THE IMPLEMENTATION AND EFFECTIVENESS OF AIR INFILTRATION STANDARDS IN BUILDINGS

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PAPER 16

CONSTANCY OF AIR TIGHTNESS IN BUILDINGS

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SYNOPSIS

In a pre-project the air tightness of 15 detached houses has been measured firstly immediately after erection, secondly after a period of 1.5 to 4.5 years. All the houses were timberframed ones, equipped with mechanical ventilation system. Only two houses out of the 15 tested show clear changes in air tightness. Thus, the air tightness behaviour of the houses seems to be fairly constant.

1. BACKGROUND

The aim of the project - the first part of which is reported in this paper - is to determine whether there are any considerable changes in the air tightness of newer onefamily houses during the first years after erection.

The degree of change of the air tightness is investigated by means of the pressurization/depressurization technique.

In this pre-investigation 15 houses were tested 1.5-4.5 years after erection (and first pressurization/depressurization test).

2. FIELD INVESTIGATION

2.1 Investigation objects

The objects were chosen from a total number of some hundreds of earlier test results. It was settled that the houses should fulfill the following demands:

- The houses should have been pressurized/depressurized in accordance with a standardized procedure (SS 02 15 51).
- Not more than five years should have elapsed since the first measurements.
- The first measurement should have been done immediately after the erection of the house.
- A low value of n_{50} (≤ 3.0 ac/h) at the first measurement.
- No air-tightening or other measures should have been undertaken after the first measurement.
- The houses should be detached ones.

The 15 houses tested hitherto are all timber framed and equipped with exhaust fan ventilation system. 7 of the houses (no. 1, 2, 8, 11, 12, 13, 14) were prefabricated as volume elements, while the others were site-built or prefabricated as surface elements. 6 of the houses are 1 1/2 floor houses (no. 4, 5, 6, 7, 8, 10); the others are 1 floor houses.

2.2 Method

The investigation is a typical comparative one. This involves some statistical approach to determine whether two measurement values with certain inaccuracies differ from each other to a statistically significant degree or not.

The inaccuracy of the measurement procedure was estimated to ±5% in n_{50}, (Kronvall[1]). Using the assumption that a single measurement value has a normal distribution round the mean, statistical theory, e.g. Sachs[2], gives the degree of difference in n_{50} between the two measurement values needed for statistical significance. Figure 1.

