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Influence of Ambient Pressure on Combustion Aerosol Standard (CAST)

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Abstract

The combustion aerosol standard (CAST) generates an aerosol in a flame. The flame is protected against ambient influence by the enclosure of the burner. Mass flow controllers regulate the gas flows of the burning gas, the oxidation gas, quench gas and the dilution. Nevertheless the first generation CAST is exposed to ambient pressure. Using the CAST as an aerosol standard for particle size and number concentration at different locations, it is essential to know the influence of the ambient pressure. A field experiment with the CAST at three locations at different altitudes showed the influence of the pressure on particle size and number concentration. In the pressure range of 860 hPa to 960 hPa the particle size is shifted from 80 nm to 95 nm. However the influence on the particle number concentration is not significant.

Scope

The combustion aerosol standard (CAST) works with specific flows for propane, air and nitrogen. The flows are controlled with mass flow controllers and kept constant according to normal conditions (0 °C, 1013 hPa). Using the CAST at different altitudes, the actual speed of the gas molecules in the combustion are a function of the atmospheric pressure. This experiment shows the influence on the ambient pressure to the particle size and concentration of the aerosol from CAST. Temperature changes are assumed to be negligible.

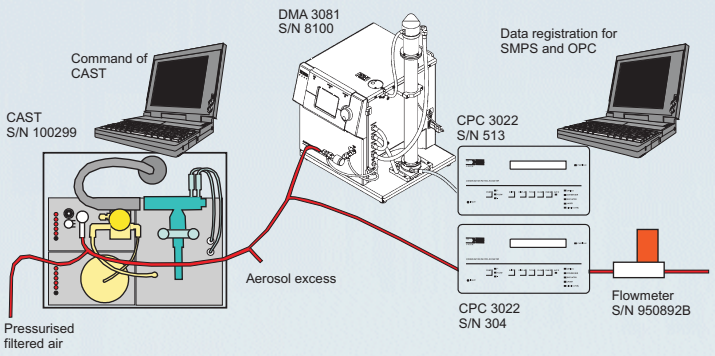
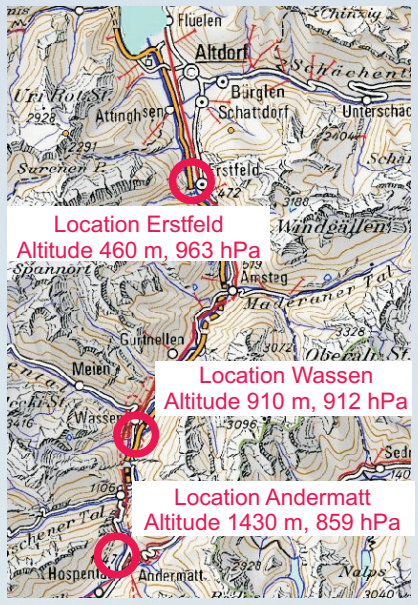


Figure 1: Experimental setup: scheme and picture of mobile laboratory (owner: inNET Monitoring AG)

Experimental Setup

The CAST, a Scanning Mobility Particle Sizer (SMPS) and a Condensation Particle Counter (CPC) were mounted in a mobile laboratory car. At three locations at different altitudes (Figure 1) measurements were performed with three different particle diameter settings for CAST. The SMPS was controlled by the Aerosol Instrument Manager (AIM) from TSI. In order to get correct size measurement in AIM the parameters for viscosity and mean free path length were adopted to actual ambient conditions (see Table 1).



Parameter	Location Erstfeld	Location Wassen	Location Andermatt
Pressure, Temperature	963 hPa; 24 °C	912.5 hPa; 20 °C	858.6 hPa; 20 °C
Viscosity	$1.8333 \cdot 10^{-5}$ kg m^{-1} s^{-1}	$1.8224 \cdot 10^{-5}$ kg m^{-1} s^{-1}	$1.8125 \cdot 10^{-5}$ kg m^{-1} s^{-1}
Mean Free Path Length	$7.0468 \cdot 10^{-8}$ m	$7.3322 \cdot 10^{-8}$ m	$7.7921 \cdot 10^{-8}$ m

Table 1: Constants for the calculation of the particle size distribution with AIM

Results

The particle diameter was evaluated as the mode of the particle size distribution (raw) and the mode of a log-normal fit to the distribution (fit). The particle number concentrations result from the integration of the size distributions (raw) and the parameters from the log-normal fit (fit) (Figure 2).

