	0.590
3	183	1½S	A	413	223	G	G	N	1.63	363	9.85	0.0718	0.705
4	184	2½S	A	448	255	G	G	N	1.33	339	10.11	0.0516	0.817
5	185	2S	A	454	271	G	G	1	1.32	358	10.16	0.0577	0.792
6	186	1½S	A	516	259	G	G	N	1.20	311	6.43	0.0662	0.673
7	188	1½S	A	462	200	G	G	N	2.30	460	16.63	0.0510	0.955
8	170	1¼S	A	179	125	G	G	N	3.89	486	33.33	0.0837	0.763
9	179	2S	A	382	207	G	G	N	1.85	383	12.79	0.0623	0.788
10	180	B	A	429	217	G	G	N	0.83	180	4.82	0.0340	0.723
11	24	B	A	532	314	G	G	1	0.90	283	5.71	0.0586	0.682
12	40	B	A	311	166	G	G	N	1.23	204	7.30	0.0406	0.701
13	51	B	A	247	135	G	G	N	1.55	209	8.07	0.0514	0.608
14	66	B	A	302	184	G	G	N	1.11	204	8.59	0.0335	0.784
15	70	B	A	385	207	G	G	1	1.52	315	8.88	0.0649	0.686
16	71	B	A	256	169	G	G	N	0.93	157	7.94	0.0256	0.791
17	101	1½S	A	365	197	G	G	N	1.88	370	10.13	0.0871	0.631
18	102	B	A	200	160	G	G	N	1.56	250	11.77	0.0633	0.597
19	121	B	A	431	216	G	G	1	0.63	136	4.23	0.0208	0.815
								AVERAGE	1.53	298.6	10.35	0.0570	0.725
								Std. Dev.	0.71	97.1	6.27	0.0203	0.093

TABLE I (P. 3)

1946 - 1960 HOUSES

HOUSE NO.	HOUSE CODE	CONST. STYLE	WALL TYPE	HEATED VOL m^3	AIR BARRIER AREA m^2	HEATING SYSTEM	DOMESTIC HOT WATER	FIREPLACE OR WOOD HEATER	Q/A @ 10 Pa, L/s m^2	Q @ 10 Pa, L/s	Q/V @ 50 Pa, h^{-1}	C m^3/s Pa^n	n
1	59	B	A	399	198	G	G	N	0.87	172	4.47	0.0379	0.657
2	2	B	A	447	211	G	G	N	0.61	129	3.21	0.0252	0.706
3	21	B	A	448	220	G	G	1	0.66	145	3.62	0.0284	0.707
4	33	4L	A	469	276	G	G	1	0.49	135	3.26	0.0261	0.713
5	41	B	A	280	151	G	G	N	1.29	196	7.33	0.0427	0.662
6	52	1½S	A	316	209	G	G	N	1.88	393	12.39	0.0913	0.634
7	61	B	A	618	263	G	G	N	1.19	313	5.01	0.0740	0.627
8	62	B	A	339	169	G	G	N	0.58	98	3.35	0.0186	0.723
9	63	B	A	465	223	G	G	N	0.68	152	3.70	0.0296	0.710
10	99	B	A	431	216	G	G	N	0.68	148	4.06	0.0269	0.740
11	100	B	A	422	213	G	G	N	0.63	134	4.00	0.0224	0.777
12	105	B	A	412	204	G	G	N	0.38	77	2.24	0.0140	0.743
13	107	B	A	402	197	G	G	N	0.72	142	3.94	0.0282	0.702
14	122	B	A	509	241	G	G	N	0.55	132	3.02	0.0245	0.730
15	123	SL	A	399	307	G	G	N	0.404	122	3.59	0.0226	0.733
16	163	B	A	460	227	G	G	N	0.79	194	4.29	0.0359	0.697
17	164	1½S	A	471	277	G	G	N	0.99	275	6.46	0.0549	0.699
18	155	B	A	579	260	G	G	N	0.97	252	4.48	0.0560	0.653
19	145	B	A	335	170	G	G	N	1.00	170	4.93	0.0409	0.618
20	173	B	A	476	233	G	G	N	0.62	146	3.60	0.0269	0.734
								Average	0.799	176.3	4.548	0.0364	0.698
								Std. Dev.	0.353	75.2	2.179	0.0194	0.043

TABLE I (p. 4)