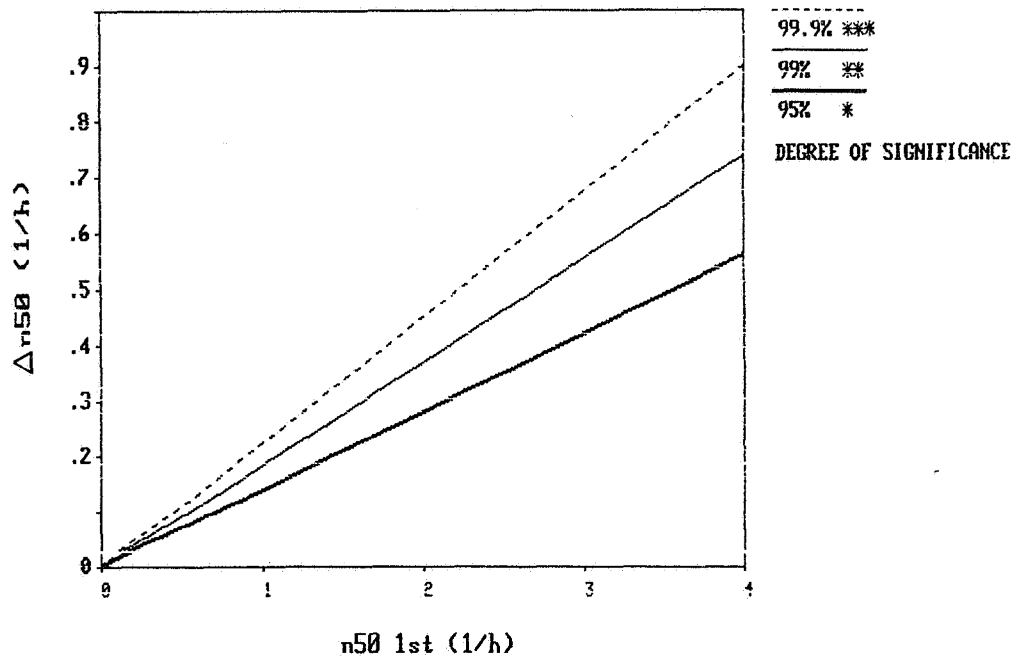


Figure 1. Required difference in n_{50} between two measurement values for different degrees of significance.

2.3 Results

The results are summarized in table 1.

The leakage characteristics of the houses tested are shown in figure 6. (Pressurization/depressurization data at 10, 20, 30, 40, 45, 50, 55 Pa fitted to a power-expression).

The coefficent, A, and the exponent B in the power expression

$$q_v = A \cdot \Delta p^B \qquad (1)$$

are given in table 1.

OBJECT NUMBER	TIME BETWEEN 1st and 2nd MEASUREMENT (year)	TEST MONTH		n_{50} (1/h)		A FLOW COEFFICIENT ($m^3/(h \cdot p^B)$)		B FLOW EXPONENT (-)		A_{eq} EQUIVALENT LEAKAGE AREA AT 4 Pa (cm^2)	
		1st	2nd	1st	2nd	1st	2nd	1 st	2nd	1st	2nd
1	3.5	12	5	1.4	1.5	33	33	0.73	0.74	1.7	1.7
2	2.5	12	5	2.4	2.1	41	35	0.78	0.78	2.2	1.9
3	2.5	1	5	1.7	1.6	71	26	0.59	0.78	2.9	1.4
4	2.5	1	5	2.1	2.1	32	35	0.76	0.72	1.7	1.8
5	2.5	1	6	1.9	1.3	56	27	0.58	0.67	2.3	1.2
6	2	3	5	1.4	1.3	46	11	0.54	0.89	1.8	0.7
7	2	3	5	0.9	1.3	8	7	0.90	1.00	0.5	0.5
8	3.5	2	6	2.5	2.5	82	62	0.59	0.67	3.4	2.9
9	1.5	2	6	2.2	2.3	38	84	0.78	0.58	2.1	3.4
10	1.5	2	6	1.6	1.7	28	25	0.69	0.73	1.3	1.2
11	4.5	1	6	2.5	2.9	27	79	0.92	0.69	1.8	3.8
12	4.5	1	6	2.4	2.5	72	91	0.66	0.61	3.3	3.9
13	4.5	1	6	2.4	2.8	76	64	0.65	0.73	3.4	3.3
14	1.5	11	6	2.4	2.6	119	91	0.50	0.59	4.4	3.8
15	1.5	2	6	1.6	1.7	35	33	0.74	0.77	1.8	1.7

Table 1.

For comparative reasons the equivalent leakage area at a pressure difference of 4 Pa (Δp_{ref}) was calculated too.

$$Aeq = \frac{1}{C_d \sqrt{\frac{2}{\rho}}} \cdot \frac{q_v(\Delta p_{ref})}{\sqrt{\Delta p_{ref}}} \qquad (2)$$

C_d (coefficient of discharge) = 0.6

ρ = density of air, kg/m^3

The relationship between n_{50} and Aeq at 4 Pa is shown in figure 2.

