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Energy, Mines and
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Canada

COMPARISON OF
AIRTIGHTNESS
RETESTING RESULTS

033-MR

PREPARED FOR THE

RESIDENTIAL TECHNOLOGY AND INDUSTRY DEVELOPMENT DIVISION
ENERGY SECTOR
ENERGY, MINES AND RESOURCES CANADA
OTTAWA, ONTARIO

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EXECUTIVE SUMMARY

Polyethylene vapour barrier and airtight drywall are two methods used by the building industry to reduce air leakage in residential homes. Concern has been expressed that polyethylene air/vapour barriers degrade over time. This concern has led various agencies to test and retest homes for air leakage. This report is the compilation of the data collected as a result of that testing.

Raw data were collected on 145 homes from various sources. Data were screened and the tests of homes were omitted from the analysis if:

1. the fan tests were done on the same house by different firms (possible inconsistency in test methods);
2. the construction of the house was not sufficiently complete (eg. no stucco, therefore the difference in airtightness is not useful); and
3. the initial air change rate per hour (ACH) was greater than 3.0 (the polyethylene was not performing as an effective air barrier).

With these omissions from the database, 90 homes remained to be analyzed. The 90 homes were separated into two groups, those with an initial ACH less than 1.5 and those with an initial ACH between 1.5 and 3.0. Data were recorded in two tables which included the ACH, the time in months, the percentage change, and the difference in change between the first test and each subsequent test.

In the analysis of the database, homes were labelled as having a marked increase if the following two criteria were met:

1. a significant increase in percentage change (>20%); and
2. a significant increase in the difference in air change (>0.3 ACH).

Of the 42 homes with an initial ACH less than 1.5, six homes met both criteria. Of the 48 homes with an initial ACH between 1.5 and 3.0, three homes met both criteria. These data indicate a relatively minor average change in airtightness. Keeping in mind the quantity of data collected and the time period examined, there is no indication that significant problems exist that would necessitate a change to the current building practice.

ABRÉGÉ

Le pare-vapeur de polyéthylène et le placoplâtre sont deux matériaux utilisés dans le domaine de la construction pour réduire les fuites d'air. Certains craignent que les pare-air/vapeur de polyéthylène ne se détériorent avec le temps. Pour cette raison, plusieurs entreprises ont effectué des études dans le but de déterminer l'étanchéité de maisons construites à l'aide de ces matériaux. Le présent rapport est une compilation des résultats disponibles de ces essais.

Des lectures ont été prises dans 145 maisons de toutes sortes. Après examen, on a choisi d'éliminer les résultats obtenus dans certaines maisons pour les raisons suivantes:

1. les essais de ventilation avaient été faits sur une même maison par différentes entreprises (manque d'uniformité possible dans les méthodes utilisées);
2. la construction de la maison n'était pas terminée (lecture d'étanchéité faussée par le fait que le revêtement extérieur de la maison n'était pas encore posé);
3. le nombre de renouvellements par heure (ACH) était plus élevé que 3,0 (ce qui indique que le polyéthylène ne remplissait pas les fonctions auxquelles il est destiné).

Après cette élimination préliminaire, il restait un échantillon composé de 90 maisons aux fins de l'étude. On a ensuite divisé ces maisons en deux groupes, celles dont le nombre de renouvellements par heure était inférieur à 1,5 et celles dont le taux se situait entre 1,5 et 3,0. Les données ont été recueillies et inscrites à deux tableaux illustrant le nombre de renouvellements par heure, le mois de l'année, le pourcentage d'écart, ainsi que la différence de lecture entre chaque test.

Aux fins de l'analyse des données, les maisons étaient considérées comme ayant une augmentation marquée si les deux critères suivants étaient présents:

1. une augmentation importante du changement en pourcentage (>20 %);
2. une augmentation importante de la différence du nombre de renouvellements par heure (>0,3 ACH).

Des 42 maisons à l'étude dont l'ACH était de moins de 1,5, six maisons correspondaient aux deux critères précédents. Des 48 maisons dont l'ACH se trouvait entre 1,5 et 3,0, trois maisons correspondaient aux deux critères précédents. Ces données démontrent qu'il y a eu un changement relativement faible au niveau de l'étanchéité. Compte tenu de la quantité de données recueillies et de la période de temps sur laquelle l'étude a été échelonnée, il n'y a pas de raisons de supposer qu'un changement des méthodes actuelles de construction s'impose.

