# COULD HEALTH RISKS FROM HIGH INDOOR PM VALUES BE SOLVED BY HVAC FILTERS?

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## ABSTRACT

A rising concern regarding health risks caused by high Particulate Matter (PM) concentrations is increasing all over the globe. There was a study in Europe [1] 2013 regarding PM concentrations impact on public health. In this study (involving 312 944 people), the conclusion was made that an increase of the $PM_{10}$ concentration with 10 µg/m$^3$, the lung cancer rate increased with 22 %. The $PM_{2.5}$ was even more dangerous, with an increase of 10µg/m$^3$ the lung cancer increased with 36 %. The PM values vary a lot round the globe, which could be seen from local measuring stations. In Ulaanbaatar, Mongolia capital city, they have very high values of PM concentrations. Annual value of $PM_{10}$ of 165µg/m$^3$ and 75µg/m$^3$ $PM_{2.5}$ has been recorded [2]. In the North part of Sweden there is a small town called Bredkälen, the annual $PM_{10}$ values here is 4,7µg/m$^3$ and the $PM_{2.5}$ is 2,9 µg/m$^3$ [3]. The recommendation from World Health Organization (WHO) is < 20 µg/m$^3$ for $PM_{10}$ and < 10 µg/m$^3$ for $PM_{2.5}$ [4]. Modern buildings are often equipped with Air handling Units with filters. Today there are filters and design technology available for designing indoor air quality (IAQ), to deliver the air quality in Bredkälen worldwide downstream a filter installation. The paper will discuss how to design indoor air quality based on the ISO Standard 16890 for HVAC filters [5] in conjunction with a newly granted patent [7]. Further on will also the paper show measuring results from in situ measurements in China and Sweden based on this technology.

## KEYWORDS

HVAC Filter**,** Filter class design, infiltration, exfiltration

- *Demonstrate the impact on Indoor Air Quality ($PM_{2.5}$) by studying two locations one with Low PM values and one with high PM values and make a recommendation of which filterclass is needded to achive a ceratain Indoor Air Quality*

### 1. Introduction

During 2016 a new ISO standard [5] for HVAC filters will come. Classification will be based on $PM_x$ removal for the filter. During the work of preparing the standard it has been found that the particle distribution in outdoor air looks quite similar round the globe (figure 1).

Demonstrate the impact of HVAC filters on Indoor Air Quality ($PM_{2.5}$) by examine two different locations, one with Low $PM_{2.5}$ values and one with high values.

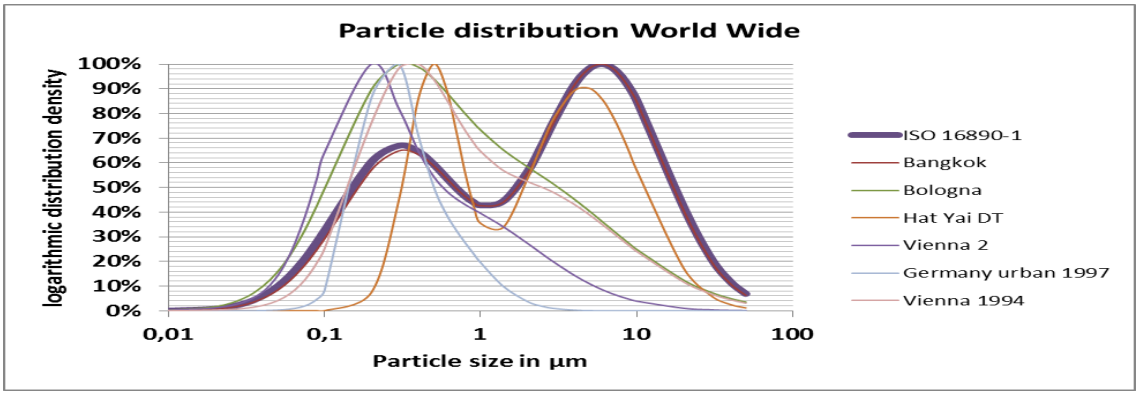



Figure 1 – Graphical representation of the normalized particle size distribution [5]

Assuming that the distribution of particles is simular all over the world, the local concentration for $PM_x$ is known and the $PM_x$ removal efficiency is known for the actual filter element, the $PM_x$ value could be calculated downstream the filter element. As an example: $PM_{2.5}$ is measured locally to 21µg/m$^3$. The $PM_{2.5}$ removal efficiency has been measured to 71 % for a specific filter element. The downstream concentration for this example will then be 21 µg/m$^3$ * (1-0,71) = 6,1µg/m$^3$. From the ISO standard [5] PM removal data for $PM_1$, $PM_{2.5}$ and $PM_{10}$ will be available. So the $PM_x$ value downstream the filter can be calculated in a similar way for all fractions.

