PERFORMANCE OF DEMAND CONTROLLED VENTILATION : CASE STUDY, ENERGY SAVINGS AND PRACTICAL RULES

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SYPNOPSIS

In order to assess the real performances of different demand controlled ventilation (DCV) systems, two of them were installed in meeting rooms of an office building.

The first system is controlled by movement detection on terminal units and has been installed in a small meeting room which is regularly used.
The second system is controlled by CO_2 detection and frequency variation on fan. It has been installed in a large meeting room (30 persons seated, up to 50 persons standing).

The systems have proved to be energy saving with correct CO_2 levels. Meeting rooms have low occupation rate due to the fact there are generally less people in meetings than the maximum allowed. Simulations have also been run considering full office buildings to estimate the variation of savings for different occupation rates and the influence of DCV in meeting room and offices on the total building ventilation losses. Practical rules for owners on how to realise a correct DCV systems were drawn in order to realise a guide.

KEYWORDS
Ventilation rate – Control – Energy conservation – Air Quality – Air change rate.

MAIN TEXT

Demand controlled ventilation (DCV) is an important solution for energy conservation in buildings due to the importance of Air change losses. Various systems are available on the market. After a bibliographic review on DCV, the aim of the study was to experiment two different systems on site, in order to assess their real performances, to extrapolate their savings on full office buildings and to inform owners of practical rules on how to realise them

1 - SYSTEMS PERFORMANCE

We have installed two meeting rooms, one with CO_2 controlled and one with movement detection DCV. The size and the occupation of these rooms are strongly different.
Each meeting room was monitored during three months on several parameters : airflow, absorbed fan power as well as CO_2 levels and outside temperatures and humidity both inside and outside. A questionnaire on occupation and comfort was given to the meeting participants.

1.1 - Movement detection controlled ventilation

The system was installed in a small meeting room for 10 persons. The room is largely occupied. It was occupied during 19 meetings lasting 1 to 3 hours in the monitoring period of 11 working days.

In order to characterise occupation, we have defined an occupation rate as :

$$\hat{o} = \frac{(\text{real amount of hours x real number of occupants})}{(\text{total amount of hours x total number of occupants})}$$

Yet the occupation rate happened to be only of 15 % during this period.

The movement detection system integrates movement on a detection lens during a period of 3 minutes and correlates it to the number of occupants. This information is processed to determine opening or closing of the Air Terminal Device's damper which position (5 positions are possible) is visualised by LED. The full system (detection lens, signal processing, visualisation LED, with 5 positions damper) is integrated in each Air Terminal Device.

The room was installed with three units covering the total surface and each of them varying from 0 to 75 m3/h. The ventilation system is a single exhaust one with air inlets on the windows and an extraction fan covering both this meeting room and a set of offices with constant airflow.

Average airflows and CO_2 levels in permanent mode are reported in figures 1 and 2.

