PAPER 7

PROBLEMS AND CONSEQUENCES OF THE PRESSURIZATION TEST FOR THE AIR LEAKAGE OF HOUSES

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Contents

Summary

Research has been carried out on the problems and consequences of a measuring method for the determination of the air leakage of houses. From the research it has appeared that the pressurization test for the air leakage of houses can be used to compare houses on air leakage. Additional measurements on the distribution of air leakage over the building components are sometimes necessary. The relation between air leakage and infiltration and hence also the relation between air leakage and energy losses due to infiltration is not clear.

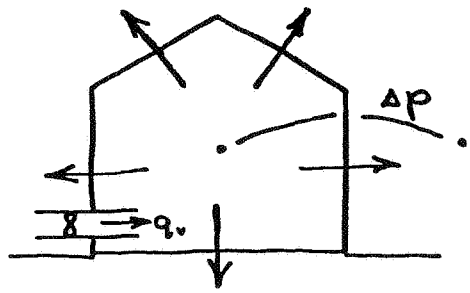
1. Introduction

Fan pressurization, blower door system, air leakage test, etc., all these are words to describe a test method for the air tightness of houses (see Refs. 1, 2, 3, 4 and 5). Infiltration losses become more important as houses are better insulated. One wishes to have a simple and less time-consuming method to quantify the air tightness of the building envelope. The important question arises whether the fan pressurization test is a reliable method in relation to occurring infiltration rates and energy losses due to this infiltration. This paper tries to give an overview on the problems and consequences of the pressurization test on houses.

2. Description of the method

A fan fixed in or on a "dummy door" pressurizes or depressurizes a house, in which all internal doors are open. The nominal value of this pressure is about 50 Pa. The pressure difference between inside and outside will be measured as a function of the air flow rate through the house (see Fig. 1).

Figure 1



In general this can be written as:

$\Delta p = f(q)$ ..... (1)

or more specifically:

$\Delta p = (q/C)^n$ .... (2)

in which:

p=pressure difference
q=air flow rate
C=air leakage coefficient
n=flow exponent

The air leakage coefficient is a function of a representative open area.

3. Problems

The following problems are associated with pressure tests:

3.1 There is a difference between the homogeneous pressure distribution over the building envelope during the test and the pressure distribution in reality. Also the pressure difference levels have an order of magnitude difference (see Fig. 2).

3.2 Where is the pressure difference measured ? More specifically:

Figure 2

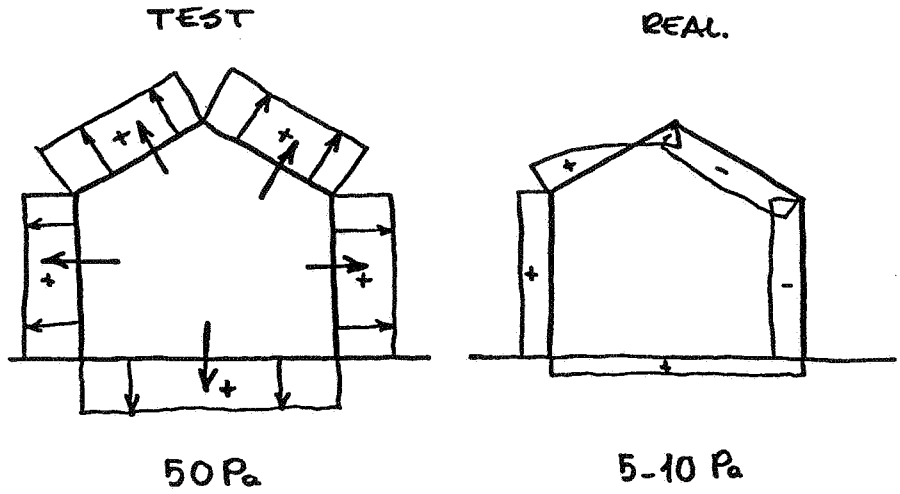
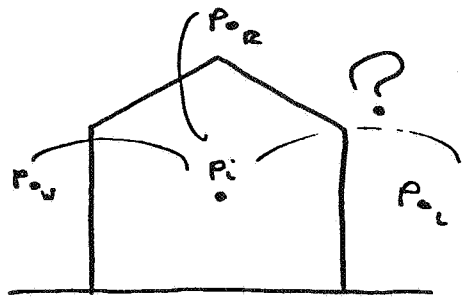


