# Expolab: A new whole body exposure chamber for assessing occupational health risks

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## Abstract

Exposures to air contaminants like chemical vapours and particles pose one of the most important health risks at the workplace. An emerging field in applied research and technology are human exposure studies. Key questions concern effects from exposures to chemicals or mixtures of chemical vapours and/or particles. The aim is to determine the effects of co-exposures by using controlled levels of multiple compound mixtures. The studies are conducted under standardized extensive exposure characterization and detailed measurements of physiological, behavioural and pharmacodynamic effects.

The air conditioning system of the IPA exposure laboratory offers a wide variety of adjustments of temperature, humidity and flow rates. To demonstrate the performance of the exposure chamber in respect of the concentration stability of generated atmospheres the results of sooty particle measurements are presented.

## Technical details of the exposure chamber and the dosage system

For a regular distribution of chemical vapours or particles in the exposure chamber it is necessary to force the flow direction of the loaded air from the floor to the ceiling. The conditioned air contaminated with the interesting substances via a T-piece is pumped through air outlets. The ceiling exhaust ventilation system removes consumed air.

## Particle generation and analyzing system

To assess the distribution of particles we chose ultra fine carbon black particles. These particles were generated by an electric arc discharge system (GFG 3000, Palas GmbH, Germany) between two consumable carbon electrodes in an argon gas environment with added oxygen. The highly concentrated particles were mixed with the complete air stream of the air conditioner. An electrostatic classifier (SMPS, model 3080, TSI Inc., USA) coupled with a condensation particle counter (CPC, model 3010, TSI Inc., USA) was used to characterize the particles and the inhomogeneity of distribution. This system detects particles in the range of 10 to 430 nm and was installed on a mobile table in the exposure chamber. The

number concentration and the sizes distributions were determined point by point (0.50 m * 0.50 m) in a height of 1.20 m, representative for the height of subject's faces during sitting in the chamber. The profile of the measurement-scheme is shown.

**Results**

Under these conditions the sooty particles have a median diameter of 53 nm and a normalized particle number concentration of 111.000 per $cm^3$. The interest standard deviation over all 35 measurement points is relatively small (2.5 %) and negligible higher than the value of 1.1 % (average: 107.000 particles per $cm^3$), determined with ten times repeated measurements in the middle of the exposure chamber.

**Summery**

All experimental investigations indicate that this whole-body exposure chamber system will present unique possibilities for experimental exposure research to assess occupational health risks. Moreover the generation and distribution of nano particles can be realized. The inhomogeneity of the synthesized sooty particles is very small and enables that all four subjects in the exposure chamber can be exposed to the same atmosphere at all time.

# Expolab: A new whole body exposure chamber for assessing occupational health risks

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## Abstract

Exposures to air contaminants like chemical vapours and particles pose one of the most important health risks at the workplace. An emerging field in applied research and technology are human exposure studies. Key questions concern effects from exposures to chemicals or mixtures of chemical vapours and/or particles. The aim is to determine the effects of co-exposures by using controlled levels of multiple compound mixtures. The studies are conducted under standardized extensive exposure characterization and detailed measurements of physiological, behavioural and pharmacodynamic effects.
The air conditioning system of the IPA exposure laboratory offers a wide variety of adjustments of temperature, humidity and flow rates (figure 1). To demonstrate the performance of the exposure chamber in respect of the concentration stability of generated atmospheres the results of sooty particle measurements are presented.

## Technical details of the exposure chamber and the dosage system

For a regular distribution of chemical vapours or particles in the exposure chamber (dimensions: 3.92 m length, 2.91 m width and 2.50 m height, total chamber volume: 28.6 $m^3$) it is necessary to force the flow direction of the loaded air from the floor to the ceiling. The conditioned air contaminated with the interesting substances via a T-piece is pumped through air outlets shown in figure 2. The ceiling exhaust ventilation system removes consumed air. A high air exchange rate (adjustable from 5 to 15 times per hour, 120 to 450 $m^3/h$) prevents inhomogeneities of the injected compounds.

## Particle generation and analyzing system

To assess the distribution of particles in the chamber we chose ultra fine carbon black particles. These particles were generated by an electric arc discharge system (GFG 3000, Palas GmbH, Germany) between two consumable carbon electrodes in an argon gas environment (flow: 5.0 l/min.) with added oxygen (air flow: 10.0 l/min.). The highly concentradted partikels where mixed with the complete air stream of the air conditioner (air flow: 360 $m^3/h$). An electrostatic classifier (SMPS, model 3080, TSI Inc., USA) coupled with a condensation particle counter (CPC, model 3010, TSI Inc., USA) was used to characterize the particles and the inhomogeneity of distribution. This system detects particles in the range of 10 to 430 nm and was installed on a mobile table in the exposure chamber, shown in figure 3. The number concentration and the sizes distributions were determined point by point (0.50 m * 0.50 m) in a height of 1.20m, representative for the height of subject's faces during sitting in the chamber. The profile of the measurement-scheme is shown in figure 4.

