VENTILATION SYSTEM PERFORMANCE

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Demand Controlled Ventilating Systems
- Practical Tests -

Dr.-Ing. H. Werner

Fraunhofer-Institut für Bauphysik
Bereich: Wärme, Klima
Leitung: Prof. Dr. Dr. hc. K. A. Gertis
Holzkirchen, Fed. Rep. Germany

Synopsis

As part of the IEA Research Program Annex 18 "Demand controlled ventilating systems" were tested in an one family testhouse in relating to energy and ventilating specific aspects. The investigation should show whether demand controlled systems are useful in dwellings or not. Following items were checked:

- Infiltration characteristics of the testhouse
- Ventilation characteristics of different systems like temperature distribution, air mouvement, ventilating efficiency, air exchange and air quality

Different systems were linked with various sensors for air humidity, oxidable gazes and carbondioxyd.

1. Infiltration characteristic of the testhouse

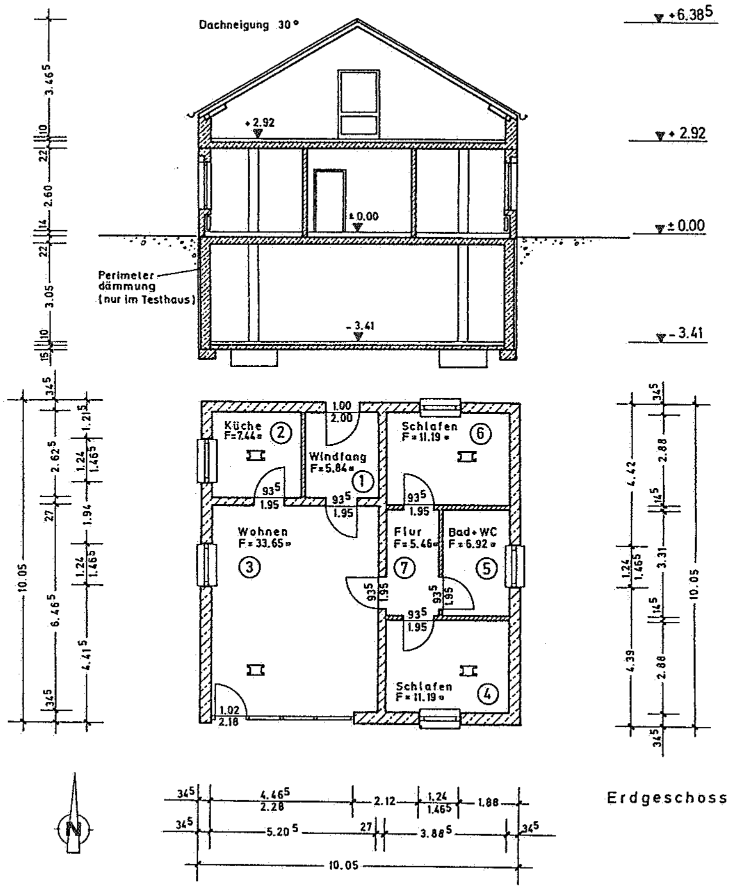


Fig. 1: Plan of testhouse

First the air infiltration characteristic of the test-building without ventilating systems has been measured. The floor area of the testhouse is 82 m^2, the height of the floor is 2,6 m. A "Blower-Door" was used to (de-)pressurize the testbuilding; in both cases a nearly identical leakage of about 300 m^3/h for a pressure difference of 50 Pa was found out. Using the equation

$$\dot{V} = k \cdot \Delta p^n \ [m^3/h]$$

a flow coefficient k = 23,9 and a pressure exponent n = 0,65 has been calculated.

window	wind-speed [m/s]	inside temperature [°C]	outside temperature [°C]	airchange [h^{-1}]
	0	21.3	4.2	0.05
shut	1.5	1.5	-0.2	0.10
	8	21.1	8.0	0.25
	0	21.0	11.0	0.15
	1,5	21,1	7.1	0.40
open	3.0	21.2	16.3	0.50
	7.0	21.2	7.4	1.11

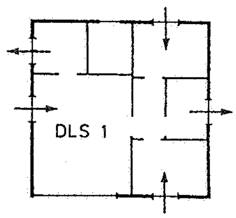
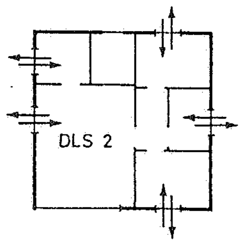
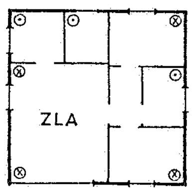
Tab. 1: Airchange rates by shut and opened window in one room by different windspeeds.

