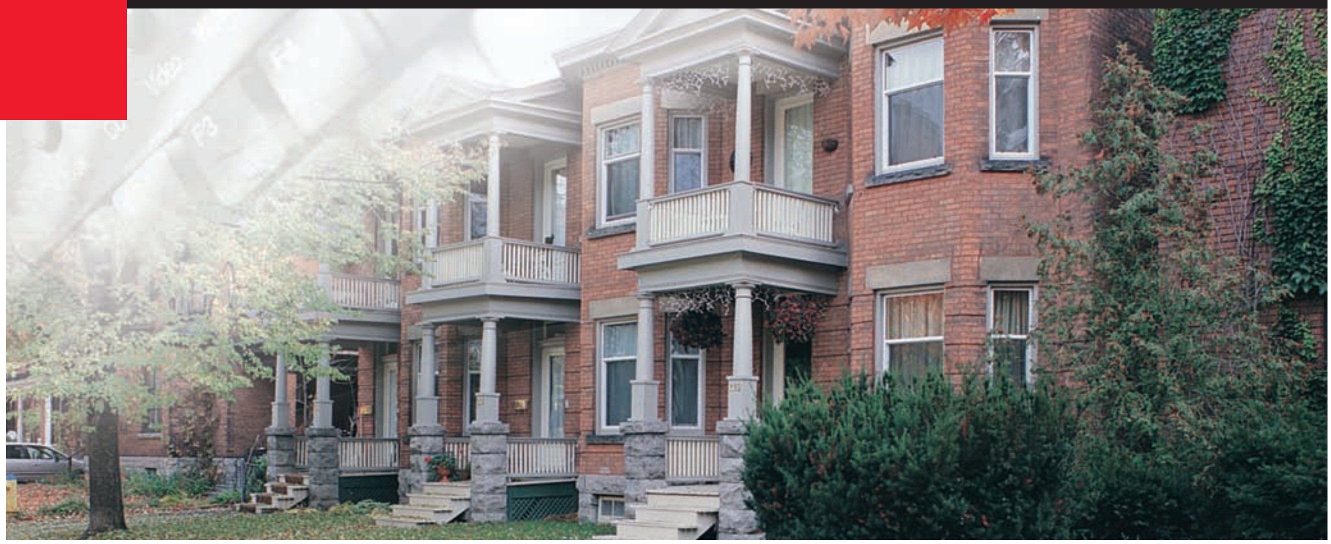
RESEARCH REPORT



Air Permeance of Building Materials: Summary Report

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AIR PERMEANCE OF BUILDING MATERIALS

SUMMARY REPORT

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17 June 1988

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This publication is one of the many items of information published by CMHC with the assistance of federal funds.

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1. MANDATE

The first attribute of a simple or composite material being part of the air barrier system for a building envelope is to offer a low air permeance.

The objectives of this study are:

a) To propose and validate a test method to measure the air permeance of building materials;

b) Using the proposed test method, measure the air permeance of several building materials at various pressure differentials (25 to 100 Pa);

c) To classify the selected building materials using the measured air flow rates per unit area (L/S-m^2).

2. EXECUTIVE SUMMARY:

2.1 BACKGROUND

This CMHC project was undertaken by AIR-INS Inc. with assistance from the Institute of Research in Construction (IRC) to propose and validate a test method to determine the air permeance of building materials. Validation of test results was conducted on orifice plates and on building materials. Using the proposed test method, a total of 126 specimens from 36 building materials were tested at static pressure differentials varying from 25 to 100 Pa.

2.2 KEY RESULTS

When applied to orifice plates, the validation process clearly shows that Air-Ins Inc. and IRC test results are within 1 to 7 % of each other.Furthermore, best accuracy is reached at pressure differentials of 75 to 100 Pa.

For building materials, the validation process shows that test results from IRC and Air-Ins Inc. are very close to each other.