1.0 INTRODUCTION

Within the past few years, considerable effort has been expended to reduce air leakage in residential homes. The building industry has incorporated numerous ideas towards achieving this goal. The most common method used is to seal a polyethylene vapour barrier in the building system. Another method that is gaining recognition utilizes the airtight drywall approach (ADA). Both methods have achieved an acceptable level of success in reducing air leakage across the envelope when combined with proper building practices. Their long term performance and their ability to avoid degradation, however, remain unknown. It is with this concern in mind that various agencies have tested and retested houses to determine if air leakage does increase with time.

Buchan, Lawton, Parent Ltd. was requested to compile and analyze available data on such tests to determine if the concern that polyethylene degrades with time was justifiable.

2.0 BACKGROUND

To minimize air leakage through the building envelope, an air barrier assembly must be constructed. This assembly must be impermeable, continuous and able to withstand any loads placed upon it. Both polyethylene and ADA can meet these requirements, at least over the short term.

Another requirement is that the air barrier be adjustable to any structural movement without allowing openings to form in the assembly. With the use of polyethylene vapour barrier, slight stretching and movement can occur without the envelope being broken. In the case of ADA, the joints must be comprised of elastic gaskets or flexible caulks to allow for movement. Naturally, each system will have a limit to the extent of movement it can accommodate without causing openings to occur.

Other factors in the long term performance of polyethylene are its composition and production techniques. From the perspective of the manufacturer, the production of polyethylene specifically suited for the building industry is a small, low-profit item. Not much attention has been directed towards engineering materials to meet the special needs of the building industry.

Because of a concern with the aging of polyethylene, the Canadian General Standards Board (CGSB) developed the standard: CAN 2-51.34 M86 "Vapour Barrier, Polyethylene Sheet for Use in Building Construction". This standard will help to ensure that the vapour barrier lasts for a minimum acceptable length of time.

Under the new standard, polyethylene film that is manufactured for use as an air/vapour barrier is required to be:

1. stabilized against heat and sunlight (ultraviolet light);
2. packaged so that it is protected from direct exposure to sunlight;
3. made only from virgin resin; and
4. of a minimum average thickness of 6 mil (150 microns).

Some of these stipulations were added as a result of past problems encountered with the chemical stability and mechanical durability of polyethylene. Prior to the standard, some polyethylenes were known to deteriorate when exposed to excessive heat or ultraviolet radiation from sunlight.

The R-2000 Program has taken a special interest in the performance of polyethylene since one of the main program requirements is a sealed building envelope. Although this can be achieved with ADA or other techniques, many R-2000 builders find sealing with a polyethylene vapour barrier to be the easiest, most effective technique for achieving airtightness.

3.0 TEST PROCEDURE

The guideline for measuring the building's overall airtightness follows the fan depressurization method as adopted by the Canadian General Standards Board under the standard CAN/CGSB-149.10-M86. This standard is designed to measure the air tightness of the whole building rather than the individual components. As a consequence, a limitation of the test is that it does not indicate where the envelope failed.

Before the test is run, all intentional openings (eg. vents and chimneys) are blocked. A large exhaust fan is mounted in an exterior doorway and exhausts air from the building at rates required to maintain the specified pressure differences across the building envelope. By measuring the air flows and pressure differences, a curve can be generated in the form $Q = C(\Delta P)^n$,

where: Q = Air flow rate, L/s
C = Flow co-efficient, $L/s \cdot Pa^n$
ΔP = Pressure difference across the building envelope, Pa
n = Flow exponent

The requirements for a valid test include a correlation co-efficient greater than 0.99 and a relative standard error of less than 5%. The exponent n, which is an indication of the type of flow, will always be between 0.5 and 1.0. Two relevant calculations derived from the fan test are the equivalent leakage area (ELA) and the air changes per hour (ACH) at 50 pascals (Pa). Both of these calculated numbers can be used to compare the air tightness of a home. The 50 pascal measurement of ACH is less prone to measurement error than the ELA at 10 pascals. For reasons of consistency and availability of data, ACH was used in this report.

4.0 DATA SOURCES

Raw data were collected on 145 houses from various sources. The sources are listed below with the corresponding abbreviations used in this report.

