VENTILATION SYSTEM PERFORMANCE

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Ventilation Systems and Removal of Particles

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1. Introduction

As part of the IEA Research Program Annex 18 "Demand Controlled Ventilation Systems" various ventilation systems were examined in a test room. During research, in addition to thermal comfort issues, removal of particles was of importance. In order to assess ventilation systems, besides using pressure - volume current graphs, the air exchange rate was frequently applied as a criterion. The air exchange rate is, however, defined only for gaseous components. The question arose as to how far the air exchange rate is suitable for assessment of transport of particles or whether a more suitable identification factor can be found.

2. Measurements and Results

To solve the problem different ventilation systems were subsequently installed in the wall of a testing room. Cigarette smoke was produced and distributed homogeneously throughout the room. After switching on the ventilation system to be tested a measurement of the concentration of particles of the size 1μm followed using a particle counter for a period of two hours. The result was an exponential reduction of concentration of particles similar to the tracer gas decay method for assertaining the air exchange rate. A typical measurement of particle concentration is shown in figure 1.

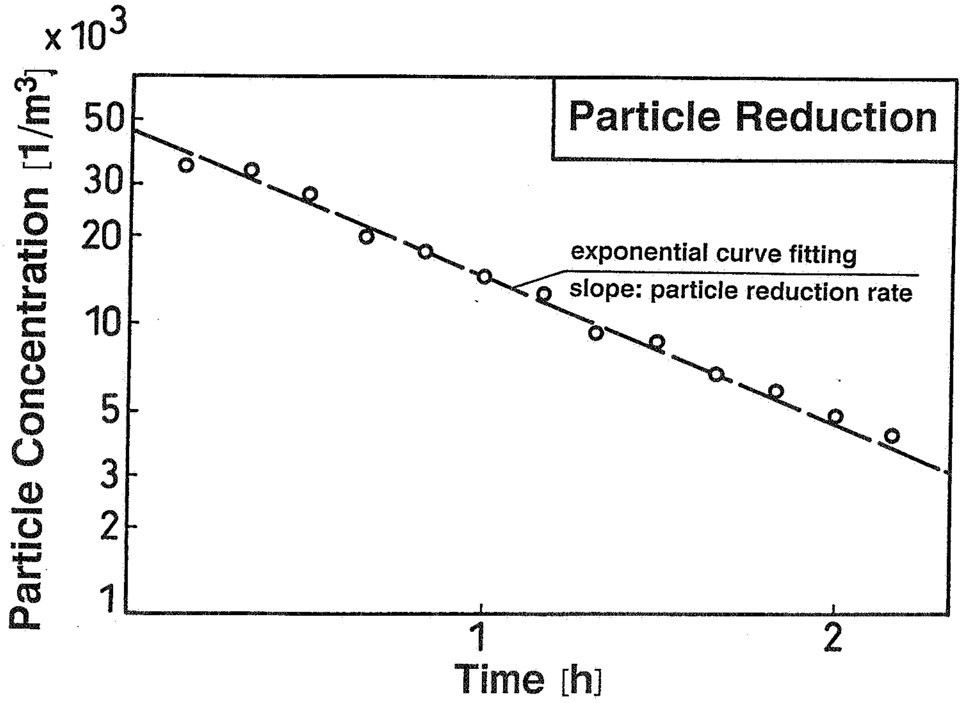

Fig. 1: Typical decay of concentration of particles (size 1μm) after switching on the ventilation system. Semi-logarithmic presentation.

The concentration decay is plotted logarithmically against the time axis. A straight line graph is the result, which depicts the reduction of particles in the room. A particle reduction rate analogous to the air exchange rate of the tracer gas decay method was defined.

$$P_i(t) = P_0 \cdot e^{-p_i \cdot t} \quad (1)$$

or

$$\ln(P_i(t)) = \ln(P_0) - p_i \cdot t \quad (2)$$

respectively

$$p_i = \frac{\ln(P_0) - \ln(P_i(t))}{t} \quad (3)$$

P_i Concentration of particles of the size i [$1/m^3$]

P_0 Concentration of particles at the time t = 0 [$1/m^3$]

p_i Particle reduction rate for particles of the size i [h^{-1}]

This definition of a particle reduction rate p_i enabled us to work out a simple method of comparing the removal of particles by ventilation systems.

Comparison of the particle reduction rate with the air exchange rate showed differences between air exchange (gas) and removal of particles. The results for each ventilation system are presented in table 1.

Ventilation System	Particle Reduction Rate p_1 [h^{-1}]	Air Exchange Rate n [h^{-1}]	Differences [%]
VS 1	1.7	1.3	+30
VS 2	1.3	1.4	-10
VS 3	1.8	1.9	-10
VS 4	3.6	2.9	+20
VS 5	2.4	2.1	+10
VS 6	4.0	2.8	+40
VS 7	3.3	2.6	+30

Tab. 1: Comparison of particle reduction rate against air exchange rate for seven tested ventilation systems.

It is shown that the ventilation systems numbers 1, 4, 5, 6 and 7 removed particles more effectively than gaseous components. The ventilation systems 2 and 3 showed the opposite, giving a better exchange of gaseous components.

3. Conclusions

Test results lead to the following conclusions. The air exchange rate alone does not suffice to describe the removal of particles by ventilation systems. The definition of a particle reduction rate provides a feasible method for comparing ventilation systems with regard to the removal of particles. When using this method it is necessary to take into account that the particle reduction rates are defined for particles of a certain size and depend on the type of the particles. Particles in the air intake are either to be avoided or suitably taken into consideration.

4. References

[1] Schwab, R.; Mayer, E.: Fortschrittliche Systeme für die Wohnungslüftung. Teil A: Raumklimatische Laboruntersuchungen. Bericht RB-10/1989 des Fraunhofer-Instituts für Bauphysik, Holzkirchen (1989).