AIR INFILTRATION REDUCTION IN EXISTING BUILDINGS

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PAPER 6

AIR LEAKAGE IN INDUSTRIAL BUILDINGS - PRELIMINARY RESULTS

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1. INTRODUCTION

In the Swedish Building Code there are recommendations for the maximum air leakage in dwellings, one-family houses as well as multi-family-houses. Most new Swedish one-family houses meet the recommendations. There are no recommendations for industrial buildings. Up to now very little has been known about the air tightness of industrial buildings and very few persons have worried about it.

In the middle of 1980 the National Testing Institute was asked by a manufacturer of building materials if we were able to carry out pressurization/depressurization tests of large industrial buildings. At that time our available fan capacity was about 8 000 m^3/h at 60 Pa. To reach this flow we used two axial fans equipped with measuring ducts with pitot tubes. Depending on our limited measuring resources we had to answer our client, that we could only carry out the measurements on industrial buildings of moderate sizes.

The test objects were selected only by our client. The design of the buildings followed two structural principles: firstly light concrete elements attached to a pre-fabricated concrete frame, secondly sheet metal attached to steel frame, with thermal insulation of mineral wool.

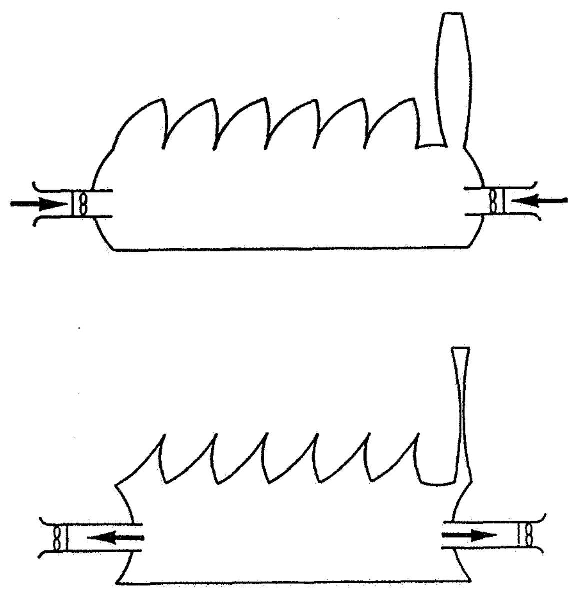

Fig. 1 Pressurization/depressurization tests of industrial building, two fans

Some of the buildings were very leaky and some were very tight. These results caused an animated discussion between manufacturers of building materials, contractors and our building authorities. During that period the National Testing Institute made the decision that equipment for measuring large industrial buildings should be developed. At the same time NORD-TEST asked for a test method especially adapted to industrial buildings.

2. DESCRIPTION OF THE EQUIPMENT

In order to fulfil the demands we could expect that the capacity of the equipment had to be 75 000 m^3/h at 60 Pa. This would mean a large fan and an enormous measuring duct. We had to think of another construction instead of the traditional measuring duct. Tracer gas was the solution to the problem. This way a long measuring duct is unneeeded. By injecting a known constant flow of tracer gas into the air flow upstream the fan and at the same time measuring the concentration of tracer gas in the air flow downstream the fan you can easily calculate the air flow:

$$Q = \frac{q}{c} \cdot 1\ 000\ 000$$

where

Q = air flow through the fan, m^3/s
q = injected tracer gas upstream the fan, m^3/s
c = tracer gas concentration downstream the fan, ppm

The tracer gas injection and mixing device is designed as two rings of tubing located in a short duct of the same diameter as the fan duct. In the walls of the tubing holes with a very small diameter are located radially. This device will inject tracer gas into the whole duct area and give a nearly perfect mixing.