The application of the test method to the 36 building materials yields the following:

- 12 materials show a non-measurable air flow;
- 9 materials show an air flow rate smaller than 0.05 L/S-m^2 at a pressure differential of 75 Pa;
- 1 material shows an air flow rate between 0.1 and 0.15 L/S-m^2 at a pressure differential of 75 Pa;
- 14 materials show an air flow rate higher than 0.15 L/S-m^2 at a pressure differential of 75 Pa;

The results also show that:

- inhomogeneity does exist within a given board;
- inhomogeneity does exist from one board to another for a specific material;
- the air flow regime through building materials having and air flow rate smaller than 0.15 L/S-m^2 is mainly laminar.

2.3 CONCLUSIONS

The test method developed by the present study has been demonstrated by the validation process to be in close agreement with the test method developed by IRC.

The test method has been shown to be capable of measuring air flow rates of 0.005 $L/S\text{-}m^2$ to 30 $L/S\text{-}m^2$ with reasonable accuracies.

The study confirmed that at pressure differentials of 25 to 100 Pa, the air flow regime through building materials is mainly laminar.

3. TEST METHOD

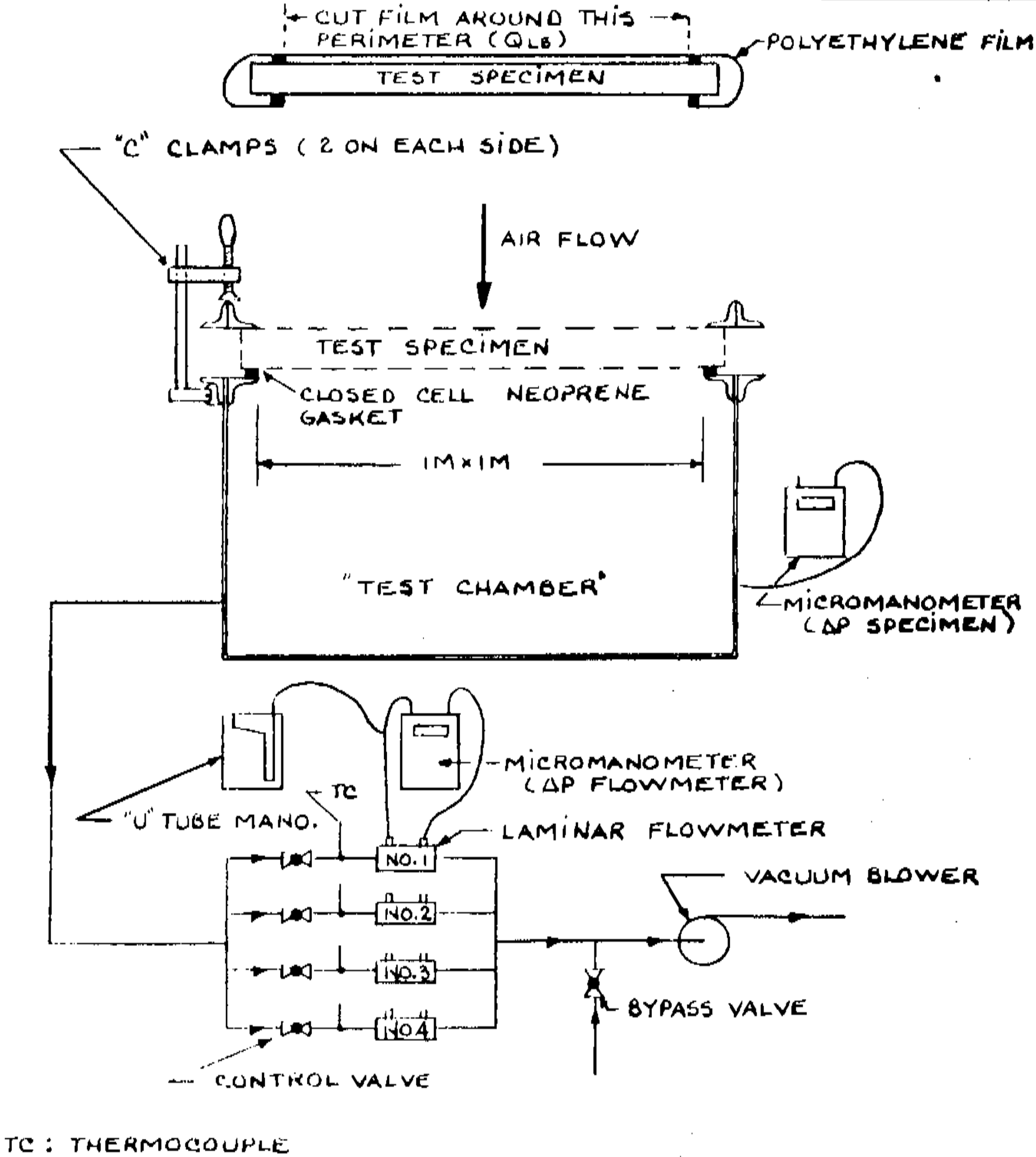
3.1 TEST APPARATUS

Figure 1 shows the different components of test apparatus. The system includes:

- a test chamber to which the specimen is to be attached;
- clamping and sealing devices;
- flow measuring devices;
- pressure measuring devices;
- a temperature measuring device;
- flow control devices (ball valves);
- a vacuum fan or blower.

3.2 TEST METHOD

After being carefully covered by a polyethylene film (permeability $\simeq$ 0.0) the specimen is put on the test chamber. For various pressure differentials the air leakage of the test apparatus (Q_L) is measured. Upon removal of the polyethylene film the air leakage through the test apparatus and through the specimen Q_{LS} is measured; subtracting Q_L from Q_{LS} the value of Q_S (air leakage through the specimen) at any pressure differential is then obtained.