1961-1980 HOUSES

HOUSE NO.	HOUSE CODE	CONST. STYLE	WALL TYPE	HEATED VOL m	AIR BARRIER AREA m	HEATING SYSTEM	DOMESTIC HOT WATER	FIREPLACE OR WOOD HEATER	Q/A @ 10 Pa, L/s m^2	Q @ 10 Pa, L/s	Q/V @ 50 Pa, h^{-1}	C m^3/sPa^n	n
1	1	B	B	458	213	G	G	1	0.522	111	3.02	0.0189	0.769
2	7	2S	A	618	268	G	G	N	0.557	149	3.84	0.0178	0.924
3	14	B	A	451	202	G	G	N	0.609	123	3.09	0.0237	0.714
4	17	B	D	667	303	G	G	1	0.377	114	1.89	0.0229	0.697
5	25	B	A	491	265	G	G	N	0.718	190	4.33	0.0377	0.703
6	26	BL	A	450	227	G	G	N	0.726	165	3.86	0.0356	0.666
7	27	2S	B	791	316	G	G	1	1.403	444	4.72	0.1320	0.527
8	28	B	A	483	212	G	G	N	0.567	121	3.15	0.0200	0.780
9	30	B	A	354	170	G	G	N	0.712	121	3.64	0.0255	0.676
10	31	2S	A	497	257	G	G	1	0.638	164	3.81	0.0310	0.723
11	32	4L	A	543	308	G	G	1	0.597	184	4.14	0.0320	0.760
12	34	B	A	481	222	G	G	N	0.463	103	2.62	0.0179	0.760
13	35	BL	B	412	238	G	G	N	0.391	92.8	2.55	0.0181	0.710
14	36	2S	B	527	276	G	G	1	0.561	155	3.90	0.0240	0.810
15	37	B	B	297	157	G	G	1	1.067	168	5.44	0.0411	0.612
16	38	B	B	511	230	G	G	1	0.509	117	2.95	0.0192	0.786
17	39	B	B	387	197	G	G	N	0.695	136	3.49	0.0322	0.627
18	42	B	D	456	214	G	G	1	0.719	154	3.70	0.0312	0.692
19	43	B	D	503	231	G	G	1	0.432	99.5	1.99	0.0229	0.638
20	44	4L	D	501	233	G	G	1	0.844	197	5.26	0.0301	0.815
21	45	4L	D	657	288	G	G	1	0.729	210	3.59	0.0413	0.706
22	46	B	D	496	220	G	G	1	0.785	173	4.18	0.0309	0.748
23	47	B	D	525	235	G	G	1	0.802	189	3.36	0.0480	0.594
24	48	4L	D	501	233	G	G	1	1.38	323	6.94	0.0671	0.682
25	49	BL	B	361	165	G	G	N	0.91	150	4.67	0.0292	0.710
26	50	4L	A	412	217	G	G	N	0.48	104	2.83	0.0202	0.710
27	53	4L	A	504	304	G	G	1	0.78	237	6.08	0.0380	0.794
28	54	4L	A	504	304	G	G	1	0.82	251	5.73	0.0474	0.723
29	55	4L	A	460	235	G	G	N	0.35	72.7	1.97	0.0167	0.693
30	56	4L	A	420	249	G	G	1	1.00	249	6.95	0.0455	0.736
31	57	2S	D	569	234	G	G	1	1.38	324	5.02	0.0898	0.557
32	58	4L	A	488	255	G	G	1	0.72	184	4.74	0.0306	0.778
33	60	BL	B	425	260	G	G	N	0.38	99.2	2.55	0.0202	0.691
34	143	B	A	451	273	G	G	1	1.25	337	10.02	0.0523	0.809
35	67	B	D	451	206	G	G	1	0.61	125	3.32	0.0225	0.746
36	68	3L	D	381	208	G	G	N	0.40	82.1	3.01	0.0119	0.839

TABLE I (p. 5)

