PAPER 6

TRACER GAS MEASUREMENTS IN LOW LEAKAGE HOUSES

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INTRODUCTION

Air infiltration is an important component of energy loss in all buildings. Wind and temperature are the driving forces for this component. For given weather conditions the size of the air infiltration is determined by the air tightness of the building envelope. A promising technique to characterize this housing quality is air leakage measurements. An air leakage standard for new construction exists already in Sweden. Results from air leakage measurement can be used to predict the overall air infiltration for a building (1,2). Predictions will however not tell anything about the air infiltration in individual rooms. When this kind of information is needed tracer gas measurements using a special technique have to be employed. A technique for doing this has been developed and applied to a tight house.

The overall ventilation rate was very low for the test house, although it had mechanical ventilation (exhaust fan). This indicates that tight houses have to have a system for mechanical ventilation and that this system has to be efficient.

DESCRIPTION OF USED TRACER GAS TECHNIQUE

The basic principle of this method is the commonly used method of measuring the air infiltration using a tracer gas. Usually a tracer gas is injected into the house at one time and the following decay of the tracer gas is monitored. The result using this method will typically be the whole house ventilation.

In our case (3) we take air samples from every room and analyse them individually. The purpose of the method is to collect information about the ventilation of individual rooms i.e. the supply of fresh air to individual rooms. The method assumes negligible air flows between rooms and nearly perfect mixing. This is considered to be true for most of the residential buildings i.e. one-family houses or apartments. Air flows between rooms will add to the inaccuracy of the method. (This has been calculated in ref. 3).

A test is made in the following way. Every room to be monitored is connected to the sampling apparatus via tubing. The sampling apparatus is connected to an analyzer. The number of sampling points is maximized to 9. When choosing sampling points, locations close to inlets or outlets should be avoided. The sampling point are preferably chosen within the area where people normally stay and are located at mid height. The tracer gas is distributed manually and the following decay is monitored. It is essential that the tracer gas is uniformly distributed within the building at the start of a test. The sampling apparatus collects air samples following a preset schedule. Typically air will be sampled automatically at each individual sampling point every 3 to 7 minutes. The analyzer and the control apparatus are located in a van during the test. Tubing is run from the van into the house to be tested. The tubing is thermally insulated in order to avoid condensation at winter. The only disadvantage with having all instrumentation in a van is that it limits possible test sites to one-family houses and apartments in buildings with a maximum height of three storeys.

RESULTS

Measurements were made in a one-storey one-family house built 1977. When the house was built special care was taken during construction to make the house very tight. Standard building technique was used. The main idea was to be very careful about sealing all joints. The goal was to be better than the Swedish Building Code. A pressurization test was made, which showed that the house only leaked 1,5 ach at 50 Pa (see fig. 1). This value is to be compared with 3,0 ach in the Code. Most new Swedish homes meet this requirement and it is not unusual to find houses with 1,5 ach at 50 Pa.

In order to determine the ventilation rate the above described equipment was used. A typical winter day was chosen for the test. The temperature was -3 ^{o}C and a light wind prevailed. The house had mechanical ventilation i.e. air is exhausted using a fan. Exhaust air vents are located in bathrooms, laundry room, kitchen. Fresh air enters the house through cracks. This type of ventilation system is fairly common in modern Swedish housing. Nowadays this system normally also includes special supply vents.

The first test was done with the ventilation system in normal operating conditions. The average air infiltration for the whole house was shown to be 0,23 ach (see table 1). This value is clearly below the recommended value of 0,5 ach in the Swedish Building Code. There is a wide variation for different rooms. Only one room was above the recommended value, with a value of 0,64 ach. The room with the lowest ventilation rate had only 0,05 ach.

During the second test the fan was turned off and the air infiltration caused by natural means was studied. This time the average ventilation for the whole house was 0,11 ach. Some of the rooms seemed to have hardly any ventilation at all (se table 1).

In a final test the fan was turned on again and the ventilation was increased by opening a couple of windows on a slight angle. This way the ventilation rate became almost acceptable, reaching the value of 0,41 ach. There is a wide variation for different rooms; the highest value being 2,05 ach and the lowest value being 0,07 ach.

DISCUSSION AND CONCLUSIONS

The purpose of an exercise such as this is to attempt to find the ventilation rate for a tight dwelling. It was clearly shown in this home that relying on only natural ventilation is not sufficient for a tight house (0,11 ach). Adding mechanical ventilation for bringing out used air wasn't enough of a remedy for this particular house (0,23 ach). The reason being that the system wasn't properly adjusted, the fan wasn't powerful enough, there were no openings where air could come in. The best way of getting adequate ventilation is to install a ventilation system with built in routes where fresh air can enter the building. The system should either be a balanced ventilation system or an exhaust fan system with special vents to the outside for supplying fresh air. In order to save energy the first system can be combined with a heat exchanger and the second system with a heat pump for heating domestic hot water.

The difference in ventilation rate for different rooms was shown to be large. Some rooms were hardly ventilated at all judging from the measurements. It is obvious that in a tight house a great deal of attention has to be paid to supplying fresh air to every room.

The actual ventilation rate in tight homes has to be studied. Furthermore a better technique for evaluating the ventilation rate for whole homes and in individual rooms has to be developed.