Source	Abbreviation
• 34 Apple Hill Energy Efficient Homes tested for CMHC	AH1 - AH34
• 15 homes in Sweden tested by the Swedish National Testing Institute	S1 - S15
• 5 Montana homes obtained from the National Center of Appropriate Technology (N.C.A.T.)	M1 - M5
• 30 low energy homes in Saskatoon tested for the National Research Council	SA1 - SA30
• 22 R-2000 homes tested by Buchan, Lawton, Parent Ltd. for the Ontario Ministry of Energy	SA-SE, KA-KE, FA-FE, EA-EL
• 20 Flair EnerDemo Homes including:	
-6 R-2000 polyethylene construction	F1 - F6
-14 R-2000 air tight drywall construction (ADA)	F7 - F20
• 12 R-2000 homes tested by Buchan, Lawton, Parent Ltd. for the Bureau of Management Consulting	H1 - H12

4.1 Data Screening

A number of anomalies and inconsistencies were noted in the raw data collected from the various sources. Before a useful analysis could be undertaken, data were screened and the tests of houses were omitted from the analysis if:

1. the fan tests were done on the same house by different firms;
2. the construction of the house was not sufficiently complete (for example, if there was no stucco); or
3. the initial air change rate per hour (ACH) was greater than 3.0.

An examination of the collected raw data revealed that the results of fan tests done on the same house by different firms varied considerably. It could be assumed that, in many of these cases, there were variations in equipment calibration and, more importantly, in building preparation. Since it was desirable to use data produced by consistent testing methods, only test results carried out by the same firm were analyzed in detail.

As many as seven air tests were performed on the 20 Flair homes within a two-year period, however, some of the initial tests were performed before the stucco was applied. For the purposes of this report, the first test conducted after the stucco was applied and the last test were included in the analysis.

Since the main focus of this analysis was polyethylene air barriers, the 14 Flair ADA homes were not included here, but have been included in Appendix A for comparison purposes.

All houses with an initial ACH greater than 3.0 were also excluded from the database, but have been included in Appendix A. These exclusions were made because it was felt that a house with an initial ACH greater than 3.0 was already quite loose and would not be comparable to a tighter house.

After screening out the tests that were felt to be inappropriate for the study, 90 houses remained to be examined.

4.2 Data Presentation

To compare the 90 houses more accurately, they were divided into two groups: those with an initial ACH less than 1.5 (Table 4.1) and those with an initial ACH between 1.5 and 3.0 (Table 4.2). The dividing point of 1.5 ACH was an appropriate one to use since it is the airtightness requirement of an R-2000 home.

Each table documents the air change rate per hour at 50 Pa (ACH) for each depressurization test. The tables also include: the time in months; the percentage change; and the absolute difference between the first reliable test and each subsequent test.

It should be noted that, in all cases, the first test shown was the first reliable test under the screening criteria. This implies that the tests were done some time after construction was fully complete, in most cases in excess of three months after completion. This limits concerns over data anomalies caused by intentional or unintentional changes to the building fabric in the immediate post-construction period.

TABLE 4.1

TEST RESULTS FOR HOUSES WITH AN INITIAL ACH LESS THAN 1.5

	FIRST RELIABLE TEST	INTERMEDIATE TEST				LAST TEST			
HOUSE	ACH@ 50 Pa	TIME (months)	ACH@ 50 Pa	% Change	Absolute Diff.	TIME (months)	ACH @ 50 Pa	% Change	Absolute Diff.
AH7	1.38					3	1.48	7.2	0.10
S1	1.40					42	1.50	7.2	0.10
S6	1.40					24	1.30	-7.2	-0.10
* S7	0.90					24	1.30	44.4	0.40
M1	0.81					12	0.83	2.5	0.02
M2	0.84					12	0.85	1.2	0.01
* M3	1.08					12	1.41	30.6	0.33
M4	0.57					12	0.66	15.8	0.09
M5	0.85					12	0.83	-2.4	-0.02
SA3	0.59					63	0.40	-32.2	-0.19
SA4	0.70					40	0.99	41.4	0.29
SA5	0.57					40	0.74	29.8	0.17
SA6	0.81					33	0.61	-24.7	-0.20
SA10	1.29					28	1.31	1.6	0.02
SA11	1.24					28	0.99	-20.2	-0.25
SA12	1.32					28	1.19	-9.8	-0.13
SA14	0.94					27	0.84	-10.6	-0.10
SA15	1.37					24	1.38	0.7	0.01
* SA16	1.03					23	1.47	42.7	0.44
* SA17	1.18					23	1.88	59.3	0.70
SA18	1.31					22	1.22	-6.9	-0.09
* SA19	1.03					19	1.36	32.0	0.33
SA21	0.82					18	0.93	13.4	0.11
* SA23	1.01					17	1.48	46.5	0.47
SA24	1.45					17	1.66	14.5	0.21
SA26	1.15					14	1.13	-1.7	-0.02
SA28	1.38					10	1.25	-9.4	-0.13
SA30	1.37					32	0.67	-51.1	-0.70
SA	1.34	12	1.45	8.2	0.11	24	1.38	3.0	0.04
SB	0.88	12	1.11	26.1	0.23	24	1.07	21.6	0.19
SC	1.12					24	1.25	11.6	0.13
SD	1.25	12	1.11	-11.2	-0.14	24	1.23	-1.6	-0.02
KB	1.34	12	1.36	1.5	0.02	24	1.57	17.2	0.23
KD	1.42	12	1.39	-2.1	-0.03	24	1.49	4.9	0.07
KE	1.24	14	1.26	1.6	0.02	24	1.37	10.5	0.13
EJ	1.35					12	1.51	11.9	0.16
EK	1.49					12	1.56	4.7	0.07
F10	1.28					24	1.03	-19.5	-0.25
F15	1.33					22	1.10	-17.3	-0.23
F16	1.29					20	1.52	17.8	0.23
F17	0.36					20	0.56	55.6	0.20
F18	0.42					20	0.43	2.4	0.01
Average	1.09		1.28	4.0	0.04		1.16	8.0	0.07
St. Dev.	0.31		0.15	12.6	0.13		0.36	23.4	0.24

