4483

EXHAUST AIR RE-ENTRY IN TWO MECHANICAL VENTILATION SYSTEMS

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The combination of exhaust and intake vents into a same body on an apartment's outside wall is worth considering when developing new ventilation techniques for dwellings. This allows, for example, free adjustment possibilities and efficient use of building materials and space. The problem when using this ventilation system is exhaust air re-entry into the intake air due to the short distance between the vents.

The purpose of this study was to quantify the severity of the re-entry problem and find out the possibilities for further development.

INTRODUCTION

In dwellings, inadequately diluted exhaust air can contaminate building intake air . The contamination, exhaust air re-entry, leads to health risks if the hygienic quality of exhaust air is low. Re-entry may also spread discomfortable odors. Condensation of exhausted water vapour can cause microbial growth and freezing damages in cold climates (1).

In this study, the re-entry problem in a mechanical exhaust-intake ventilation system was investigated. The intake vent of the system was in the same body with the exhaust vent on an outside wall of the building. Re-entry was highly probable because the distance between the vents was only 7.5 cm.

The exhaust air re-entry in the system was quantified and compared to the re-entry in a mechanical exhaust ventilation system. The re-entry quantity was also compared to contaminant leaks in an apartment building.

concentration into the exhaust air duct of the apartment B 13. The two ventilation adjustments and other procedures were similar to previous measurements.

The first measurements indicate both the tracer leaks inside the building from apartment B 13 and the re-entry of exhausted tracer through supply air routes. In the second measurements, tracer could enter the apartments only through supply air routes. For the comparison of the two sets of measurements, tracer concentrations in the apartments were calculated as percentages of tracer release concentrations (in B 13 or B 13 exhaust air).

RESULTS & DISCUSSION

Exhaust air re-entry

The average re-entry quantity was 2.2 % in the apartment B 13. In the apartments in the building D, the averages varied from 3.8 to 6.8 % (table 1). Thus, the re-entry was one and a half to three times greater in the mechanical exhaust-intake ventilation system than in the control system.

When comparing the dilution factors in table 1, the differences between the ventilation systems are more clear. The effective vent distances are far greater than the actual 7.5 cm indicating the effects of the vent shaping.

The variation in the re-entry quantities especially in the mechanical exhaust-intake ventilation system is large. Most important factors that contribute to the variation are the differences in wind velocity and direction during the measurement periods and the differences of exhaust air velocity between the apartments (3). Some variation can also be a result of non-identical measurement methods (e.g. differences in the sampling and in the concentration averaging time).

Table 1. The exhaust air re-entry, dilution factors and effective vent distances in the two ventilation systems.

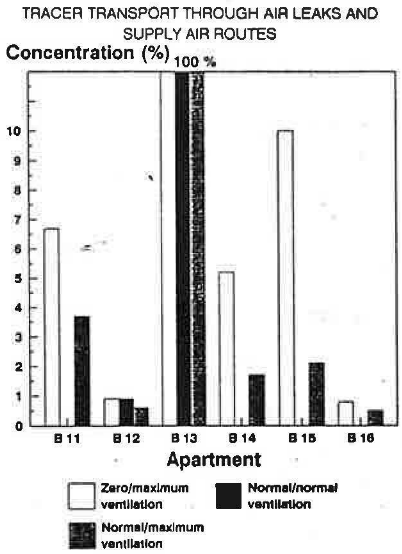
Apartment	N	M	Re-entry (%) Mean ± SD	Dilution factor Mean ± SD	Effective distance (m) Mean ± SD
B 13	581	18	2.2 ± 2.1	150 ± 220	50 ± 44
D 23	508	12	5.3 ± 4.2	32 ± 19	30 ± 25
D 25	446	13	3.8 ± 3.0	41 ± 28	25 ± 19
D 28	271	14	6.8 ± 6.0	19 ± 15	12 ± 9

N is the number of observations.
M is the number of measurements.

Contaminant leaks

When tracer was released in the apartment B 13, the greatest concentrations (0.8 - 10 %) were detected on zero/maximum ventilation (zero adjustment in B 13/maximum adjustment in the other apartments). Concentrations in the other apartments on normal/maximum ventilation were 0.5 - 3.7 %. On normal/normal ventilation the concentrations were clearly smallest, 0 - 0.9 % (figure 1).

The figure 2 illustrates exhausted tracer re-entry into building B. On normal/maximum ventilation some concentrations were also greater (0 - 1.6 %) than on normal/normal ventilation (0 - 0.7 %).