A constant concentration technique is being developed for this purpose. The idea being to inject tracer gas continouosly into each room of an apartment or a house and to maintain a constant concentration of tracer gas in the whole house. By measuring the supply of tracer gas to each room the supply of fresh air to each room will be known directly. The only disadvantage with this system will be that no information as to the air flows between rooms is obtained. In standard buildings air flows between rooms will however have no effect on the measurement of the fresh air supply to an individual room. This is assuming perfect mixing within minutes. Problems with keeping a constant concentration may arise if there is an abrupt change in ventilation rate. In most houses this should normally not happen, this is especially true for houses with mechanical ventilation. An additional advantage with the system is the possibility of making long-term measurements of the ventilation rate.

Ventilation in modern tight housing is very often a neglected area. It is however possible to monitor the ventilation rate for whole homes and individual rooms in detail already today. Still better information will be available once the constant concentration tracer gas technique is developed.

REFERENCES

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hr^{-1}

Room	Case 1	Case 2	Case 3	(m^2)
1 (kitchen)	0,16	0,18	0,25	21,6
2 (living-room)	0,18	0,16	0,33	31,5
3 (bedroom)	0,25	0,07	0,07	14,3
4 (den)	0,14	0,16	0,30	10,2
5 (bedroom)	0,16	0,05	0,16	12,5
6 (hallway)	0,07	0,16	0,34	15,8
7 (den)	0,10	0,38	2,05	10,2
8 (bedroom)	0,10	0,27	0,69	12,4
9 (storage)	0,01	0,64	0,28	21,6
10 (gameroom)	0,02	0,16	0,37	29,7
				180,0

Case 1: Natural ventilation (vents closed)
Case 2: Mechanical ventilation, all windows and doors closed
Case 3: Mechanical ventialtion, windows open on a slight angle

Case 1: Average 0,11 hr^{-1}
Case 2: Average 0,23 hr^{-1}
Case 3: Average 0,41 hr^{-1}

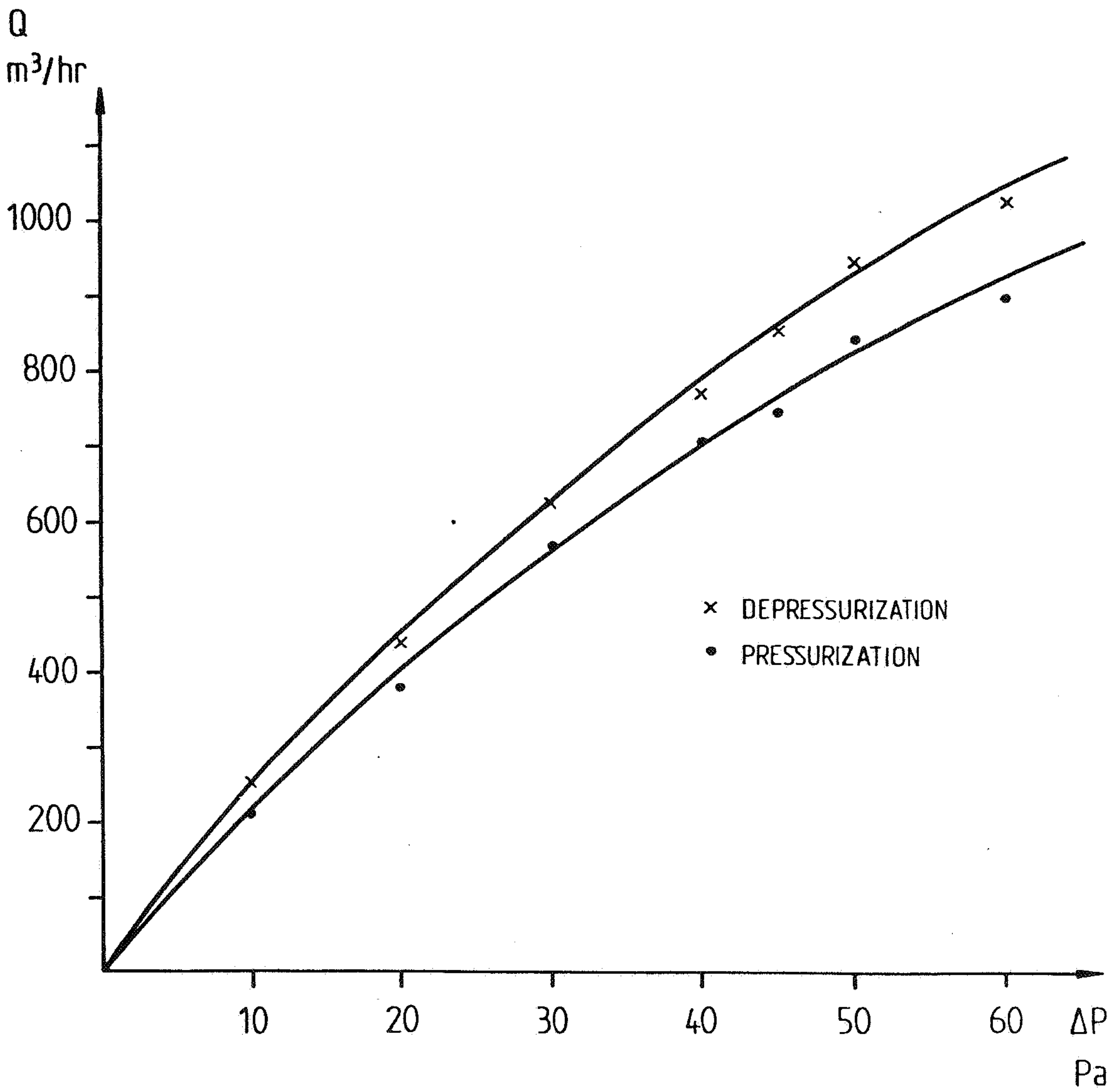

Figure 1. Air leakage vs. pressure difference inside-outside for the test house