Figure 3



Where should the outside pressure tap be placed during the measurements ? As one can imagine, due to wind and thermal forces, there is a difference in pressure between windward or leeward wall and roof (see Fig. 3).

This is one of the reasons to pressurize a house to about 50 Pa because, at that level, this influence is relatively small. But, even with 50 Pa pressure difference in a windy climate, there are enough circumstances under which accurate pressurization measurements are impossible.

3.3 The result of the pressurization test is an air flow rate at a certain pressure difference level. There is no quantitative information about the distribution of the leakages. Leakages to adjacent houses can play an important role (see Fig. 4).

3.4 In reality, the flow through cracks, caps, etc. can be laminar at some moments, at least at very low pressures, during the pressurization test at 50 Pa the flow will be more turbulent (see Fig. 5).

Figure 4

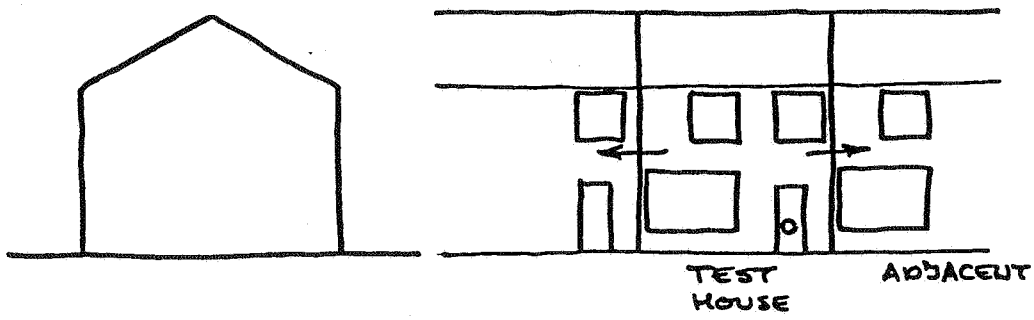


Figure 5

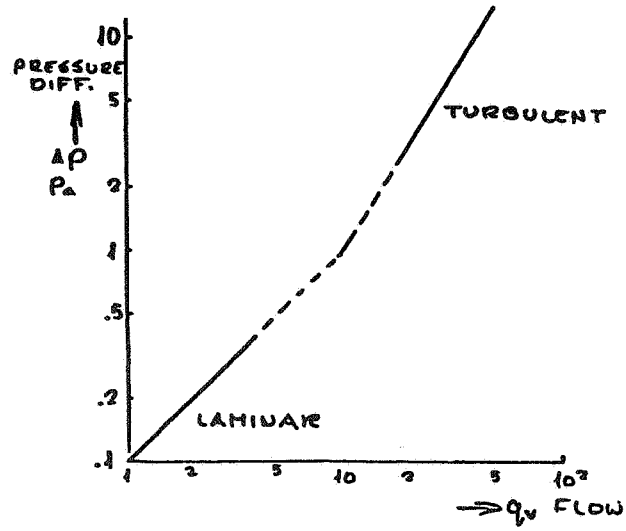
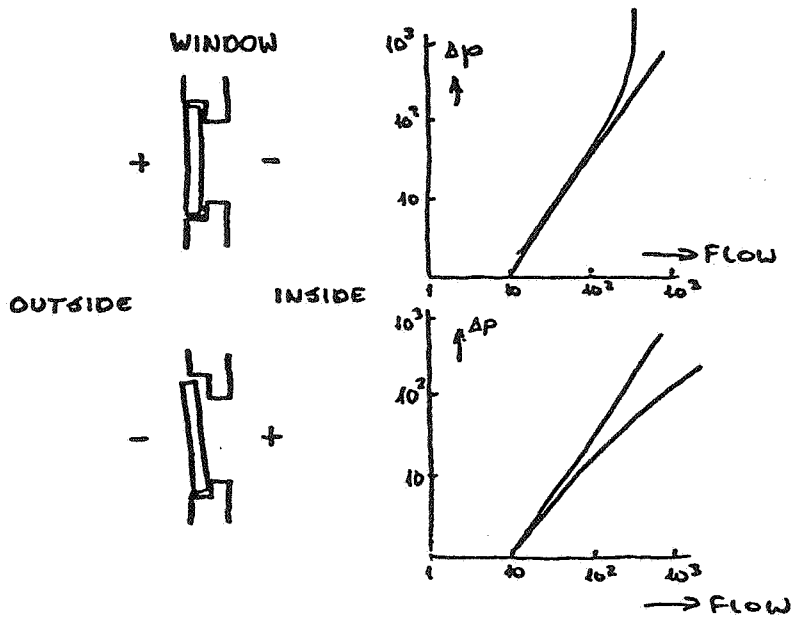


