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HVAC AIR FILTER TESTING THE NEED OF A FIELD TEST METHOD

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SYNOPSIS

Air filters may be used to reduce indoor airborne concentration which is one of the main indoor air pollutant. Air filters performances have to be measured in order to be able to select the right product for a given application. But differences do exist between laboratory and field filter test results and HVAC installations have to be controlled regularly.

EUROVENT 4/10 recommendation (***1***.) describes guidelines for the evaluation of the performances of HVAC air filters according to particle size in an installation. The objective of our study was the assessment of the method and its use in real application. The same type of air filters (G4 pleated filter, F6 bag filter and F8 compact filter) has been tested according to EUROVENT 4/9 method (laboratory, ***2***.) and EUROVENT 4/10 method (field).

After the method has been validated, it has been used to determine the in-situ fractional efficiency of an installation (HVAC system for offices building) located in Lyon (France).

Main conclusion of our study is that EUROVENT 4/10 method is suitable for filtration efficiency field measurement in a simple way (according to "good practice") and can be considered as a valuable tool for HVAC installation control.

INTRODUCTION

People breathe approximately 15000 litres of air each day and spend more or less 80 % of their time in indoor environments. So, quality of indoor air is of major importance regarding health and comfort of people and there is naturally an increase for the need of “good” indoor air quality.

Air contains naturally a lot of various particles and gases (air contaminants). Depending on a lot of parameters – industrial activity, weather conditions, etc. – the amount of air contaminants may exceed values which are considered critical from comfort and health point of view. In this case, air contaminant concentration has to be reduced.

There is no clear relationship between indoor and outdoor particle concentration. Indoor particle concentration depends on outdoor concentration, indoor particle sources, type of ventilation, etc. Air filters can be used to reduce indoor airborne concentrations by their use on the ventilated air. That means that air filter performances have to be measured in order to be able to select the right product for a given application. Laboratory standardised test methods exist (EN 779, EUROVENT 4/9, ASHRAE 52.2) but differences do exist between laboratory and field filter test results (***3***., ***4***., ***5***.). Also, HVAC installations have to be controlled regularly. So, there is a need of a validated method for the in-situ filtration efficiency measurement. EUROVENT 4/10 recommendation describes such a method. The aim of our study was the assessment of this method and its use in real conditions.

DIFFERENCES DO EXIST BETWEEN LABORATORY AND FIELD FILTER TEST RESULTS

As an example of what it is possible to obtain when laboratory and field filter test results are compared, *Figures 1* to *4* show that these differences concern filtration efficiency as well as dust holding capacity.

In *Figures 1* and *3*, the fractional efficiency (0.2 to 0.3 µm) of 2 different filters is expressed according to pressure drop. For each type of filter, 2 filters have been used, one for loading with the ASHRAE dust (EUROVENT 4/9 test method) and one for loading with atmospheric (natural) dust while the filter was ventilated with outdoor air without any prefiltration. In both cases the fractional efficiency was measured on latex neutralised particles. Test results show that the efficiency is lower when the filter is loaded with natural dust (at the same pressure drop). The same kind of result is obtained for the whole particle size range covered by the optical particle counter used for the measurements (from 0.2 to 3 µm).

Regarding dust holding capacity of the filters (*Figures 2* and *4* ; the amount of dust arrested by the filter was measured by weighting of the filter), the examples given in this paper show that considering 450 Pa final pressure drop, dust holding capacity of the filter may be 10 times less with natural dust than with ASHRAE dust (*Figure 2*). That means that the ASHRAE dust does not reflect the properties of the natural dust.