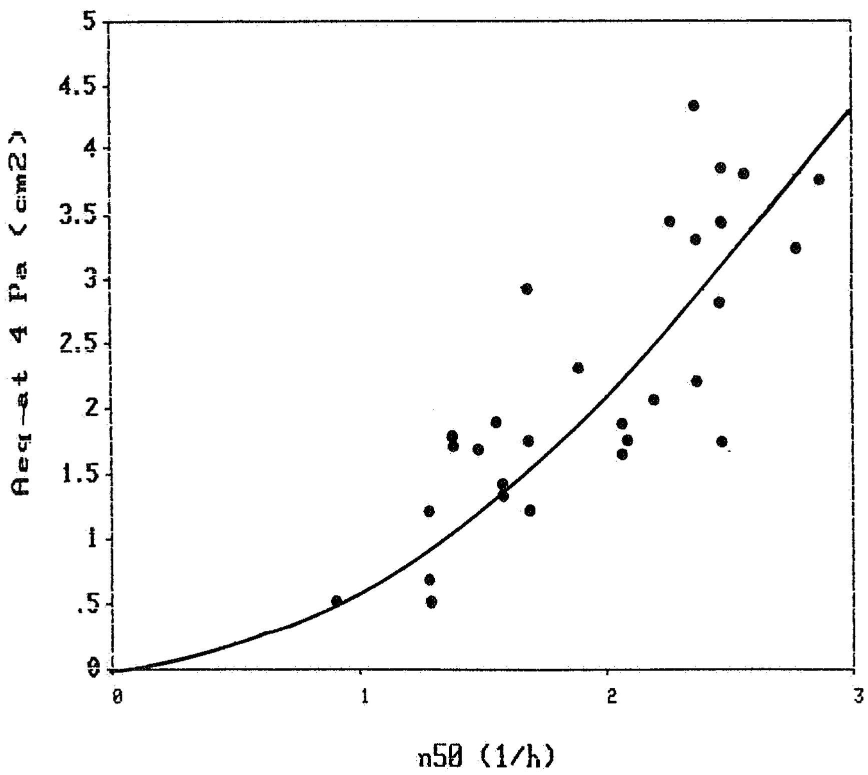


Figure 2. The equivalent leakage area, Aeq, at 4 Pa vs. n_{50}. The curve origins from data fitted by means of the least square method:

$Aeq = 0.66 \cdot n_{50}^{1.69}$, $r^2 = 0.72$

The results of the first and the second measurement are shown in figure 3, (n_{50}), and figure 4, (Aeq).

The result of a curve fit to a straight line is:

$n_{50}^{2nd} = 0.063 + 0.995\ n_{50}^{1st}$, $r^2 = 0.78$.

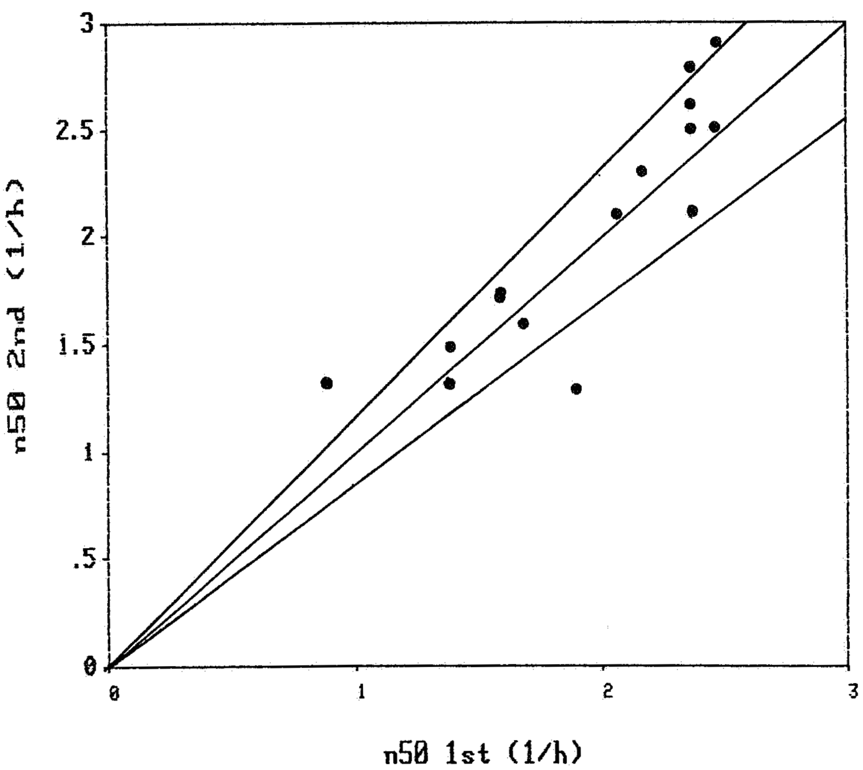


Figure 3. n_{50} at the first and the second measurement. The area between the lines symmetric around the line y = x illustrates the field within which there is no significant (95% level) difference between the two measurement values.