Figure 6



3.5 The possibility of changing air leakages by pressing open or sucking tight a window in its frame must be considered (see Fig. 6).

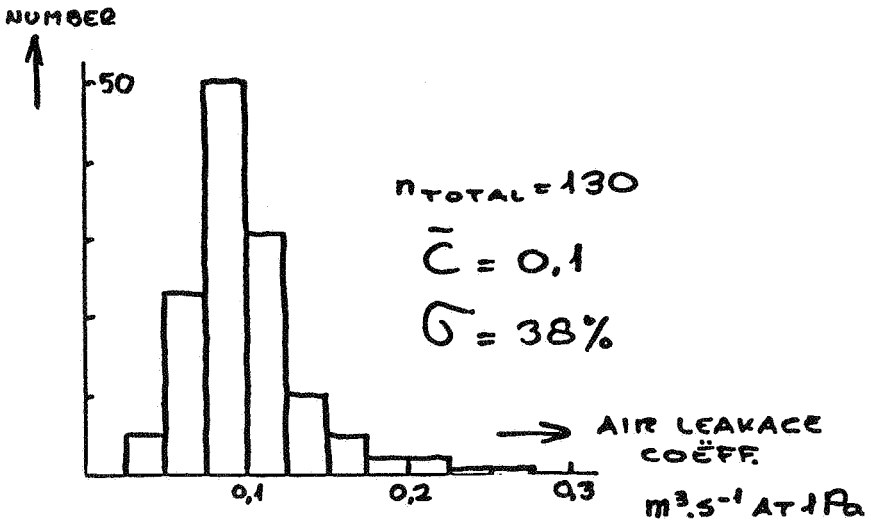
3.6 Replacing a door by a dummy changes the outside envelope of the house and so its air tightness a little.

To study these problems for the Dutch situation some measurements and calculations have been carried out (paragraph 5).

4. Measurements

4.1 The air leakage value of houses in the Netherlands.

Figure 7



A building co-operation carried out 130 (de)pressurization tests (see Ref. 6). A number of 130 cannot be statistically representative for 4.4 million houses, but all 130 can be qualified as typical houses for the Netherlands, normal price, size, building practice, etc. The results can be seen in Fig. 7. The mean air leakage value is 0.1 m3/s at 1 Pa with a standard deviation of 38%. These values are measured with all ventilation ducts open.

For comparison, Fig. 8 shows values of houses in other countries (see Refs. 7, 8 and 9).

The following remarks can be made:

- In Sweden some ventilation openings are blocked off during the test.

- The number of houses measured is too small to be representative for the total number of houses in other countries.

4.2 Distribution of air leakages over the building envelope.

In four houses the leakage of all components in the envelope were measured separately. Table 1 shows the results.

