

On site monitoring of smoking lounges in an office building based on the PM_{2.5} indicator

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Abstract

In this paper are summarized the final results of a two-month continuous monitoring campaign on seven smoking lounges and some copy areas in a building housing the offices of a big company. The monitoring is based in particular on the detection of suspended particulates, in order to confirm some experimental correlations of the PM₁₀/PM_{2.5} ratio in this critical situation.

The experimental measures have been performed in smoking lounges equipped following the technical requirements of the Italian Regulation (DPCM 23 December 2003) recently approved (10 January 2005).

The final results show how PM₁₀ and PM_{2.5} concentrations in the proximity of smoking areas were similar to the conditions of an outdoor high-polluted environment while inside smoking lounges the mean values detected were respectively 110 and 60 µg/m³ confirming the PM₁₀/PM_{2.5} ratio of between 1.5 and 2.5 reported in technical literature.

As a conclusion it is possible to underline how the presence of HVAC plants with specific requirements (no air recirculation, inlet air flow-rate 105 m³/h per person, ΔP of 5 Pa between smoking lounge and surrounding areas) is able to prevent the diffusion of passive smoke in no-smoking areas. Moreover, the extra-small particulates (PM_{2.5} and PM₁) are not removed enough inside smoking lounges due to the great decrease of the filter capitation efficiency for particulate matter with diameters lower than 3–5 µm.

1 Introduction

The possibility of a continuous monitoring of airborne particulate with portable equipments allows one to evaluate with high precision the concentration of small



particulates in indoor environments in order to validate the ventilation efficiency of HVAC systems in smoking lounges.

In the present study concentrations of PM_{10} and $PM_{2.5}$ have been monitored in an office building equipped with smoking lounges according to technical requirements of the new Italian regulation DPCM 23 December 2003, regarding the health risks of workers exposed to passive smoking.

In fact is well known that the particulate concentration in indoor environments due to environmental tobacco smoke (ETS) in the absence of an appropriate air exchange rate grows to a level much higher than the maximum threshold limits for human health in outdoor areas [2].

As a consequence of a high concentration of fine airborne particulates a significant incidence of lung and heart disease in the exposed population may occur.

2 The particulate monitoring campaign

On-line monitoring of temperature, relative humidity, CO, CO₂ and fine particulates (PM_{10} and $PM_{2.5}$) has been performed for a two-month period in 20 significant areas of an office building including all the smoking areas.

The measuring protocol for the evaluation of smoking lounges has been pointed out by the Department of Applied Physics of the University of Rome "La Sapienza" in cooperation with Italian Istituto Superiore di Sanità (ISS) [3, 4].

For thermal-hygrometric measures and CO and CO₂ detection an LSI BABUC-M has been utilized connected with a hot-wire velocity air probe in order to evaluate the air change rate. Fine particulate PM_{10} has been detected with a Dust Track Mounter TSI mod. 8520 in conformity with technical requirements of V annex of the Italian Environmental Ministry Decree 23/11/1994.

Ultra-fine particulates $PM_{2.5}$ have been detected with $PM_{2.5}$ EN LVS equipment (see figure 1), according to the En 12341 regulation [5, 6] and Italian Law Decree n° 60 02/04/2002 [7]; the suction air flow rate is equal to 38 litres/minute and the monitoring period range is between 12 and 24 hours.

In each room all the described parameters have been monitored three times in different occupation conditions but always when HVAC systems were switched on.

For a complete evaluation of IAQ building the experimental measures have been performed in all the seven smoking areas, in the surrounding copy areas and in the 8 meeting rooms distributed in all the five floors of the structure under examination.

3 Experimental results

The data coming from the two-month monitoring campaign inside the described building are reported in the following tables.



In table 1 the measures realized in copy areas and in meeting and boardrooms are given while in table 2 the IAQ analyses of the HVAC equipped smoking lounges are reported.



| | |
|-------------------------------------|---|
| Monitoring efficiency: | particulate with diameter 10 μm or lower, according Italian DL/1994 and EN12341. |
| Adjustable suction air flow: | 0.9/1.5 m^3/min . |
| Air flow control: | electronic mass flow control |
| Suction head: | 1.0 HP double section |

Figure 1: $\text{PM}_{2.5}$ EN LVS equipment.

For a better comprehension of the data, in bold are reported those values (coming from the mean of the results of the three monitorings) exceeding the comfort and health limits deduced from the following Italian regulations:

| | |
|-----------------------------|--|
| T, UR | Technical Regulation UNI 10339 |
| CO , CO_2 | Italian Ministry Decree n. 159 25/11/1994 |
| PM_{10} | Italian Ministry Decree n. 159 25/11/1994 |
| $\text{PM}_{2.5}$ | Environmental Ministry Decree n. 60 02/04/2002 |

Table 1: Meeting rooms and copy areas monitoring results.

