Occupancy controlled ventilation in refurbished office building, combining presence and CO_2 detection

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SUMMARY

From September 2015 to March 2016, UTC engaged in a major refurbishment of its Design and Research Center located in Culoz (France). Originally built in 1983, this building was intended to accommodate the Air Side Engineering team with about 60 permanent employees.

The objective was first to increase the Energy Efficiency and the Indoor Air Quality of the building for the well-being of the occupants, but also to demonstrate and showcase to visiting customers a "technological and evolutionary platform" of our offer and innovations in real conditions of use.

By selecting A+ Class certified materials and energy efficient equipment (heat pump, heat recovery Air Handling Unit, sensors , easy and smart controller, ...), and by carrying out detailed commissioning and follow-up of the equipment (MANAG'R(1) methodology), it was possible to demonstrate a high level of performance to share with designers and installers.

This article details the characteristics and functions of the installation, the fresh air management strategy, and finally, the performance obtained for different room types and situations.

KEYWORDS

IAQ – Ventilation – CO_2 – Presence detection – Air Handling Unit

1 BUILDING HVAC INSTALLATION (FRESH AIR PART ONLY)

1.1 Building description – design parameters

The building consists of two levels of 260 m^2 each, for a total volume of 1630 m^3. The maximum number of occupants is 80, distributed as shown in the table 1 below:

Table 1: number and distribution of occupants in the different types of rooms

Level	Open Space	Individual office	Meeting room	Total
Level 0 - North	12	3	0	15
Level 0 - South	12	2	12	26
Level 1 - North	12	1	10	23
Level 1 - South	12	4	0	16
TOTAL	48	10	22	**80**

The sizing of the fresh Air Handling Unit (AHU) is based on a value of 25 m^3/h per person, in accordance with the French regulation for workers. The nominal air flow rate of the AHU is 2 000 m^3/h.

1.2 Ventilation strategy

The ventilation rate is directly adapted to the building occupancy, while keeping the possibility of maintaining a minimum ventilation during vacancy phases, such as during the night. For individual offices, occupancy is detected by a "presence detector" (fig.1-4), while for open spaces and meeting rooms, it is done by CO_2 sensors (fig.1-5). Those sensors have a direct action on "all or little" air registers (fig.1-2) and modulating air dampers (fig.1-3). The dampers plates are equipped with air flow regulators which allow a minimum air flow even when dampers are closed (fig. 1-1).

Other air flow regulators are installed upstream and calibrated to the design value. Thus, when dampers are open, they ensure a maximum air flow and automatic balance of the aeraulic circuit. The only parameter which guarantees the distribution in the different parts of the circuit is the air pressure inside the circuit. Its value must be at least 50Pa in all parts of the air circuit. A higher value generates useless energy consumption and potentially acoustic disturbances, while a lower value no longer allows the self-balancing of the fresh air distribution circuit.

AHU control is based on the pressure measured in the circuit. When the building is empty, the dampers are closed and a minimum air flow is sufficient to maintain the pressure at its set point. As occupants arrive, the air dampers open and the AHU must progressively increase the air flow to maintain the pressure set point.

(1) (2) (3) (4) (5)

Figure 1: components for fresh air flow control .
(1) air flow regulator, (2)"all or little" register, (3) modulating damper, (4) presence detector , (5) CO_2 sensor

2 MEASUREMENTS – RESULTS

During the building refurbishment, particular attention was given to the design and inspection of the fresh air circuit: conformity to the drawings, air tightness of the rigid parts of the pipes, minimum length of flexible pipes, connection between all parts checked, etc… The installer was of course informed of the importance of potential issues and was also particularly aware of possible mistakes.

2.1 Control measurements of the fresh air circuit

On final completion of the installation, measurements have been realized to check both pressure and air flow at **ALL** fresh air circuit extremities, and at **SOME** intermediate distribution points. The pressure set point was 90 Pa at the discharge of the AHU. The different measurements are grouped in Table 2 below. Figure 2 shows the location of the measurement points in the schematic of the fresh air circuit.

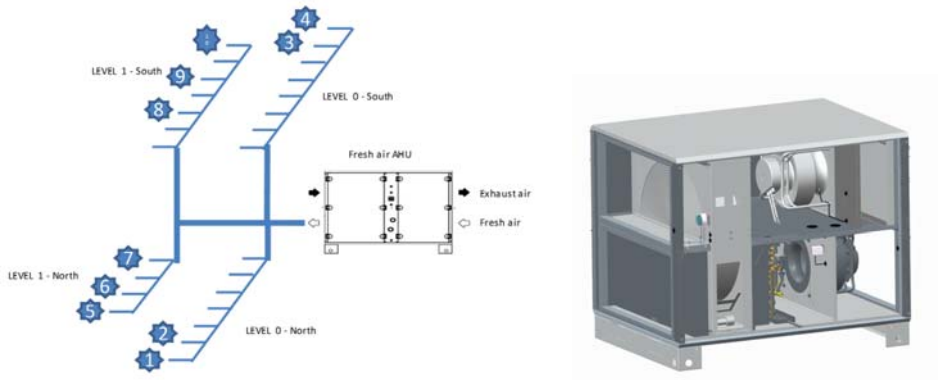

Figure 2: Measurement points location on fresh air circuit / Compact AHU ….

