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EXPERIMENTAL EVALUATION OF A HYGROREGULATING NATURAL VENTILATION SYSTEM

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ABSTRACT

In the framework of a CEC-DGXVII demonstration project a hygroregulating natural ventilation system is being evaluated in 52 occupied apartments. Therefore a multi purpose automated tracer gas equipment has been developed enabling the detailed monitoring of air flow rates in 60 rooms continuously. In addition the humidity levels, CO_2 levels and air temperatures are measured as well as the outdoor climate. The first measurement campaigns partly used for evaluation of the measurement system are reported and show an impressive amount of data enabling various types of detailed analysis. The ventilation and air quality parameters of the apartments equipped with the humidity controlled ventilation system are compared with those of the reference apartments.

1. INTRODUCTION

The detailed study of the flow rates in natural ventilated apartments, as well as the air quality in these apartments, is carried out in the framework of the CEC-DGXVII demonstration project "Passive humidity controlled ventilation in existing dwellings". The main intention of this project is the study of the possibilities of humidity controlled air inlet and outlet devices in comparison with ordinary inlets and outlets. Therefore, a detailed monitoring programme is running in 3 apartment buildings of which the main features are indicated in table 1.
All apartments have a ventilation duct in the kitchen, WC and bathroom.
A detailed description as well as the theoretically predicted performance of the humidity controlled inlet and outlet devices is given in (1).
This paper gives global results of the first measurement campaigns. More refined results will be published later on.

TABLE 1. Characteristics of the monitored buildings

Location	Year of construction	Number of floors	Number of apartments monitored	
			Reference	Humidity controlled
Namur (Belgium)	1978-1982	9	9	9
Orsay (France)	1969-1973	5	10	10
Schiedam (The Netherlands)	1965	10	7	7

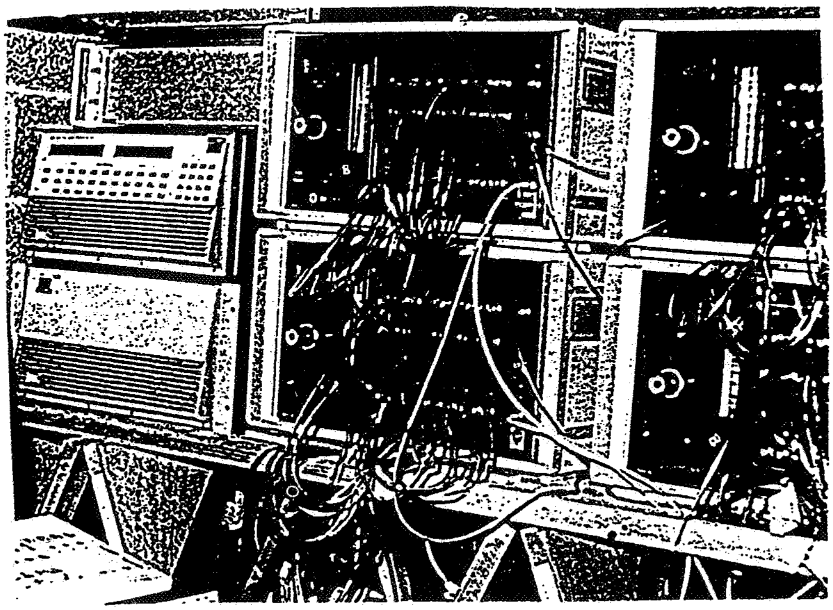

FIGURE 1. The BBRI-MATE System

2. THE MEASUREMENT SYSTEM

The ambition of the project is rather high : a detailed study of the ventilation and air quality in some 20 apartments at the same time. For practical and budgettary reasons, most of the attention is focused on the ventilation ducts. The MATE-system (Multipurpose Automated Tracergas Equipment) allowing to follow 60 channels automatically (fig. 1) was developed for this purpose. The system determines for each duct : the air temperature (°C), the flow rate (m^3/h), the CO_2-level (ppm), the humidity level (Pa, g/kg).
Wind direction and velocity, outdoor air temperature, humidity and CO_2-level are also recorded. One complete cycle of all measurements requires some 20 minutes.
It is planned to have 3 to 4 measurement campaigns in the 3 buildings, each campaign taking some 3 to 4 weeks or between 6 and 12 months of data. The first complete campaign started in October 1989 and the last campaign is planned for the spring of 1991.