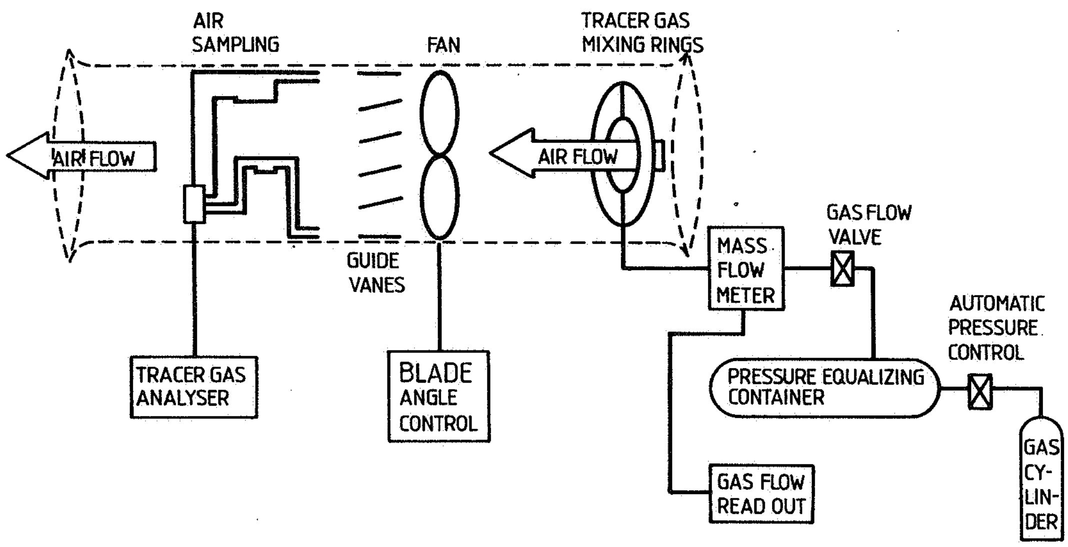

Fig. 2 Schematic view of equipment

The fan is an axial fan type AXICO, size 1 000 mm diameter. The air flow rate is changed by changing the blade angle of the fan. This can be done continuously while the fan is running. In order to measure the tracer gas flow there is an electronic mass flowmeter connected to the injection rings. A steady constant tracer gas flow is obtained by using a pressure equalizing container installed between the gas cylinder and the gas flow meter. The pressure equaling container is equipped with an automatic pressure control. The injection system is working at a pressure of 0,3 MPa.

Downstream the fan four air sampling tubes are located in a duct of the same diameter as the fan duct.

The concentration of tracer gas in the air downstream the fan is measured by an IR-analyzer. As a tracer gas N_2O is used. The fan unit containing the tracer gas injection system and sampling system is mounted on a special trailer. An undercarrige running on rails allow the fan unit to be moved backward and forward and also turned around easily on the trailer. All controls and measuring devices except for the mass flow meter are located in a van. To connect the fan unit to a building there are special connecting boxes.

3. DESCRIPTIONS OF TESTED BUILDINGS

Till now we have carried out three measurements on large buildings using our new equipment. In the following you will find a short technical description of each building.

3.1 Building A

Light-concrete elements attached to a pre-fabricated concrete frame. On the roof there are two rooms, which contain parts of the ventilation system. Those rooms are made of sheet metal attached to a steel frame. Inside the building there is a mechanical workshop.

During the measurement the ventilation system was shut down and sealed off on the outside of the building. All exterior doors were shut, but not sealed off. Internal doors were kept open.

Sizes:	Floor area	4 137 m^2
	Volume inside	36 373 m^3
	Building envelope area, inside walls and roof	6 796 m^2

3.2 Building B

Light-concrete elements attached to a pre-fabricated concrete frame. The building is new and is used as a wholesale store. During the measurments the building was sealed off in the same way as Building A.

Sizes:	Floor area	6 524 m^2
	Volume inside	61 127 m^3
	Building envelope area, inside walls and roof	9 876 m^2

3.3 Building C

Steel-frame with pre-fabricated wall-elements attached to it. The wall elements are made of polystyren covered on both sides with plaster board. The facades are made of sheet metal. The thermal insulation on the roof is made of mineral wool. The roof structure is on both sides covered with sheet metal. The building has a welded plastic air/vapor barrier.

The building was about two years old and used as a tennis hall with six tennis courts and service spaces.

During the measurements the building was sealed off in the same way as Building A.

Sizes:	Floor area	4 236 m^2
	Volume inside	31 622 m^3
	Building envelope area, inside walls and roof	5 809 m^2

4. EXPERIMENTAL RESULTS

In the following you will find the results.