1961 - 1980 HOUSES

HOUSE NO.	HOUSE CODE	CONST. STYLE	WALL TYPE	HEATED VOL m^3	AIR BARRIER AREA m^2	HEATING SYSTEM	DOMESTIC HOT WATER	FIREPLACE OR WOOD HEATER	Q/A @ 10 Pa, L/s m^2	Q @ 10 Pa, L/s	Q/V @ 50 Pa h^{-1}	C $m^3/s\ Pa^n$	n
37	69	B	D	564	257	G	G	2	0.64	165	3.29	0.0323	0.707
38	72	3L	D	381	208	G	G	N	0.55	114	3.42	0.0221	0.714
39	73	1½S	D	494	258	G	G	N	0.62	161	4.74	0.0216	0.871
40	74	B	A	411	218	G	G	1	0.56	123	3.22	0.0256	0.681
41	75	B	D	470	214	G	G	I	0.40	85.2	1.93	0.0180	0.675
42	76	B	A	526	238	G	G	1	0.47	111	2.72	0.0180	0.790
43	77	4L	D	462	241	G	G	N	0.48	117	2.99	0.0214	0.738
44	78	4L	D	462	241	G	G	N	0.55	133	2.97	0.0295	0.654
45	79	B	A	479	221	G	G	1	0.55	121	2.66	0.0261	0.667
46	80	B	A	490	229	G	G	1	0.60	137	2.90	0.0302	0.657
47	81	B	A	497	227	G	G	1	0.620	141	2.83	0.0326	0.635
48	82	4L	A	430	241	G	G	N	0.846	204	4.61	0.0491	0.618
49	83	B	A	464	217	G	G	N	0.645	140	3.58	0.0254	0.741
50	84	B	B	422	214	G	G	N	0.465	99.6	2.48	0.0216	0.664
51	85	B	A	419	206	G	G	N	0.346	70.7	1.88	0.0141	0.700
52	86	B	A	433	203	G	G	N	0.853	173	3.64	0.0458	0.577
53	87	2S	A	436	226	G	G	N	0.447	101	2.43	0.0219	0.663
54	88	2S	D	438	232	G	G	1	0.484	112	3.36	0.0176	0.804
55	89	BL	A	347	213	G	G	N	0.358	76.4	2.32	0.0164	0.668
56	90	B	A	443	215	G	G	N	0.280	60.2	1.63	0.0107	0.750
57	91	B	A	450	224	G	G	N	0.383	85.3	2.09	0.0173	0.693
58	92	BL	A	351	207	G	G	N	0.521	108	2.64	0.0309	0.542
59	93	4L	A	455	366	G	G	1	0.707	258	5.66	0.0603	0.632
60	94	B	D	607	320	G	G	N	0.698	224	4.34	0.0410	0.737
61	95	2S	B	600	314	G	G	1	0.498	156	3.88	0.0204	0.883
62	96	4L	B	465	260	G	G	N	0.531	138	3.16	0.0292	0.674
63	97	BL	D	455	281	G	G	1	0.628	177	3.91	0.0405	0.640
64	103	4L	D	438	319	G	G	1	0.388	124	4.43	0.0152	0.912
65	104	4L	B	593	343	G	G	1	0.518	178	2.90	0.0434	0.613
66	106	B	B	492	230	G	G	1	0.411	94.4	2.28	0.0171	0.742
67	116	B	A	494	231	G	G	1	0.464	108	2.52	0.0204	0.723
68	117	2S	A	524	262	G	G	N	0.755	198	3.81	0.0453	0.640
69	118	B	A	462	219	G	G	N	0.357	77.7	2.40	0.0109	0.853
70	119	4L	A	489	257	G	G	1	0.504	129	3.28	0.0221	0.767
71	120	B	E	499	250	E	E	N	0.471	118	2.58	0.0240	0.691
72	108	4L	D	559	327	G	G	N	0.747	245	4.56	0.0534	0.661
73	109	2S	B	601	306	G	G	1	0.937	287	4.88	0.0646	0.648

TABLE I (p. 6)