What also have to be considered is the air leakage (infiltration and exfiltration) to the building when calculating IAQ. The amount of leakage depends on air tightness of the building envelope, wind speed, temperature difference over the building envelope, air flow rate balance between exhaust air and supply air and where the leakages are located. When there is a mechanical ventilation system with a supply fan and exhaust fan, the normal way is to design the system to create an under pressure in the building by adjusting the exhaust fan so the exhaust air flow is 10 % more than the supply air flow rate. The reason for this is that we want to prevent air with high humidity entering the building envelope. If that happens we will have a condensation in the building envelope, creating mold problems.

A patent has been granted, “Method for filter selecting” [7]. The method comprising the steps of: measuring a pollution level present in the air, determining a filter parameter based on a combination of the measures pollution level and the requested IAQ downstream, providing the filter system with a filter having a filter parameter matching the requested IAQ; measuring a pollution level of the air provided by the filter system in which the selected filter is arranged. The “Method for filter selecting” has been applied for the measuring results in this papier.

According to WHO guidelines [4], the outdoor air concentration for $PM_{10}$ should be < 20 µg/m$^3$, and $PM_{2.5}$ should be < 10 µg/m$^3$. The steering committee for this guide line has concluded “that there is no convincing evidence of a difference in the hazardous nature of particulate matter from indoor sources as compared with those from outdoors” [6]. Therefore is the particulate matter recommended for outdoor air applicable for indoor air.

## 2. Objective

The objective with this project was to show the influence from different filter classes on IAQ. Two locations were examined one location with low $PM_x$ values and one location with high values.

## 3. In situ measurements

During 2015 measurements were done in two different locations:

- Office building in Gothenburg ($PM_{2.5}$: 6,5µg/m$^3$, 2013 annual average for outdoor air) [8]
- MANN+HUMMEL Shanghai, Office and production facility ($PM_{2.5}$: 61µg/m$^3$ 2013 annual average for outdoor air) [9]

## 4. Measurement Method

For the Swedish office building in Gothenburg the measurements of $PM_x$ were done in the general ventilation systems (figure 2). The filtration efficiency was measured for the supply air filters with a Palas Fidas Mobile [10] by measurements upstream and downstream the filter. Further on, the PM concentration was logged in the outdoor air and in the exhaust air. The $PM_x$ value in exhaust air is assumed to be an average value for IAQ. The logging procedure was done in intervals of 30 minutes with continuously switch between outdoor air and exhaust air.

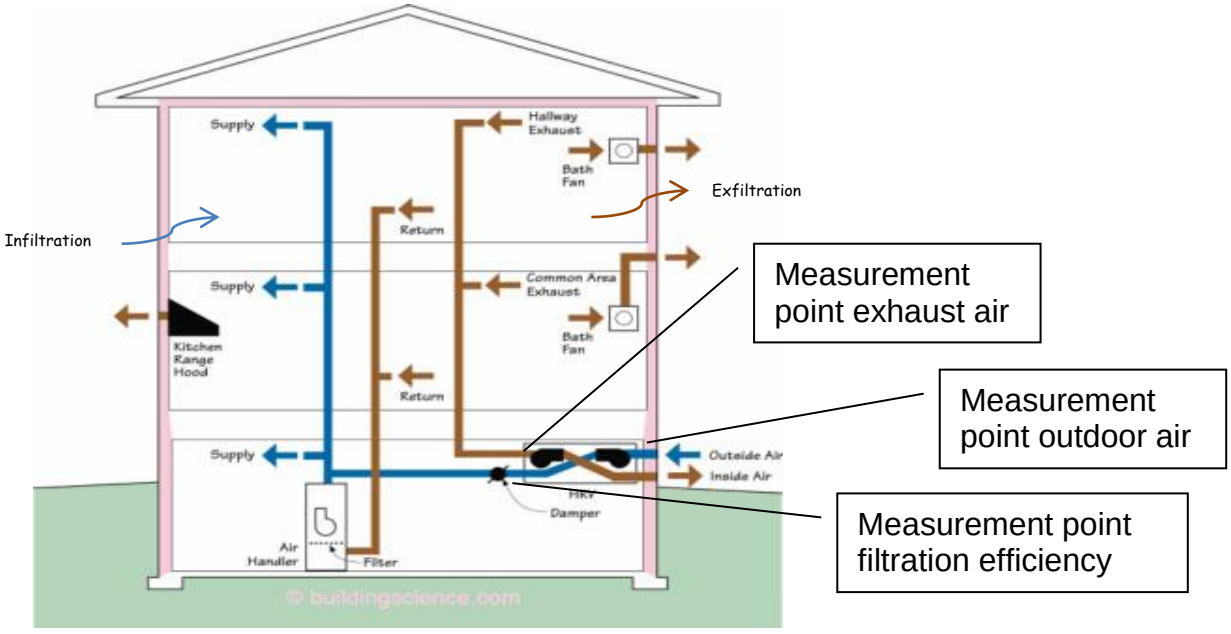



Figure 2 – Description of general ventilation system [11]

