ExIS Summary of HD PMP test results with DMM

Introduction and background

The main driver behind Particle Measurement Programme (PMP) has been the impact of particles on human health. There is a growing consensus amongst health experts that ultrafine particles (<100 nm diameter) may have the greatest adverse impact on human health. In the past, only particulate mass in vehicle and engine emissions has been regulated.

In 2001, the Governments from France, Germany, the Netherlands, Sweden and United Kingdom agreed to develop new methods and procedures to facilitate the control of ultrafine particles within a regulatory framework. The mandate for the PMP Working Group was to develop new particle measurement techniques to complement or replace the existing particulate mass measurement, with special consideration to measuring particle emissions at very low levels.

The two first phases of the PMP programme improved the filter method for particulate mass emissions and introduced a particle number method. The latter has been manifested in draft new versions of UN-ECE regulations. In phase 3, inter-laboratory correlation exercises for light-duty vehicles and heavy-duty engines have been conducted. For the heavy-duty engines reported now, repeatability and reproducibility of particle number measurements has been investigated by transporting a “Golden” engine and two “Golden” particle measurement systems to each test laboratory.

The next (on-going) task in the PMP programme is a round robin exercise, where laboratories in EU, Japan, Korea and Canada have showed their interest to participate. This programme is to be completed in 2011. Work will also be initiated to develop calibration methods for particle number counters.

Summary of DMM results

During some of the tests conducted in the second measurement campaign in JRC, an AVL Micro Soot Sensor (MSS) was employed to determine the mass of soot emitted and a Dekati Mass Monitor (DMM) was used to measure the mass of solid particles. The test engine was a modern 7,8 litre, 6-cylinder IVECO Cursor 8 engine in EU III specification equipped with a diesel particulate filter. The results from the two mentioned instruments are summarized in **Figure 1**.

Over the cold start WHTC test cycles, both MSS and DMM measured mass concentrations ~10% of those determined gravimetrically. This fraction is similar to that determined for cold NEDC tests during the light-duty inter-laboratory correlation exercise.

In the hot start test cycles, DMM shows that the contribution of solid particles was only 0,5% of the gravimetrically determined PM, i.e. volatile particle mass contributed to total PM by ~99,5%. The DMM particle number signal was at the detection level of the instrument, which is around 300 #/cm^3. The dedicated PMP instrument showed number concentrations below 300#/cm^3. The MSS instrument showed much higher soot content of the PM. This observation was not substantiated by any other measurement method, indicating that measurements were made below the detection

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level – which is unlikely due to higher readings than the specified sensitivity level for this instrument – or that there was interference from gaseous components.