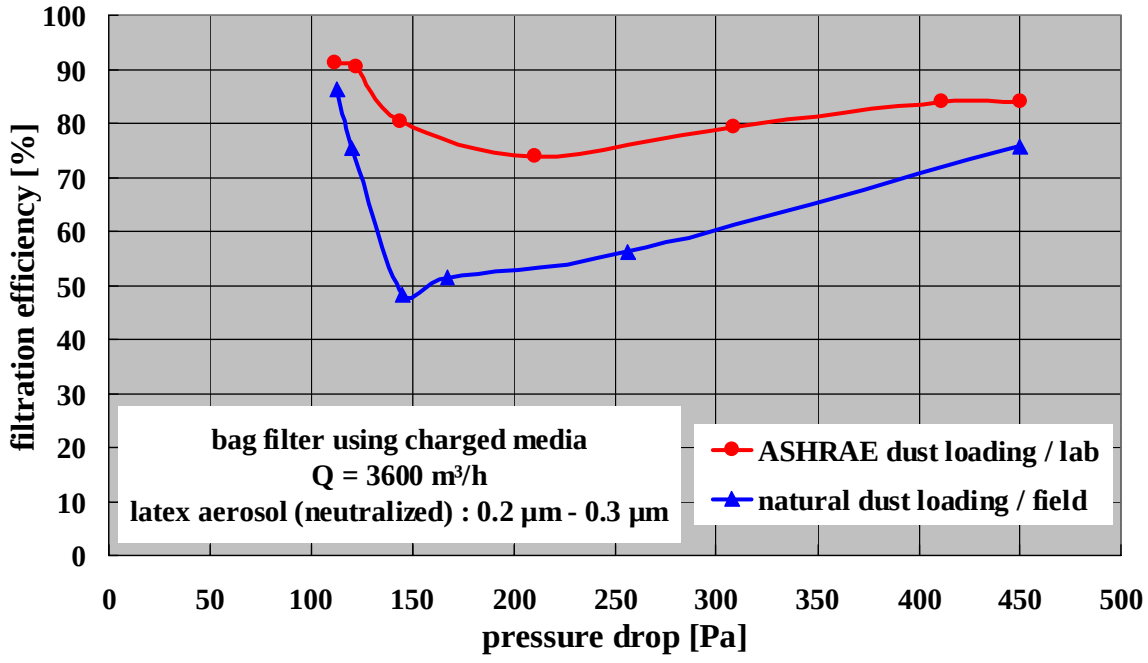

Figure 1. The filtration efficiency of a filter according to pressure drop and dust loading.

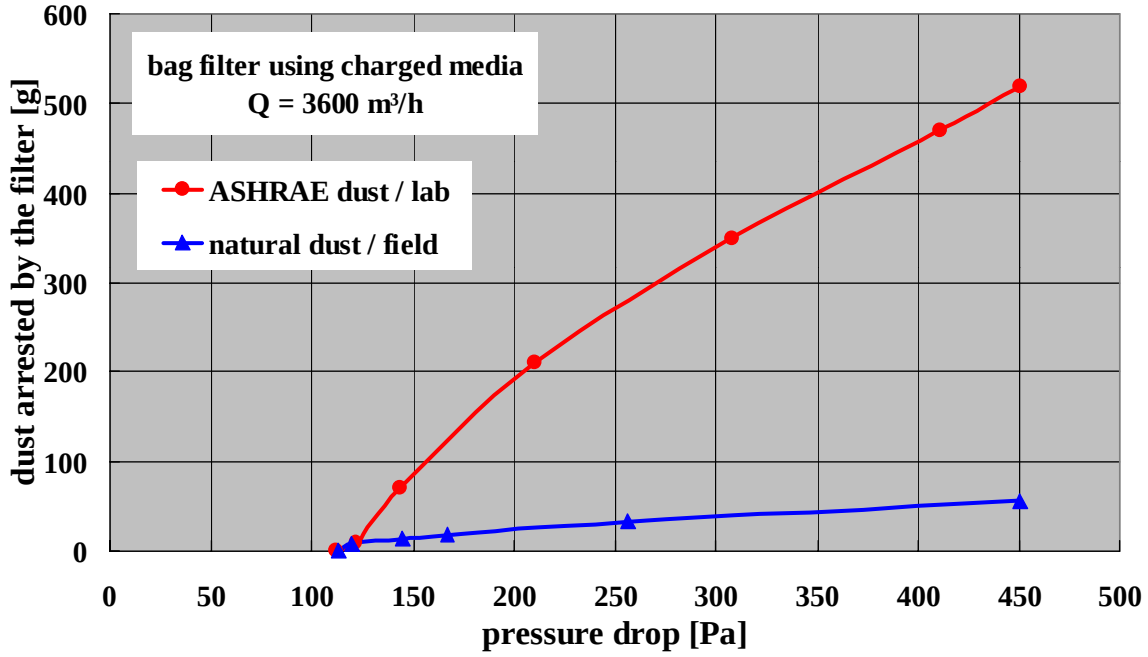

Figure 2. The mass of dust arrested by a filter according to pressure drop and type of dust.