AIR INS Inc.			
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4. EXPRESSION OF RESULTS

The results are expressed by Q_{AVG}, Q_{MIN}, Q_{MAX}, R_{AVG}, P_{AVG}, K_{AVG} and n_{AVG}

These symbols are defined as:

Q_{AVG} = Average air flow rate through the material at P = 75 Pa.

Q_{MIN} = Minimum measured air flow rate through the specimen at P = 75 Pa.

Q_{MAX} = Maximum measured air flow rate through the specimen at P = 75 Pa.

P_{AVG} = Air permeance of the material at P = 75 Pa.

R_{AVG} = Air resistance of the material at P = 75 Pa.

K_{AVG}, n_{AVG} = Average constant values in the flow equation:

$$Q_{AVG} = K_{AVG} \quad (\Delta P)^{n_{AVG}}$$

where: K_{AVG} = Variable dependant on the intrinsic air permeability of the material.

n_{AVG} = Variable representing the type of flow $(0.5 < n < 1.0)$:

n = 1.0 Laminar flow
n = 0.5 Turbulent flow

4.1 BUILDING MATERIALS TEST RESULTS

Results are summarized in Tables 1 and 2. Table 1 lists all materials showing non-measurable air flows, while Table 2 lists in ascending order the materials which showed a measurable air flow at pressure differentials varying from 25 to 100 Pa.

TABLE 1: MATERIALS SHOWING A NON-MEASURABLE AIR FLOW
($P_{AVG} \leq 8 \times 10^{-8}$ m/Pa-S)

MATERIAL (no.)	DESCRIPTION
4	2 mm, smooth surface roofing membrane
5	2.7 mm, modified bituminous torch on grade membrane (glass fiber mat)
8	Aluminum foil vapor barrier
12	1.3 mm, modified bituminous self-adhesive membrane
13	2.7 mm, modified bituminous torch on grade membrane (polyester reinforced mat)
19	9.5 mm, plywood sheathing
27	38 mm, extruded polystyrene
28	25.4 mm, foil back urethane insulation
31	24 mm, phenolic insulation board
32	42 mm, phenolic insulation board
35	12.7 mm, cement board
36	12.7 mm, foil back gypsum board