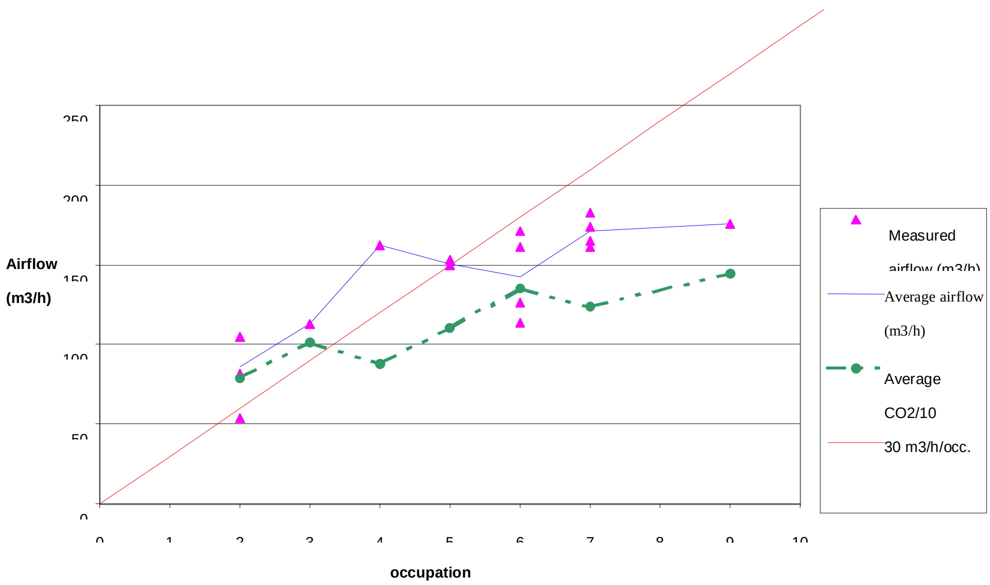

Figure 1 : average airflow depending on occupation

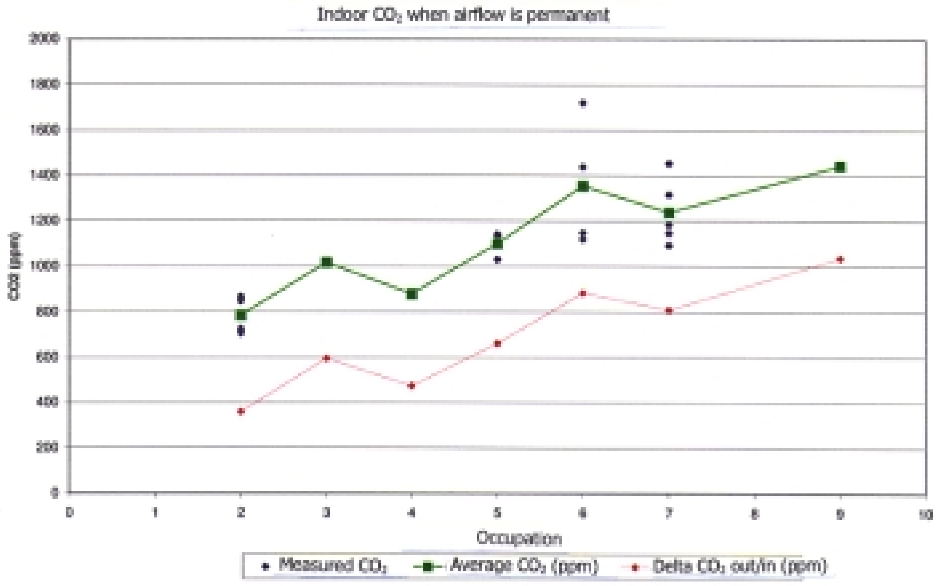

Figure 2 : average CO_2 levels depending on occupation

We can note that the system reacts correctly to the real occupation of the room although position of occupants (the detection cones of the three ATDs cross each other) and their activity have sometimes induced different airflows for the same occupation.

As the controlled airflow in the room (that has varied from 50 to 200 m^3/h) is quite low compared to the permanent airflow coming from offices (585 m^3/h) the fan absorbed power (270 W) varied very little (± 10 W).

French thermal regulation in buildings requires the ventilation stops during non-occupied periods (nights, week-ends…) and airflows of 30 m3/h/people at work.

The mean airflow obtained on the measuring period of occupation (11 working days of 10 hours occupation) is 46 m^3/h which is to compare to a permanent designed ventilation rate of 300 m^3/h. We can conclude that energy savings are important (85 %) due to the fact that even when a room is widely occupied, it is not fully occupied.

1.2 CO_2 controlled ventilation

This second system was installed in a large meeting room (30 persons seated and up to 50 standing). This room is very seldom used and not fully occupied. Test were made during two periods. The first period of 17 working days was in summer. The room was used 8 times for short meetings (less than two hours). The occupation rate noted was 1.7 %. The second period, in September, was more representative of standard room occupation. On 14 working days, the room was used for 5 meetings but on wider periods (2 to 7 hours). Therefore, the occupation rate was of 4.2 %.

