

# RESPIRATORY TRACT DEPOSITION OF DIESEL ENGINE EXHAUST PARTICLES – COMPARISON BETWEEN HEALTHY SUBJECTS AND SUBJECTS WITH COPD

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## INTRODUCTION

Numerous epidemiological studies have shown a correlation between increased morbidity and mortality rates and aerosol mass concentrations. Studies also show that the most harmful particles might be found in the ultrafine size range, as they exist in very high number concentrations. This suggests that the regulation of PM<sub>10</sub> or PM<sub>2.5</sub> might not be the best way to reduce adverse health effects caused by airborne particles. The deposited fraction and dose has also shown great variability between different individuals and aerosols. It is therefore important to investigate the deposited fraction and dose for different kinds of aerosols, breathing patterns, shapes of the lung, etc. to be able to find the factors that affect the deposition of aerosol particles. It has been suggested that certain sub-populations are more susceptible to adverse health effects of airborne particles. One such group is those diagnosed with chronic obstructive pulmonary disease (COPD). In this study the deposited fraction and dose of diesel exhaust particles are measured in both healthy lungs and lungs with COPD.

## METHODS

In this study the size-resolved deposited fraction and deposited dose of diesel engine exhaust particles were measured with the RESPI instrument (Löndahl et al. 2006). The measurements were done on 10 healthy subjects (5m/5f) and 10 subjects (7m/3f) with varying degree of COPD, from mild to moderate. One healthy male was excluded from the study as his breathing was far from normal relaxed breathing. A Volvo diesel engine (Volvo TD40 GJE, 4.0 L, four cylinders, 1996) with no exhaust after treatment was used with a typical MK1 diesel fuel (sulphur content  $\leq 10$  ppm). The engine was operated in a motor test bench to simulate different running conditions. The deposited fraction was measured for two different aerosols; one during idling engine conditions and one during transient load conditions according to the urban driving part of the standardized European Transient Cycle (ETC) protocol. The deposited fraction according to the International Commission for Radiological Protection model (ICRP, 1995) was calculated for each subject and compared to the measured values. The deposited dose was calculated for one hour exposure to  $100 \mu\text{g}/\text{m}^3$  for both aerosols.

## RESULT AND CONCLUSIONS

The average deposited fraction and dose for the two groups and aerosols are presented in Table 1. The study showed a statistically significant difference in deposited fraction between the groups. For both studied driving conditions, the deposited fraction is lower for the subjects with COPD compared to the healthy subjects, but the deposited dose is higher. The higher deposited dose for the subjects with COPD is expected as they breathe with a higher minute volume than the healthy subjects. The difference in deposited fraction between the two aerosols can most probably be explained by the different size distributions. The aerosol from the idle driving contains more nucleation mode particles for which the probability of deposition is high.

Table 1: Average deposited fraction (DF) and deposited dose for exposure to 100  $\mu\text{g}/\text{m}^3$  of diesel exhaust particles during one hour.

	Idle driving		Transient driving	
	DF	Dose ( $\mu\text{g}$ )	DF	Dose ( $\mu\text{g}$ )
Healthy	0.65	13.2	0.47	11.5
COPD	0.57	16.6	0.40	14.3

When comparing the measured size-resolved deposited fractions with those of the ICRP model, the measured deposition for the healthy group agrees well with the ICRP model but as in earlier studies with RESPI it shows a higher deposition (Figure 1). The measured deposited fractions for the group with COPD show a different pattern compared to the ICRP model, which indicates that the damages in the lung from the disease also affects the deposition and not only the difference in breathing patterns between the two groups. The difference in deposited fraction between the healthy group and the group with COPD is most significant in the particle size range between 20 nm and 70 nm where the deposited fraction is higher for the healthy group, Figure 1. In this size range, the ICRP model predicts the highest deposition to be in the alveolar region. COPD affects the alveolar region, for example with emphysema which cause a gradual destruction of the alveolar walls.

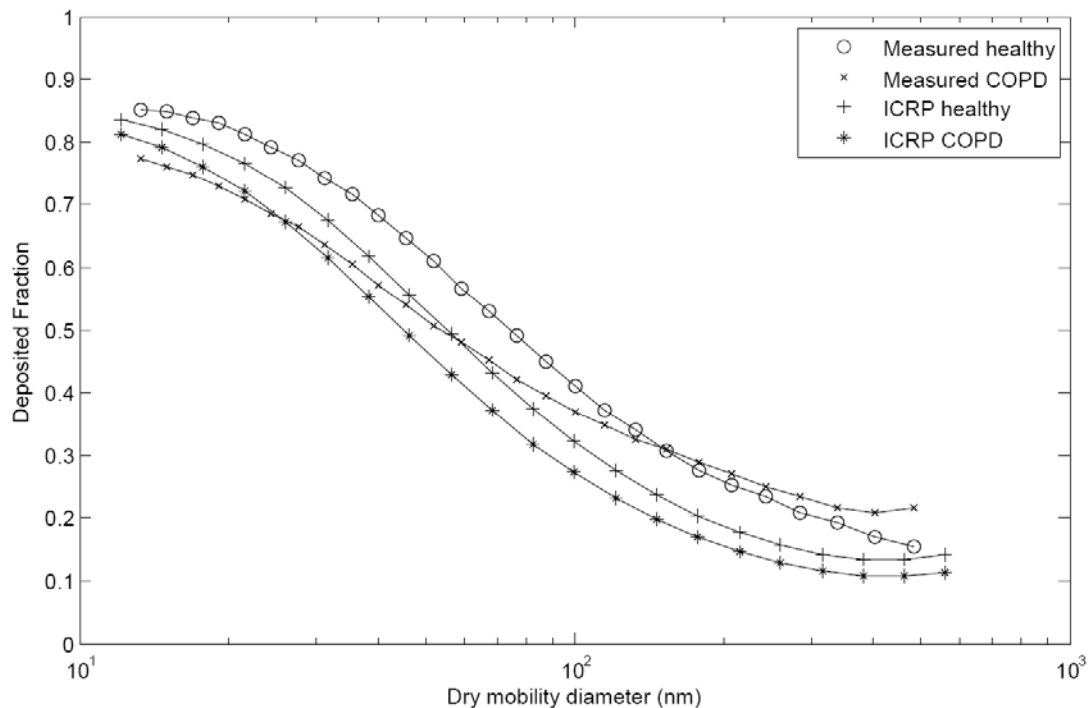


Figure 1: Measured deposited fraction and calculated deposited fraction with the ICRP model for the idle driving conditions.

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#### REFERENCES

- ICRP Publication 66. 1995. Human Respiratory Tract Model for Radiological Protection, 66. International Commission on Radiological Protection.
- Löndahl J, Pagels J, Swietlicki E, Zhou JC, Ketzel M, Massling A, Bohgard M. 2006. A set-up for field studies of respiratory tract deposition of fine and ultrafine particles in humans. *Journal of Aerosol Science* 37:1152-1163.