Impact of the filtration system on the indoor-outdoor particles concentration relationships in an air conditioned office building

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ABSTRACT

The objective of this study is to measure the impact of various classes of filters in the HVAC system on the IAQ in an office building. It aims at understanding outdoor-indoor concentrations and filtration relashionships in order to guide filtration system designs.
Various filters classified G4, F7 and F9 (according to the standard EN 779), new and used, were placed in the HVAC system of an office building ventilated with 100 % outdoor air and located in the suburb of Lyon (southeast France). Particle size distributions were measured outdoors, indoors and in the return duct of the ventilation system (balanced ventilation system).
These data were used to investigate filtration efficiency and relationships between indoor and outdoor particle concentrations.
Results show a dramatic reduction of fine particle using high efficiency filters (F7, F9). As for larger particles (> 1 µm) no significant improvement of IAQ is measured, indoor air can even present higher concentrations of large particles due to the presence of various indoor sources.
A high efficiency filtration system can then be used sucessfully to reduce indoor exposures to fine particles but its impact on total particles concentration is limited. This solution has to be taken into account and integrated in a global approach for a better IAQ.

KEYWORDS
Filters, particles, indoor air quality

INTRODUCTION
Indoor air quality and particles exposures are today of major concern in building systems designs.
Concentrations of particles indoors depend upon the fraction of outdoor particles that penetrate through the building shell or are transported via the air handling system, the generation of particles by indoor sources, and the loss mechanisms that occurs indoors such as filtration or deposition [1-6].
At the interface between indoor and outdoor air, filters play a significant role. As for the regulation concerning filtration systems, they are today requirements for filtration levels on fresh and recycled air (French regulation : filtration of fresh air with filters classified G4 at least and air recycled with filters classified F5). However regarding to indoor air quality no specific particles concentrations or specified or required.
This study aims at investigating filtration efficiency and relationships between indoor and outdoor particle concentrations in order to guide filtration system designs.

MATERIEL AND METHODS

Building

The office building (figure 1) is located in an industrial area, close to a beltway. Only the first floor is instrumented. The area is 450 m2 and includes an open space, various offices, a kitchen and lavatories.

Figure 1 : Outside view of the office building

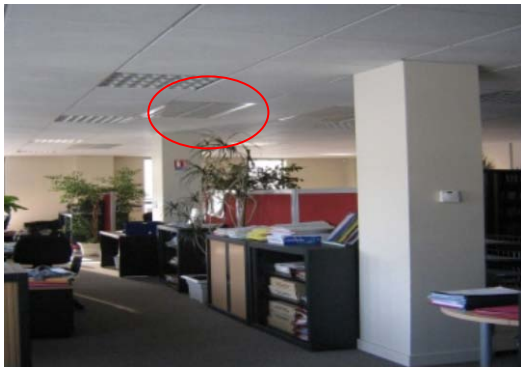

Figure 2 : Air supply device

HVAC system

The air handling unit is equipped with an energy recovery system (balanced ventilation system). It operates 24h/24h with an air flow of 1000 m^3/h. There is no recycled air inside the building.

Ventilation fans are equipped with electronic variable speed transmission but there is no automatic regulation based on air pressure drop.

Fresh air is supplied through ceiling mounted fan coils equipped with G3 filters. They are used for air conditioning and heating and operate with 100 % recycled air (figure 2).

Filters

Filters classified G4, F7 and F9 (according to the europena standard EN 779) are alternatively tested on the air handling unit. Front filters dimensions are 305 mm x 500 mm x 48 mm.

The filter is set on the air handling unit and the system operates one full night to renew the indoor air. Measurements are carried out during the day after.

Measurements

Initial filter efficiencies are first measured on a test rig accordind to the EN 779 standard. The measurments are then carried out on site. Table 1 summarizes all the measurements carried out and the location of the measurement devices.

Measurement	Location
Air flow rate	Supply air duct Air outlet duct
Particle size distribution and concentrations	inlet air before filter inlet air after filter indoor (office) outlet air

Table 1: locations of measurement devices

Particles concentrations are measured five times a day at 8 a.m, 10 a.m, 12 a.m, 2 p.m. and 4 p.m. At each hour 3 sets of measurements are averaged to obtain the result.

