ULTRAFINE PARTICLE MONITOR MODEL 3031 AND 3031-1 THEORY OF OPERATION

APPLICATION NOTE UFP-001

Developed under the auspices of European Union sponsored prestigious UFIPOLNET[#] project, the Ultrafine Particle (UFP) Monitor incorporates field-tested technologies offering its users the highest level of reliability and performance [1-3]. The operational principle is based on diffusion charging of particles, followed by size segregation within a Differential Mobility Analyzer (DMA) and detection of the aerosol via a sensitive electrometer. The flow schematic is shown in Figure 1. An aerosol sample is drawn into the instrument continuously at a rate of 5.0 L/min. Within the instrument, the aerosol sample mixes in an equalization tank to smooth out short-term fluctuations in the aerosol sample and then passes on to the diffusion charger as described below.

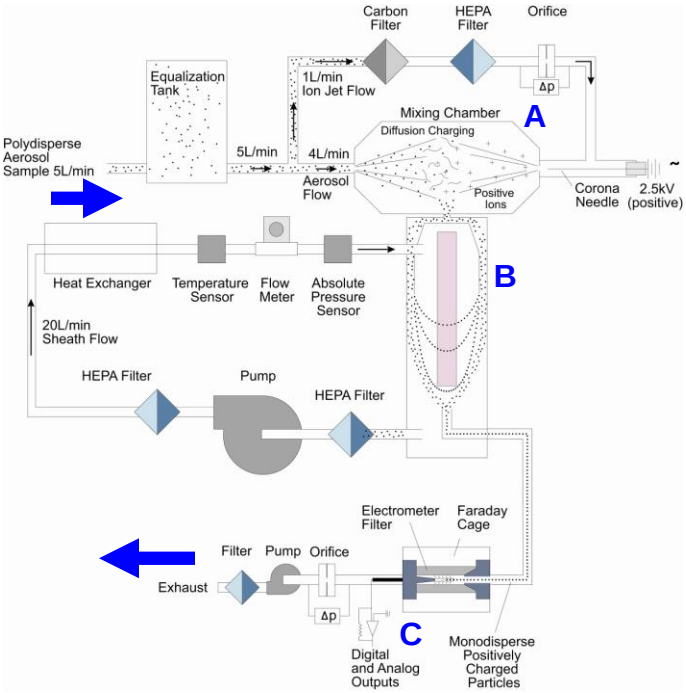

Figure 1. Flow schematic

(A) Diffusion Charger

The charging device in the UFP Monitor is a "Corona-Jet" charger [4]. Within the charger, the total flow of 5.0 L/min is split into 1.0 L/min passing through two filters (a carbon and a HEPA) and an ionizer and 4.0 L/min of aerosol remaining as sample flow. The flow streams are merged in a mixing chamber where particles in the aerosol flow mix with the ions carried by the filtered clean air. This patented *counter-flow diffusion charging** brings the aerosol particles into a well-defined, charge state. The separation of particles makes the charging process more efficient and reproducible. The charged aerosol then moves onto the DMA for size segregation.

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UFIPONLET stands for **U**ltra**f**ine Particle Size Distributions in Air-**Po**llution Monitoring **Ne**tworks

(B) Differential Mobility Analyzer

The DMA contains two concentric metal cylinders, an outer cylinder and the inner *high voltage* cylindrical rod. The polydisperse aerosol and sheath air are introduced at the top of the DMA column and flow down the annular space between the cylinders. The aerosol surrounds the inner core of sheath air, and both flows pass down the annulus with no mixing of the two laminar streams. The inner cylinder, the collector rod, is maintained at a controlled negative voltage, while the outer cylinder is electrically grounded. This creates an electric field between the two cylinders. The electric field causes positively charged particles to be attracted through the sheath air to the negatively charged collector rod. Particles are precipitated along the length of the collector rod (see Figure 2). The location of the precipitating particles depends on the particle electrical mobility, the DMA flow rate, and the DMA geometry. Particles with a high electrical mobility are precipitated along the upper portion of the rod; particles with a low electrical mobility are collected on the lower portion of the rod. Particles within a narrow range of electrical mobility exit with the monodisperse air flow through a small slit located at the bottom of the collector rod. These particles are transferred to the electrometer to determine the particle concentration. The remaining particles are removed from the sheath flow with a high efficiency filter and routed to the top of the column as a re-circulating flow.

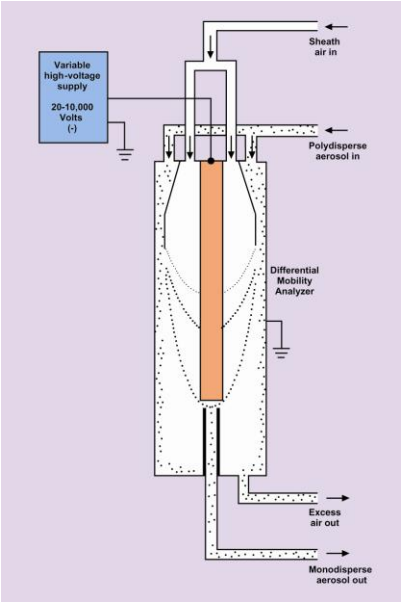

Figure 2. Operation principle of the DMA

(C) Electrometer

After leaving DMA, the aerosol enters a faraday cage where the particles, and their charge, are collected on particle filter. The filter is conductive, and is electrically connected to the input of a sensitive electrometer amplifier. By successively stepping the DMA voltage and measuring the current at each step with the electrometer, an on-board computer calculates and reports the number concentration for each of the six size channels. One measurement cycle takes 10 minutes (approx.) with an additional one minute zeroing time between cycles.

References

[1] ^ Zschoppe A.; Hilleman, A and Caldow R. (2007) "Aerosol mobility spectrometry based on diffusion charging," presented at the European Aerosol Conference, September 2007, Salzburg, Austria.

[2] ^ Wehner B. et al. (2007) "The new UFP 300: Comparison with a DMPS," presented at the European Aerosol Conference, September 2007, Salzburg, Austria.

[3] ^ Gerig W. et al. (2007) "UFIPOLNET: Concentration of particle number distributions at 4 stations in Europe," presented at the European Aerosol Conference, September 2007, Salzburg, Austria.

[4] Medved, A., Dorman, F., Kaufman, S.L., and Pöcher, A. (2000) "A New Corona-based Charger for Aerosol Particles," *Journal of Aerosol Science*, 31:P616-P617.

^ References [1]-[3] can be downloaded at http://www.umwelt.sachsen.de/lfug/luft-laerm-klima_15945.html