| MEETING ROOMS AND COPY AREAS | T[°C] / UR[%] | PM ₁₀ [µg/m ³] | PM _{2.5} [µg/m ³] | CO [ppm] | CO ₂ [ppm] |
|------------------------------|---------------|---------------------------------------|--|----------|-----------------------|
| LIMITS | | 150 | 50 | 8 | 650-700 |
| 3rd floor | | | | | |
| Meeting room | 23.2/58.8 | 65 | 38 | 0 | 687 |
| Copy area 1 | 23/63.2 | 96 | 50 | 0 | 887 |
| Copy area 2 | 23.1/57 | 58 | 30 | 0 | 713 |
| | | | | | |
| 2nd floor | | | | | |
| Meeting room | 22.5/58 | 44 | 22 | 0 | 510 |
| Copy area 1 | 24/63.2 | 144 | 72 | 0 | 927 |
| Copy area 2 | 23.1/57 | 112 | 66 | 0 | 611 |
| | | | | | |
| 1st floor | | | | | |
| Meeting room | 23.3/59.3 | 48 | 20 | 0 | 775 |
| Copy area 1 | 24/63.2 | 109 | 58 | 0 | 650 |
| Copy area 2 | 23.1/57 | 100 | 54 | 0 | 537 |
| | | | | | |
| Lounge | | | | | |
| Meeting room | 23.1/59.6 | 70 | 32 | 0 | 640 |
| Board room | 24.3/63.1 | 35 | -- | 0 | 610 |
| Copy area | 24.1/65 | 70 | 37 | 0 | 580 |
| | | | | | |
| -1st floor | | | | | |
| Training room 1 | 22.2/61.3 | 60 | 25 | 0 | 660 |
| Training room 2 | 21/64.9 | 59 | 28 | 0 | 680 |
| Meeting room | 22.1/64.8 | 45 | 21 | 0 | 700 |

4 Conclusions and further developments

The results of the monitoring data, with particular regard to the validity of the specific requirements of HVAC in smoking lounges contained in new Italian regulations, lead to some interesting considerations about IAQ in office buildings with correct smoking policy:



Table 2: Smoking lounges monitoring results.

| SMOKING AREAS | T[°C] / UR[%] | PM ₁₀ [µg/m ³] | PM _{2.5} [µg/m ³] | CO [ppm] | CO ₂ [ppm] |
|---------------|---------------|---------------------------------------|--|----------|-----------------------|
| LIMITS | | 350 | 95 | 8 | 650-700 |
| 4th floor | 21.2/58.3 | 110 | 58 | 0 | 710 |
| 3rd floor | 22.3/61 | 128 | 63 | 0 | 650 |
| 2st floor | 22.1/62.5 | 149 | 77 | 0 | 930 |
| 1st floor | 22.4/64.2 | 75 | 52 | 0 | 650 |
| Lounge | 23.3/59.5 | 100 | 57 | 0 | 626 |

- the presence of HVAC plants with good filtration and ventilation efficiency is sufficient to guarantee the overall respect of IAQ regulation standard; however it is important to underline that captation efficiency of the system decrease in a significant way for ETS extra fine particulates (PM_{2.5} and PM₁);
- the physical separation of smoking lounges from non-smoking areas, coupled with the appropriate pressure difference of 5 Pa and a cross air velocity > 0.2 m/s, imposed by DPCM 23 December 2003, is able to avoid any crossing of airborne ETS pollutant in smoke-free areas;
- the extra fine particulate concentration in all meeting rooms does not exceed comfort values even in the presence of full occupancy;
- the sporadic presence of high concentrations of particulates (PM₁₀ and PM_{2.5}) in the copy area is a consequence of the presence of toner and other copy materials coupled with an insufficient air extraction flow-rate;
- in all the 20 areas, the PM₁₀/PM_{2.5} ratio is between 1.5 and 2.5 confirming the poor literature data available for extra fine particulate monitoring in offices.

A further monitoring campaign will be performed in the next few months in order to confirm this preliminary data with a deeper analysis of the presence of extra-fine particulate PM_{2.5} and PM₁.



References

- [1] Decree of the President of the Ministry Council, DPCM 23 December 2003.
- [2] UN Environment Program and WHO Report. Air pollution in the world's megacities. A Report from the UN Environment Programme and WHO. Environment 1994; 36: 5-37.
- [3] Ministero per l'Ambiente. Relazione sullo Stato dell'Ambiente 2001. 2001, 350.
- [4] De Santoli L., Fracastoro G., (1998) *La qualità dell'aria negli ambienti interni. Soluzioni e strategie.* (in Italian). Collana AICARR.
- [5] BRFSS Coordinators. State-Specific Prevalence of Current Cigarette Smoking Among Adults and the Proportion of Adults Who Work in a Smoke-Free Environment -United States, 1999. MMWR 2000; 49: 978-82.
- [6] Chang LT, Suh HH, Wolfson JM et al. Laboratory and field evaluation of measurement methods for one-hour exposure to O₃, PM_{2.5} and CO. J Air & Waste Manag Assoc 2001; 51: 1414-22.
- [7] G. Invernizzi, A. Ruprecht, R. Mazza, E. Majno, E. Rossetti, P. Paredi, R. Boffi, La misurazione in tempo reale del particolato fine prodotto da fumo di sigaretta negli ambienti indoor: risultati di uno studio pilota. Epidemiologia & Prevenzione anno 26 gennaio-febbraio 2002.