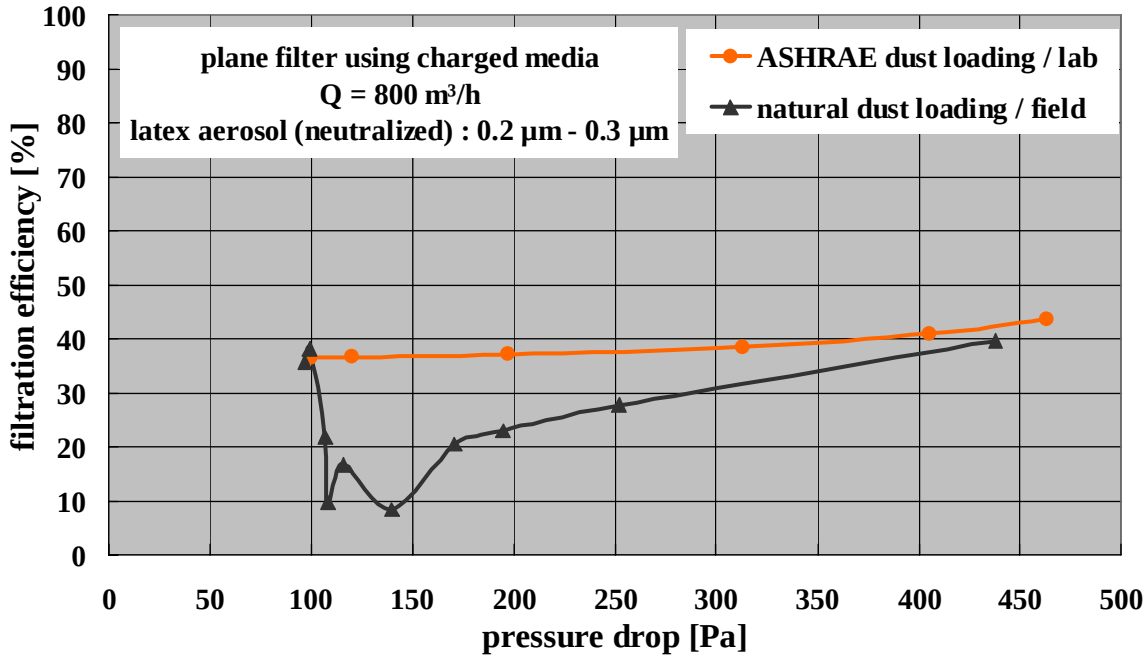

Figure 3. The filtration efficiency of a filter according to pressure drop and dust loading.