NOTE: * indicates homes that exhibitted a significant increase in percentage change (>20%) and a significant increase in the difference in air change (>0.3 ACH)

TABLE 4.2

TEST RESULTS FOR HOUSES WITH AN INITIAL ACH BETWEEN 1.5 AND 3.0

	FIRST RELIABLE TEST	INTERMEDIATE TEST				LAST TEST			
HOUSE	ACH@ 50 Pa	TIME (months)	ACH @ 50 Pa	% Change	Absolute Diff.	TIME (months)	ACH @ 50 Pa	% Change	Absolute Diff.
AH1	2.94					3	3.04	3.4	0.10
* AH2	2.32	3	2.60	12.1	0.28	6	2.95	27.2	0.63
AH3	2.17	3	2.35	8.3	0.18	6	2.23	2.8	0.06
AH4	1.54	3	1.59	3.2	0.05	6	1.61	4.5	0.07
AH5	2.96	3	2.85	-3.7	-0.11	6	2.68	-9.5	-0.28
AH6	2.66					3	2.69	1.1	0.03
S2	2.40					30	2.10	-12.5	-0.30
S3	1.70					30	1.60	-5.9	-0.10
S4	2.10					30	2.10	0.0	0.00
S5	1.90					30	1.30	-31.6	-0.60
S8	2.50					42	2.50	0.0	0.00
S9	2.20					18	2.30	4.5	0.10
S10	1.60					18	1.70	6.3	0.10
S11	2.50					54	2.90	16.1	0.40
S12	2.40					54	2.50	4.2	0.10
S13	2.40					54	2.80	16.7	0.40
S14	2.40					18	2.60	8.3	0.20
S15	1.60					18	1.70	6.3	0.10
SA1	1.57					63	1.28	-18.5	-0.29
SA2	2.94					63	2.21	-24.8	-0.73
SA7	1.60					33	1.63	1.9	0.03
SA8	1.63					33	1.91	17.2	0.28
SA9	2.72					33	2.45	-9.9	-0.27
SA13	1.56					28	1.09	-30.1	-0.47
* SA20	2.06					18	2.79	35.4	0.73
SA22	1.99					18	2.04	2.5	0.05
SA25	1.98					14	1.84	-7.1	-0.14
SA27	2.34					14	2.14	-8.5	-0.20
SA29	1.62					10	1.39	-14.2	-0.23
SE	1.53	12	1.54	0.7	0.01	24	1.50	-2.0	-0.03
KA	1.51	12	1.47	-2.6	-0.04	24	1.39	-7.9	-0.12
KC	1.78					24	1.52	-14.6	-0.26
FA	1.88	12	2.09	11.2	0.21	24	2.00	6.4	0.12
FB	2.37	12	2.52	6.3	0.15	24	2.50	5.5	0.13
FC	1.71	12	1.73	1.2	0.02	24	1.52	-11.1	-0.19
FD	1.70	12	1.79	5.3	0.09	24	1.79	5.3	0.09
FE	1.89	12	1.72	-9.0	-0.17	24	1.89	0.0	0.00
EA	2.64	12	2.17	-17.8	-0.47	24	2.23	-15.5	-0.41
EB	2.65					12	2.37	-10.6	-0.28
EC	2.62	12	2.99	14.1	0.37	24	2.92	11.5	0.30
ED	2.18	12	2.01	-7.8	-0.17	24	2.15	-1.4	-0.03
EE	1.81					12	2.00	10.5	0.19
EF	1.80	12	1.51	-16.1	-0.29	24	1.89	5.0	0.09
* EG	1.84	15	2.05	11.4	0.21	27	2.32	26.1	0.48
EH	1.78					12	1.83	2.8	0.05
EI	1.97					12	2.12	7.6	0.15
EL	1.86					12	2.13	14.5	0.27
F9	1.62					24	1.78	9.9	0.16
Average	2.07		2.06	1.0	0.02		2.08	0.6	0.01
St. Dev.	0.43		0.49	9.9	0.22		0.49	13.7	0.29