- The particle size increases with the ambient pressure (between 0.09 nm/mbar and 0.28 nm/mbar) (Figure 3).
- The influence of ambient pressure is presumably larger in relation to the diameter for smaller particles (Figure 3).
- The number concentration from SMPS is systematically smaller than the concentration resulting from the curve fit (Figure 4). The reason for this effect is not yet known, it never occured during the measurement in the stationary laboratory.
- The influence of ambient pressure to the particle concentration is smaller than the uncertainty of the concentration measurement (Figure 4).

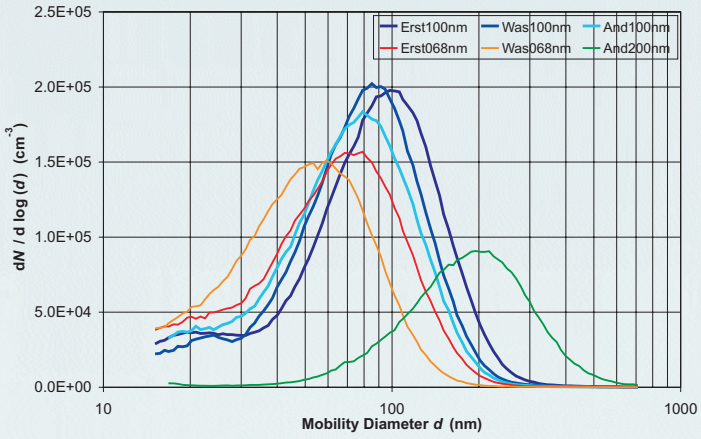


Figure 2: Average particle size distributions from SMPS at three locations and for three different CAST-settings

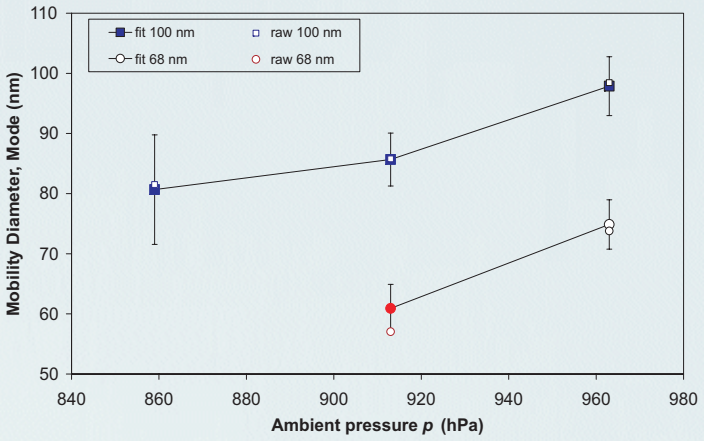


Figure 3: Measured particle mobility diameters as a function of ambient pressure. Results from raw and fit values.

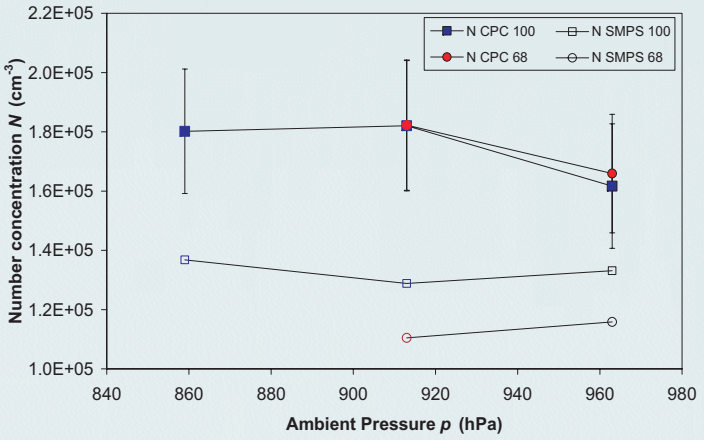


Figure 4: Measured particle number concentrations as a function of ambient pressure. Results from raw and fit values.

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