1961 - 1980 HOUSES

HOUSE NO.	HOUSE CODE	CONST. STYLE	WALL TYPE	HEATED VOL m^3	AIR BARRIER AREA m^2	HEATING SYSTEM	DOMESTIC HOT WATER	FIREPLACE OR WOOD HEATER	Q/A @ 10 Pa, L/s m^2	Q @ 10 Pa, L/s	Q/V @ 50 Pa, h^{-1}	C m^3/s Pa^n	n
74	110	2S	B	595	305	G	G	1	0.627	206	3.93	0.0334	0.759
75	111	2S	B	586	332	G	G	1	0.459	139	3.68	0.0215	0.851
76	112	2S	B	586	332	G	G	1	0.594	197	4.42	0.0310	0.804
77	113	2S	B	601	306	G	G	1	0.718	220	4.06	0.0440	0.699
78	114	B	A	364	189	G	G	N	0.388	73.4	2.19	0.0151	0.687
79	124	BL	A	590	341	G	G	1	0.571	195	4.06	0.0336	0.763
80	125	B	A	595	303	G	G	N	0.595	180	3.34	0.0362	0.697
81	144	B	A	456	224	G	G	N	0.608	136	3.71	0.0231	0.770
82	176	1½S	A	642	336	G	G	1	0.691	232	3.96	0.0474	0.690
83	177	B	B	518	233	G	G	1	0.316	73.8	2.00	0.0105	0.847
84	168	4L		479	222	G	G	1	0.977	217	5.14	0.0420	0.713
85	169	B	A	476	225	G	G	N	0.466	105	3.06	0.0151	0.840
86	166	B	A	444	209	G	G	N	0.584	122	3.01	0.0248	0.692
87	160	B	A	462	222	G	G	N	0.72	159	3.97	0.0301	0.723
88	161	B	A	542	298	G	G	1	0.48	141	3.20	0.0245	0.761
89	147	BL	A	467	251	G	G	N	0.70	177	4.19	0.0356	0.697
90	148	B	J	592	264	G	G	2	0.666	176	3.10	0.0384	0.661
91	149	B	D	506	275	G	G	N	0.392	108	2.34	0.0219	0.693
92	150	B	B	466	257	G	G	1	0.478	123	2.32	0.0339	0.558
93	151	B	A	412	201	G	G	N	0.578	116	3.13	0.0231	0.700
94	152	BL	D	491	268	G	G	N	0.453	121	2.99	0.0214	0.753
95	153	1S	B	244	205	E	E	1	0.382	78.6	3.73	0.0148	0.725
96	141	B	A	356	183	G	G	N	0.40	72.3	2.76	0.011	0.818
97	142	B	A	535	241	G	G	N	0.50	120	2.77	0.0206	0.765
								Average	0.613	153.16	3.57	0.03046	0.7175
								Std. Dev.	0.225	65.82	1.27	0.01718	0.0784

TABLE I (p. 7)