The CO_2 controlled system is composed of :

- a CO_2 sensor situated in the occupied zone close to the exhaust grill
- a frequency converter to regulate fan speed.

The system is a supply mechanical ventilation designed for 1500 m^3/h. Fan and ducts supply only this meeting room. Although all parameters can be adjusted, the regulation parameters were to have a proportional response starting from 400 ppm indoor CO_2 to the maximum as indicated in figure 3.

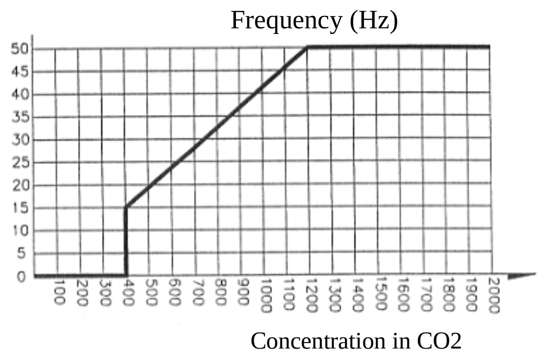

Figure 3 : frequency regulation parameters

Average airflows and CO_2 levels in permanent mode are reported in figures 4 and 5.

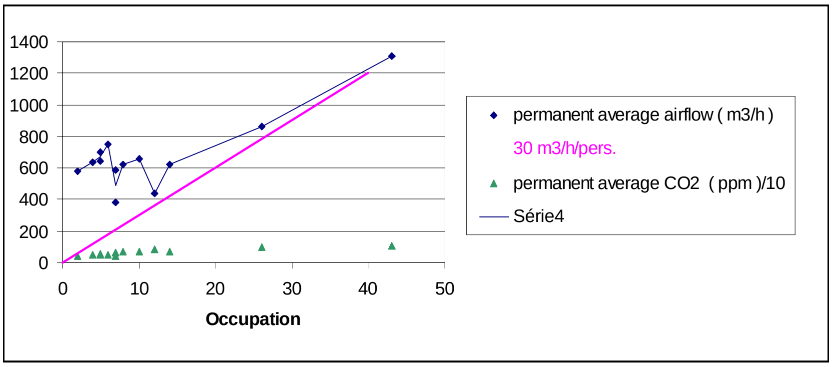

Figure 4 : average airflows depending on occupation

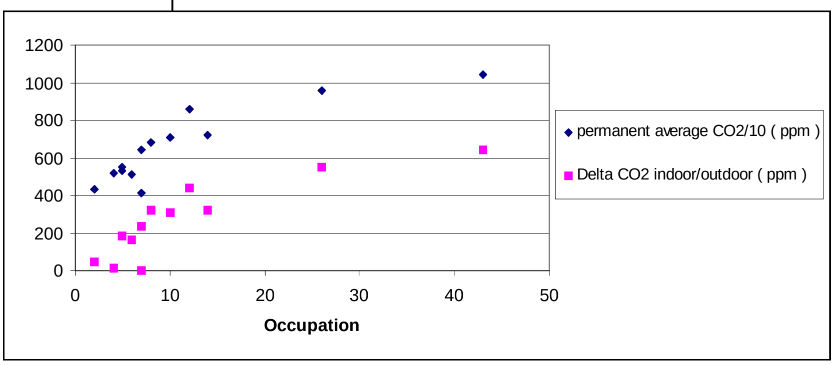

Figure 5 : average CO_2 levels depending on occupation

This system also reacts correctly to real occupation.
We have noted that due to the high outdoor CO_2 levels (340 to 500 ppm), even at night, the airflow very seldom came back to zero (in average, zero was reached only 12 % of scrutation time).This shall be settled by adjusting the regulation on site.

