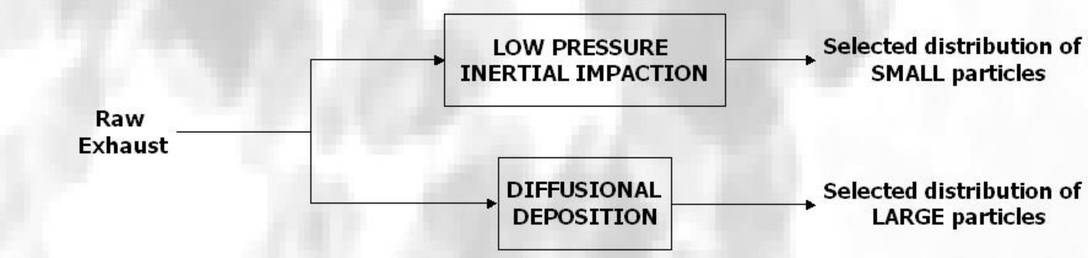
Design and evaluation of a selective particle size sampler for continuous delivery of different size ranges of diesel exhaust particles for health effect studies

Dimitrios Boudouris, Eleni Papaioannou, Penelope K. Baltzopoulou and Athanasios G. Konstandopoulos

Aerosol & Particle Technology Laboratory
CERTH/CPERI, P.O. Box 361, Thermi Thessaloniki 57 001, Greece
Phone: +30 2310 498192 Fax: +30 2310 498190 E-mail: agk@cperi.certh.gr http://apt.cperi.certh.gr

MOTIVATION

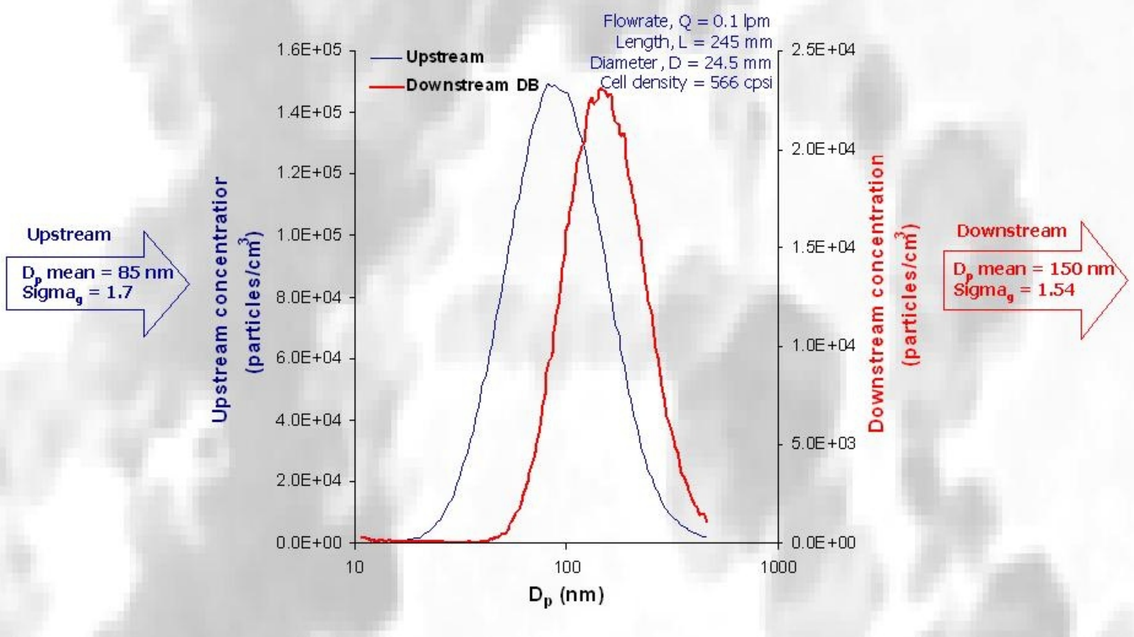
The objective of this study is the design, construction and evaluation of a **Selective Particle Size (SPS)** sampler able to provide continuous delivery of diesel soot particles of specific size ranges. The design of the sampler combines principles of aerosol transport phenomena and separation technologies. Particles smaller than a given size are removed from the exhaust by **diffusional deposition**, while removal of particles above a given size is achieved by **low pressure inertial impaction**. Diesel exhaust from modern engines has a typical particle size distribution with mean mobility diameter about 80-90 nm. We illustrate the use of the developed sampler by demonstrating the continuous delivery of two different size distributions with about 60 and 150 nm mean diameter respectively. The sampler can be used for biological exposure with appropriate sample dilution and conditioning.