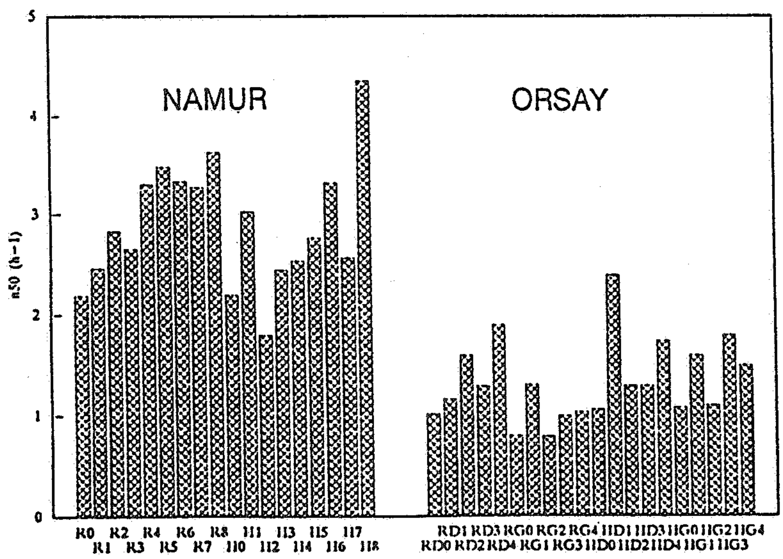

FIGURE 2. Pressurization results Namur and Orsay

The measurement of flow rates, CO_2- and humidity levels is done by one centralised sensor for each variable. Calibration tests indicated an accuracy of better than 10 % in the range 10-80 m^3/h.

3. AIRTIGHTNESS OF THE APARTMENTS

The airtightness of 18 apartments in Namur and 20 apartments in Orsay, as well as the leakage distribution was measured. The results are presented in figure 2.
The apartments in Orsay are very airtight. The air change rate for a pressure difference of 50 Pa is on the average 1.3 h^{-1}.

4. FLOW RATES - AIR QUALITY

4.1. Recorded data

The amount of data collected is impressive, each day some 60 000 observations of flow rates, air temperatures, humidity and CO_2 levels in the kitchen, WC and bathroom of each of the 20 apartments as well as the outdoor temperature, wind speed and direction, humidity and CO_2 levels, various wind pressures on facades are recorded.
An analysis of the measurements in Orsay for the 2 measurement periods 1-19 October 1989 and 6-28 January 1990 is given in 4.2 to 4.5.

4.2. Flow rates

The average daily flow rate for the 20 apartments in Orsay is shown in fig. 4 as a function of time.
The average air change rate for all 20 apartments is 0.62 h^{-1} (0.71 for reference apartments, 0.53 for humidity controlled apartments). The average weather conditions were : θe = 9 °C and v = 3.1 m/s, which are comparable with the average winter conditions in this region.
Fig. 3 shows that the total flow rate is rather stable with the exception of the period 22-28 January, characterised by very high wind speeds.

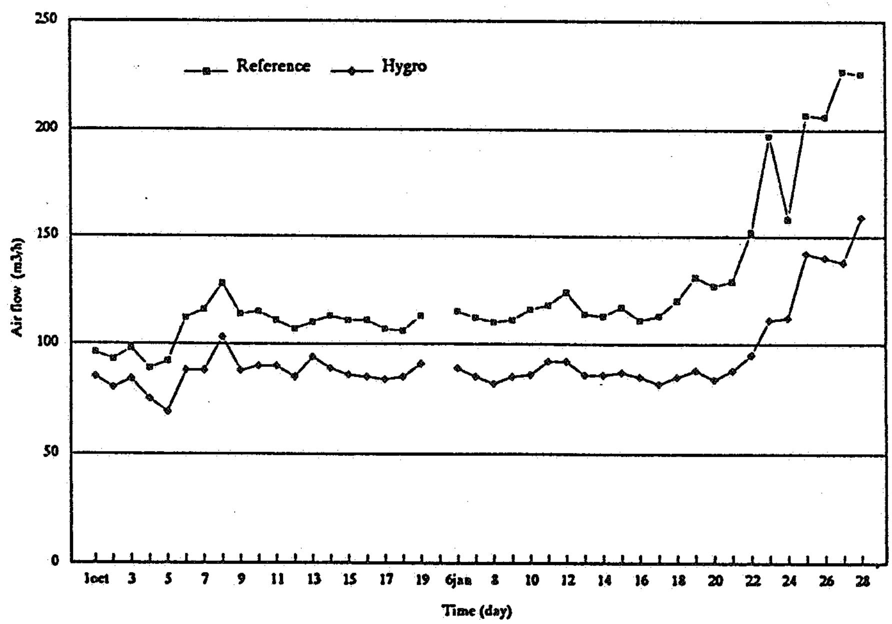

FIGURE 3. Daily average flow rates for the average reference and humidity controlled apartments in Orsay.

