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Counting particles with the principles of Condensation vs. Diffusion

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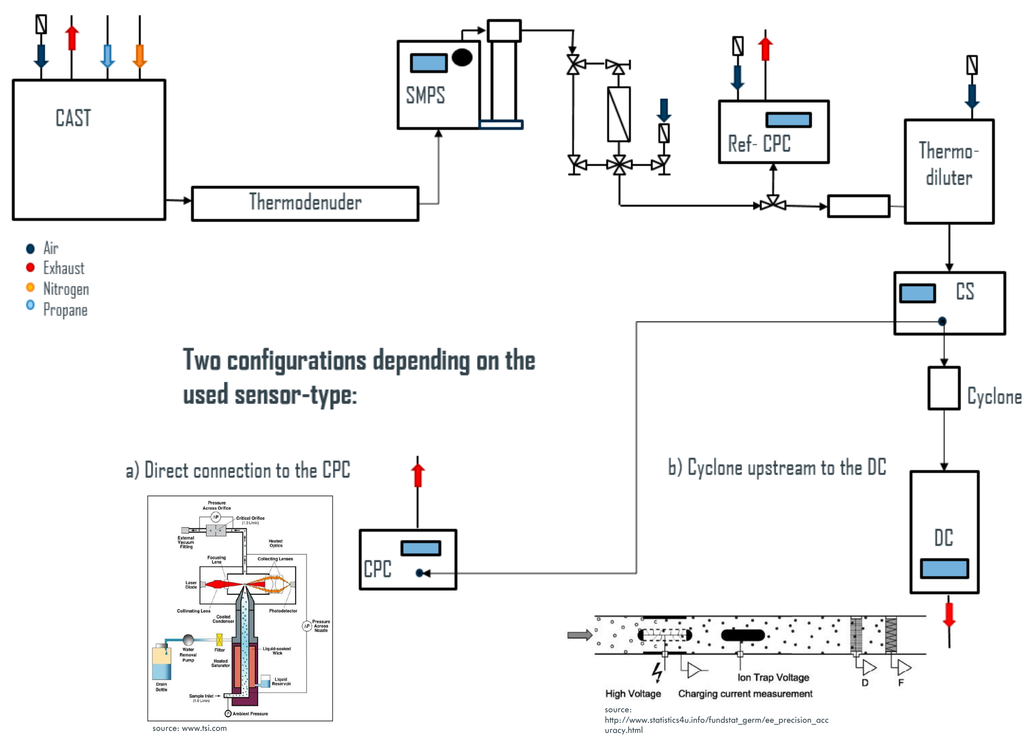
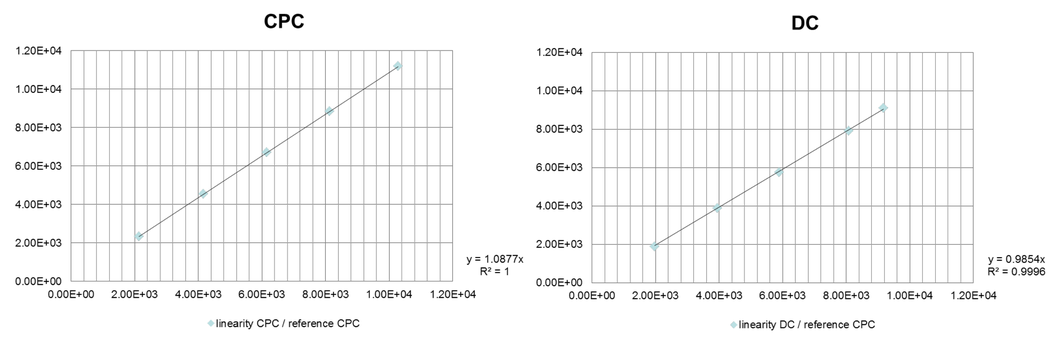
Motivation:

This work presents the comparison of two different sensor-types that can be used in portable emission measurement systems (PEMS) for solid particle number (SPN) emissions. One version is the condensation particle counter (CPC) and the other is the diffusion charger (DC). The solid particle number is measured in two completely different ways. A CPC detects particles through an optical method while a DC determines particles by measuring applied charges. For this work two exemplary PN PEMS were constructed. Besides the sensor they consist of a heated dilution unit and a catalytic stripper. For both PEMS versions of the counting type, linearity and efficiency was checked corresponding to the suggested values of the draft-regulation with monodisperse soot-aerosol versus a reference PMP-CPC.

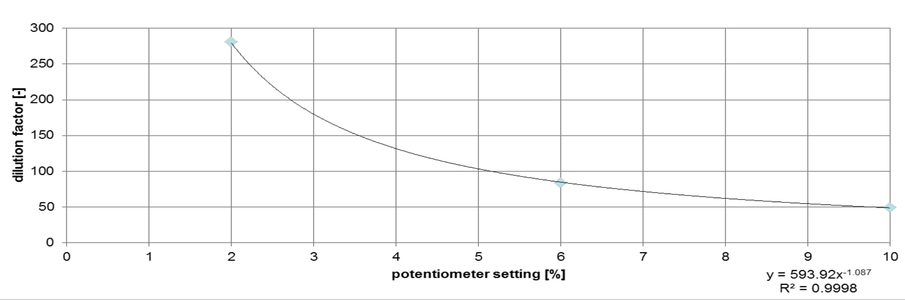
Experimental set up:



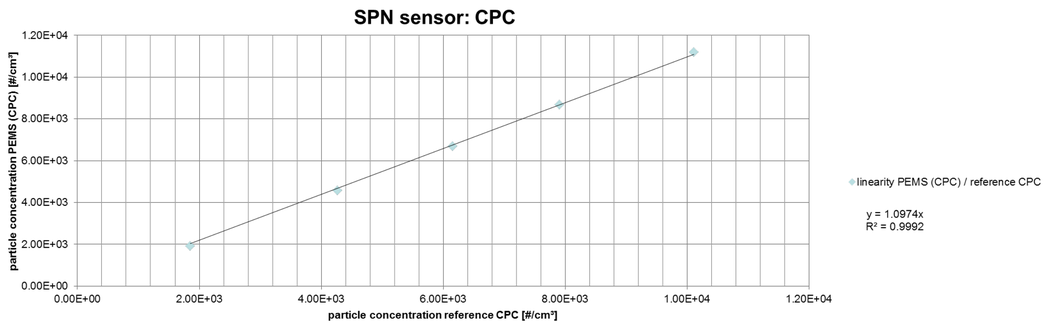
Single linearity sensor-check:

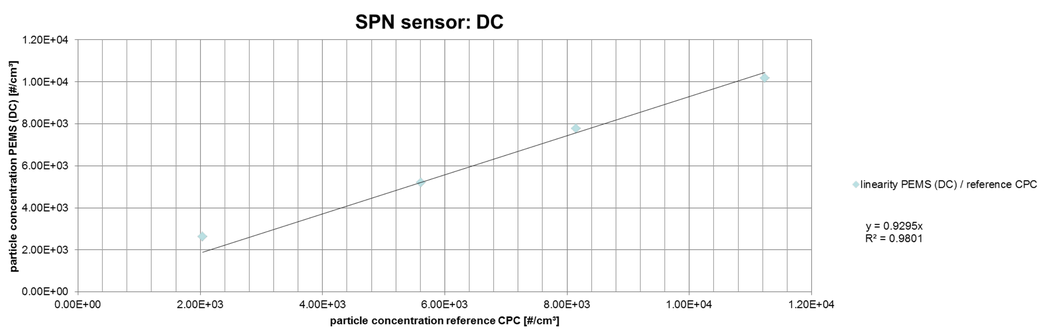


Thermodiluter check:

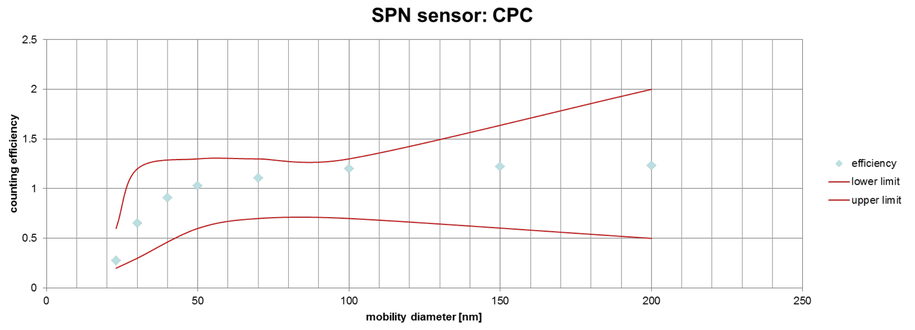


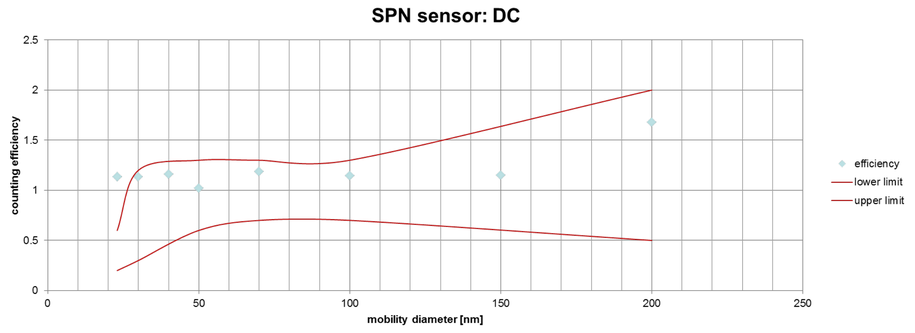
System-linearity check (monodisperse soot aerosol, dp = 70nm)





System-efficiency (monodisperse soot aerosol of different sizes)





Linearity requirements

$\lvert\chi_{min} \times (a_1 - 1) + a_0\rvert$	Slope a_1	Standard error SEE	Coefficient of determination r^2
≤5% max	0.90 - 1.10	≤10% max	≥0.950

Efficiency requirements

d_p [nm]	23	30	50	70	100	200
E(dp) PN analyser	0.2 – 0.6	0.3 – 1.2	0.6 – 1.3	0.7 – 1.3	0.7 – 1.3	0.5– 2.0

Summary and conclusion:

The system based comparison of both sensor-types gives promising results. The linearity of the PN-PEMS-CPC has a slope of 1.0974 and a determination coefficient of 0.9992. The slope of the linear equation of the PN-PEMS-DC amounts a value of 0.9295 and the coefficient of determination is 0.9801.
It can be stated that both PN-PEMS comply with the linearity requirements of ± 10 % with 70 nm soot like solid particles but in total the reading is 17% different comparing the systems directly to each other.
The efficiency response results for the whole size range from 23 to 200 nm of both sensors shows clear differences. The efficiency curve of the PN-PEMS-CPC can be found within the required limits. The PN-PEMS-DC behaves different at the lower and upper end of the size range. For particles with a mobility diameter of 23 nm the efficiency value lies clearly outside the demanded limits. At a mobility diameter of 200 nm there is also a significant increase of the efficiency value up to 1.6 (60 % higher reading). This can be an evidence for the influence of multiple charged particles on the measurement.
In general also attention should be paid to the setup. Because of the system based validation measurements the particle number the sensor sees is reduced. For that reason higher particle-concentrations are needed which should be considered on the choice of the reference CPC´s calibration range.

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