System Effects on Filtration Efficiency

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Abstract

Allergies and over-sensitivity have become very common and are increasing. Every third child and every fourth adult is affected in Sweden. As we spend close to 90% of our life indoors, the quality of our dwellings is of crucial importance. Therefore, a block of flats adapted to the needs of allergic persons was built in Göteborg, Sweden. A technical evaluation was carried out from 1990 to 1996, covering the design, the construction and the handing over and occupation phases. A thorough examination of the particle content of the indoor air was performed. Some outdoor air enters through leakage pathways in the building envelope. The size of this airflow depends on how leaky the envelope is and the balance of the airflow between exhaust and supply air. Another parameter that has an impact on filtration efficiency is how much air bypasses the filter cassette.Results show that a ventilation system installed with a class F7 filter gives a filtration efficiency corresponding to a class F6 filter, depending on leakage effects in the envelope and the system.

Introduction

Between 1992 and 1993 a block of 27 flats adapted to the needs of persons with allergies was built in Göteborg under the name Sundbo (healthy living). Sundbo is, above all, intended for families with asthma and/or respiratory allergies but persons with contact allergies have also been taken into consideration in the planning stage. The objective was to create a good environment for these people both as regards allergies and comfort.

In connection with the debate on the indoor environment the requirements for air quality have increased. One result of this is that the demands on the filters which separate particles from the air have also increased and filters with a higher degree of separating capacity have been installed. A class F7 filter was installed in Sundbo on the supply air side. Since not all supply air passes through the filter, (air leaking from the filter cassette, exhaust surplus, leakage in the building envelope), however, a lower filtration efficiency is obtained.

The percentage of supply air which passes through the filter and the percentage of the supply air which is unfiltered in Sundbo was analysed by means of measurements and calculations. This report gives an account of the results of the measurements and calculations.

Methods

In order to quantify the percentage of supply air that passes through the filter, measurements were made of the leakage in the building envelope, the filter cassette and the balance of the airflow between exhaust and supply air. Calculations of the extent of infiltration and exfiltration were made with a multizone programme, (Herrlin 1987, Bring 1988).

After the percentage of unfiltered air was determined, an analysis was made to find the actual filtration class of the installation.

The air tight capacity of the building envelope was measured in a flat according to (2). All sources of supply and exhaust airflow and the stove canopy were taped shut. Windows and outer doors were closed. The outer door was then exchanged for a door equipped with a fan with which the entire flat could be pressure tested.

The exhaust airflow was measured with exhaust air devices (3) in the flats. The supply air flow was measured with tracer gas (3).

In order to detect ***air that bypasses the filter cassette*** in the duct, the tightness of the cassette was tested. The filter surface, (not the seals surrounding the cassette) was sealed with plastic wrap, after which a pressure-flow curve of the cassette was charted.

In order to obtain the leakage flow during operation, the pressure drop over the supply air filter was measured under normal operating conditions.

The percentage of ***infiltration and exfiltration*** as a function of the flat's tightness was estimated for one year. The climate data used for the period was Stockholm 1974.

The leakage of exhaust air to the supply airflow was measured with tracer gas.

As the percentage of supply air that does not pass through the filter was known, the particle content entering the flat via the supply air was calculated.

Results

Air Leakage in the Filter Cassette

As shown in the diagram, the leakage over the filter cassette in this particular installation was 3.4 l/s which corresponds to 0.9% of the supply airflow.

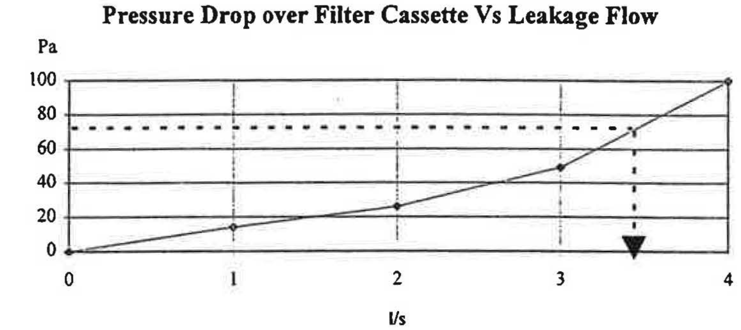

Diagram 1

Surplus Exhaust Air

The percentage of exhaust air was 25 % more than supply air.

Leaks in the Building Envelope

The mean value of the infiltration as a function of the tightness of the building envelope during the heating season (5,200 h) has been calculated. (see Diagram 2).

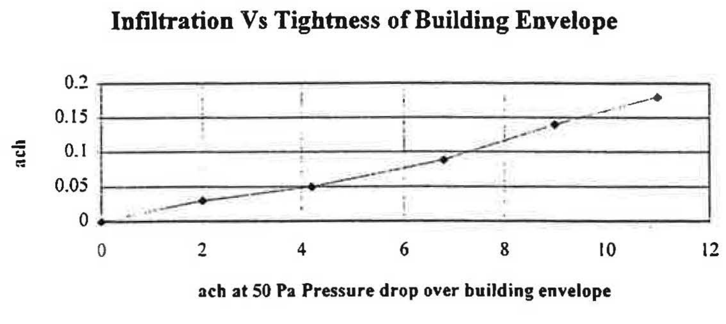

Diagram 2

The diagram shows the infiltration flow in ach during a heating season as a function of the leakage of the building envelope at 50 Pa pressure difference. In the calculation, the supply airflow was the same as the exhaust airflow.

