


Respiratory protection against nanoparticles : elements for a better respirators selection guidance

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Classical procedure for the selection of an adequate RPD

1. Workplace characterization

- Oxygen fraction in air
- Temperature, relative humidity
- Operation
- Length of the period of work
- Others risks

2. Pollutant and emission characterizations

- Chemical nature
- Occupational Exposure Limit (OEL)
- Size distribution
- Mean and maximal concentration in the workplace atmosphere



4. Type of Respiratory Protective Device

- Filtering or air-supplying device
- Assigned Protection Factor (NF EN 529 (2005)) > minimal protection required
- Appropriate precautions

3. Respiratory protection required

Minimal protection defined by the ratio between maximal concentration in the workplace and OEL



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Objectives of the study

- Background:

- Filtration efficiency of fibrous filters used in RPDs increases when decreasing particle size under 150 nm (Mouret G., Chazelet S., Thomas D., Bemer D., *Discussion about the thermal rebound of nanoparticles*; Sep. And Pur. Tech., 78, pp. 125-131; 2011)
- The first results on two half-masks on a Sheffield head show that leakages control protection factor level and particle size effect (Brochot C., Michielsen N., Chazelet S., Thomas D.; *Measurement of protection Factor of respiratory Protective Devices Toward Nanoparticles*; Ann. Occup. Hyg., 56, pp. 595-605, 2012)

- Objectives:

To study the effects of:

- the type of RPD
- the fit of the mask on the face
- the respiratory flowrate (work rate)
- the particle morphology (agglomerates vs spherical particles)

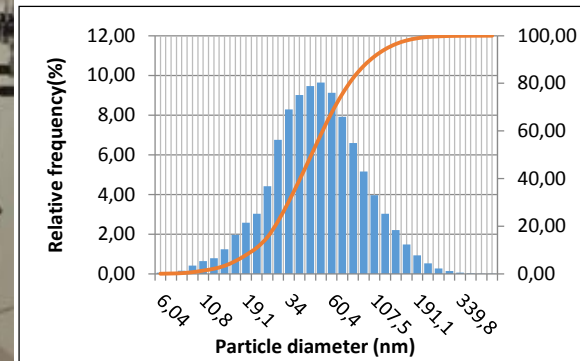
On the evolution of the protection factor with particle size under 150 nm

PRORESPI test bench



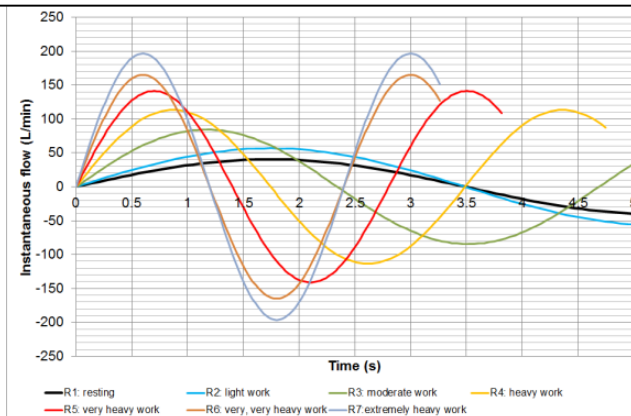
MEASUREMENTS (Nanoscan TSI):

- Outside concentration $C_o(dp)$
- Inside concentration $C_i(dp)$
- Relative pressure inside facepiece $P'(t)$



RESPIRATORY FLOWRATE:

- Breathing simulator
- Ventilated volume and frequency defined according to ISO/DIS 8996 (1987) R_i (i:1..7)