4.1 Building A

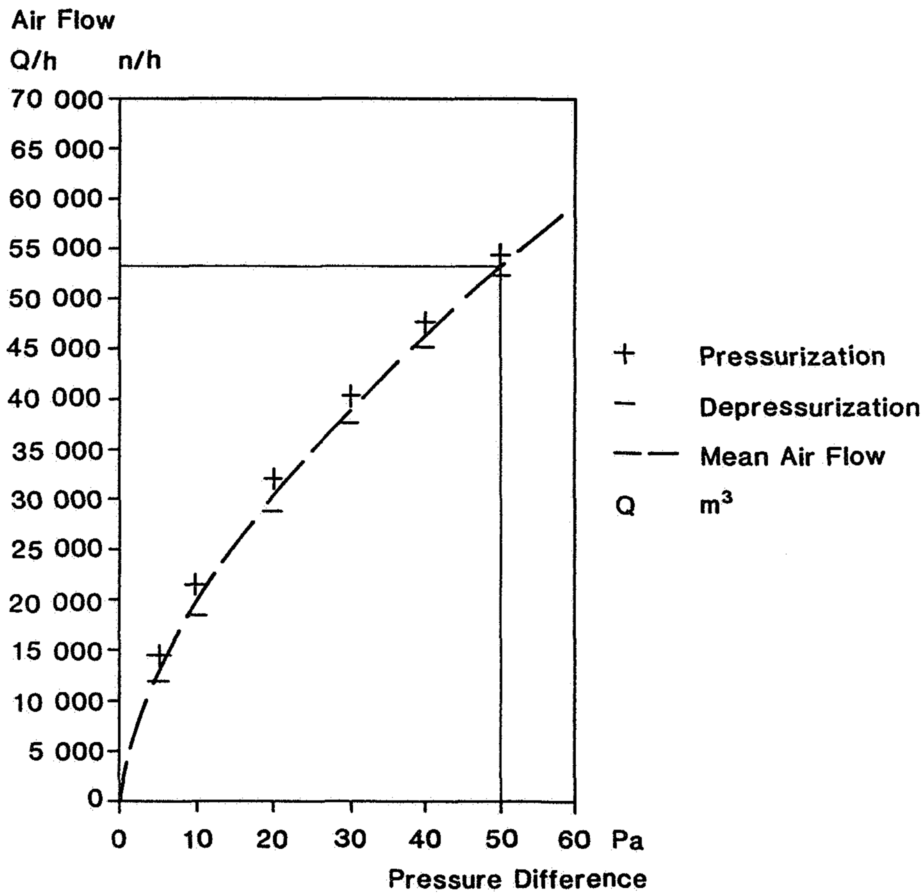

Fig. 3 Air flow as a function of pressure difference

ACH at ±50 Pa: 1,5

Air flow per m^2 of building envelope at 50 Pa (pressurization): 8,0 m^3/h

Air flow per m^2 of building envelope at 50 Pa (depressurization): 7,7 m^3/h

Mean air flow per m^2 of building envelope at ±50 Pa: 7,9 m^3/h

4.2 Building B

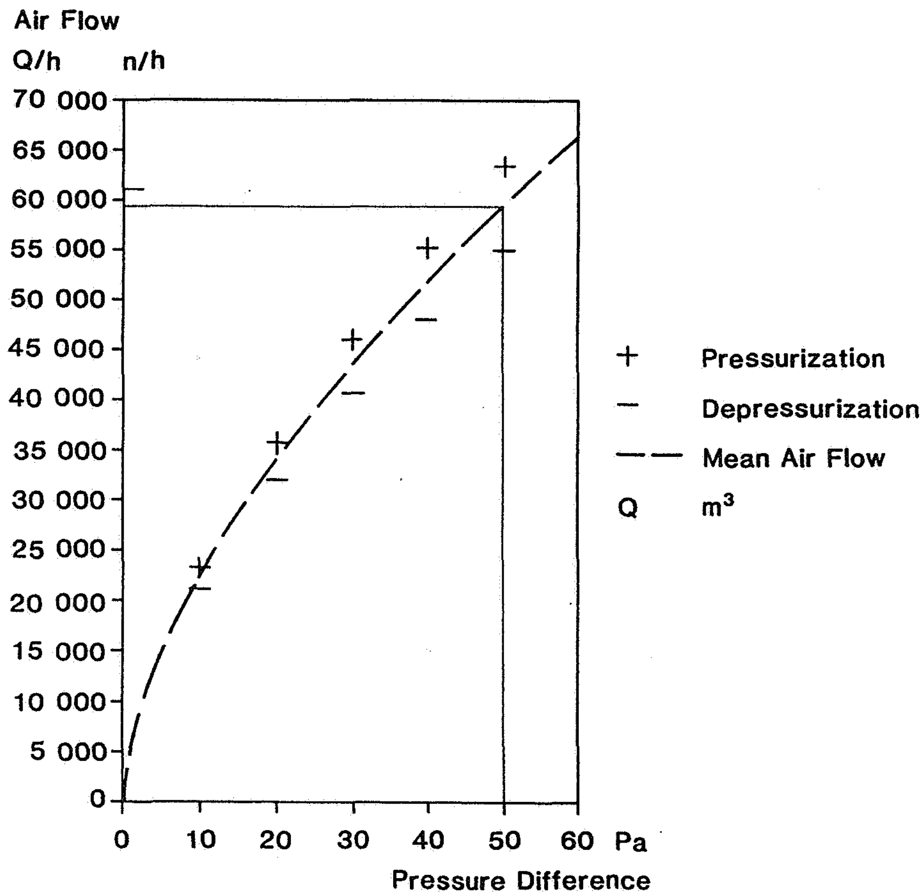

Fig. 4 Air flow as a function of pressure difference

ACH at ±50 Pa: 1,0

Air flow per m^2 of building envelope at 50 Pa (pressurization): 6,4 m^3/h

Air flow per m^2 of building envelope at 50 Pa (depressurization): 5,6 m^3/h

Mean air flow per m^2 of building envelope at ±50 Pa: 6,0 m^3/h

4.3 Building C

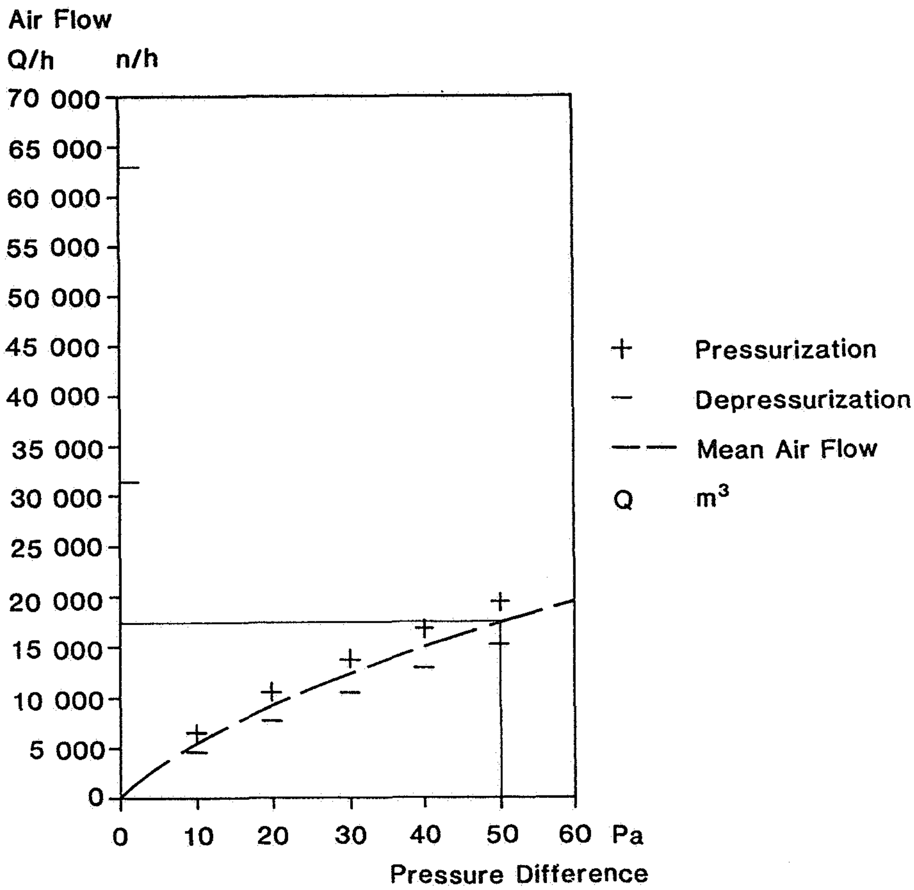

Fig. 5 Air flow as a function of pressure difference

ACH at ±50 Pa: 0,6

Air flow per m^2 of building envelope at 50 Pa (pressurization): 3,4 m^3/h

Air flow per m^2 of building envelope at 50 Pa (depressurization): 2,7 m^3/h

Mean air flow per m^2 of building envelope at ±50 Pa: 3,0 m^3/h

A typical one-family house (1) which meets the recommendations in the Swedish Building Code will have an air leakage in the order of 4,5 $m^3/h/m^2$ of building envelope, at ±50 Pa.

5. CONCLUSION

The tests were performed during a week in June 1983. These preliminary results indicate that the envelopes of industrial buildings can be as tight as the envelope of a one-family house, i.e. a house meeting the recommendations in the Swedish Building Code.

Our goal was to see if we were able to perform pressurization tests on large buildings. The performed measurements show that we have a pressurization measurement system with a capacity of 75 000 m^3/h at 60 Pa. The system can easily be operated by two persons.

There are questions concerning the benefit of testing large buildings. We think that the test results will be a valuable contribution to the knowledge of how to design air tight industrial buildings. It has been claimed that air tight industrial buildings are unneeded, as their ventilation systems will cause large air flows and there are a large number of door openings during the day. This is partly true, but the fact is that most factories are not in use 16 hours a day. The time the factory is closed down the building is of course still heated. Therefore one way to save energy in industrial buildings is to reduce the air infiltration by making them air-tight.

6. REFERENCES

1. BLOMSTERBERG, Åke
   "Air leakage in dwellings" (in Swedish)
   Royal Institute of Technology, Sweden, No 15, 1977