LOW ENERGY HOUSES

HOUSE NO.	HOUSE CODE	CONST. STYLE	WALL TYPE	HEATED VOL m^3	AIR BARRIER AREA m^2	HEATING SYSTEM	DOMESTIC HOT WATER	FIREPLACE OR WOOD HEATER	Q/A @ 10 Pa, L/s m^2	Q @ 10 Pa, L/s	Q/V @ 50 Pa, h^{-1}	C m^3/s Pa^n	n
1	3	BL	F	734	387	E	E	1	0.34	132.0	2.83	0.0160	0.917
2	4	2S	F	494	409	E	E	1	0.22	88.5	2.20	0.0152	0.765
3	5	2S	FS	627	376	E	E	2	0.19	71.0	1.42	0.0119	0.776
4	178	B	DS	500	246	G	G	1	0.329	80.8	1.78	0.0163	0.695
5	9	B	FS	684	315	E	E	2	0.19	58.4	1.00	0.0108	0.733
6	10	2S	C	464	295	O	E	1	0.29	85.9	1.88	0.0195	0.644
7	11	B	ES	734	331	G	G	2	0.31	101.7	1.57	0.0197	0.713
8	12	B	F	624	269	E	G	1	0.31	84.2	1.38	0.0189	0.649
9	16	2S	F	988	384	G	E	N	1.38	530.0	4.72	0.1480	0.554
10	18	2S	E	785	370	G	G	2	0.51	187.6	2.96	0.0320	0.768
11	19	B	E	1011	410	E	E	2	0.50	205.1	2.60	0.0335	0.787
12	20	2S	F	656	313	G	G	N	0.10	30.1	0.59	0.0048	0.797
13	22	1½S	E	468	291	E	E	N	0.40	117.8	2.79	0.0235	0.700
14	23	2S	F	612	320	E	E	N	0.22	69.5	1.25	0.0140	0.696
15	29	BL	E	393	233	E	E	1	0.33	76.4	2.20	0.0148	0.713
16	171	1 3/4S	FS	649	311	E	E	N	0.374	116.4	1.93	0.0242	0.682
17	98	2S	E	452	228	E	E	N	0.29	67.0	1.64	0.0134	0.699
18	115	4L	E	555	290	E	E	N	0.43	124.9	2.30	0.0281	0.648
19	146	B	E	600	261	E	E	1	0.31	80.4	1.65	0.0139	0.762
20	126	B	FS	472	227	G	G	N	0.131	29.8	0.62	0.0070	0.629
21	127	B	GS	462	221	G	G	1	0.15	34.0	0.77	0.0074	0.662
22	128	4L	E	540	265	G	G	1	0.28	73.8	1.31	0.0182	0.608
23	129	BL	I	444	210	GHW	G	1	0.39	81.7	2.19	0.0148	0.742
24	130	4L	GS	433	315	G	E	N	0.135	42.6	1.04	0.0091	0.670
25	131	B	FS	500	227	GHW	G	N	0.081	18.5	0.37	0.0042	0.643
26	132	B	FS	495	259	G	G	N	0.113	29.3	0.74	0.0049	0.777
27	133	B	FS	467	220	G	G	N	0.130	28.4	0.53	0.0082	0.540
28	134	4L	FS	464	276	G	G	N	0.099	27.7	0.76	0.0045	0.789
29	135	5L	FS	571	297	G	G	1	0.154	45.9	0.76	0.0115	0.601
30	136	4L	E	378	212	G	G	N	0.182	38.2	1.14	0.0075	0.707
31	137	B	E	612	299	G	G	N	0.217	64.9	1.09	0.0145	0.651
32	138	BL	E	490	289	G	G	N	0.076	22.0	0.54	0.0039	0.751
33	139	B	E	457	220	G	G	N	0.098	21.4	0.45	0.0054	0.599
34	140	BL	F	686	298	G	E	1	0.264	79.0	1.53	0.0121	0.815
35	156	2S	F	553	279	E	E	1	0.252	70.2	1.44	0.0136	0.713
36	157	B	E	396	191	G	G	N	0.20	38.6	1.18	0.0068	0.754
37	158	4L	E	394	200	G	G	N	0.26	52.9	1.52	0.0103	0.711
38	159	2S	F	454	288	E	E	N	0.19	54.6	1.28	0.0116	0.673
39	165	2S	FS	583	445	E	E	N	0.10	45.7	0.83	0.0097	0.673
40	167	2S	FS	659	493	E	E	1	0.12	58.3	0.99	0.0115	0.705
								Average	0.266	81.6	1.49	0.0169	0.7028
								Std. Dev.	0.214	83.8	0.87	0.0225	0.0746

TABLE II. PRESSURE TEST RESULTS ACCORDING TO THE AGE OF THE HOUSES

	Average Air Changes per hour @ 50 Pa, n_{50}	Standard Deviation	Number of Houses in Sample
Pre 1945	10.35	6.27	19
1946-1960	4.55	2.18	20
1961-1980	3.57	1.27	97

TABLE III. PRESSURE TEST RESULTS FOR THE LOW-ENERGY HOUSING GROUP

Average Air Changes per hour at 50 Pa, n_{50}	Standard Deviation	Number of Houses in Sample
1.49	0.87	40

TABLE IV. PRESSURE TEST RESULTS FOR LOW-ENERGY HOUSES SORTED ACCORDING TO WALL TYPE AND VAPOUR BARRIER LOCATION

	Average Air Changes per hour @ 50 Pa, n_{50}	Standard Deviation	No. of Houses
Single Stud Walls			
a. Conventional Vapour Barrier Location	1.72	0.75	16
b. Sandwiched Vapour Barrier	1.16	0.50	5
Double Stud Walls			
a. Conventional Vapour Barrier Location	1.91	1.23	9
b. Sandwiched Vapour Barrier	0.93	0.45	10

TABLE V. PRESSURE TEST RESULTS SORTED

ACCORDING TO CONTRACTOR

Contractor	Average Air Changes per hour @ 50 Pa, n_{50}	Standard Deviation	No. of Houses in Sample
A	2.13	0.43	6
G	2.65	0.50	4
H	3.24	0.76	17
N	3.24	0.71	4
C	3.54	1.42	12
F	3.56	0.68	5
B	3.88	0.89	8
I	3.94	0.55	8
D	4.69	1.88	7
		TOTAL NO. OF HOUSES	71