NOTE: * indicates homes that exhibitted a significant increase in percentage change (>20%) and a significant increase in the difference in air change (>0.3 ACH)

5.0 ANALYSIS

In defining the significance of any variance in air changes per hour (ACH), it is important to look at both the absolute difference in the test results for each house over time and the percentage change over time. For example, a 'tight' house could have a relatively small 'absolute difference', yet have a high percentage change between the first and subsequent air depressurization tests. Conversely, a 'loose' house could have a low percentage change, yet have a relatively high absolute difference.

For this reason, two sets of bar graphs were produced (see Figures 5.1 and 5.2 on pages pages 9 and 10). The bar graphs show the number of houses in each "Absolute Difference" range and the number of houses in each "% Change" range.

Using the data from Tables 4.1 and 4.2, it was possible to isolate the houses that had a marked increase.

Houses were considered to have a marked increase if the following two criteria were met:

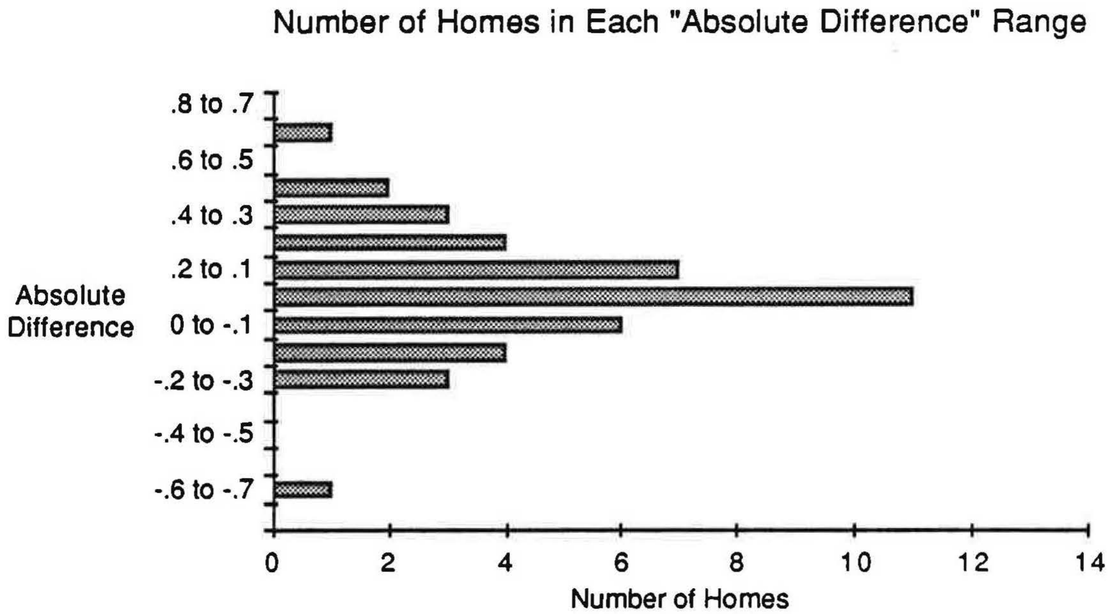
1. a significant increase in percentage change (greater than 20%);
2. a significant increase in the absolute difference in air change rates (greater than 0.3 ACH).

In Table 4.1 (initial ACH <1.5), six houses out of the 42 analyzed met both criteria. In Table 4.2 (initial ACH between 1.5 and 3.0), three houses out of the 48 met both criteria.