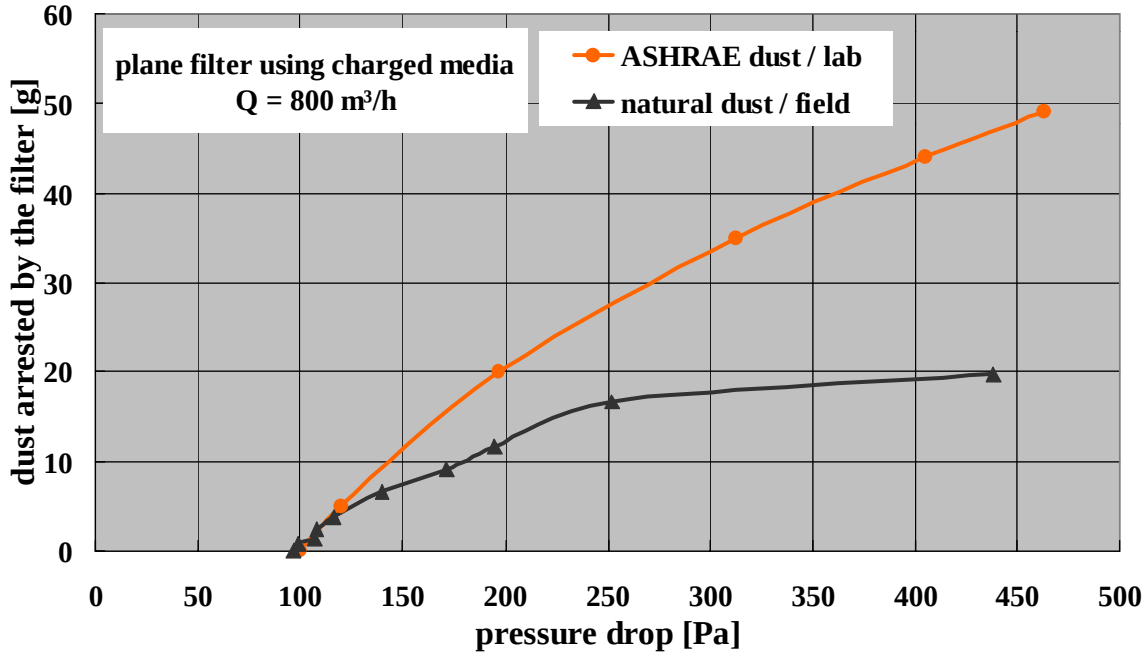

Figure 4. The mass of dust arrested by a filter according to pressure drop and type of dust.

MORE ABOUT EUROVENT 4/10 METHOD

EUROVENT 4/10 recommendation describes a method for the in situ determination of the fractional efficiency of general ventilation filters. This method requires the measurement of particle concentrations upstream and downstream of the filter to be tested according to particle size (0.2 to 1 µm), with an optical particle counter. This method may be used for installation having one filter only and for a bank consisting of many filters. This method may be used for the filtration system only and also for the complete installation (including fan, batteries, etc.).

Ventilation air is mainly composed by number of particles having diameter less than 1 µm but additional values for bigger particles may be included if possible. *Figure 5* gives an example of the apparatus which has to be used for such measurements. It is necessary to use a dilution system in order to avoid coincidence errors in the counter (too many particles at the same time in the measuring system).

Sampling of air is done at the center of the measuring sections (upstream and downstream) or, if different, at a point where the concentartion of particles is representative of the average of the whole section.

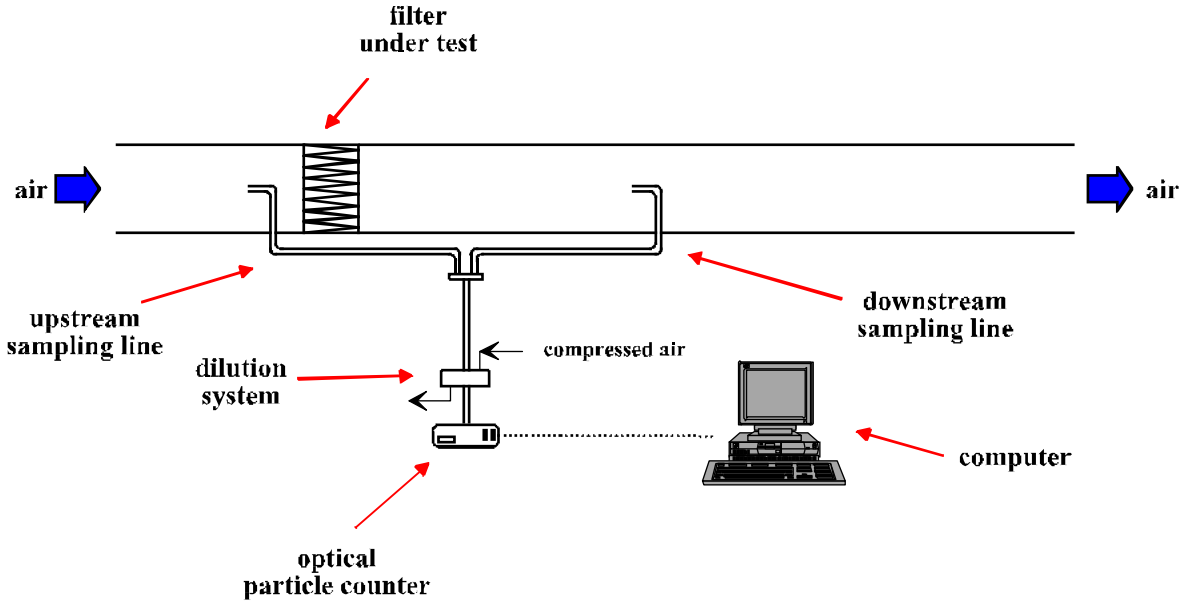

Figure 5. Typical testing apparatus used for in-situ measurements (EUROVENT 4/10).