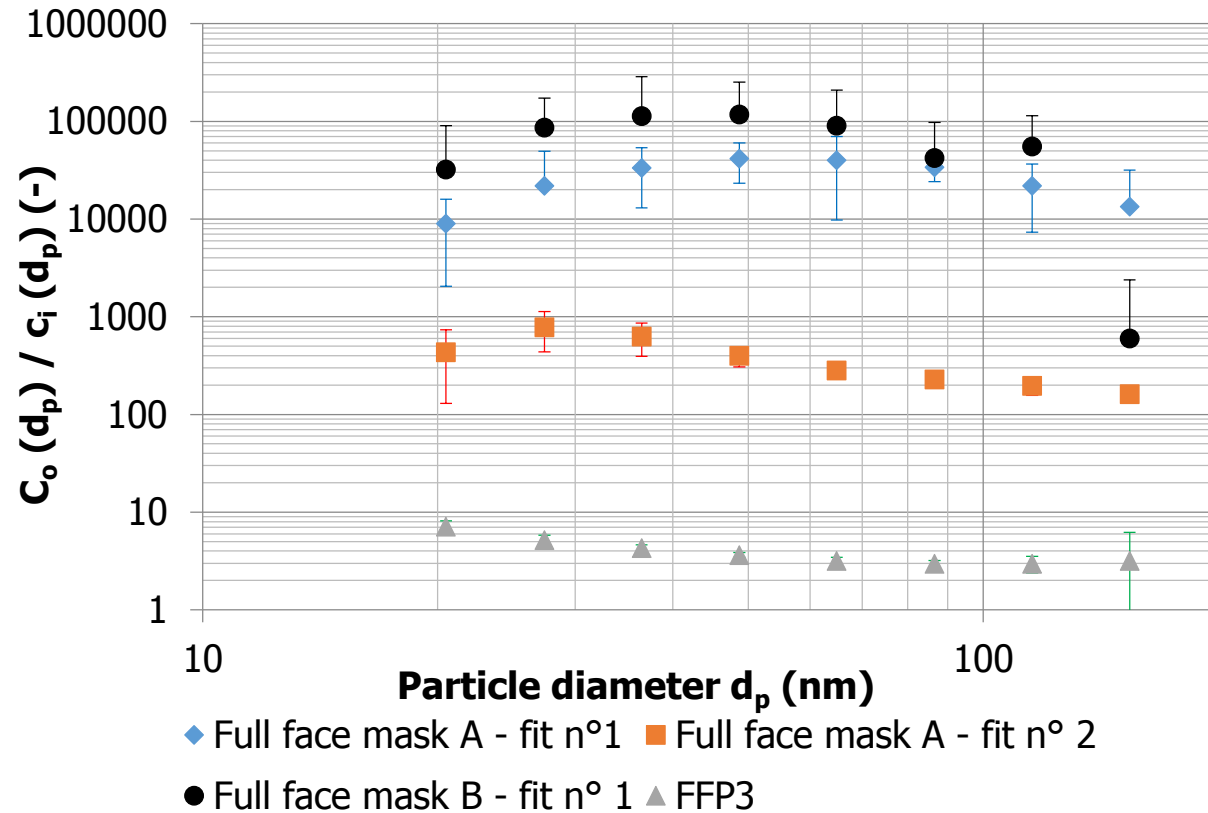


RESPIRATOR PERFORMANCE:

- Protection factor $PF (= C_o/C_i)$ function of:
 - dp
 - R_i
 - facepiece position on Sheffield head

Experimental results

- Effect of the fit of the RPD



- measurement of the protection factor
- characterization of the fit by a quantitative fit testing method by negative pressure: Quantifit (OHD)