TABLE 2. Minimum, average and maximum daily values for the average of the 10 reference apartments and the 10 humidity controlled apartments, respectively, Orsay, 1-19 October 1989 and 6-28 January 1990.

	MINIMUM		AVERAGE		MAXIMUM	
Total air change rate (h^{-1})	0.50	0.39	0.71	0.53	1.28	0.90
x kitchen (m^3/h)	36	30*)	53	49*)	94	87*)
x WC (m^3/h)	23	17	37	21	69	35
x bathroom (m^3/h)	26	16	37	24	65	37
Outside temperature (°C)	0.4		9.1		16.0	
Wind speed (Trappes) (m/s)	1.4		3.1		8.1	

*) Ordinary outlet grilles

According to (2) we propose the following model

$Q = Av^2 + B\Delta T + C$ (m^3/h)

which in our case leads to :

$Q = 69 + 2.1v^2 + 1.9\Delta T$ (m^3/h)

The standard deviations are s_A = 0,22 (F=91), s_B = 0.59 (F=11) and r = 0.86

4.3. CO_2-levels

Fig. 4 shows the average CO_2-levels and extracted CO_2-quantities for the Orsay apartments. Table 3 gives a summary of the results.
There is a significant difference in extracted CO_2-quantities between the reference and the humidity controlled apartments. This is probably due to a difference in occupation pattern. The difference between the highest and lowest average daily values is very large, especially if one knows that the outdoor CO_2-concentration is 400 ppm. The average CO_2-level is - as might be expected - strongly correlated with the total air change rate.

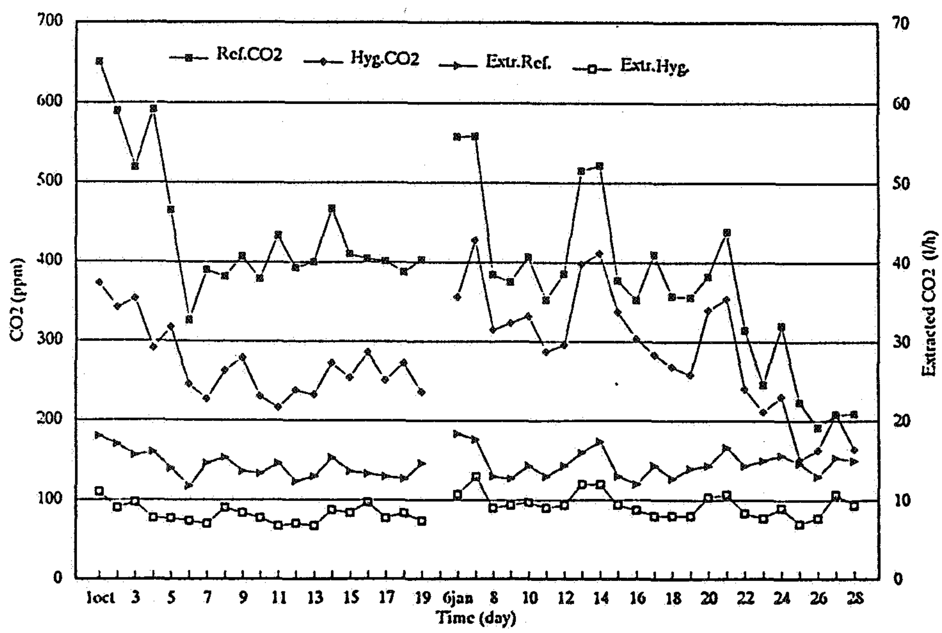

FIGURE 4. Average CO_2-levels and extracted CO_2-quantitites for the Orsay apartments.

TABLE 3. Minimum, average and maximum daily values of CO_2 for the average of the 10 reference apartments and of the 10 humidity controlled apartments; Orsay, 1-19 October 1989 and 6-28 January 1990.