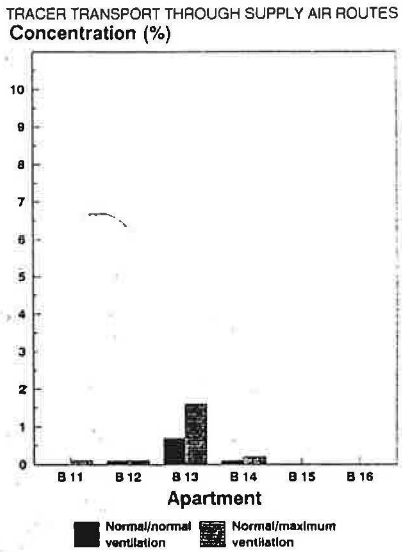


Figure 1. Concentrations in the building B when tracer was released in the apartment B 13.

Figure 2. Concentrations in the building B when tracer was released in the exhaust air of B 13.

The tracer concentrations in the other apartments depend on the ventilation-induced pressure differences between the apartments. Most clearly this can be seen in the figure 1.

Generally highest tracer concentrations were detected in the apartments B 14 (figures 1 and 2) and in B 11 and B 15 (figure 1). These apartments have a common wall, floor or ceiling with the apartment B 13.

In order to compare the two tracer routes, the magnitude of air leaks is roughly evaluated by substraction in the table 2. The greatest differences can be seen on normal/maximum ventilation. 0.5 - 3.6 % of the tracer is transported through air leaks only. The tracer quantities through supply air routes are at least ten times smaller. In the apartments B 11, B 14 and B 15, the magnitude of air leakage is about the same than the re-entry into the apartment B 13. On normal/normal ventilation, minor air leaks can - surprisingly -be detected only in the apartment B 12. Zero or negative results in the other four apartments are due to minimal tracer concentrations (near to the detection limit).

Table 2. The comparison of air leaks to exhaust air re-entry in the building B.

Apartm.	Concentration (%) through air leaks and supply air	Concentration (%) through supply air routes	Concentration(%) through air leaks (supply air routes substracted)
A) Normal/normal ventilation			
B 11	0	0	0
B 12	0.9	0.1	0.8
B 13	100	0.7	Not substractable
B 14	0	0.1	< 0
B 15	0	0	0
B 16	0	0	0
B) Normal/maximum ventilation			
B 11	3.7	0.1	3.6
B 12	0.6	0.1	0.5
B 13	100	1.6	Not substractable
B 14	1.7	0.2	1.5
B 15	2.1	0	2.1
B 16	0.5	0	0.5

A) Normal/normal ventilation: the exhaust fans in B 13 and the other apartments were on a normal adjustment.
B) Normal/maximum ventilation: the exhaust fan in B 13 was on a normal adjustment and in the other apartments on a maximum adjustment.

Limitations

Atmospheric water vapour and carbon dioxide have absorption bands on the analytical wavelength 4.45 µm. The detection limits in the literature vary from 0.07 to 1 ppm.

Here, the detection limits were evaluated on the basis of the calibration curve and averaging error. The re-entry measurements are reliable (concentrations were generally an order of magnitude greater than the estimated detection limits, which varied from 0.15 to 3 ppm). The contaminant leakage measurements, especially the normal/normal ventilation, are not very reliable (concentrations were very near the detection limit 0.15 ppm).

CONCLUSIONS & RECOMMENDATIONS

Compared to the mechanical exhaust ventilation system, one and a half to three times greater re-entry quantities do not support the use of the mechanical exhaust-intake ventilation system in dwellings.

On the other hand, the pressure-induced air leaks between the apartments can transport almost equal contaminant quantities in the mechanical exhaust ventilation system. Pressure differences and contaminant leaks between the apartments should be negligible in the mechanical exhaust-intake ventilation system.

In order to determine the applicability of the mechanical exhaust-intake ventilation system, one needs quidelines for the maximum allowable re-entry. For example in Finland, the recirculation of bathroom and kitchen exhaust air into living rooms is not allowed for hygienic reasons. On the other hand, there are no limits for contamination leaks in the mechanical exhaust system.

The practical advantages still support further development of the mechanical exhaust-intake system. For example, further shaping of the vents or exhaust air velocity increase might reduce the re-entry. The use of dilution factors or effective distances can be useful in testing the effects of improvements.

ACKNOWLEDGEMENTS

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