EXPERIMENTAL

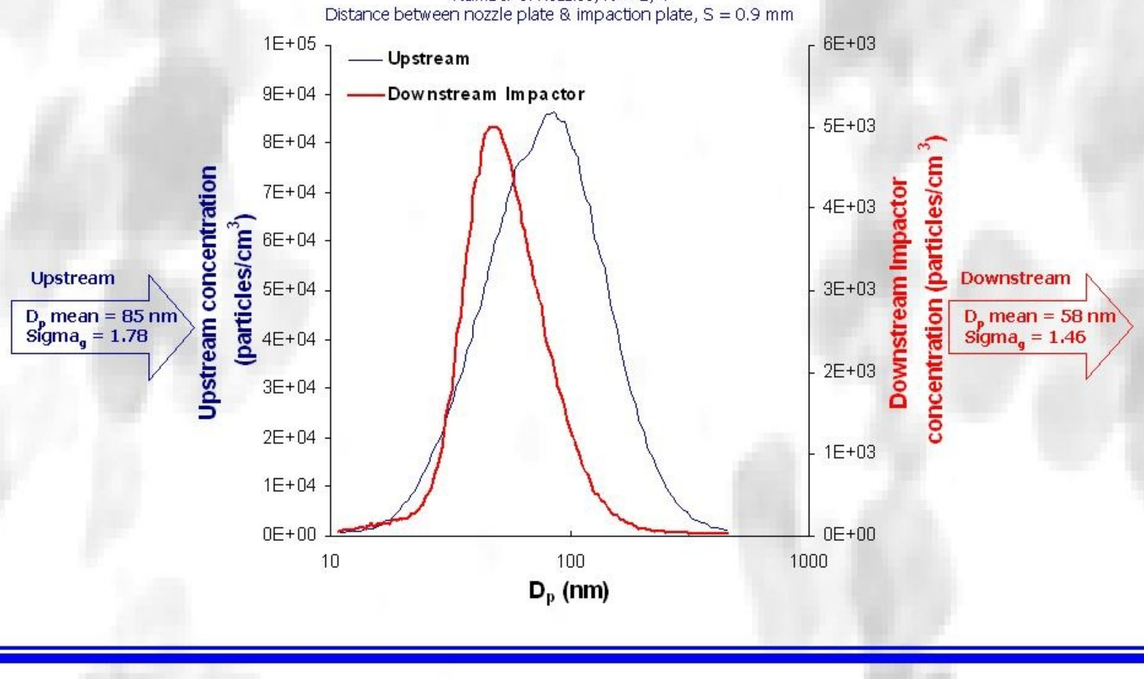
DIFFUSIONAL DEPOSITION – Selection of Large Particles

With this method, larger particles than a given size can be removed from the exhaust by diffusional deposition. The **Diffusion Battery (DB)** principle of operation is based on the fact that as aerosol particle size decreases, diffusion becomes an increasingly important mechanism controlling particle transport. Specifically, for particle sizes up to about 100 nm diffusion is the dominant mechanism controlling particle transport. As an aerosol is passed through a DB consisting of an array of small channels, some particles will deposit on the channel walls due to their random Brownian motion. A diffusion battery was realized employing different lengths of "flow through" cordierite honeycombs with 245 mm diameter and 566 cells/in2 (cpsi)