**Fig. 1:** View into the ExpoLab with four subjects

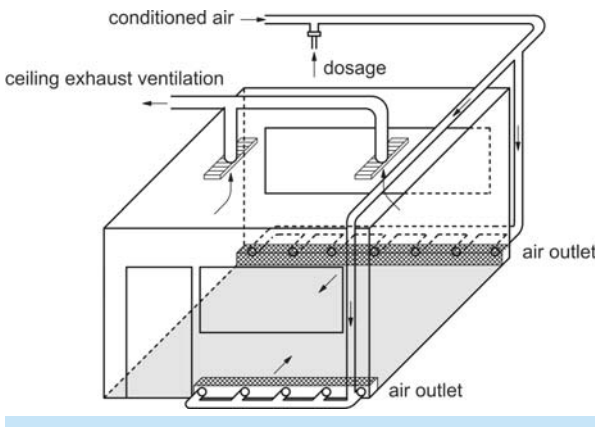


**Fig. 2:** Schematic view of the airflow system

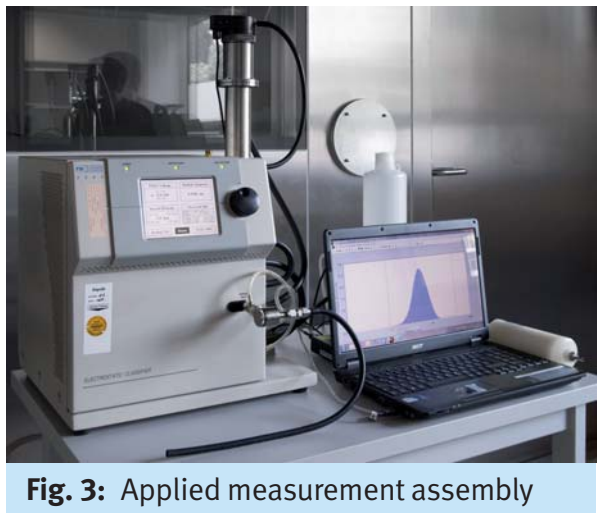

**Fig. 3:** Applied measurement assembly

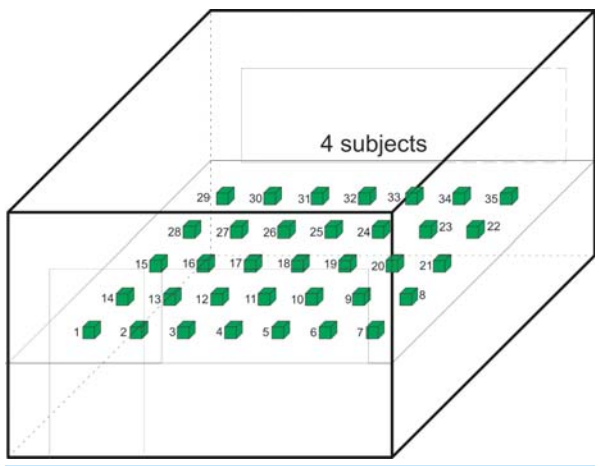


**Fig. 4:** Sequence of measured points in the ExpoLab

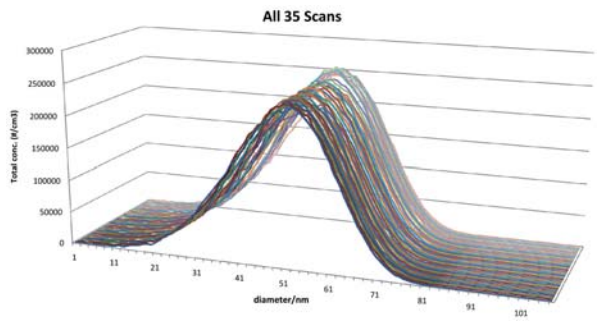


**Fig. 5:** Particle size distributions of all measurement points

## Results

Under these conditions the sooty particles have a median diameter of 53 nm and a normalized particle number concentration of 111.000 per $cm^3$. The interesting standard deviation over all 35 measurement points is relatively small (2.5 %) and negligible higher than the value of 1.1 % (average: 107.000 particles per $cm^3$), determined with ten times repeated measurements in the middle of the exposure chamber at measurement point 18.

## Summary

All experimental investigations indicate that this whole-body exposure chamber system will present unique possibilities for experimental exposure research to assess occupational health risks. Moreover the generation and distribution of nano particles can be realized. The inhomogeneity of the synthesized sooty particles is very small and enables that all four subjects in the exposure chamber can be exposed to the same atmosphere at all time.