In figure 4 the results of the measurements expressed as equivalent leakage area at 4 Pa are shown.

The result of a curve fit to a straight line is:

$Aeq^{2nd} = 0.430 + 0.775\ Aeq^{1st}$, $r^2 = 0.44$.

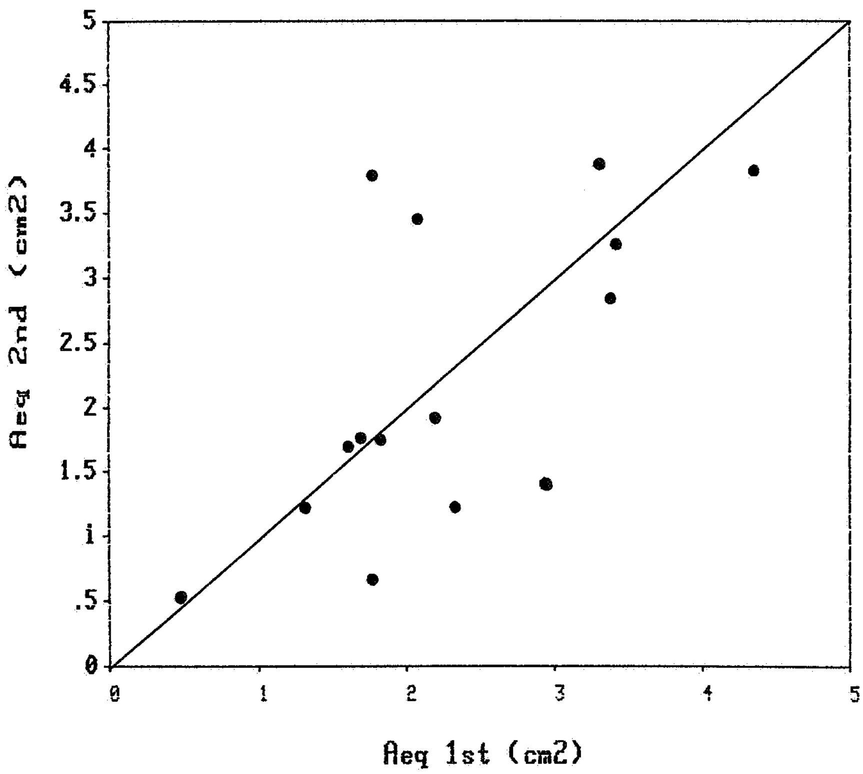


Figure 4. Aeq at 4 Pa at the first and the second measurement.

The alterations in n_{50} and Aeq are plotted versus each other in figure 5.