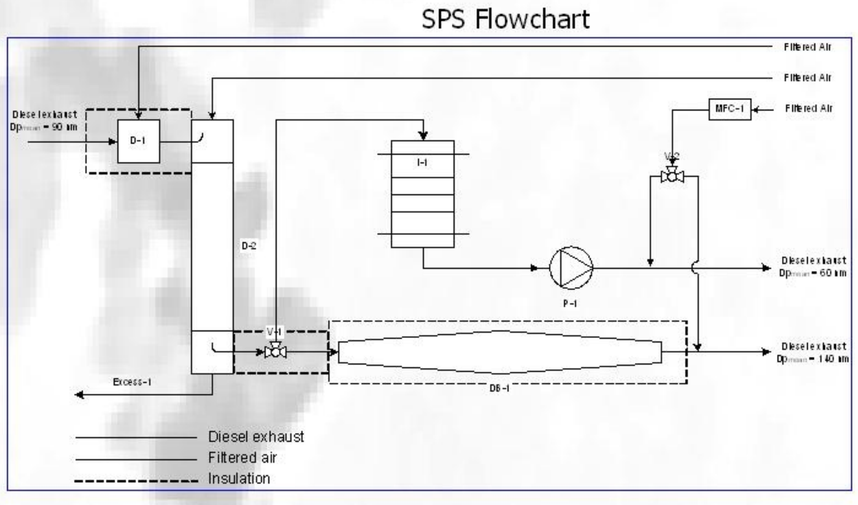
LOW PRESSURE INERTIAL IMPACTION – Selection of Small Particles

- Based on this concept, removal of particles above a given size occurs by inertial impaction. The aerosol flow is accelerated through a nozzle directed at a flat plate. The impaction plate deflects the flow to form a 90° bend in the streamlines. Particles with sufficient inertia as quantified by their Stokes number, Stk, are unable to follow the streamlines and impact on the plate. Smaller particles follow the streamlines, avoid contact with the plate and exit the impactor
- The aerodynamic particle size at which the particles are separated is called the cut-point diameter. This is a function of the impactor flow rate and nozzle diameter. The small size of diesel particles necessitates the use of low pressures in the impactor and this means that the limiting trajectory which separates the non – collected than the impacted particles will be at pressures much lower than atmospheric.