	MINIMA		AVERAGE		MAXIMA	
	REF.	HUMID.	REF.	HUMID.	REF.	HUMID.
CO_2-levels						
* average (ppm)	590	550	800	680	1 050	830
* kitchen (ppm)	630	550	850	710	1 100	880
* WC (ppm)	580	550	700	690	1 060	840
* bathroom (ppm)	560	540	750	650	990	760
CO_2-quantities						
* total (l/h)	35	20	43	27	55	39
* kitchen (l/h)	15	11	20	15	25	23
* WC (l/h)	10	4	12	6	17	9
* bathroom (l/h)	8	4	11	6	19	9

If we assume the formula :

$CO_2 = 400 + A/Q$ (ppm)

we find :

$CO_2 = 400 + 48073/Q$ (ppm)

where the standard deviation is $s_A = 1066$ (F=45) and r = 0.82

The CO_2 quantities extracted give a good picture of the occupancy (since each occupant produces some 15...20 l/h of CO_2) at the condition that there are no other CO_2-sources like gas cookers and that most of the air leaves the apartments through the ducts. A first indication of the importance of air leaving the apartment through the facade openings is obtained by asking the numbers of occupants during the night.

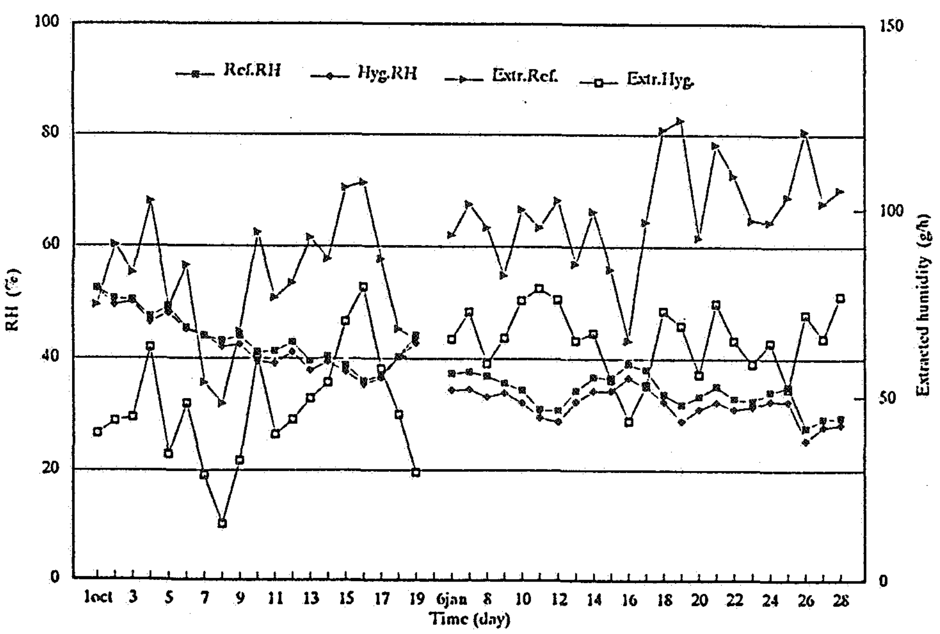

FIGURE 5. Daily average humidity levels and daily extracted quantities of water vapour for the Orsay apartments

TABLE 4 Minimum, average and maximum daily values for the 10 reference apartments and for the 10 humidity controlled apartments in Orsay, 1-19 October 1989 and 6-28 January 1990.

	MINIMA		AVERAGE		MAXIMA	
	REF.	HUMID.	REF.	HUMID.	REF.	HUMID.
Relative humidity						
* average (%)	28	25	38	37	53	52
* kitchen (%)	29	28	39	39	53	54
* WC (%)	26	24	35	34	46	48
* bathroom (%)	28	25	41	37	59	55
Extracted humidity						
* total (g)	144	46	273	170	372	238
* kitchen (g)	50	30	106	86	153	138
* WC (g)	24	-6	62	31	94	49
* bathroom (g)	65	22	105	53	139	77

4.4. Humidity

There are no important problems observed due to mould growth or condensation. Fig. 5 shows the average humidity levels and the water vapour quantities evacuated per day. Table 4 summarizes the results.

5. CONCLUSIONS

Detailed measurements of extraction flow rates and air quality parameters are running in some 52 apartments in France, Belgium and the Netherlands. The results of the first measurement campaign show very interesting results. The first analysis of the measurement data as well as the detailed calibration measurements on the measurement system indicates a very large potential for various types of analysis.

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