RESULTS

Air flow rate

Table 2 presents the results of the air flow measurements in the ventilation ducts. Results show that despite the different pressure drops due to the filters, the air flowrate is monitored to remain almost constant .

filter	G4		F7		F9	
	air inlet	air outlet	air inlet	air outlet	air inlet	air outlet
air flow rate (m^3/h)	1075	114	1057	1152	1039	1124

Table 2 : Air flowrates in the ventilation system

Filters efficiency

Table 3 show the efficiency of the different filters measured in laboratory (accordind to the EN 779 standard test) and on site, in the supply air duct.

	G4	F7	F9	G4	F7	F9
particle diameter (µm)	efficiency (%) (EN 779 test)			efficiency (%) (on site)		
0.2-0.3	2	67	84	6	54	69
0.3-0.5	2	74	89	10	64	77
0.5-0.7	4	80	92	15	73	84
0.7-1	6	86	95	21	80	87
1.2	11	90	97	39	86	89
2.3	38	95	98	64	90	90
3.5	74	98	99	74	94	91

Table 3 : Filters efficiency in the supply air duct, flowrate 1000 m^3/h

The effiency obtained on site in the suplly air duct is lower then the efficiency measured on test rig for with the ashrae dust for the F7 and F9 filters and higher for the G4 filter. This is partly due to the difference between the ashrae dust and the atmospheric aerosol. Results match however the different efficiency classes.

Indoor/Outdoor particles concentration ratio

Figure 3 show the indoor/outdoor particle concentration ratio obtained for each filter.
On site results show a dramatic reduction of fine particle (<1µm) using fine filters.
The indoor/outdoor ratio is below 60 % with a G4 filter, 42 % with a F7 filter and 35 % with a F9 filter. The indoor/outdoor concentration ratio decreases as the class of the filter is better.
As for larger particles (> 1 µm) no significant improvement of IAQ is measured. Indoor air can even present higher concentrations of large particles due to the presence of various indoor sources.

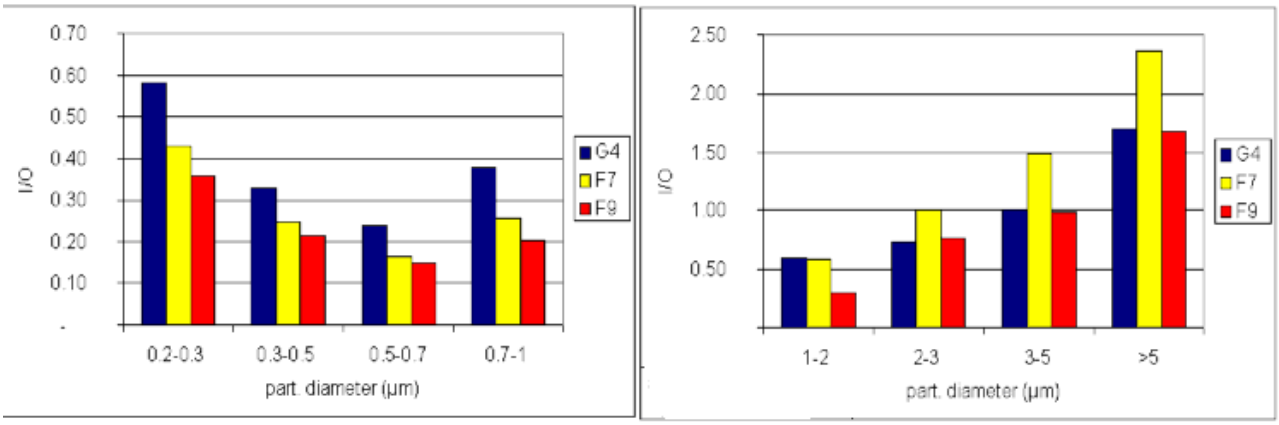

Figure 3 : indoor/outdoor particle concentration ratio

CONCLUSION

Results show that high efficiency filtration systems can then be used successfully to reduce indoor exposures to fine particles but its impact on larger particles concentration is limited. This solution has to be integrated in a more global approach for a better IAQ where indoor sources are also taken into account.

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