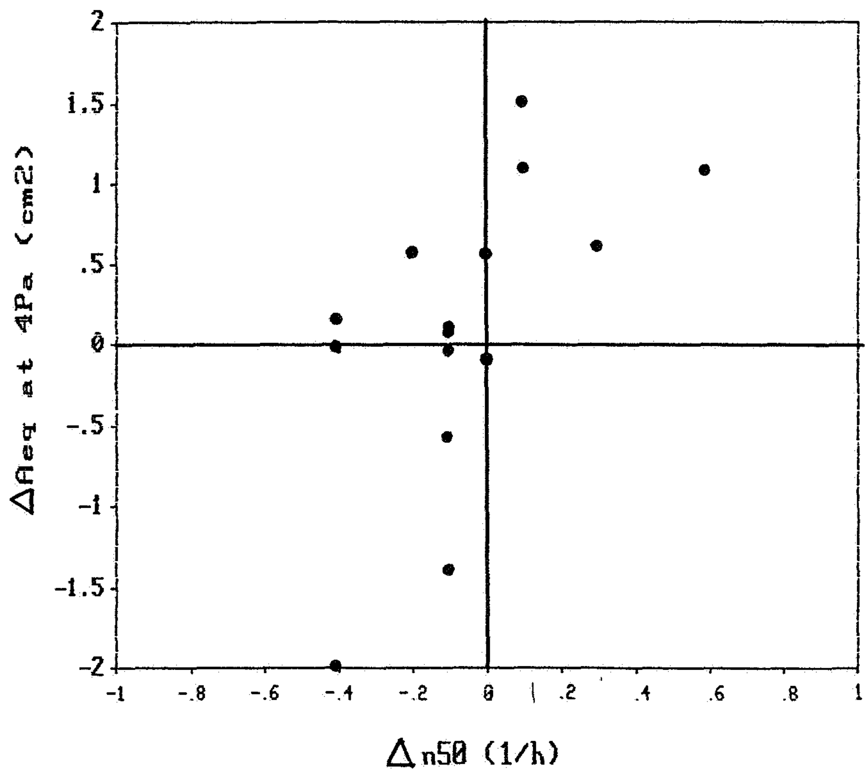
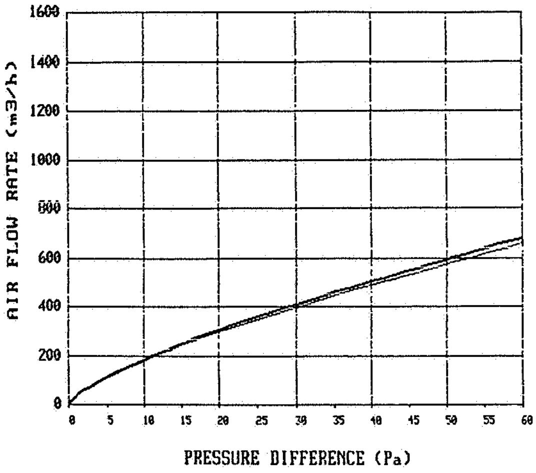


Figure 5. Alterations in n_{50} and Aeq. Negative values stand for deteriorated air tightness (higher n_{50} and Aeq at the second measurement compared to the first one).

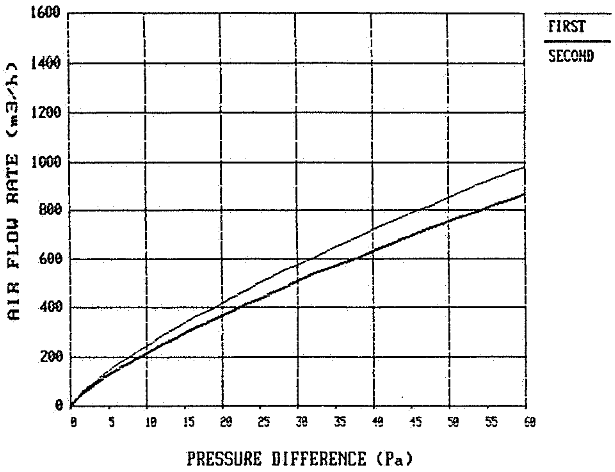
2.4 Discussion

If n_{50}-values from two measurements are compared to each other (figure 3), only four objects out of the investigated 15 ones show significant differences. The air tightness according to n_{50} has deteriorated in three cases (clearly in one case), and improved in one case.

The results indicate that the air tightness behaviour of the houses seems to be fairly constant.