Figure 6 reports the fan mean absorbed power versus occupation of the room. When airflow was zero, a residual power of 17 W was measured due to the frequency converter.

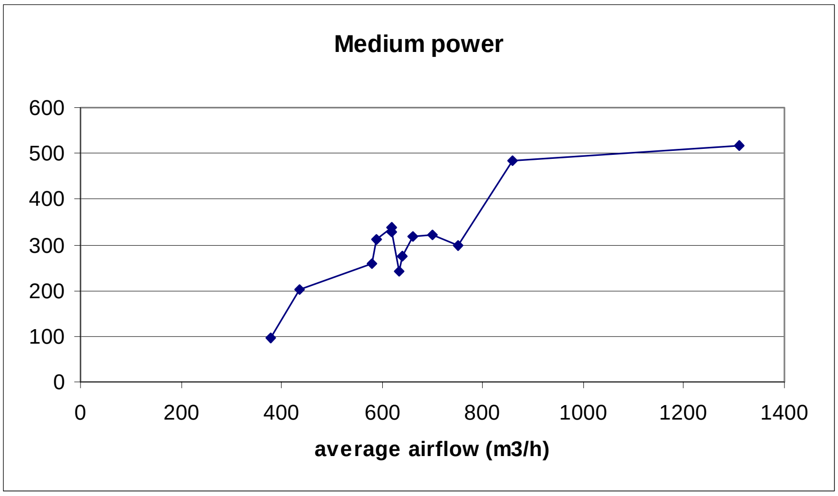

Figure 6 : mean fan absorbed power depending on occupation

Energy savings can be calculated on both periods.
During the summer period, the ventilation run during 16 hours with an average airflow of 580 m^3/h.
In September, it ran 18.30 hours with an average airflow of 670 m^3/h.
The energy savings due to the CO_2 controlled ventilation were of 75 %.

2 – Energy savings :

The occupation rates of both rooms have been very low. This fact was not expected from the smaller room which is known to be used very often. Although the room is quite always booked (19 meeting in 11 days), these meetings represent a small amount of time (38 h 45 out of 120 h) due to short meeting length (2 hours). Moreover, the average number of occupant is generally half of maximum. Both parameters induce a low total occupation rate of 15% even this meeting room is regularly and often used. This occupation rate can be considered quite representative of a standard occupation for such a meeting room.

Due to the low occupation, energy savings on both rooms have been respectively of 85 and 75%.

On a full office building, constituted of 11 offices and these two rooms, using a DCV individual system in the meeting rooms would induce 70% savings (pay-back time for French market and electrical power : 2 years); In addition, if the offices were installed with presence detection system, energy savings on the building would increase by 82% (pay-back time : 3 years)

3 – Installation guidelines

DCV systems are mainly interesting on buildings with sensible occupation variations (either in number of occupants or in time-occupation) and large heating or cooling loads : conference rooms, meeting rooms, waiting rooms, restaurants, libraries, offices…)

First, for a correct DCV systems, different zones of similar occupation must be defined and at minimum, on sensor per zone is necessary.
This sensor must detect a parameter representative of the real room occupation.

- For optical systems, the lens covered zone must be carefully chosen when locating the sensor. These zones must represent all the room and avoid to have double detection in some areas.
- For CO_2 sensors, the location must be representative of the occupation zone value (in the zone or in the exhaust for mixing air-diffusion only).Drafts, heat sources, occupants, doors and dead zone shall be carefully avoide

Finally, the airflow variation can be through a damper or through the fan. In the first case, duct pressure has to be stable. Fan control can still be necessary for large airflow variation.

CONCLUSION

DCV systems are really interesting for energy savings (> 70% savings) in intermittent occupation rooms while maintaining correct CO_2 levels. Different systems exist and can be employed. Both tested systems have correctly reacted to occupation which wa confirmed by the questionnaires' survey of occupants. This study is now continuing on writing a practical guide for owners on how to realise a correct DCV system.

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