TABLE 2 : MATERIALS HAVING A MEASURABLE AIR FLOW

MATERIAL NO.	DESCRIPTION	Q_{AVG} at 75 Pa	Q_{MIN} at 75 Pa	Q_{MAX} at 75 Pa	R_{AVG} at 75 Pa	P_{AVG} at 75 Pa	K_{AVG}	N_{AVG}	RATING AS PER IRC
		$(L/S-m^2)$	$(L/S-m^2)$	$(L/S-m^2)$	(Pa-s/m)	(m/pa-s)			
18	8 mm plywood sheathing	0,0067	0,0000	0,0222	$1.13x10^{7}$	$8.87x10^{-8}$	0,00011	0,944	3
21	16 mm flakewood board	0,0069	0,0006	0,0181	$1.09x10^{7}$	$9.19x10^{-8}$	0,00010	0,979	3
15	12.7 mm Gypsum board (M/R)	0,0091	0,0055	0,0118	$8.23x10^{6}$	$1.22x10^{-7}$	0,00012	1,000	3
20	11 mm flakewood board	0,0108	0,0075	0,0134	$6.92x10^{6}$	$1.45x10^{-7}$	0,000145	0,998	3
22	12.7 mm particle board	0,0155	0,0121	0,0178	$4.84x10^{6}$	$2.07x10^{-7}$	0,000210	0,996	3

TABLE 2: MATERIALS HAVING A MEASURABLE AIR FLOW (continued)

MATERIAL NO.	DESCRIPTION	Q_{AVG} at 75 Pa	Q_{MIN} at 75 Pa	Q_{MAX} at 75 Pa	R_{AVG} at 75 Pa	P_{AVG} at 75 Pa	K_{AVG}	N_{AVG}	RATING AS PER IRC
		$(L/S\text{-}m^2)$	$(L/S\text{-}m^2)$	$(L/S\text{-}m^2)$	(Pa-s/m)	(m/pa-s)			
6	Reinforced non-perforated polyolefin	0,0195	0,0171	0,0218	3.84×10^{6}	2.60×10^{-7}	0,000272	0,989	3
14	12.7 Gypsum board	0,0196	0,0170	0,0219	3.83×10^{6}	2.61×10^{-6}	0,000266	0,995	3
23	15.9 mm particle board	0,0260	0,0130	0,0375	2.88×10^{6}	3.47×10^{-7}	0,000431	0,949	3
16	3.2 mm tempered hardboard	0,0274	0,0184	0,0422	2.73×10^{6}	3.66×10^{-7}	0,000399	0,979	3

TABLE 2: MATERIALS HAVING A MEASURABLE AIR FLOW (continued)

MATERIAL NO.	DESCRIPTION	Q_{AVG} at 75 Pa	Q_{MIN} at 75 Pa	Q_{MAX} at 75 Pa	R_{AVG} at 75 Pa	P_{AVG} at 75 Pa	K_{AVG}	N_{AVG}	RATING AS PER IRC
		$(L/S\text{-}m^2)$	$(L/S\text{-}m^2)$	$(L/S\text{-}m^2)$	(Pa-s/m)	(m/pa-s)			
30	expanded polystyrene type 2	0,1187	0,0214	0,2799	6.32×10^{5}	1.58×10^{-6}	0,00163	0,993	1
11	30 lb roofing felt	0,1873	0,1674	0,2081	4.01×10^{5}	2.50×10^{-6}	0,002535	0,996	n/c
9	15lb non-perforated asphalt felt	0,2706	0,2480	0,2957	$2,77\times10^{5}$	3.61×10^{-6}	0,003607	1,000	n/c
10	15 lb perforated asphalt felt	0,3962	0,3266	0,4774	1.85×10^{5}	5.28×10^{-6}	0,006629	0,947	n/c
33	Glass fiber rigid insulation board with a spunbonded olefin film on one face	0,4880	0,4305	0,5781	1.54×10^{5}	6.51×10^{-6}	0,006877	0,987	n/c

