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Volatile properties of CNG and Diesel bus emissions produced during steady state and transient driving modes.

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An analysis of the emissions from 14 CNG and 5 Diesel buses was conducted during April & May, 2006. Studies were conducted at both steady state and transient driving modes on a vehicle dynamometer utilising a CVS dilution system. This article will focus on the previously un-investigated volatile properties of particles emissions from 4 CNG vehicles from within this group.

Particle number concentration data was collected by three CPC's (TSI 3022, 3010 & 3782WCPC) having D50 cut-offs set to 5nm, 10nm & 20nm respectively. Size distribution data was collected using a TSI 3080 SMPS with a 3025 CPC during the steady state driving modes. (figure 1.) Ambient air was used for the primary dilution.

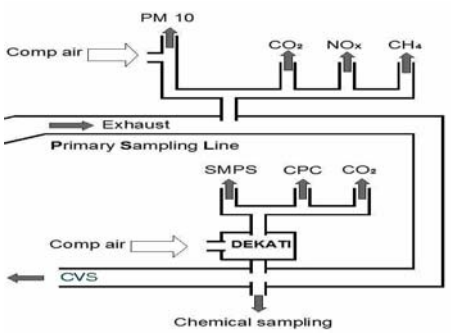

Figure 1. Sampling System

The vehicles were tested against a transient DT80 driving cycle as shown in Figure 2. An example of time series data generated during the driving cycle by one of the vehicles is shown in figure 3. A distinct relationship between engine load, particle number and NOx can be seen. This can be further related to the acceleration phases ecountered during the driving cycle.

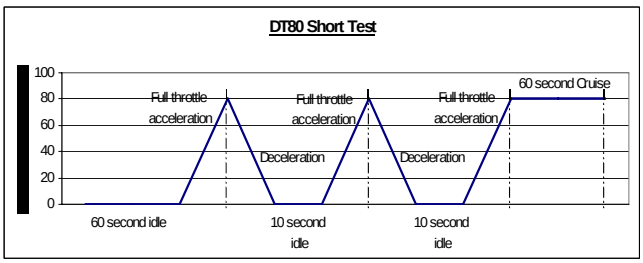

Figure 2. The DT80 Driving Cycle

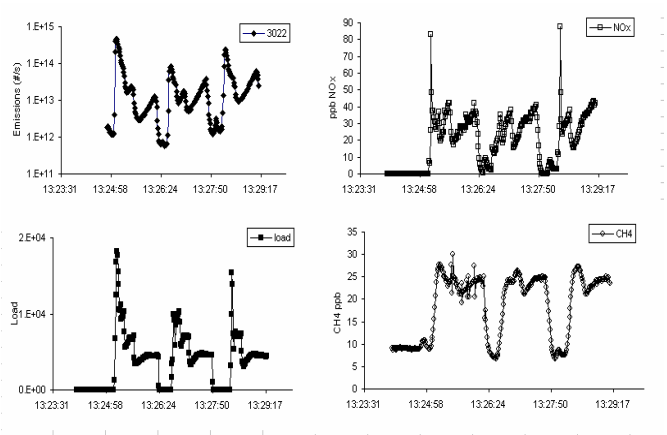

Figure 3. Load, Particle Number, NOx and CH_4 data for a bus driven at the transient DT80 cycle

During transient cycles, mono-disperse "slices" of between 5nm & 25nm were measured. The volatility of these particles was determined by placing a thermodenuder before the 3022 and the SMPS and measuring the reduction in particle number concentration as the temperature in the thermodenuder was increased. This was then normalised against the total particle count given by the 3010 CPC to provide high resolution qualitative information on the reduction in particle concentration with respect to temperature.

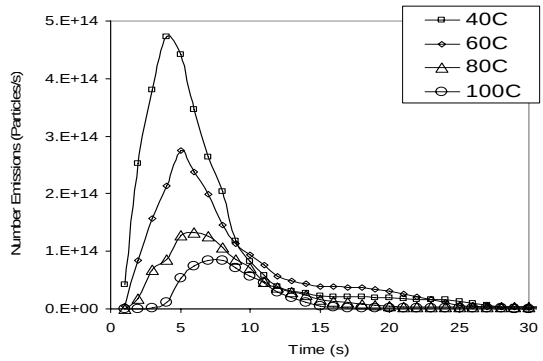

Figure 4. Volatilisation of emissions produced during a transient cycle. Temperatures within the thermodenuder range from 40°C through 100°C

Closer analysis of the volatility of particles emitted during transient cycles on a per second basis show that volatilisation begins at around 40°C with the majority occurring at 80°C. Of note, differing levels of volatility were shown to exist between particles produced during different periods in the cycle. This can be clearly seen in figure 4 which shows us that those particles produced during acceleration phases exhibit higher volatility then those produced during a deceleration or stable phase. This variation in volatility appears to follow changes in both NOx emissions and load. Given ambient ammonia concentrations it is thought that these particles may be partially comprised of ammonium nitrate which has a volatilisation temperature of 75˚C.

Particles smaller then 20nm were shown to be highly volatile. Figure 5 shows the normalised change in average number concentration between transient cycles for 5 different CNG buses as the temperature in the thermodenuder is increased.

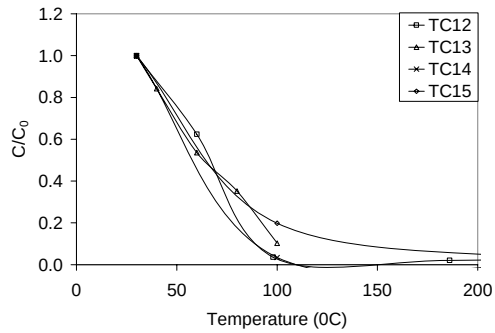

Figure 5. Change in average concentration per transient cycle with respect to temperature for 4 CNG buses labelled TC12 through TC15.