ASSESSMENT OF EUROVENT 4/10 METHOD

First of all, EUROVENT 4/10 method has been assessed by its use for the filtration efficiency measurement of a simple installation located at CETIAT. This installation consists of a straight duct having constant square cross section (*Figure 5*). Three different types of filters (new filters) have been used successively within the installation (*Figure 6*). Air filters which have been selected cover the wide filtration efficiency range commonly use in HVAC installations when medium or high filtration efficiency is required.

filter	1	2	3
type	pleated	bag	compact
class (EN 779)	G4	F6	F8
Q [m³/h]	2400	3600	3600

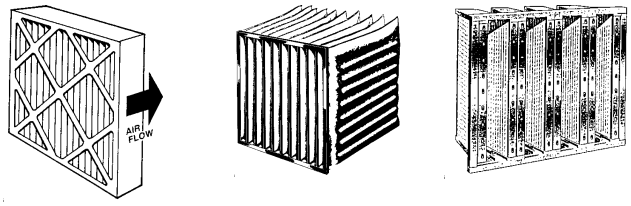

*Figure 6. Air filters used for EUROVENT 4/10 method assessment (pictures from **6.**).*

The three types of filters have also been tested according to EUROVENT 4/9 recommendation after they have been removed out of the installation and installed in the test rig used for laboratory measurements (*Figure 7*) ; the fractional efficiency was measured on

latex particles and the results have been compared to those obtained by the use of EUROVENT 4/10 method.

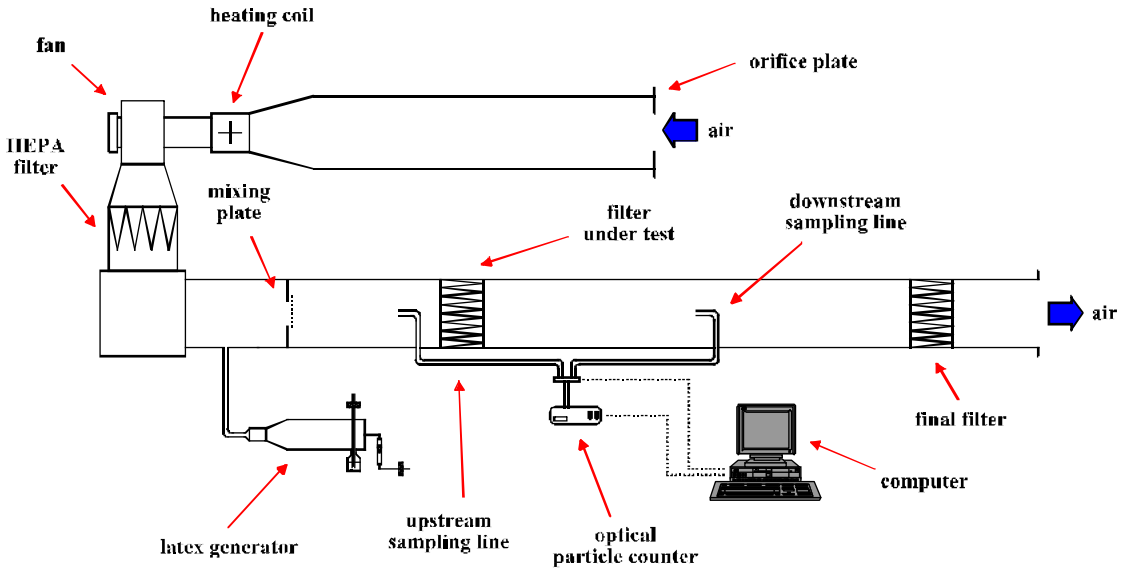

Figure 7. Schematic diagram of test rig used for laboratory measurements (EUROVENT 4/9).