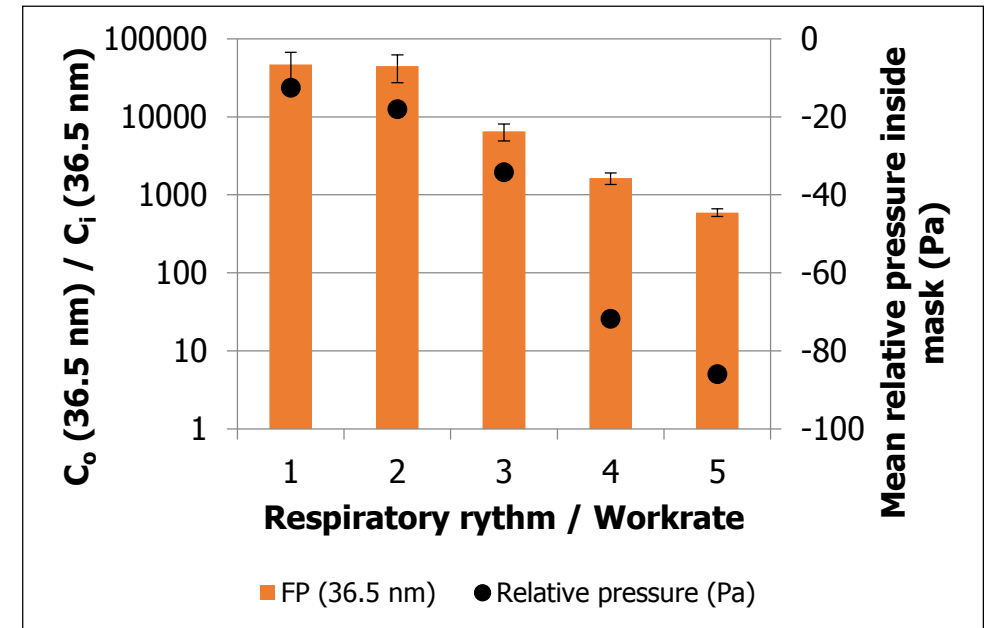
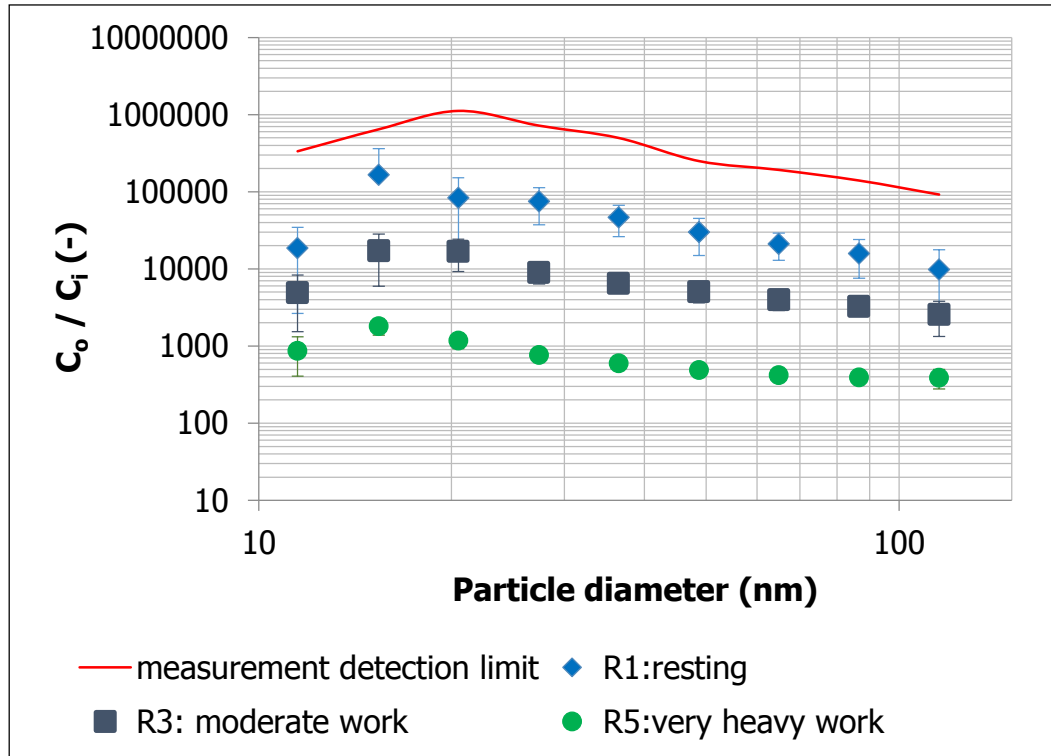


Full face mask	Fit factor (Quantifit) (-)
A – fit n°1	1550
A – fit n°2	50
B – fit n°1	816

- Protection factor of filtering full face mask increases when the particle size decreases
- 2 different fits of the same RPD can lead to 2 different levels of respiratory protection
- Fit factor determined by Quantifit is an indicator of a good fit