Table 2: Pressure and air flow at different fresh air circuit locations

# point	Room type	Measurements P(Pa)/Qv(m^3/h)	Nominal Air flow m^3/h	Gap % ref. nominal
1	Individual office	78/31	25	+24
2	Open-space	75/55	60	-8
3	Individual office	74/25	25	0
4	Open-space	74/57	60	-5
5	Open-space	68/-	90	-
6	Open-space	73/-	90	-
7	Meeting room	66/210	250	-16
8	Individual office	70/-	30	-
9	Open-space	71/100	90	+11
10	Open-space	73/102	90	+13

N.B. : the different registers of the circuit have been forced in open position for those measurements

2.2 CO_2 level in different types of rooms

In order to be sure that fresh air flow is sufficient, CO_2 levels have been recorded and verified in different rooms and for different conditions.

Figure.3. gives an example of CO_2 level in an individual office during normal use (left) and in degraded use (right) during an improvised short meeting of 3 persons.

In this last condition, a short term high IAQ degradation is observed with a fresh air flow designed for only one as the fan coil unit is sized for only one person. Nevertheless, the calculated ICONE[1] index during this day period is 1(low containment) while ICONE index is 0 (null containment) in normal use. CO_2 levels in open-spaces and in a meeting room without occupancy control have also been recorded in order to compare.

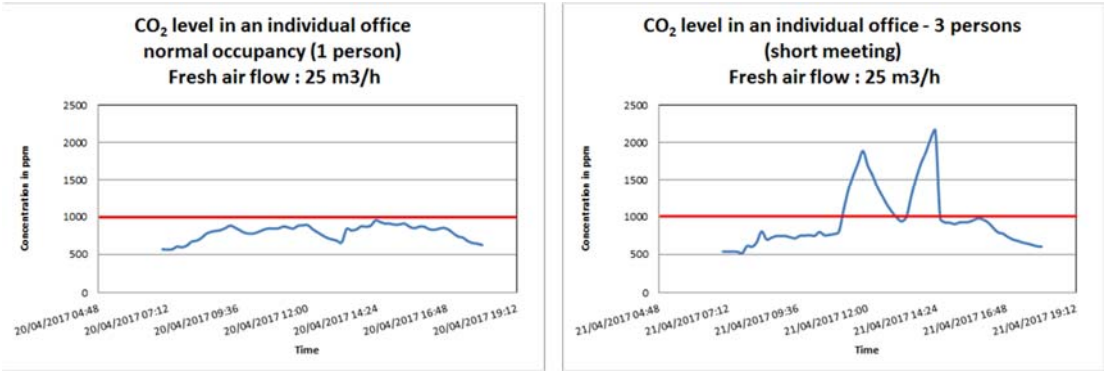

Figure 3: CO_2 level inside an individual office in “normal” or “degraded” conditions of use

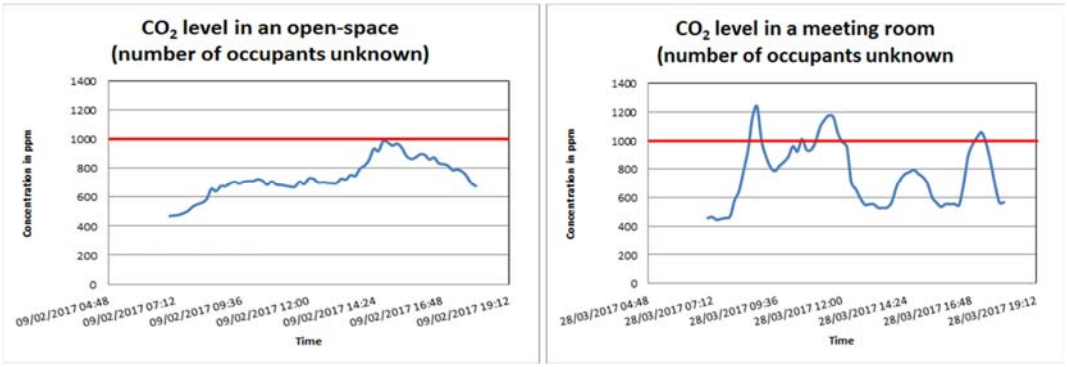

Figure 4: CO_2 level inside an open-space and inside a meeting room (for 10 persons max.)

[1] ICONE index : containment index defined by CSTB. From 0 (null containment) to 5 (extreme containment)

3 CONCLUSIONS – PROSPECT

An occupancy controlled ventilation based on CO_2 and presence detection has been installed during the refurbishment of a 1980's office building. The MANAG'R approach has been applied, especially the controls and measurements all along the work and the commissioning of the installation. The HVAC system was designed to supply, at the right location, 25 m^3/h of fresh air per occupant, in accordance to the French regulation for workers.

In those conditions and after controlling that the installation complied with the design, we are today able to ensure that ICONE index, in the different types of rooms, stays between 0 and 1, regardless the conditions.

This permanent "field test" building is now equipped with a permanent control of the indoor $PM_{2.5}$ level, maintained under 10 $\mu g/m^3$ (WHO recommendation) through complementary equipment . Furthermore, the indoor air chemical and biological pollutants will soon be treated with plasma-photocatalysis technology.