DEMAND CONTROL VENTILATION SYSTEMS : PERFORMANCES OF CO2 DETECTION

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ABSTRACT

In France, in non residential buildings, these systems are generally controlled by either a CO_2 sensor or optical movement detection (infrared).

The part of the study we present here was to determine :

- laboratory tests methods to assess the performances of CO2 sensors for ventilation application.
- the working performances of these sensors, and particularly the long term stability in a meeting room.
- a methodology to assess the performances of CO2 DCV system in French technical agreement

The main results of this study are :

- it is easy to characterize (to calibrate) the sensors
- the long term stability is good enough,
- the slight concentration gradient makes the choice of sensor location easier.

A methodology to assess the performances of CO2 controlled ventilation system (both for IAQ and energy) has been developed within the framework of a technical agreement

INTRODUCTION

The DCV systems for premises service industries with variable activity in the time are interesting solutions allowing real energy saving without sacrificing for all that the obtaining of a good IAQ. However, to characterize correctly their performances in the respect for the statutory requirements concerning the QAI but also the energy decreases, the passage of a Technical Agreement is necessary in France.

This paper defines for the sensors measuring the rate of CO2 of the trial modalities allowing characterizing them in laboratory

For the sensors of CO2, a calibration is perfectly feasible and reproducible. The reaction of the sensor to increasing levels of content in CO2 is recorded. The obtained performances can be rather different from precision announced by the manufacturers.

The behaviour in work of the sensors was tested in a meeting room. This phase showed that, in the instrumented room (42 m^2), there was no pressure gradient of concentration of CO2 what confirms the results of a previous bibliographical study.

The position of the sensor in the room thus has not enough influence on its answer if it is not situated in a draught. The follow-up in the time of the sensors of CO2 showed drift in the time (eight months) of the answer of the sensors.

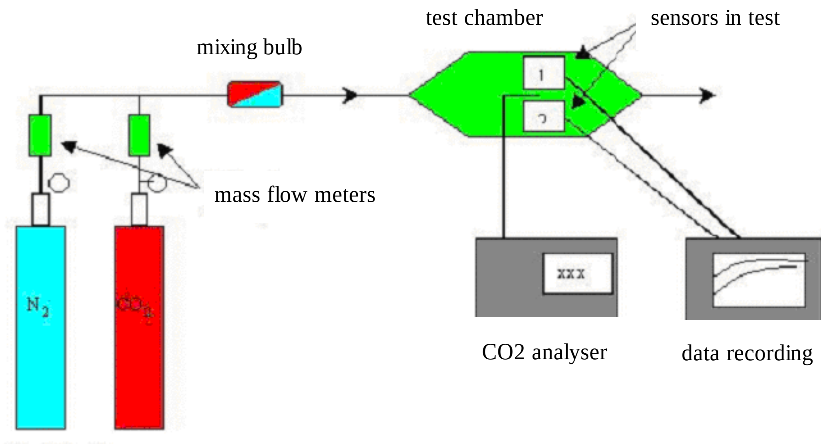
LABORATORY TESTS

Test bed

The sensor tests consist in estimating their answer in a CO2 atmosphere for various concentrations corresponding to their operating range. The test line includes:

- a test chamber in which are placed the sensors to be tested.
- mass flow meters allowing the injection of the regulated flow (mixture CO2 / N2). Flow meters are calibrated, so a control of the concentration is not necessary.
- bottle of pure nitrogen and bottle of mixture CO2/N2 with concentration guaranteed by the supplier.
- a data recording system

For the tests, the sensors (2 at most) are placed in the test chamber.



For 3 to 6 values of CO2 concentrations are determined, according to the range of each sensor (even more if the range of measure of the device is widened) and they are injected in the test chamber. Considering the weak volume of the test chamber the completion of this one is considered as immediate.

For each sensor we measure the slope of transition between two definite values as well as the value of stabilization, by rising in content of CO2 and by coming down(by falling). The values are the same on the way up and in the way down. The values of stabilizations are compared with the real values in the test chamber for qualifying the sensor.

Results

The attempts show the absence of hysteresis ; a calibration in increasing values only is sufficient.

The response times are about 5 or 7 minutes and seem sufficient enough for the concerned applications. We note however that it is here about a response to an immediate level in a test chamber of weak volume. The sensor response time in field can be different.

