



Steady state and transient dynamometer vehicle emission measurements using a DiSC

N.K. Meyer^{1*}, E.R. Jayaratne¹, M.Fierz², H. Burtscher², Z.D. Ristovski¹
 1. International Laboratory for Air Quality and Health, QUT, Australia.
 2. Institute for Aerosol and Sensor Technology, FHNW, Switzerland

Analysis of the particulate size and number concentration emissions from a fleet of inner city medium duty CNG buses was conducted using the newly available Diffusion Size Classifier in comparison with more traditional SMPS's and CPC's. Studies were conducted at both steady state and transient driving modes on a vehicle dynamometer utilising a CVS dilution system. Comparative analysis of the results showed that the DiSC provided equivalent information during steady state conditions and was able to provide additional information during transient conditions, namely, the modal diameter of the particle size distribution.

Until recently simultaneous real time measurements of both size and number concentration of nanoparticles produced in combustion processes has been somewhat limited by cost and complexity. Lately, the Diffusion Size Classifier (DiSC - Fierz et. al. 2005) has been able to provide this information in a cheap and portable package. The DiSC operates on the principle similar to that of a diffusion charger, collecting singly charged particles on a filter stage and determining their number concentration. With the addition of a second stage for collecting *very small* singly charged particles resolution of the ratio of the charge on each plate is possible and provides information on size and number ratio.

During steady state measurements particle number concentration data was collected by two CPC's (TSI 3022, 3782 WCPC) and the DiSC. (Figure 1) Size distribution data was collected using a TSI 3080 SMPS with a 3022 CPC during the steady state driving modes and with the DiSC during both transient and steady state modes. Ambient air was used for the primary dilution. Particle number concentration measured by the DiSC closely followed that of the 3782 albeit with a slightly higher count efficiency. (the 3782 had recently been calibrated). The modal diameter of the size distribution as measured by the DiSC was shown to be, on average, 10nm less than that measured by the SMPS. Oscillation in the modal diameter as measured by the DiSC are related to the periodic engagement of the vehicles air conditioning system. This can be correlated with corresponding oscillations in the measured CO₂.

Figure 2 presents the result obtained from the emissions of a CNG vehicle during transient driving cycles. Given complications with the dynamometer during this particular test the observed emissions increase between cycles. However, this provides a good case for showing that the DiSC is capable of following the particle number measurements obtained using the 3022 CPC. The ability of the DiSC to provide real time particle size information was achieved by comparing this with the normalized ratio of the particle concentration as measured by the 3782 CPC versus that measured by the 3022 CPC. The 3022 has lower cut-off diameter (5nm) and a larger transfer function than that of the 3782 (cut-off diameter 20nm). Thereby when the ratio [3782]/[3022] approaches zero we assume that the particles present can only be seen by the 3022. This effect is evidenced in the lower portion of figure 2 where particle diameter as measured by the DiSC and the ratio [3782]/[3022] are presented. During the idle phase at the onset of the cycle the DiSC indicates particle size of approximately 120nm. This corresponds to SMPS measurements conducted during idle steady state conditions (Figure 1). Likewise at peak particle concentrations, which occur at high loads the DiSC indicates particle diameters of 20-30nm. This also corresponds to steady state particle diameters measured at high loads. So, given the above two assumptions hold, we see that a low value of the [3782]/[3022] ratio shows lower particle diameters and a higher value shows higher particle diameters. So Figure 2. shows that during the transient cycles real time qualitative measurements of particle diameter using the DiSC are possible.

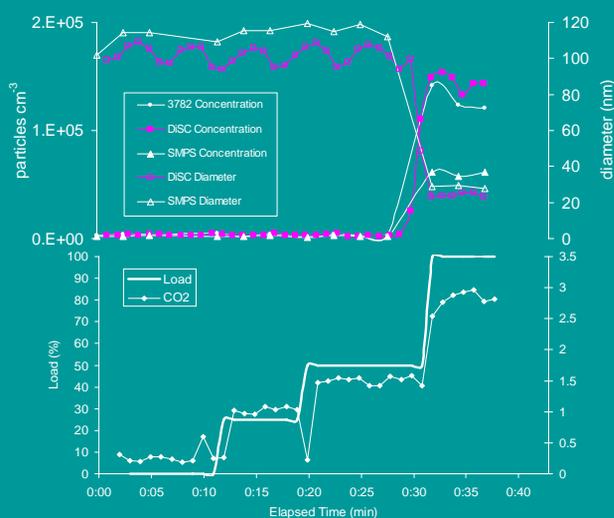


Figure 1. Particle Size and Number Concentration data measured at idle, 25%, 50% and 100% engine loads during steady state conditions. Engine Load (%) and CO₂ (%) are shown in the lower section of the figure.

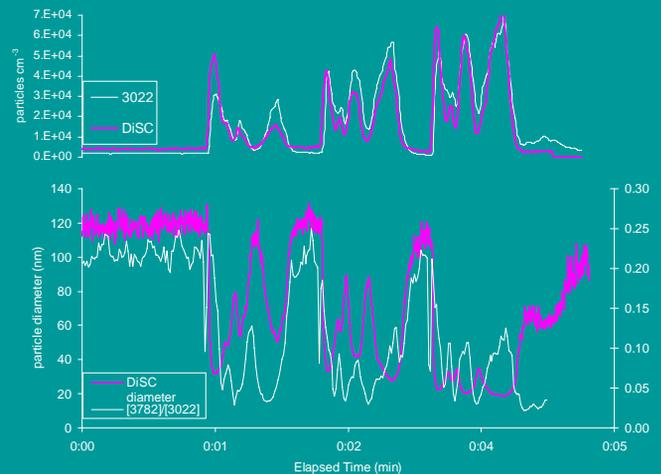


Figure 2. Particle Number Concentration as measured by the DiSC and 3022 and corresponding particle diameter as measured by the DiSC during transient conditions. Supplemental qualitative data is provided by comparing the ratios of the particles concentrations as measured by the 3782 and 3022 CPC's

References: Fierz, M., Steigmeier, P., and Burtscher, H., Selective measurements of solid particles measured with the Diffusion Size Classifier. ETH Nanoparticle Combustion Conference Proceedings, 2006