Table 5.1 (page 11 documents the number of houses which met various combinations of the criteria.

FIGURE 5.1

BAR GRAPHS FOR HOUSES WITH AN INITIAL ACH LESS THAN 1.5



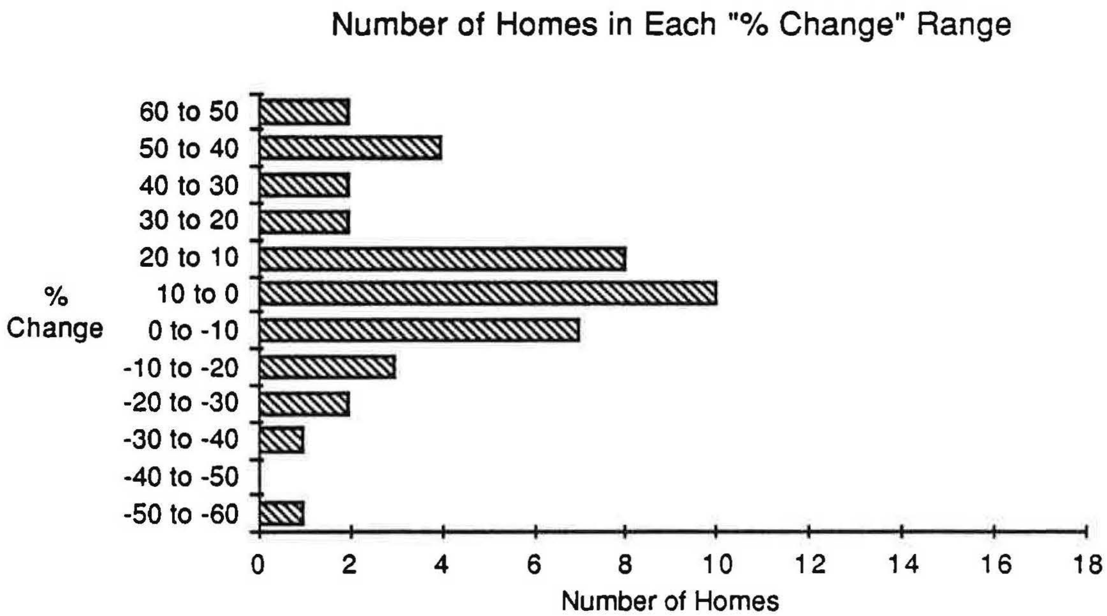
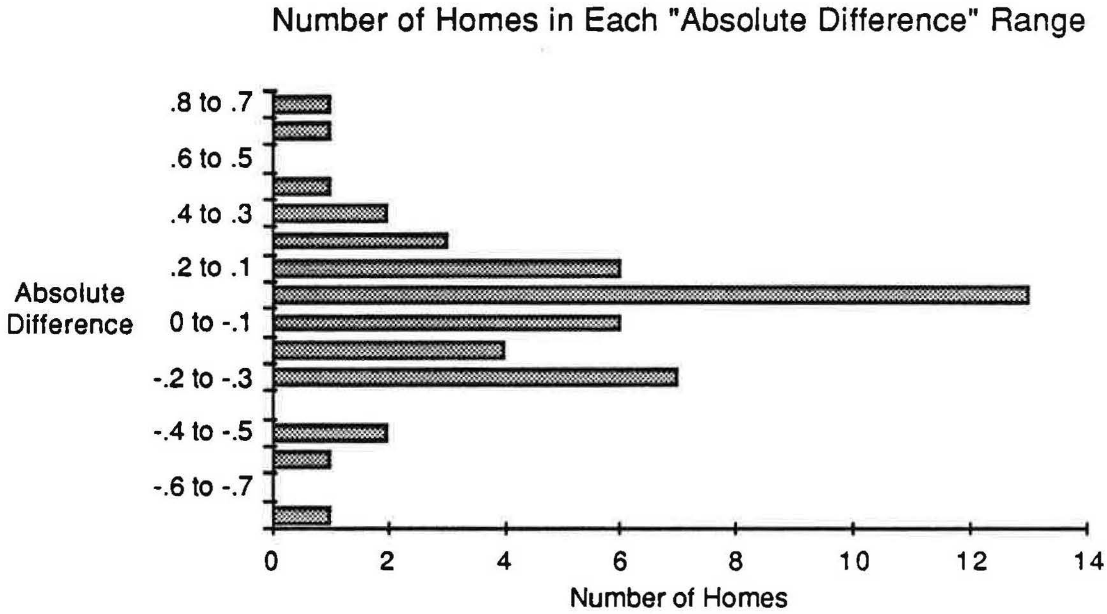