The $PM_X$ removal over the filter element was measured on site. The $PM_x$ value in the supply air was calculated based on measured $PM_x$ concentration in outdoor air at the building and the $PM_x$ removal efficiency for the actual filter element in the air handling unit (AHU).

Filter class M5 and F9 were installed in the AHU and the measurement time for each filter class was at least 24 hours. The result for a complete working day has been analyzed for each filter class. The following factors have been analyzed:

- Filtration efficiency regarding $PM_x$, measured in AHU on site
- $PM_x$ concentration outdoor air
- Calculated supply air PMx concentration (based on measurements on site)
- $PM_x$ concentration exhaust air (IAQ)
- Ratio between $PM_x$ concentration, exhaust air/outdoor air

## 5. Results

**Gothenburg**, city size approximately 550 000 inhabitants
Office building located next to highway, AHU operating hours from 06.00 – 18.00
Supply air: Filter class M5 according to EN779:2012, bag filters, polyester media

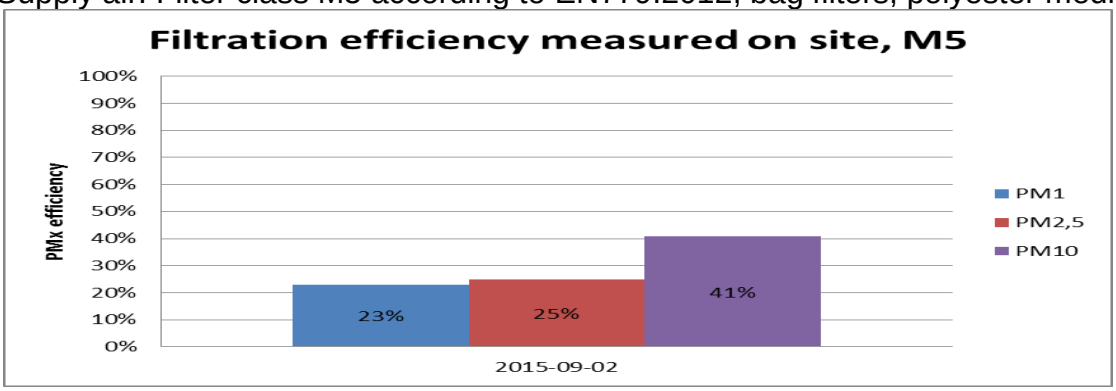



Figure 3: Office building in Gothenburg, $PM_x$ removal efficiency for M5 filters

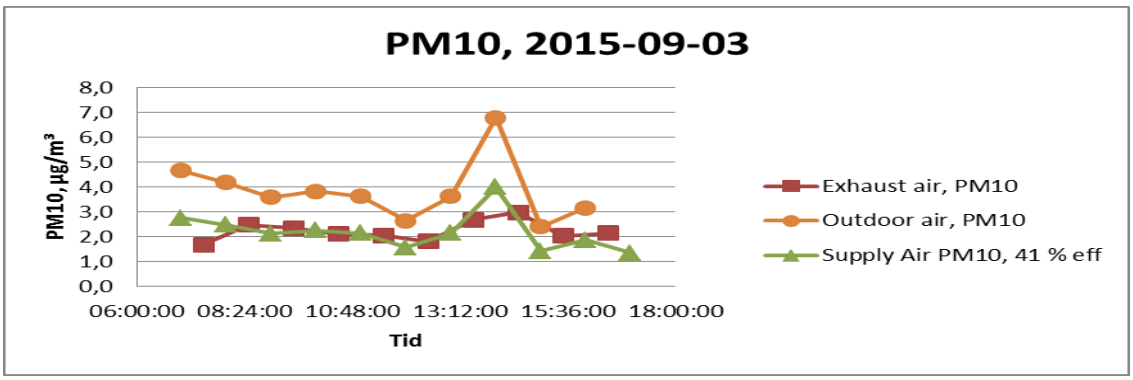



Figure 4 $PM_{10}$ concentrations in Gothenburg in office building

Supply air: Filter class F9 according to EN779:2012, bag filters, polypropylene media