Nominal air exchange rates have been determined with the tracer gas decay method. For calm a rate of about 0,05 h^{-1} was measured, for low wind forces the air exchange rate was about 0,1 h^{-1} and for strong wind about 0,25 h^{-1}. Because of these results the testhouse can be called as "air-tight". Window ventilation caused air exchange rates between 0,5 and 7,5 h^{-1} corresponding to the number of tilted windows and different wind forces. After having measured the lenght of all joints a joint-coefficient of 0,13 $m^3/h \cdot m \cdot Pa^{2/3}$ was calculated. Pressurisation test data led to an air exchange rate of N_{50} = 1,4 h^{-1} at 50 Pa. For calm and low wind forces the equation for the "infiltration air exchange rate"

$$N_{inf} = N_{50}/20$$

could be testified through tracer gas measurement data.

2. Airflow- and air exchange rates

running mode	wind-speed [m/s]	wind-direction rate $[h^{-1}]$	air-change	Location of Ventilating System
off	1.5	E	0.10	Decentral Vent. Syst. 1 
max. power	1.5	E	0.55	
off	2	W	0.10	Decentral Vent. Syst. 2 
min. power	2	E	0.30	
max. power	2	E	0.60	
off	0 6.5	- W	0.10 0.25	Central Vent. Syst. 
on	2 7	E W	1.0 1.05	

Tab. 2: Measured airchange rates with decentral vent. systems. The ground plan shows the number and position of the devices.

The air flow rates of the decentral ventilating systems have been measured before installation. Maximum airflow rates of most systems were about 35 to 55 m^3/h; systems with a closing device were sufficiently airtight. In some cases the measured maximum air rates have been about 50 % lower than announced by manufacturers. Then the decentral systems were installed in the testhouse and the air exchange rates have been measured under different climatic conditions and running modes. The airtightness of the building was not affected with decentral systems with a closing device (air exchange rates about 0,10 h^{-1} for calm). Using a central ventilating system rates from 0,10 to 0,30 h^{-1} corresponding to different wind forces have been measured. Running with maximum power the decentral ventilating systems caused air exchange rates about 0,50 h^{-1} in the ground floor of the testbuilding. The central system caused rates about 1.0 h^{-1} independent of climatic conditions.

3. Ventilation perfomance

Draught effects have been noticed only with the strongest decentral system with an air flow rate of about 100 m^3/h. The other systems with lower air flow rates located at the top of the window frames or the central system did not cause draught. Using decentral systems noise levels have to be accepted. Comparing measured and calculated air change rates it was noticed, that by use of all decentral systems with combined supply- and exhaust air the measured air exchange reates have been considerably lower than the calculated ones. This effect was noticed for all running modes and can be explained by a short circuit airflow.

4. Humidity controlled systems

A relative humidity controlled ventilating system with a central exhaust fan and decentral air inlets has been installed in the testhouse. For the adjustable summer mode a range of regulation from 45 to 65 % r.h. corresponding to an exhaust airflow from 38 to 110 m^3/h was found out. For winter mode a range of regulation from 35 to 50 % r.h. was measured, corresponding to an exhaust airflow from 75 to 110 m^3/h. Using the booster divice in the kitchen air outlet the airflow could be increased to 120 m^3/h. The additional exhaust air opening was closed automatically after 70 minutes. The measured air exchange rates caused by this system lay between 0,25 and 0,65 h^{-1} corresponding to the chosen running mode and relative indoor humidity; draught effects have not been noticed. The examined system can be used for a humidity controlled basic ventilation of dwellings. The booster device allows a considerable increase of the kitchen exhaust airflow when needed.

In the kitchen and the bathroom of the testhouse decentral ventilating systems were connected with capacitive humidity sensor. Using this configuration relative humidity could be controlled without problems. For a decrease of high humidity caused by the simulation of cooking or showerbath with decentral ventilating systems a runtime of about 1 or 2 hours was necessary. For practical use however inexpensive humidity sensors have to be developed.