For both methods (laboratory, field) calculation of the fractional efficiency is the same : for a given particle size, the fractional efficiency is the ratio of the number of particles retained by the filter (upstream concentration minus downstream concentration) to the number of particles fed upstream of the filter (upstream concentration). Upstream and downstream concentrations are measured alternatively and successively upstream and downstream of the filter under test, with an optical particle counter (PMS LASAIR 210) having 7 channels covering the 0.2 – 5.0 µm particle size range.

Test results are given in *Figures 8* to *10*. Several measurements have been carried out successively on the atmospheric (natural) aerosol according to EUROVENT 4/10 recommendation. This has been done because the variability of the atmospheric aerosol composition (type of particles, concentration, size) along time may influence the results (blue lines in the figures). It can be observed that differences between the results of the efficiency decrease as the efficiency of the filter increases and decrease when the particle size decreases. For the biggest particles larger than 2 to 3 µm, test results may be different because the amount of counted particles is low.

The efficiency of the filters measured on latex particles (EUROVENT 4/9) appears close to the one measured on the atmospheric aerosol, especially in case of medium efficiency filter (*Figure 8*). There are some differences for the 2 other filters (*Figures 9* and *10*) but its not so significant. Such trend in the results has been observed in the past (*7.*).

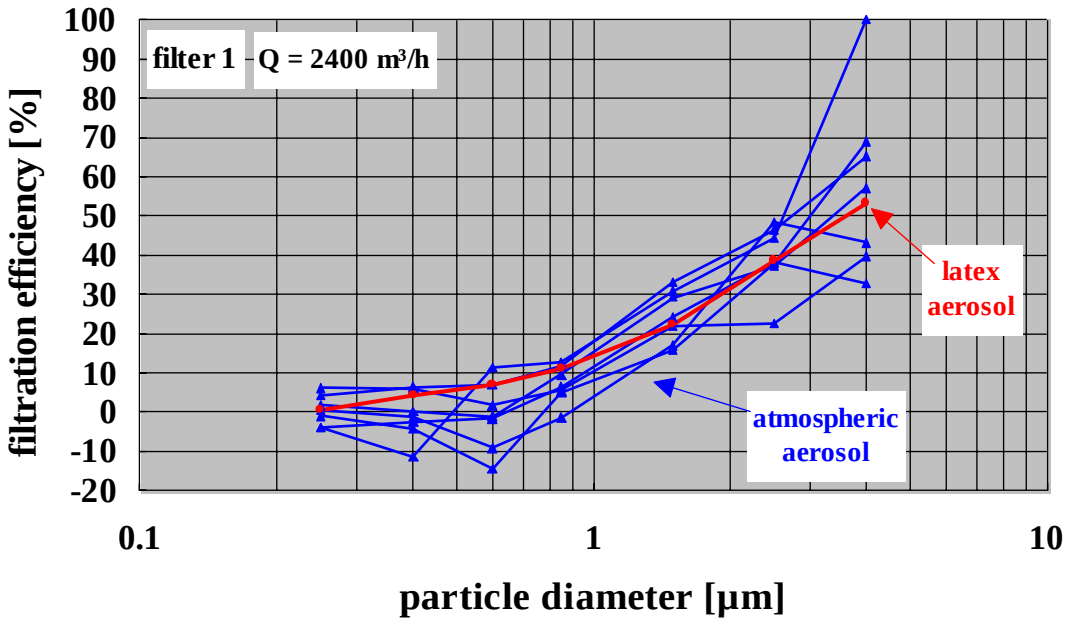

Figure 8. The filtration efficiency of filter 1 according to particle diameter.