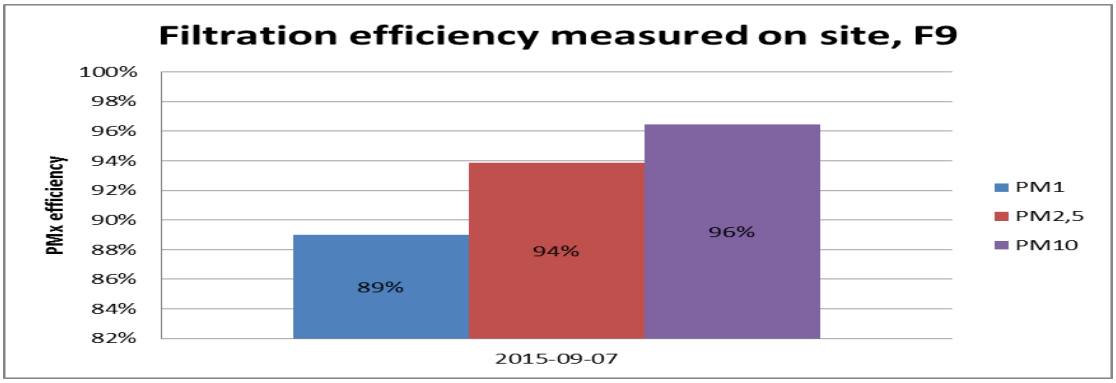


Figure 5 Office building in Gothenburg, $PM_x$ removal efficiency for F9 filters

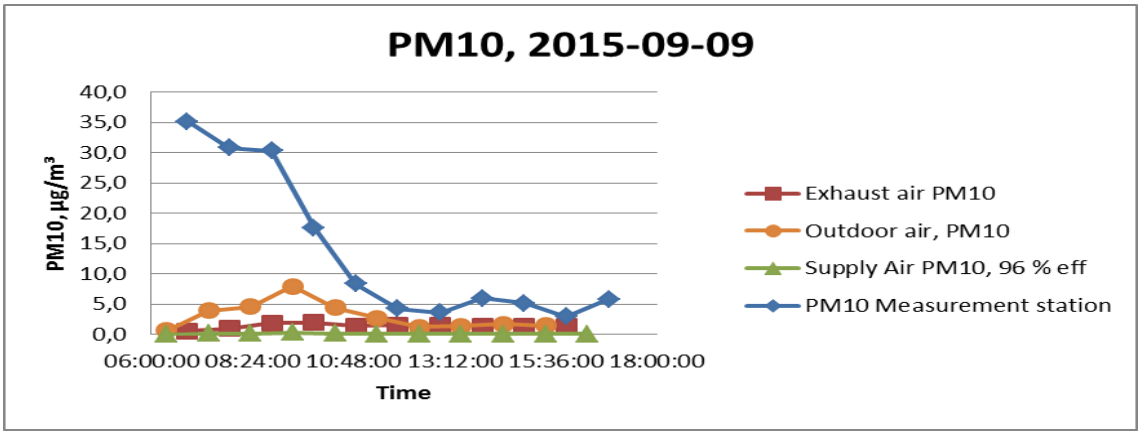


Figure 6 Figure 4 $PM_{10}$ concentrations in Gothenburg in office building

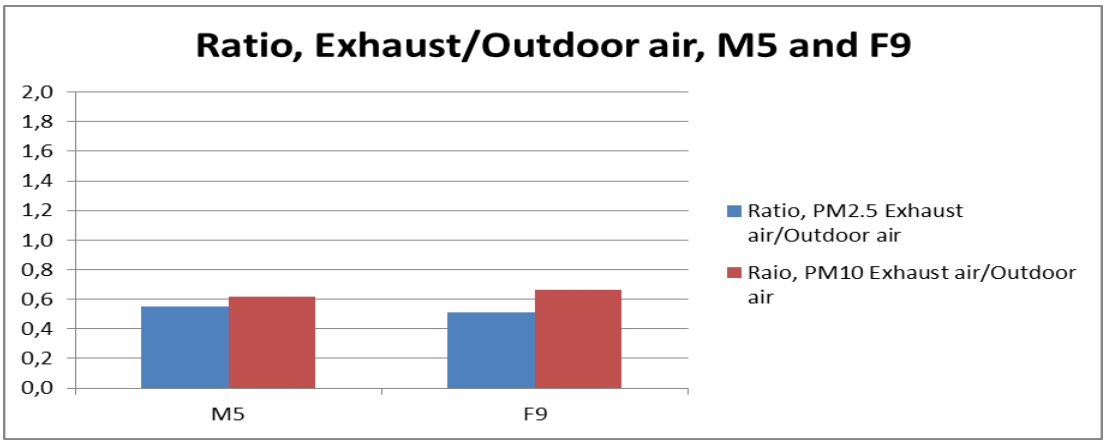
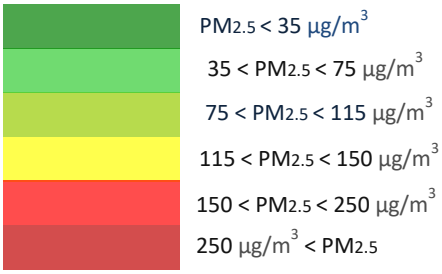