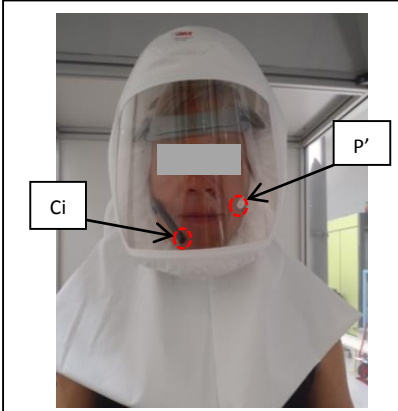
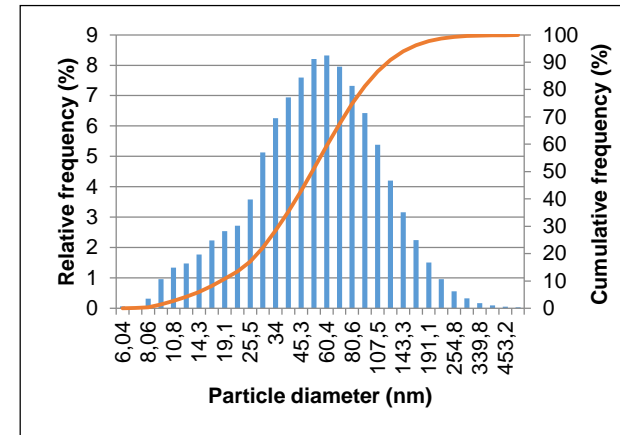
Experimental results

- Protection level of a full face mask - Effect of the respiratory flowrate



- Protection factor of filtering full face mask increases when the particle size decreases
- Increasing respiratory flowrate decreases the protection factor
- Pressure inside mask decreases when the respiratory flowrate increases

NaCl chamber with test subjects



- MEASUREMENTS**
(Nanoscan TSI):
- Outside concentration $C_o(dp)$
 - Inside concentration $C_i(dp)$
 - Relative pressure inside facepiece $P'(t)$

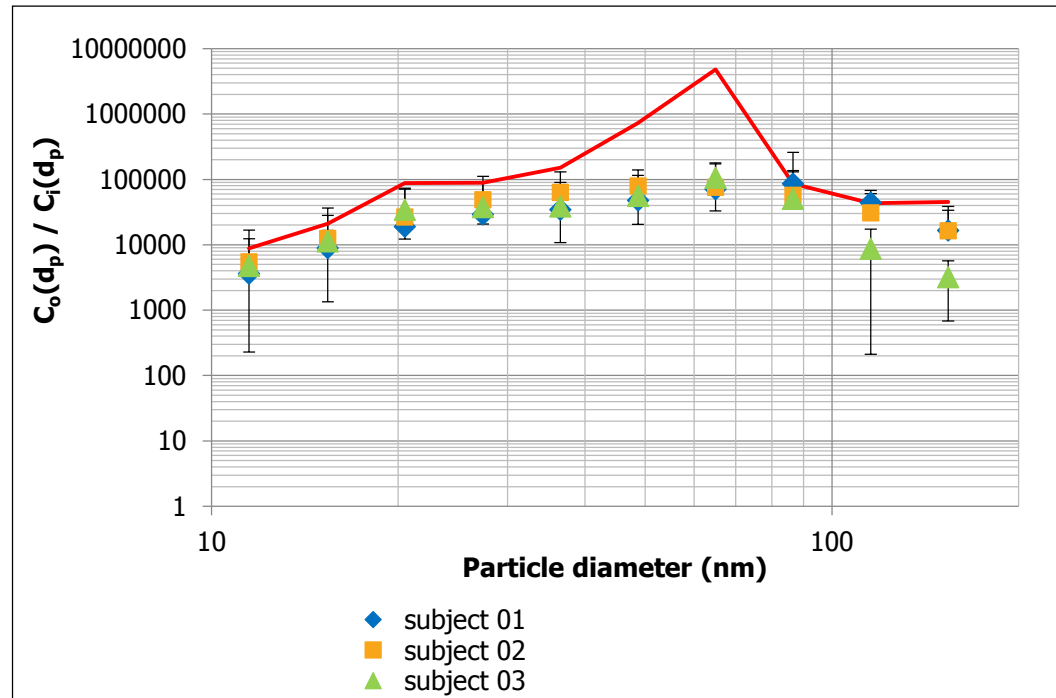
Exercise n°	Description
1	Normal breathing
2	head movements
3	Speaking
4	Bending over
5	Walking at high speed : 6 km/h

RESPIRATOR PERFORMANCE:

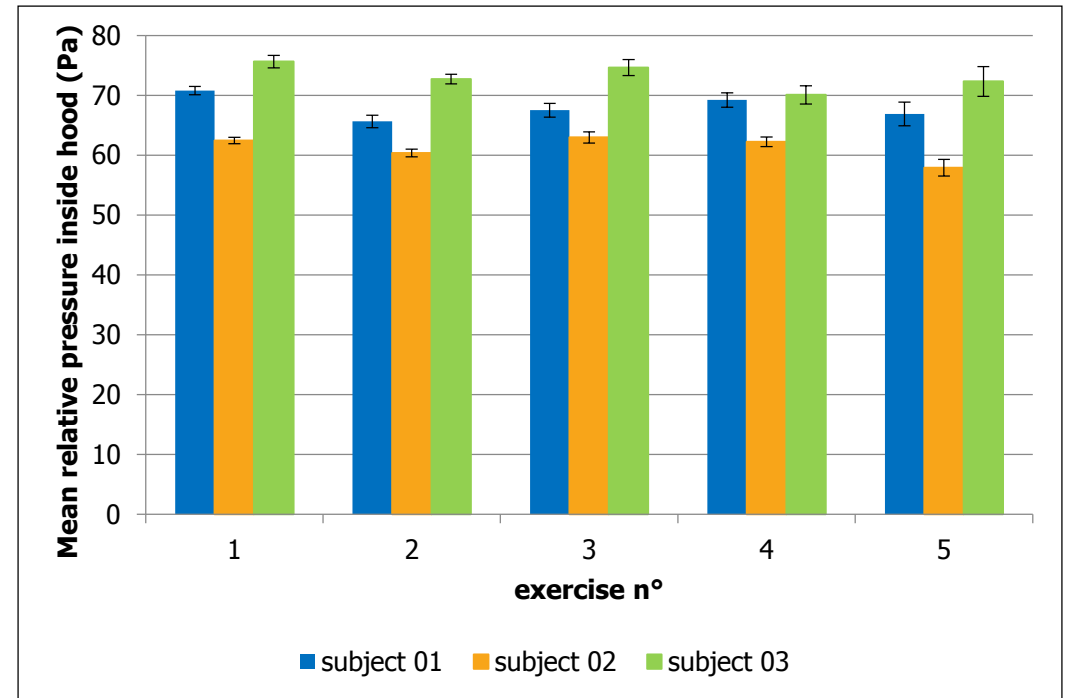
- Protection factor $PF (= C_o/C_i)$ function of:
 - dp
 - subject
 - exercise

Experimental results on test subjects

- Protection level of a powered air-purifying hood
Results on 3 different test subjects doing physical exercises



Protection factor in NaCl chamber for 3 test subjects as a function of particle size – exercise n° 2: head movement



Mean relative pressure inside hood measured on 3 subjects in NaCl chamber for the 5 exercises

- Very high level of respiratory protection are measured for this type of hood, independant of the test subject and the exercise realized

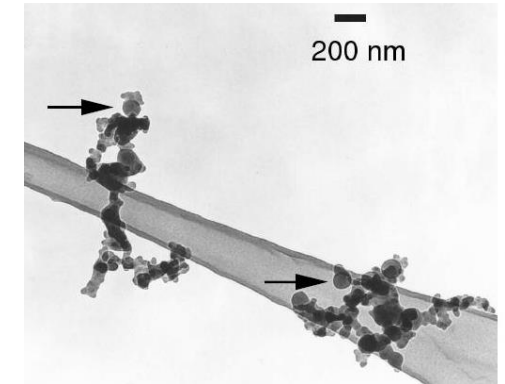
Conclusions

- First conclusions

- Measurements realized on different types of filtering RPDs show an increase of the respiratory protection with the decrease of the particle size under 150 nm
- A good respiratory protection depends on a good fit
- The respiratory protection is a function of the workrate

- Perspectives of the study

- Work on the links between protection factor, relative pressure inside mask, fit factor
- Modification of the aerosol with the generation of soot agglomerates in the PRORESPI test bench
- Evolution of the protection factor as a function of the filter clogging (case of the long-period wearing the RPD in a high concentrated atmosphere)



Schnaiter; Atmos. Chem. Phys., 6, 2981 (2006)



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