TABLE VI. PRESSURE TEST RESULTS SORTED

ACCORDING TO CONSTRUCTION STYLE CONVENTIONAL HOUSES 1961-1980

	Average Air Changes/ hour at 50 Pa, n_{50}	Standard Deviation	Number of Houses
Bungalow	3.04	0.81	46
Bi-level	3.37	0.85	10
1½ Storey	4.35	0.55	2
2 Storey	4.38	1.68	15
Split Level	4.49	1.81	24

TABLE VII. PRESSURE TEST RESULTS FOR SASKATOON AND OTTAWA SAMPLES OF CONTRACTOR BUILT HOUSES

	Average Air Changes per hour @ 50 Pa, n_{50}	Standard Deviation	Number of Houses in Sample
Ottawa Houses	4.41	1.07	63
Saskatoon Houses	3.60	1.12	65

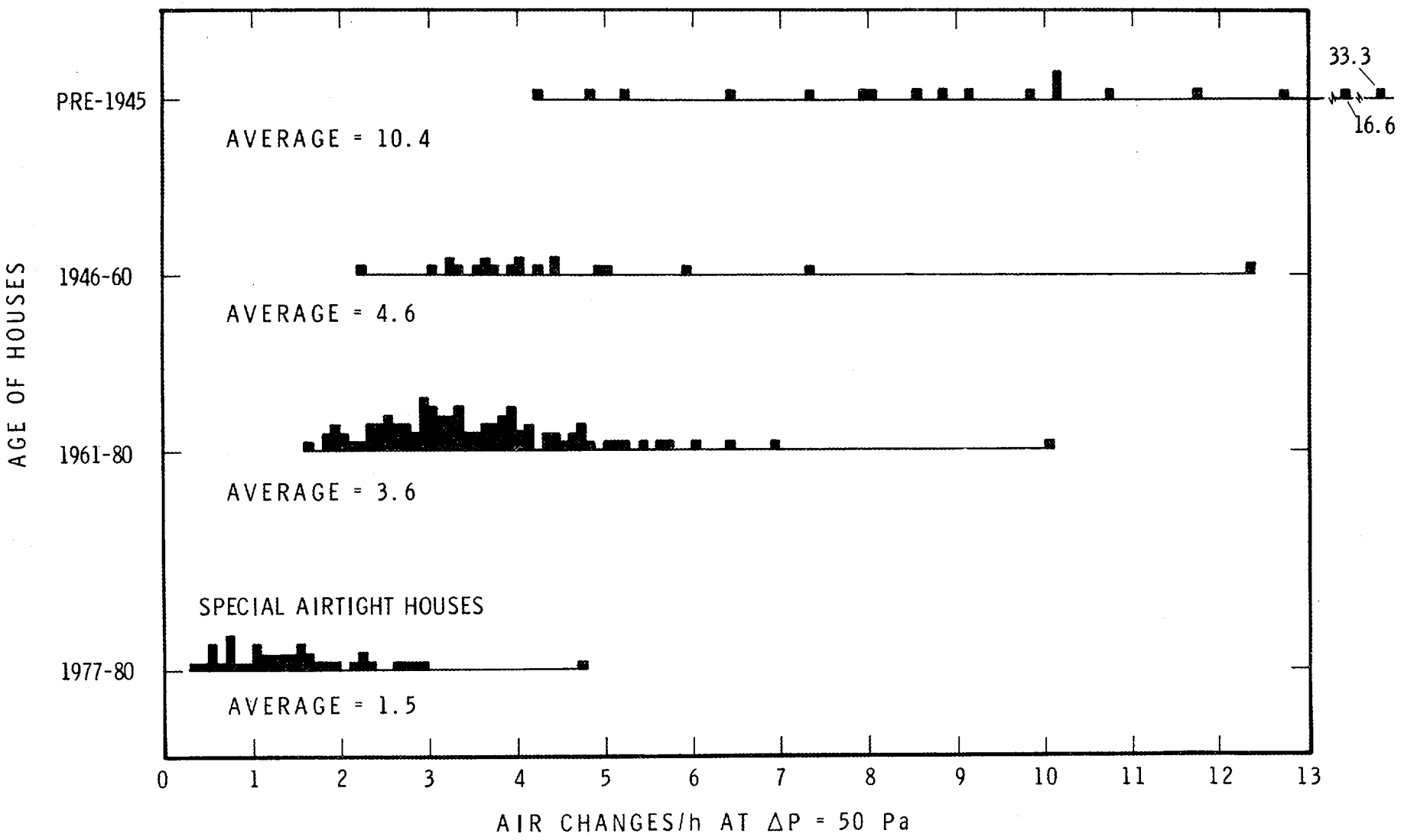

FIGURE 1

PRESSURE TEST RESULTS FOR SASKATOON HOUSE SAMPLE

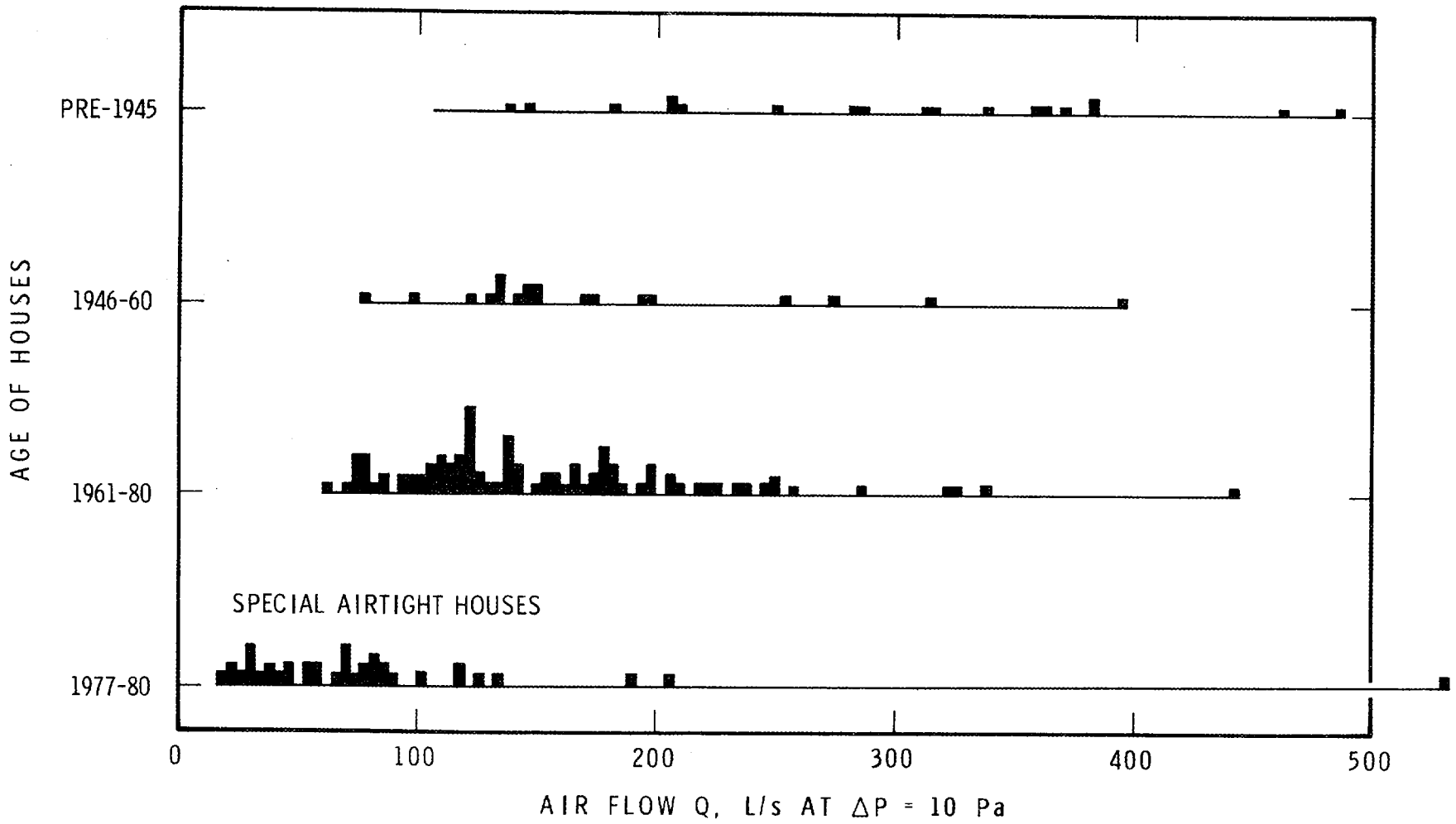

FIGURE 2

PRESSURE TEST RESULTS FOR SASKATOON HOUSE SAMPLE