The average distances (answer), are given in the table hereafter below and compared with the precision announced by the sensors builders. It is necessary to note that our uncertainties of calibration are 1 % on the gas standard and 1 % on flow meters and drives to a total calibration uncertainty of 2 %.

	Average deviation		Maximal deviation		Manufacturer value
Sensor	ppm	%	ppm	%	
A	124	10	198	17	± 100 ppm
B	80	8	114	16	± 50 ppm
C	213	23	483	66	± 140 ppm
D	72	10	189	19	± 150 ppm
E	143	12	481	44	± 90 ppm

In a general way the raised average deviation are of the order of 100 - 200 ppm, what is quite superior to the announced precision.

It is also necessary to consider that the drift in the time of the sensors is not integrated because the tested probes are new.

We also note that the results obtained by the sensors E, in double chamber and automobile grading are not appreciably better.

FIELD TESTS

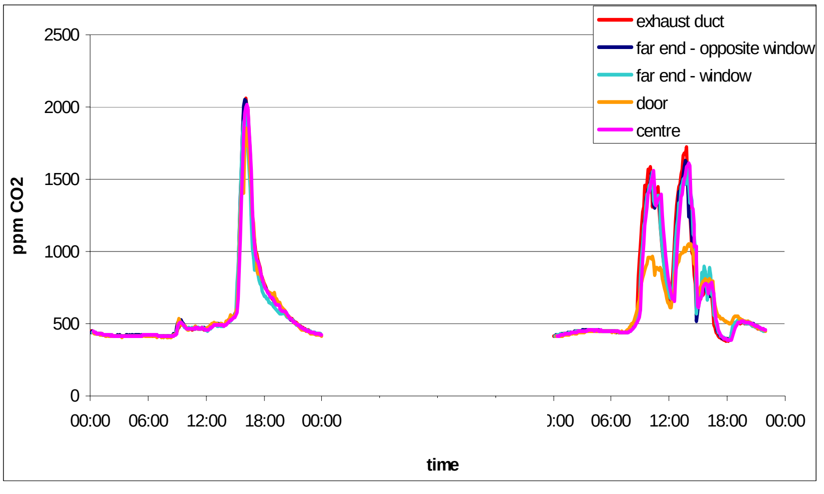
The CO_2 sensors previously tested in laboratory have been implemented in a meeting room. This meeting room is 7 m long, 6 m wide and 2,7 m height. It is equipped with window sliding with poor airthightness.
A mechanical ventilation system has two outlets (60 m3/h each).

CO_2 concentration gradient in the meeting room.

The CO_2 concentration has been continuously monitored (photo acoustic analyser) in five points :

- in the extract duct (behind one outlet),
- near the window in the far end of the meeting room
- in the far end of the meeting room opposite the window
- near the door
- at the centre of the room

The graph hereafter watches for two days the concentration in CO_2 :



The first day we can notice that all the curves are merged : there is thus no CO2 concentration gradient in the meeting room.

The second day, the CO2 concentration near the door is lower than the concentration in the other points of the room because the door has remained half-opened.

In both cases, and although the window is not airtight we don't notice dispersal for the point of measure situated near this one.

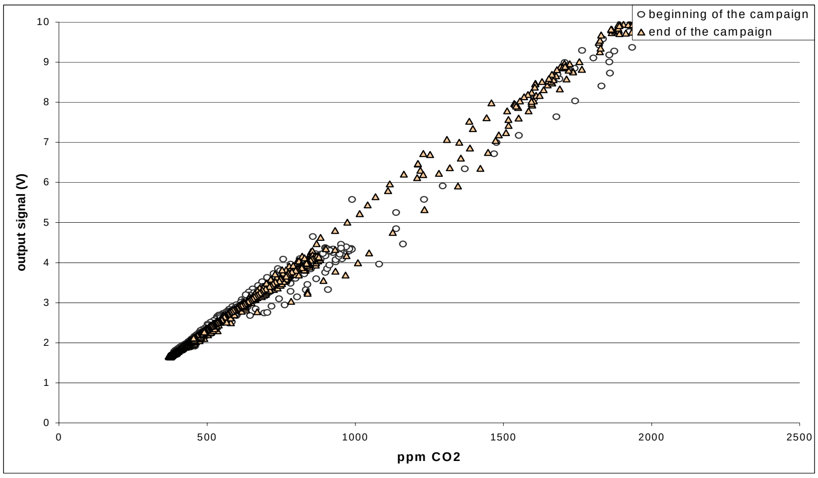
We can conclude that the CO2 concentration is homogeneous in all the volume with the exception of the zone situated near the front door.