Figure 7 Result from office building in Gothenburg

**Shanghai**, city size approximately 24 000 000 inhabitants
Office, engineering, manufacturing & warehouse building
Supply air: Filter class F9 according to EN779:2012, bag filters, polypropylene media
Measurements made in Shanghai [12]

| **$PM_{2.5}$** | A=Measuring during low concentration | B= Measuring during high concentration |
|---|---|---|
| Outdoor concentration: | 24,4 µg/m³ | 173,8 µg/m³ |
| Downstream F9 filter: | 0,6 µg/m³ | 22,7 µg/m³ |
| $PM_{2.5}$ efficiency: | 97 % | 87 % |

Table 1, Measurement data from Shanghai




$PM_{2.5}$ concentration in indoor environment

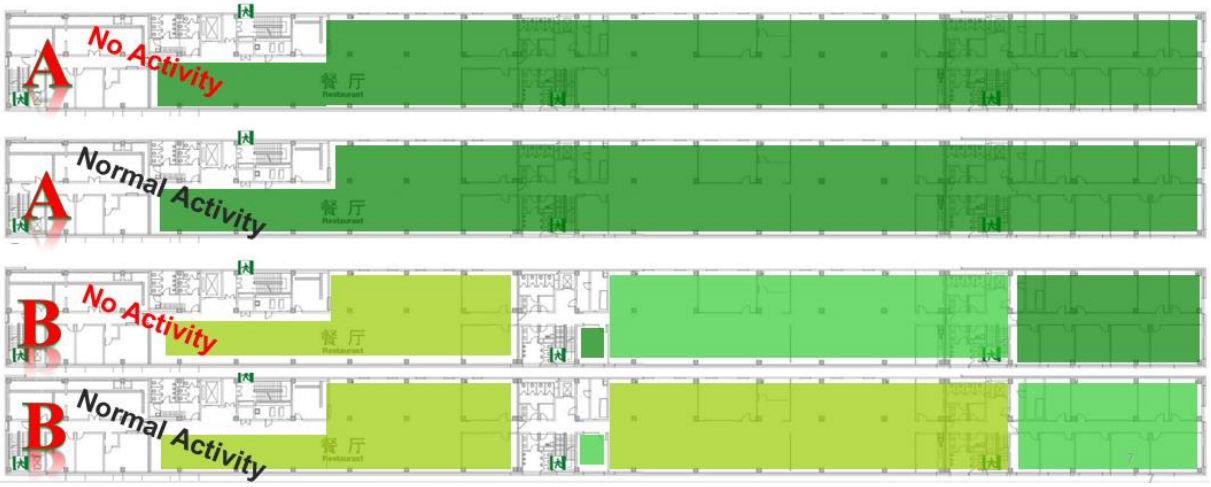



Figure 9. Measurement from IAQ in Shanghai facility

## 6 Conclusions

- In this project we have shown that health risks from high indoor PM values caused by high outdoor values could be solved by HVAC filters, Table1 and figure 9.

- The annual value regarding $PM_{2.5}$ for Shanghai is 61µg/m$^3$. From the measurements it is shown that $PM_{2.5}$ removal for F9 filters are 87-97%. So the downstream value in Shanghai for PM2.5 would be 8- 2 µg/m$^3$. Which meets the requirement from WHO (< 10 µg/m$^3$) and quiet close to the value in Bredkälen (2,9 µg/m$^3$).

- The filtration efficiency for the same type of filter in different environments is in the same range for F9, Shanghai 87-97% in Gothenburg 94 % (figure 5 and Table 1)

- In areas with low outdoor PM concentration the impact on indoor environment is negligible regarding filter class; the difference in IAQ between M5 and F9 filter in Gothenburg was insignificant (figure 7).

- In polluted areas, like Shanghai, the high filtration efficiency significantly improves the IAQ, especially during days with high PM concentrations (figure 9 and Table 1)

## 7. References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