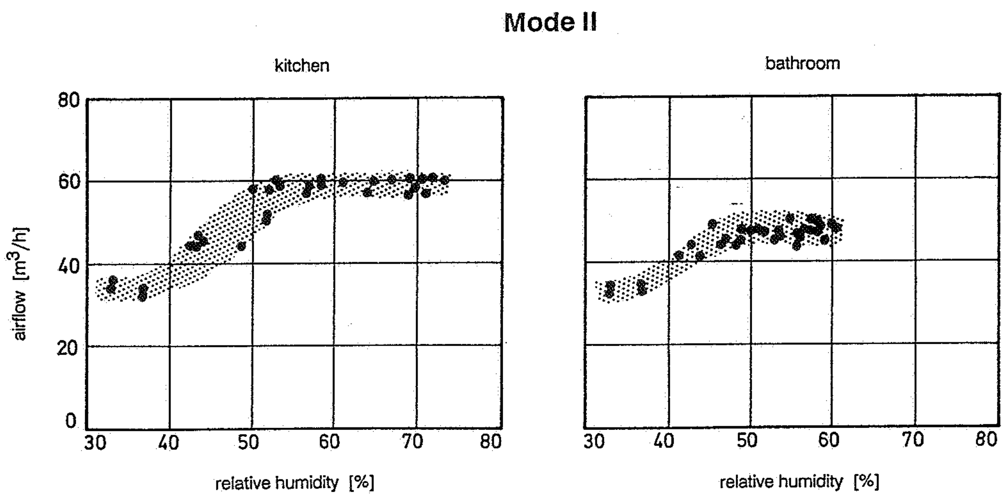


Fig. 2: Measured values of airflow through air outlets in kitchen and bathroom for different rates of relative humidity and "mode II". (Range of regulation announced by manufacturer is from 23 % to 58 % r.h.)

5. Air quality control

The regulation characteristics of the examined air quality controllers seem to be adequate for a demand controlled ventilation. The sensitivity can be chosen and allows a wide range regulation of air quality. The examined sensors reacted on tobacco smoke, solving agents and human odor. In order to decrease the air-pollution caused by the smoke of 4 cigarettes in the living room runtimes of about 1 - 2 hours were necessary with most of the decentral systems. A CO_2-controlled ventilating system could not be realized with most of the decentral systems. The air flow rates of these systems were too low to prevent an increase of the CO_2-concentration over 0,1 Vol % (Pettenkofer-limit) when for instance four persons sat in the living room. Assessing to demand controlled ventilating systems in general can be said that a control of relative humidity can be realized with air change rates about 0,5 h^{-1} (basic ventilation). For an effective control of air quality (tobacco, smoke, CO_2, odor) higher air flow rates are required.

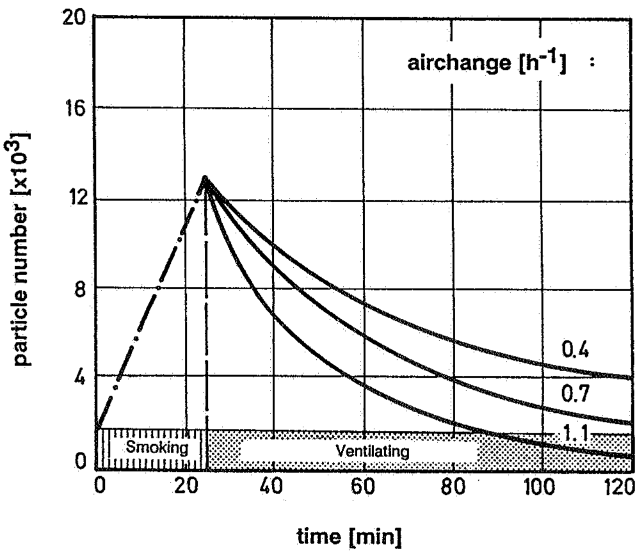


Fig. 3: Number of 1 µm-particles after cigarette smoking with different ventilating systems

6. Summarization

This research has given information about the ventilating performance of different ventilating systems for dwellings and the usability of air quality and humidity sensors for demand control. New questions refering to measurement and calculation techniques are seen:

- measurement methods for leakiness of joints
- determination of air flows between rooms
- distribution of supply air in rooms

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