Table 1 : Distribution of air leakages over the envelope of houses.

Houses	Components				
	Facades	Ducts	Roof and wall/roof connection	Unknown	Total dm3/s at 1 Pa
Apartments (concrete)					
1	42%	58%	x	-	22
2	17%	76%	x	7%	25
Single family houses (masonry)					
1	10%	27%	42%	21%	125
2	25%	27%	43%	5%	140

- *not determined*
x *not relevant*

The unknown air leakages may be the ground floor leakages, leakages to adjacent houses, etc.

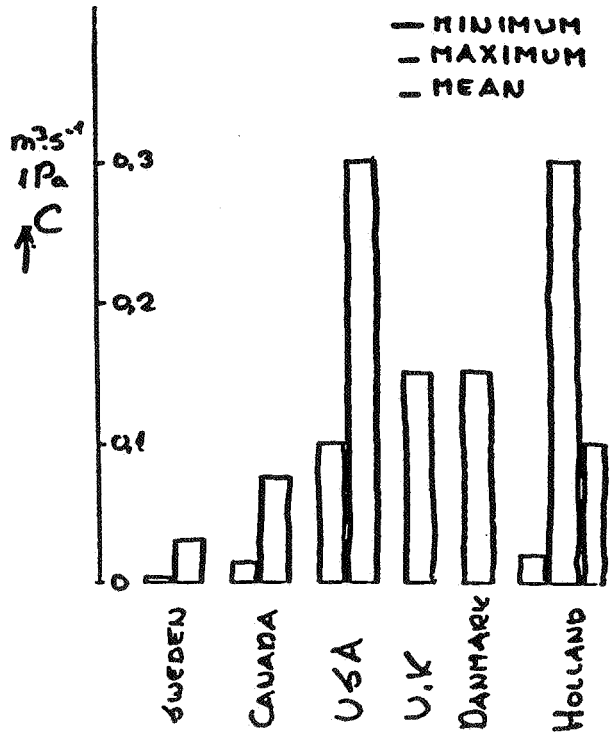


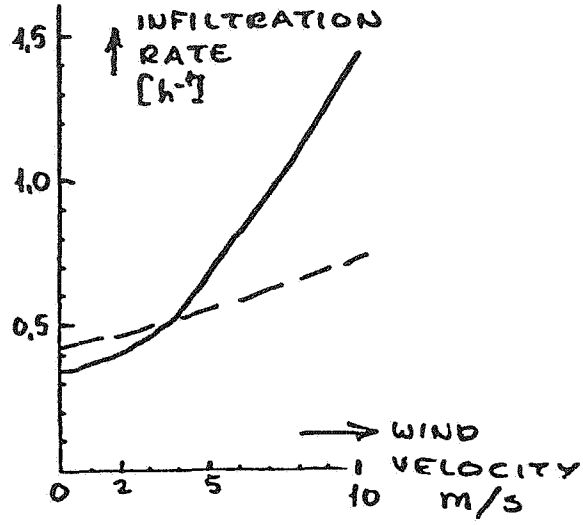
Figure 8

5. Relation between pressurization results and infiltration rates

A direct relation cannot exist due to the following reasons:

- Two houses with the same total air leakage can have different infiltration rates caused by:
  - another distribution of air leakages
  - another wind-environment
- Another problem is that the ratio between the air leakage co-efficient and the infiltration rate is not constant (see Fig. 9)

Figure 9



$$\text{RATIO } R = \frac{C}{a_2} \neq \frac{C}{a_5} \neq \frac{C}{a_{10}}$$

R=C/a2#C/a5#C/a10 .... (3)

in which:

R=ratio
C=air leakage coefficient
a(i)=infiltration rate at i m/s wind velocity

6. Relation between air leakage and energy losses due to infiltration

With a calculation model (see Ref. 10) in which all leakages can be simulated, calculations have been made to show an example of the influence of:

- the distribution of air leakages (see Fig. 10)
- the temperature distribution in the house (see Fig. 11)
- the wind climate or wind distribution (see Fig. 12)

From these figures it can be seen that:

- another distribution of air leakages can change the infiltration heat losses by up to 15%
- another temperature distribution can change the infiltration heat losses up to about 20%
- another wind climate can change the infiltration heat losses up to about 30%

These calculations have been carried out without changing parameters to any great extent.