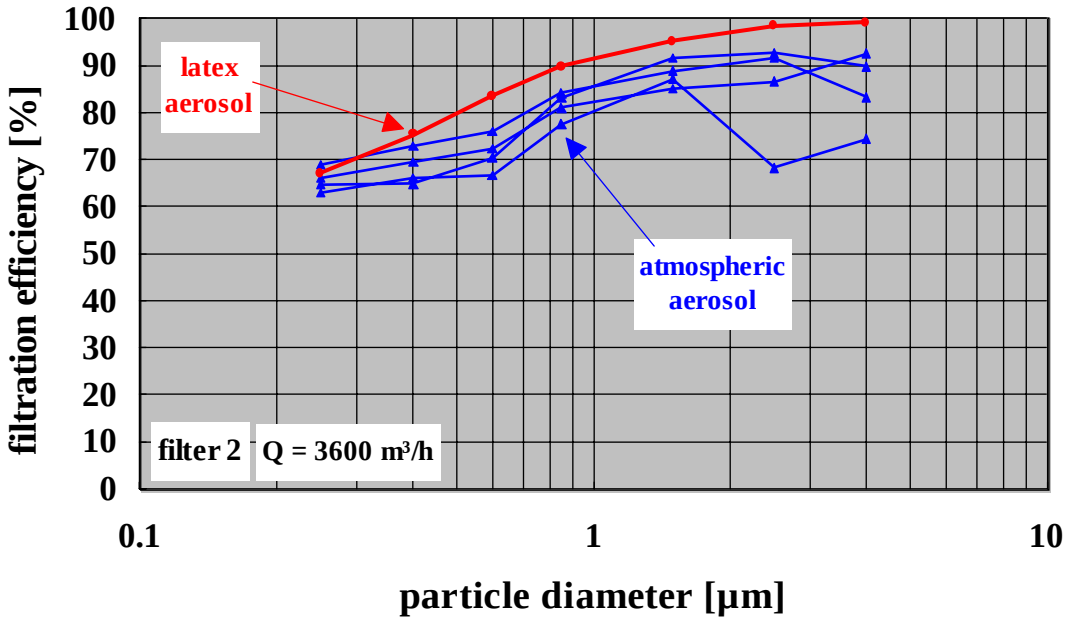

Figure 9. The filtration efficiency of filter 2 according to particle diameter.

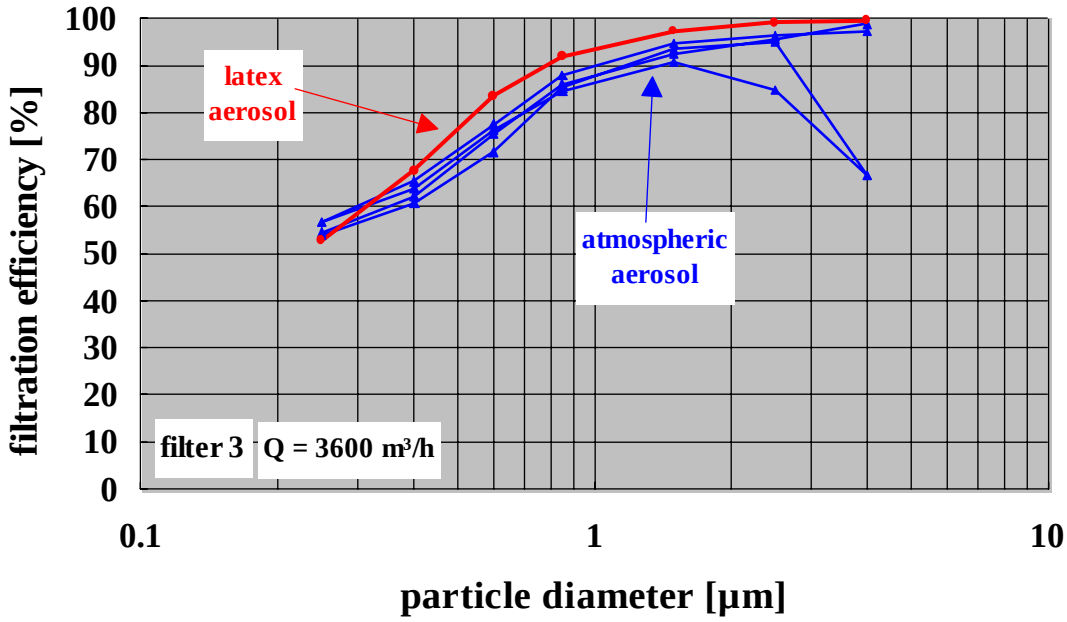

Figure 10. The filtration efficiency of filter 3 according to particle diameter.