House 1



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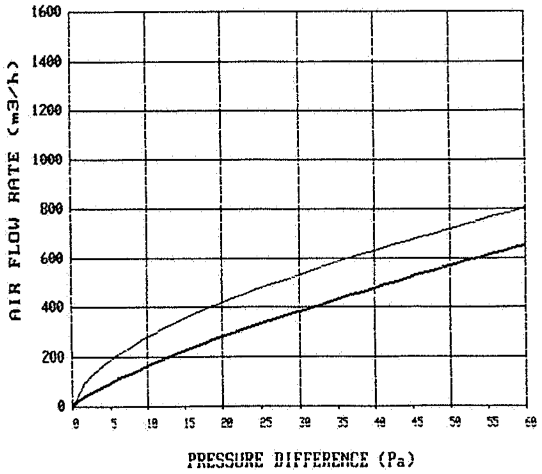

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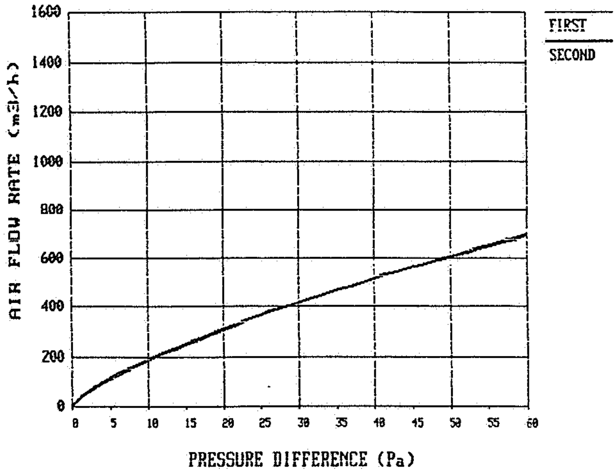

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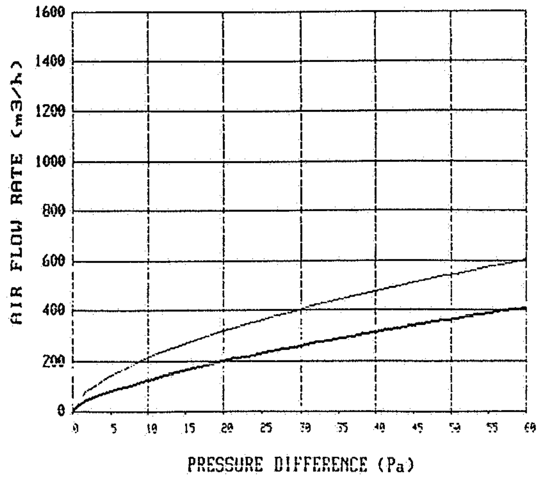

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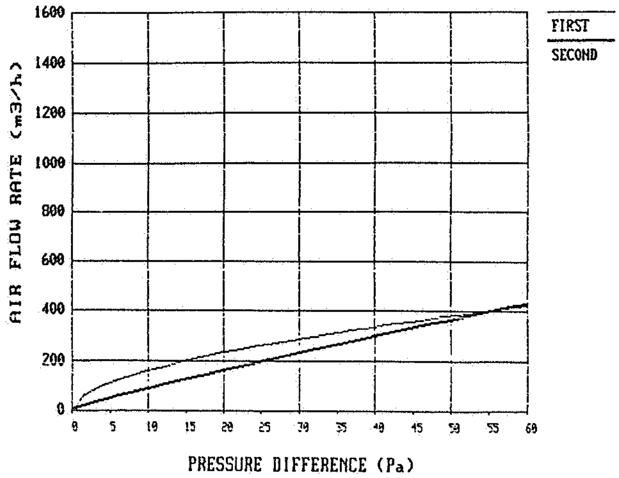
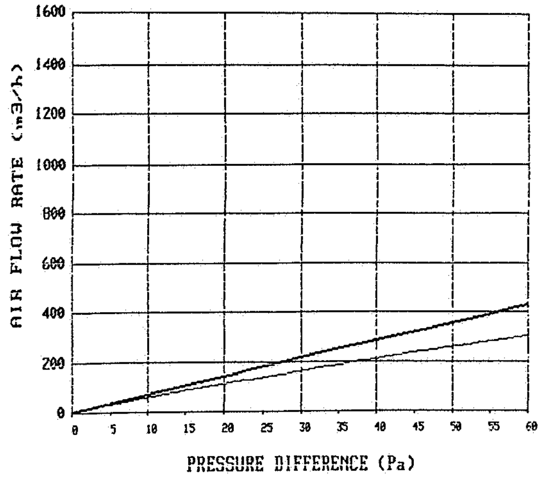