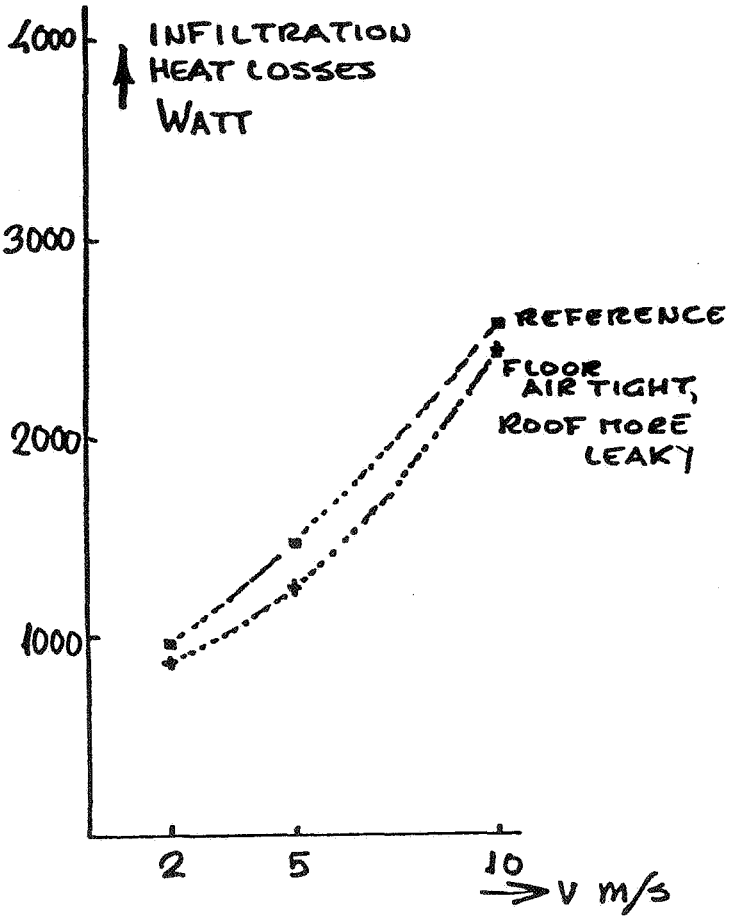


Figure 10

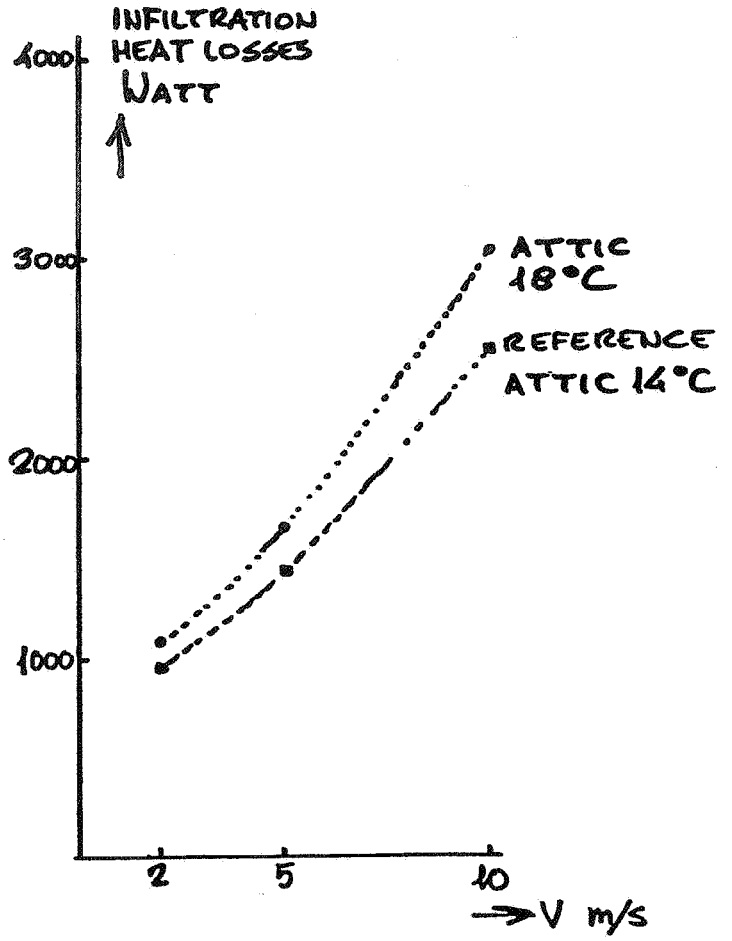


Figure 11

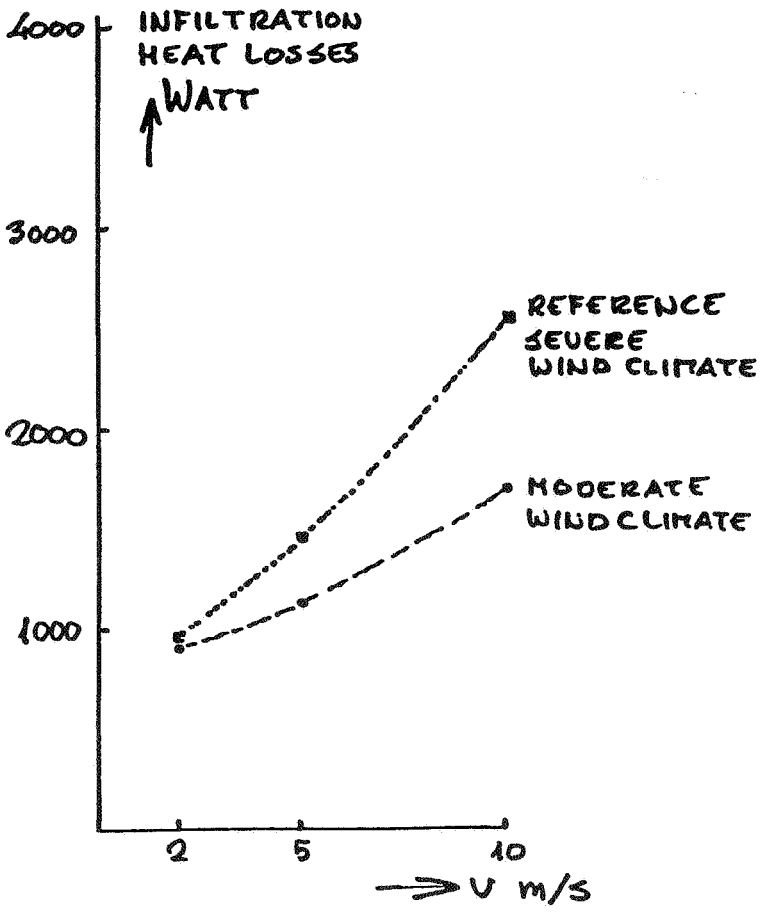


Figure 12

7. Conclusions

7.1 The pressurization test is a suitable method to compare houses on air leakage.

7.2 If the air leakage of a house does not meet a certain criterion, careful measurements on the distribution of air leakage are necessary to:

- make a final judgement
- know where to start with improvements

7.3 In some cases pressurization at the same time of adjacent houses can be necessary.

7.4 In single family houses in the Netherlands, the main important leakages are:

- the connection between walls and roof construction
- the ventilation- and flue-ducts

7.5 More industrial constructed houses with concrete elements seem to have less air leakage than traditional masonry houses.

7.6 Relations of air leakages with infiltration rates and energy losses due to infiltration are not clear.

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