Tests results given in *Table 2* are typical of those which have been obtained during the measurements (EUROVENT 4/10).

	filter 1		filter 2		filter 3	
dp [µm]	efficiency [%]	uncertainty ± [%]	efficiency [%]	uncertainty ± [%]	efficiency [%]	uncertainty ± [%]
0.2 – 0.3	1.7	6.2	68.8	2.0	56.8	3.7
0.3 – 0.5	0.1	4.0	72.8	1.7	65.6	8.0
0.5 – 0.7	-1.1	4.1	76.0	2.1	77.6	9.8
0.7 – 1.0	9.5	6.7	84.3	1.7	88.0	4.3
1.0 – 2.0	29.2	5.7	88.8	1.8	94.7	1.1
2.0 – 3.0	37.3	20.7	91.8	5.6	96.5	2.1
3.0 – 5.0	57.1	50.1	83.4	15.5	97.3	3.4
Q [m³/h]	2400		3600		3600	

Table 2. Typical results of the efficiency of the filters measured according to EUROVENT 4/10 method.

The uncertainty on the average fractional efficiency corresponds to a two-sided confidence interval of the average value based on a 95 % confidence level. The uncertainty on the

efficiency remains quite low for particle having diameter less than 2 µm and for even more larger particles when the efficiency of the filter increases. That means that depending on the conditions (type of filter, variability of the aerosol) it may be possible to obtained efficiency values for particles greater in size than 1 µm.

USE OF EUROVENT 4/10 METHOD IN REAL APPLICATION

After EUROVENT 4/10 method has been validated, it has been used to determine the efficiency of an installation (HVAC system for offices building) located downtown Lyon (France). Results of this field measurement are given in *Table 3*. The efficiency has been measured 4 times, then the average efficiency has been calculated as well as the uncertainty. The efficiency increases as the particle diameter increases up to 3 µm and the uncertainty on the average efficiency is small. For larger particles (3.0 – 5.0 µm) the efficiency is smaller but the uncertainty is high (42.6 %). Airflow rate of the installation has been measured too (87000 m^3/h).

dp [µm]	efficiency 1 [%]	efficiency 2 [%]	efficiency 3 [%]	efficiency 4 [%]	efficiency average [%]	uncertainty ± [%]
0.2 – 0.3	**24.3**	**21.8**	**20.1**	**19.1**	**21.3**	**3.6**
0.3 – 0.5	**33.0**	**28.9**	**27.7**	**26.3**	**29.0**	**4.6**
0.5 – 0.7	**49.1**	**39.3**	**38.8**	**39.2**	**41.6**	**8.0**
0.7 – 1.0	**63.4**	**69.1**	**58.5**	**71.6**	**65.7**	**9.3**
1.0 – 2.0	**82.9**	**91.9**	**94.0**	**103.6**	**93.1**	**13.5**
2.0 – 3.0	**96.1**	**89.3**	**95.9**	**100.0**	**95.3**	**7.1**
3.0 – 5.0	**45.5**	**100.0**	**66.7**	**100.0**	**78.0**	**42.6**

Table 3. The filtration efficiency of the HVAC installation measured according to EUROVENT 4/10 method.

CONCLUSION

There is no doubt that differences do exist between laboratory and field filter test results, especially for filters which carry out electrostatic charges. Along life of filter which is often expressed in term of the increase of its pressure drop, we have seen that the fractional efficiency may be different depending of the type of dust used to load the filter (typically atmospheric dust and ASHRAE synthetic dust). The ASHRAE synthetic dust does not reflect natural dust (atmospheric) and dust holding capacity of a filter calculated on ASHRAE dust appears often several times higher than the one calculated on the natural dust.
So, the in-situ measurement of the filtration efficiency of an HVAC installation appears necessary. This measurement is of a great importance in case of control of an installation. EUROVENT 4/10 recommendation describes a method for the in-stu fractional efficiency measurement, in other words, the efficiency by particle size. This method has been validated

and test results show that filtration efficiency values according to both methods described by EUROVENT 4/9 and EUROVENT 4/10 respectively are close.

Finally, main conclusion of our study is that EUROVENT 4/10 method is suitable for filtration efficiency field measurement in a simple way (according to "good practice") and can be considered as a valuable tool for HVAC installation control.

ACKNOWLEDGMENT

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