House 6

Figure 6 (cont)



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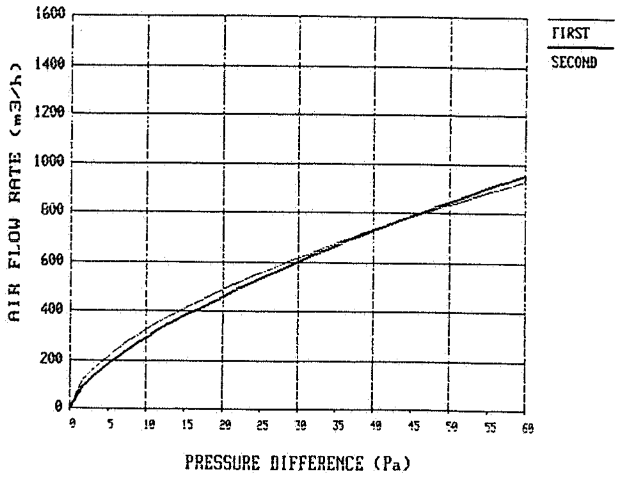

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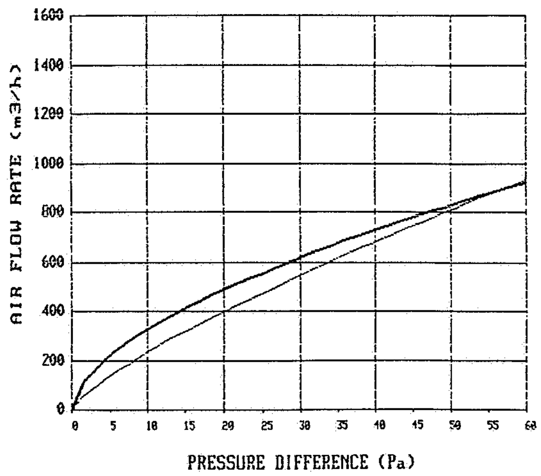

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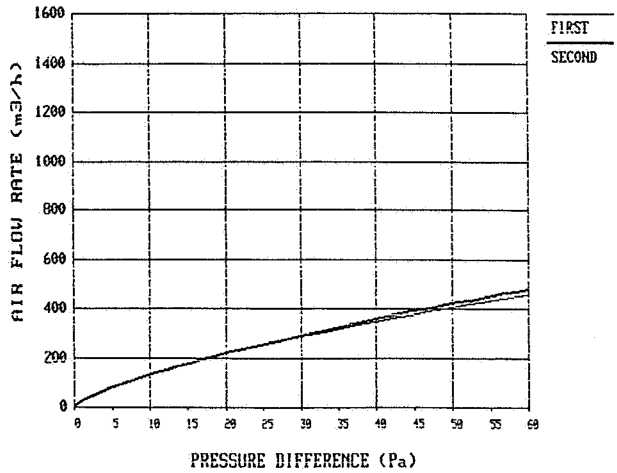

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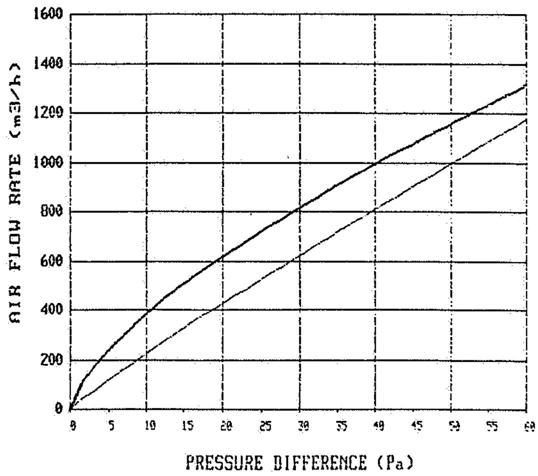