The tightness of the sample flat was 0.7 ach at 50 Pa. As the flat is relatively tight and the surplus of exhaust air is high there is no exfiltration in the flat.

Leakage of Exhaust Air to Supply Air

According to measurements *no exhaust* air leaked over to the supply air.

A Summary of the Impact of the Different Factors

Table 1

	Percentage of supply air bypassing filter, %
Leakage in filter cassette	1
Infiltration due to surplus exhaust air	25
Infiltration due to exfiltration	0
Leakage of exhaust air to supply air	0
Total	26

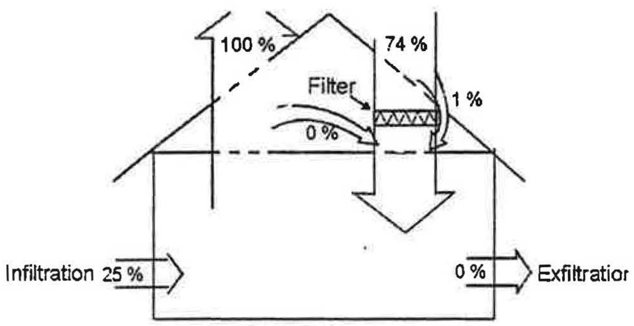

Figure 1. Distribution of airflow in the flat

In the sample flat, 74% (100-26) of the supply air passes through the filter, (see Table 1 and Figure 1). What impact does this have on the particle content of the indoor supply air?

The particle content of the supply air was calculated as a function of the percentage of supply air passing through the filter. The percentage of the air which bypasses the filter is assumed to be unfiltered and to have the same particle content as the outdoor air. A diagram has been designed in which we can read the particle content /m^3 air as a function of the percentage of supply air passing through the filter. Filter classes F6 and F7 have been chosen as parameters in the diagram.

An outdoor load was calculated with a particle content of 10µg/m^3 air (the measured background load at Sundbo). The filtration efficiency for each filter class was used in the calculation, as well as data from measurements of the particle content and fractions of the outdoor air. The particles were assumed to have a density of 1,000 kg/m^3.

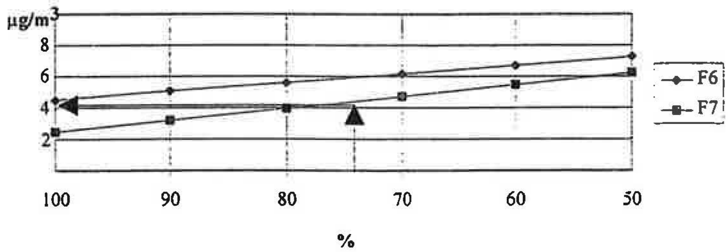

Diagram 3. The particle mass as a function of the percentage of air passing through the filter

The ventilation system where the measurements were made has an F7 filter. As only 74% of the supply air passes through the filter, the particle mass increases from 2,5µg/m^3 (if 100 % of the air passes through the filter) to 4,5 µg/m^3. This increase corresponds to a change from filter class F7 to F6 (see Diagram 3).

Discussion

In order to obtain a good indoor environment in urban settings, it is important to filter the outdoor air. The results of this study indicate that choosing a filter of high class is not enough. If the objective is to filter as large a percentage of the outdoor air as possible, it is important to adjust airflow, the tightness of the building envelope and the tightness of the filter cassette.

With today's building and installation technology, it is possible to maintain a maximum tightness of the building envelope of 0.5 ach at 50 Pa, which gives 2% infiltration, 0, or negligible leakage over the filter cassette and an adjustment of the supply and exhaust airflow to 5% accuracy. The percentage of outdoor air which bypasses the filter will be on the average 7% (2%-5% during a heating season). More than 7% is not realistic for structures built with today's building technology.
In a building with a tightness of 1 ach at 50 Pa, which gives 5% infiltration. 1% leakage over the filter cassette and a surplus of 9% exhaust air, on the average 15% of the air will not be filtered during a heating season.

Table 2. Comparison of installed filter class and obtained class due to system effects

Installed filter class	Obtained filter class due to 7% of supply air bypassing the filter	Obtained filter class due to 15% of supply air bypassing the filter
F9	Somewhat lower than F8	Somewhat lower than F7
F8	F7	Between F7 and F6
F7	Between F7 and F6	F6

The higher the filter class chosen, the more classes lost owing to system effects. Calculations and measurements indicate that it is difficult to obtain a higher filtration efficiency than F7 in buildings constructed with today's building and installation technology.

Acknowledgements

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References

(1) Bring, A., Herrlin, M., 1988. User's Manual - MOVECAMP-PC(R) - An Air Infiltration and Ventilation System Simulation Programme. Bris Data AB, Saltsjöbaden, Sweden.

(2) SS021551 (2nd edition).

(3) NVG (Nordic Ventilation Group),1995, Metoder för mätning av luftflöden i ventilationsinstallationer, (Methods for Measuring Airflow in Ventilation Installations). Meyer Information Förlag AB, Gävle, Sweden.