FIGURE 5.2

BAR GRAPHS FOR HOUSES WITH AN INITIAL ACH BETWEEN 1.5 AND 3.0



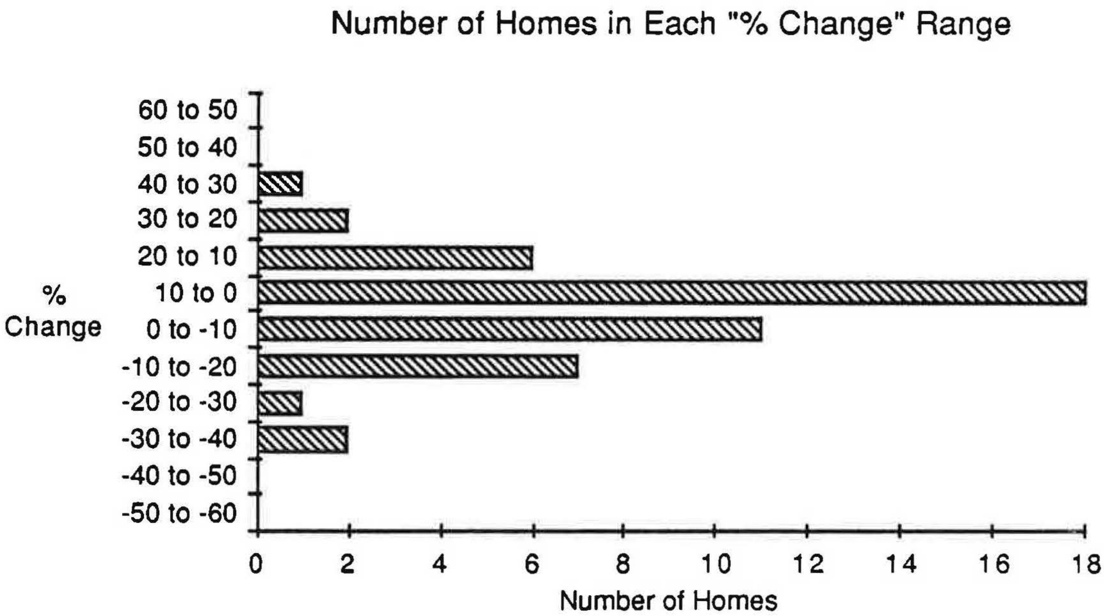


TABLE 5.1

HOUSES MEETING VARIOUS COMBINATIONS OF CRITERIA

Criteria	*ACH less than 1.5*	*ACH between 1.5 and 3.0*
A % Change > 20% increase	10	3
B. Absolute Change > 0.3 ACH	6	6
C. % Change > 20% increase Absolute Change > 0.3 ACH	6	3
Total Houses in Group	42	48

5.1 Multiple Test Data

A significant amount of raw data analyzed for this report included houses which had been retested more than two times. Some analysis was undertaken to determine if there was a common pattern to the changes in test results over time. It was felt that, if there was a pattern of sudden increase between two tests with little change before and after that increase, it would be an indication of catastrophic, probably physical, damage to the air barrier of the building. If the pattern emerged indicating gradual increases in the air change test results, this would be evidence of a gradual degradation of the air sealing characteristics. No common pattern was discerned in the group of houses for which multiple test data waweres collected, making the analysis inconclusive.

It should be noted that it was not the intent of this report to address the cyclic characteristics of building envelopes. Although some data were available for that purpose, the main objective was to determine if polyethylene air/vapour barrier degraded over a longer period of time.

6.0 COMMENTS AND CONCLUSIONS

The main purpose of this study was to look for indications that air barriers, which relied on sealed polyethylene, degraded significantly with time. It was hypothesized that, if data from a wide variety of such houses indicated a general and significant reduction in the airtightness of the buildings over time, one possible cause of the problem could be the mechanical or chemical degradation of the polyethylene.

Data examined under this study indicated relatively minor changes in average airtightness (decreases of well under 10%). As well, a relatively small proportion of houses actually showed a marked increase in airtightness.

These observations do not support the hypothesis that polyethylene degrades when used as an air barrier for residential buildings. If the examination had found that polyethylene degraded, it would have been recommended that building practices be changed. However, the pieces of data do not support the need for change at this time.