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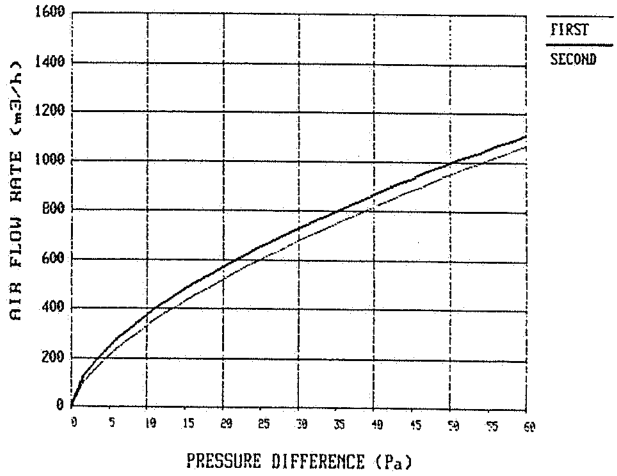
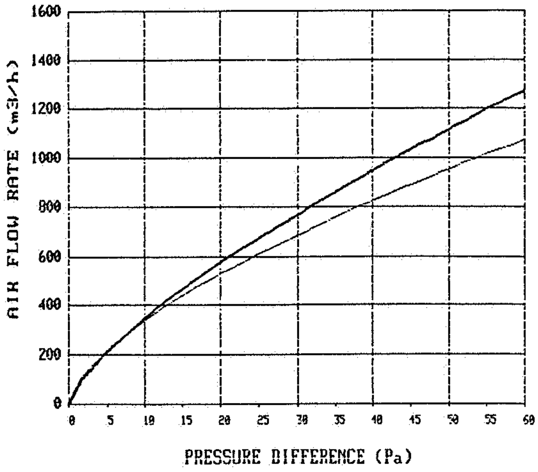


House 12

Figure 6 (cont)



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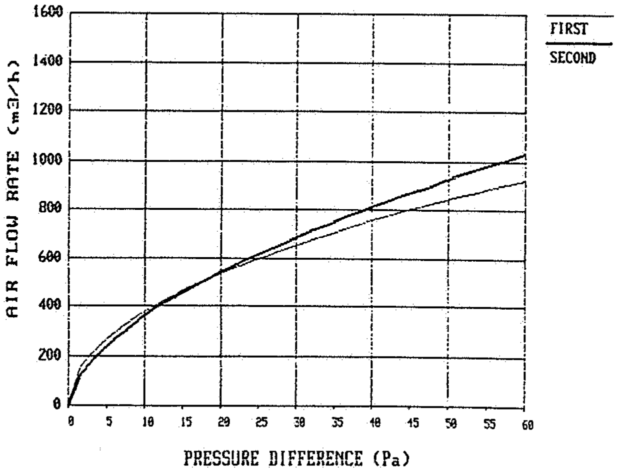

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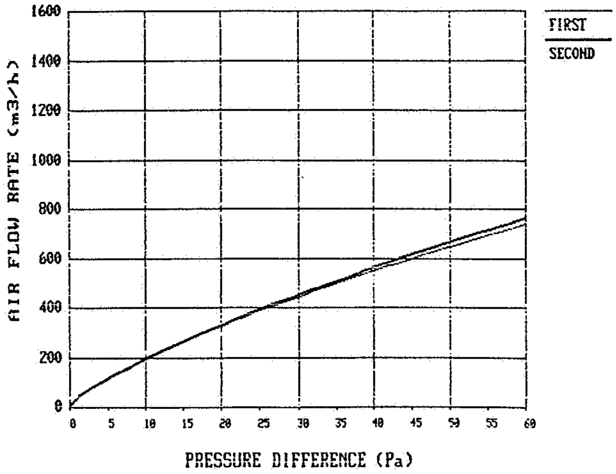

House 15

Figure 6

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