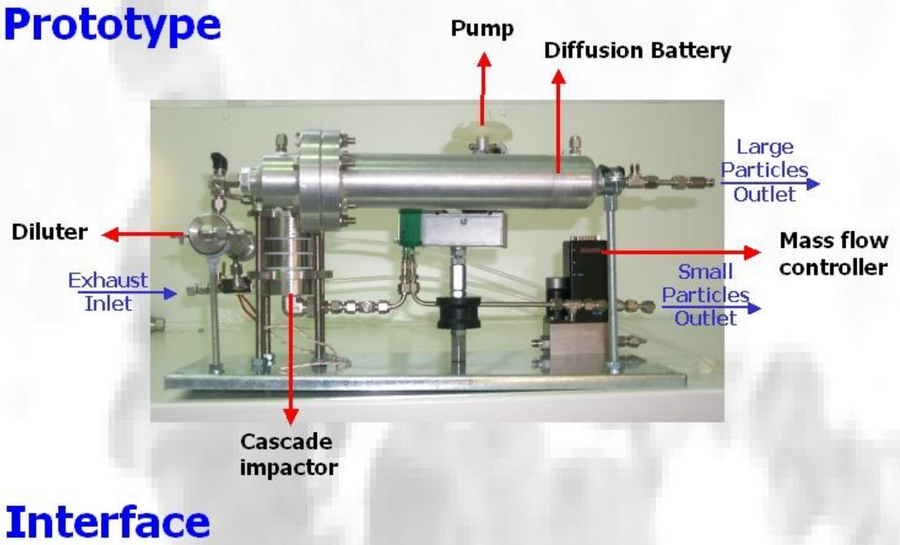


SPS Components

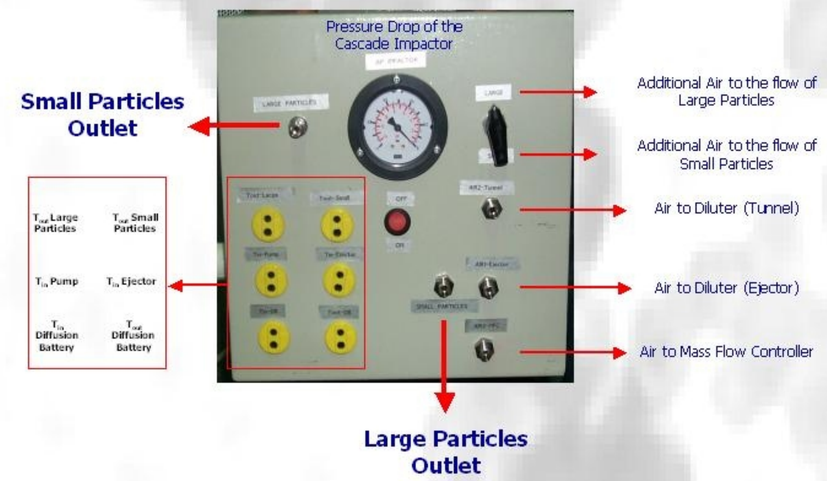
- **Diluter**
- **Diffusion Battery** (DB) – "high pass" filter
- **2-Stage Low Pressure Impactor** – "low pass" filter



SPS Prototype

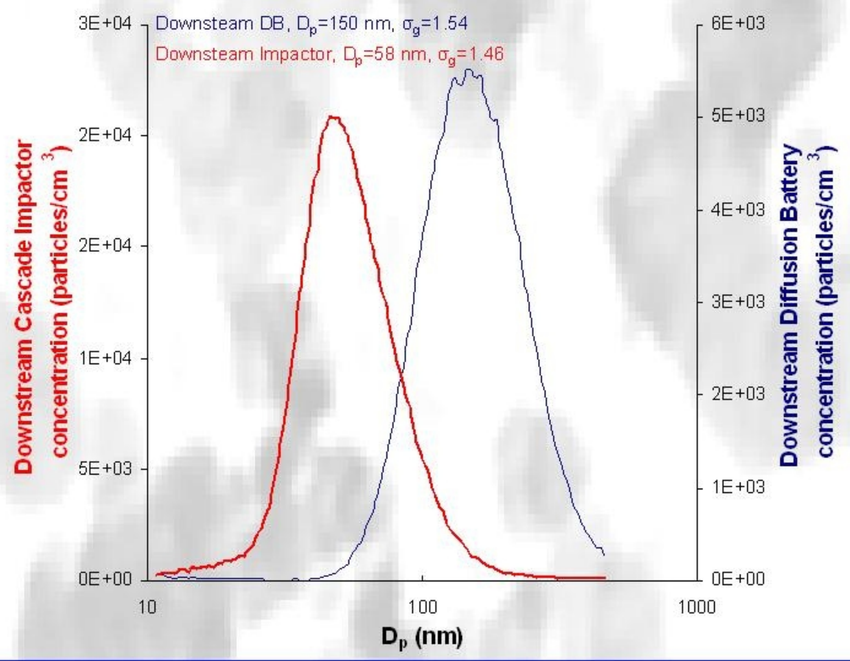


SPS Interface



CONCLUSIONS

- Applying the SPS to diesel exhaust it has been possible to obtain two widely separated size distributions for biological exposure studies.
  The small particle distribution has a mean diameter = 58 nm and σ_g = 1.46
  The large particle distribution has a mean diameter = 150 nm and σ_g = 1.54
- Future work concentrates on combing the separation principals to obtain distribution with a smaller σ_g



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