It allows that there are only few constraints on the position of the sensor in the room as far as is avoided the zones of fresh air :

- nearness the windows,
- nearness the internal doors,
- nearness the inlets,

Performances in work of the CO2 sensors

The graphs below show for one CO2 sensor (but it's the same for all the sensors) the output signal (in Volt) according to the CO2 concentration (ppm) measured in the extract duct in the beginning of the measurements campaign (april 2002) and at their end (november 2002).

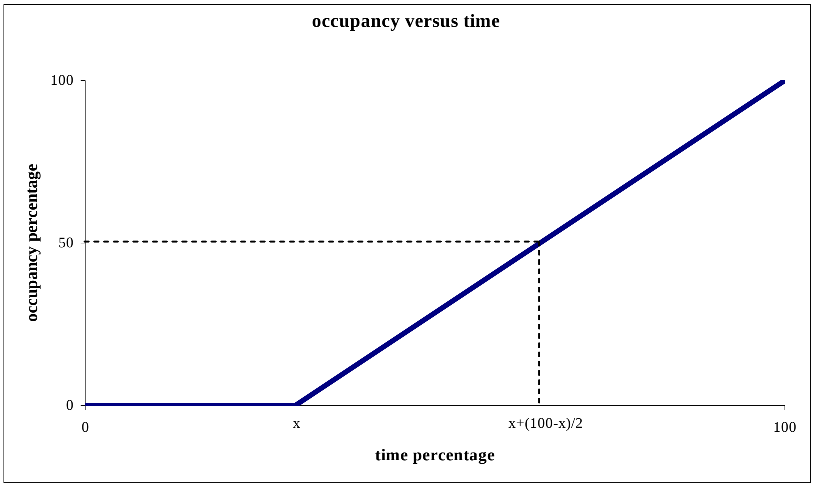


We can note that, in eight months, there was no drift in the time of the response of the sensors.

ASSESSMENT OF PERFORMANCES FOR A TECHNICAL AGREEMENT

The new French thermal regulation (RT2000) takes into account energy saving by controlled ventilation system subject to maintain indoor air quality ; a technical agreement (Avis Technique) allows both to make sure of IAQ and to quantize energy saving.

A survey has given informations of occupancy of tertiary premises (offices, meeting rooms, primary et secondary classrooms, cinemas, …). The time schedule occupancy has been simplified as follow :



x depends on premises.

The energy earning will be calculated on the base:

- of the rate of occupation,
- by taking into account a minimal flow during the period modulated of (generally 10 % of maximal flow)
- by taking into account the precision of the used sensors,

Example of a landscaped office

- maximal flow : Qn
- rate of inoccupation : x = 10 %

  ⇒ during 10 % of time 0.1*Qn

  ⇒ during 90 % of time Qn / 2

equivalent energy airflow rate

- without DCV : Qn
- with DCV system : ((90 * Qn / 2) + (10 * 0,1*Qn))/100 = 0,46 Qn

Consideration about uncertainties

The French IAQ requirement is a maximum of 1000 ppm CO2 ; a note indicates that this value corresponds to 700 ppm above outside. Taking into account an average outside value of 400 ppm, the technical agreement accept a target indoor value of 1100 ppm.

The requirement is 700 ppm above outside : if the sensor has a precision of y ppm it will be advisable to adjust the controlled value so that the internal distance between inside and outside is (700-y) ppm.

The airflow of the system (on occupancy) will be affected by a coefficient of 700 / (700-y).

So the equivalent airflow rate is = (700 / (700-x)) * (90 * Qn / 2) + (10 * 0,1*Qn))/100

The table hereafter gives the influence of the precision x on the energy equivalent airflow :

y (ppm)	**20**	**50**	**100**	**200**
Q (m3/h)	**47,3 Qn**	**49,5 Qn**	**53,5 Qn**	**64,0 Qn**

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