The lack of negative evidence does not conclusively prove that problems with polyethylene air barrier systems will not develop over a period of a decade or more. Both the quantity of data collected and the time period examined in this study are far less than a representative sample of Canadian houses, or even a significant portion of the lifetime of that housing.

APPENDIX A

TABLE A.1

FLAIR AIRTIGHT DRYWALL APPROACH (ADA) HOUSES

HOUSE	FIRST RELIABLE TEST ACH@ 50 Pa	TIME (months)	LAST TEST ACH @ 50 Pa	% Change	Absolute Diff.
F1	1.67	23	1.48	4.2	-0.19
F2	1.05	20	1.17	16.7	0.12
F3	1.51	24	1.69	8.3	0.18
F4	1.46	24	1.42	6.3	-0.04
F5	1.19	24	1.05	-11.8	-0.14
F6	1.21	23	1.42	17.4	0.21
F7	1.17	11	2.20	88.0	1.03
F8	1.59	24	1.44	-9.4	-0.15
F11	0.89	21	1.01	13.5	0.12
F12	1.12	22	0.98	-12.5	-0.14
F13	0.84	20	0.94	11.9	0.10
F14	1.14	21	1.16	1.8	0.02
F19	0.81	19	1.04	28.4	0.23
F20	0.71	20	0.80	12.7	0.09
Average	1.17		1.27	12.53	0.10
St. Dev.	0.30		0.37	24.71	0.30

TABLE A.2

TEST RESULTS FOR HOUSES WITH AN INITIAL ACH GREATER THAN 3.0

	FIRST RELIABLE TEST	INTERMEDIATE TEST				LAST TEST			
HOUSE	ACH@ 50 Pa	TIME (months)	ACH @ 50 Pa	% Change	Absolute Diff.	TIME (months)	ACH @ 50 Pa	% Change	Absolute Diff.
AH1	3.37	3	3.17	-5.9	-0.20	6	3.36	-0.3	-0.01
AH2	3.93	3	3.77	-4.1	-0.16	6	4.10	4.3	0.17
AH3	3.16	3	3.25	2.8	0.09	6	3.51	11.1	0.35
AH5	3.52	3	3.12	-11.4	-0.40	6	3.31	-6.0	-0.21
AH6	3.40	3	3.94	15.9	0.54	6	3.46	1.8	0.06
AH7	3.31	3	3.73	12.7	0.42	6	3.85	16.3	0.54
AH8	4.84	3	3.97	-18.0	-0.87	6	4.19	-13.4	-0.65
AH9	3.32	3	3.00	-9.6	-0.32	6	2.74	-17.5	-0.58
AH10	3.45	3	3.56	3.2	0.11	6	3.86	11.9	0.41
AH11	4.83	3	3.83	-20.7	-1.00	6	3.69	-23.6	-1.14
AH12	3.10	3	3.99	28.7	0.89	6	3.47	11.9	0.37
AH14	4.37					6	4.62	5.7	0.25
AH16	3.58					3	3.62	1.1	0.04
AH17	3.94					6	4.43	12.4	0.49
AH18	3.97	3	4.03	1.5	0.06	6	4.67	17.6	0.70
AH19	4.32	3	4.30	-0.5	-0.02	6	4.22	-2.3	-0.10
AH22	4.09					3	3.99	-2.4	-0.10
AH23	3.86	3	3.57	-7.5	-0.29	6	3.18	-17.6	-0.68
AH24	4.34	3	3.98	-8.3	-0.36	6	3.94	-9.2	-0.40
AH25	4.12	3	3.89	-5.6	-0.23	6	3.90	-5.3	-0.22
AH26	4.34					3	4.34	0.0	0.00
AH27	4.05	3	4.20	3.7	0.15	6	4.02	-0.7	-0.03
AH28	5.96	3	6.23	4.5	0.27	6	6.31	5.9	0.35
AH29	3.60	3	3.40	-5.6	-0.20	6	3.51	-2.5	-0.09
AH30	3.57					3	3.76	5.3	0.19
AH31	3.37	3	3.43	1.8	0.06	6	3.22	-4.5	-0.15
AH32	3.76	3	4.32	14.9	0.56	6	4.51	19.9	0.75
Average	3.91		3.84	-0.35	-0.04		3.92	0.74	0.01
St. Dev.	0.63		0.67	11.7	0.45		0.67	11.1	0.44