TABLE 2 : MATERIALS HAVING A MEASURABLE AIR FLOW (continued)

MATERIAL NO.	DESCRIPTION	Q_{AVG} at 75 Pa	Q_{MIN} at 75 Pa	Q_{MAX} at 75 Pa	R_{AVG} at 75 Pa	P_{AVG} at 75 Pa	K_{AVG}	N_{AVG}	RATING AS PER IRC
		$(L/S\text{-}m^2)$	$(L/S\text{-}m^2)$	$(L/S\text{-}m^2)$	(Pa-s/m)	(m/pa-s)			
24	11 mm plain fiberboard	0,8223	0,7374	0,8916	$9.12x10^{5}$	$1.10x10^{-5}$	0,011470	0,990	n/c
25	11 mm asphalt impregnated fiber board	0,8285	0,7461	0,8942	$9.05x10^{4}$	$1.10x10^{-5}$	0,011266	0,995	n/c
1	Spunbonded olefin film	0,9593	0,8410	1,0684	$7.82x10^{4}$	$1.28x10^{-5}$	0,012790	1,000	n/c
2	Perforated polyethylene #1	4,0320	2,5558	5,9343	$1.86x10^{4}$	$5.38x10^{-5}$	0,201203	0,694	n/c
3	Perforated polyethylene #2	3,2307	2,7986	3,7219	$2.32x10^{4}$	$4.31x10^{-5}$	0,187891	0,659	n/c

TABLE 2: MATERIALS HAVING A MEASURABLE AIR FLOW (continued)

MATERIAL NO.	DESCRIPTION	Q_{AVG} at 75 Pa $(L/S\text{-}m^2)$	Q_{MIN} at 75 Pa $(L/S\text{-}m^2)$	Q_{MAX} at 75 Pa $(L/S\text{-}m^2)$	R_{AVG} at 75 Pa (Pa-s/m)	P_{AVG} at 75 Pa (m/pa-s)	K_{AVG}	N_{AVG}	RATING AS PER IRC
29	Expanded polystyrene (type 1)	12,2372	9,4547	15,2111	$6.13x10^3$	$1.63x10^{-4}$	0,251356	0,900	n/c
26	Tongue and groove planks	19,1165	18,0594	20,1736	$3.92x10^3$	$2.55x10^{-4}$	1,670934	0,564	n/c
17	Glasswool insulation	36,7327	22,9763	87,9639	$2.04x10^3$	$4.90x10^{-4}$	0,61088	0,949	n/c
34	Vermiculite insulation	70,4926	32,4266	108,5586	$1.06x10^3$	$9.40x10^{-4}$	1,0296	0,979	n/c
7	Cellulose insulation	86,9457	75,2354	100,3396	$8.63x10^2$	$1.16x10^{-3}$	1,3217	0,970	n/c

5. CONCLUSIONS

- The air permeance of building materials is a basic variable of concern in making an effective air barrier system. The determination of air permeance made by the present study will certainly prove to be helpful in the selection of materials to build a good air barrier system.

- The test method developed by the present study is in close agreement with the test method developed by IRC. This was demonstrated by the validation process.

- The test method may be applied to rigid (sheathing), flexible and loose materials, regardless of dimensions (length, width and thickness).

- The test method has been shown to be capable of measuring air flow rates with reasonnable accuracies at 1/10 of the suggested flow rate for a type 3 air barrier system and at 200 times the maximum suggested flow rate for a type 1 air barrier system.

- The study confirmed that at pressure differentials of 25 to 100 Pa the air flow regime through building materials is mainly laminar. Therefore, the evaluation of air flow resistance through a composite system can be calculated in the same manner as the resistance to heat or the resistance to current flow.

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