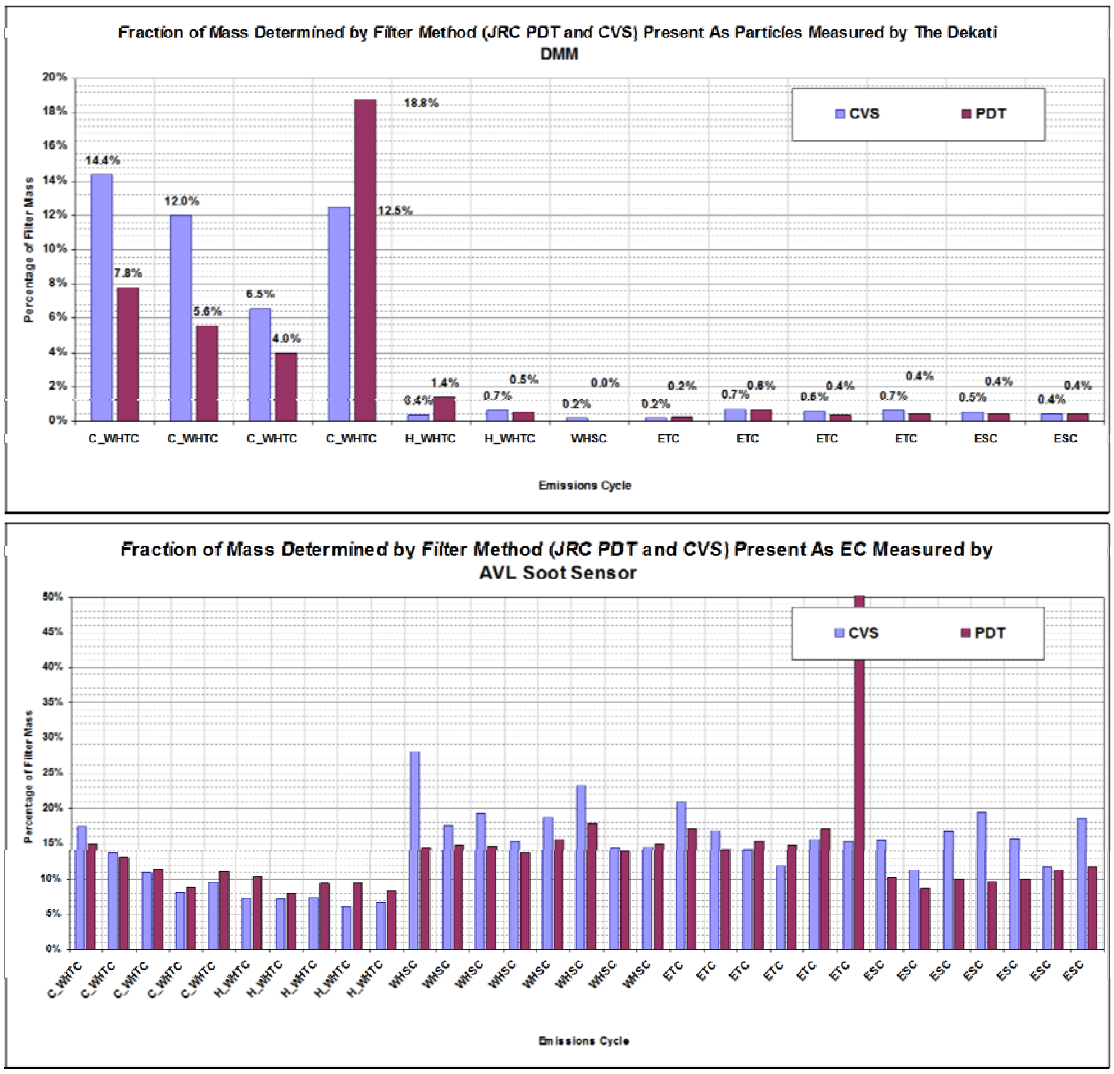

Figure 1. *Fraction of mass determined by filter method presented as solid particles by DMM (upper graph) and elemental carbon by DMM (lower graph)*

The complete draft report referred to here, and from which the data discussed here originate, is available for downloading at the UN-ECE web site[1].

[1] Jon Andersson, Athanasios Mamakos and Giorgio Martini: "Particle Measurement Programme (PMP) Heavy-duty Inter-laboratory Correlation Exercise (ILCE_HD) Final Report – *Draft version.*" January 2010. The report is available for downloading at the Internet site of UN-ECE at: http://www.unece.org/trans/main/wp29/wp29wgs/wp29grpe/pmp24.html

Background information about the DMM-230a instrument from Dekati

The Dekati Mass Monitor (DMM) was developed to provide data on real-time particle mass emissions in the exhaust from diesel and petrol engines. The operating principle is basically similar to the well-proven ELPI instrument, with the addition of a mobility channel that provides data for calculation of the effective particle density that is used for determination of particle mass emissions. Important factors such as, ease of use, robustness and reliability have been considered in the development of the DMM instrument.

Despite the discussed number-based measurement standards, the mass emission is still used in all regulatory measurements. Conventional PM measurements are based on gravimetric filter weighing, resulting only in a total, cumulative mass emission. Real-time data from DMM provides second-by-second information about particle total mass during accelerations, decelerations and different speed points immediately during the measurement. This is of particular interest in, e.g. determining DPF loading and development of regeneration strategies. DMM also provide information about the size distribution (mass median size and geometric standard deviation). With a detection limit below 1 µg/m^3, DMM provides better resolution than competing instruments in this field. Furthermore, DMM measures not only soot but all particles. Preferably, volatile particles can be removed in the dilution process to mimic the PMP sampling conditions for solid particle measurement, as described above.

The latest development of the DMM instrument hardware (DMM-230a) includes sheath air for the charger, which enables longer intervals of operating time between cleaning. The latest software also provides total particle number emissions similar to the PMP protocol. These features were introduced in the autumn 2008. Thus, DMM is now a “complete” instrument providing results on particle mass, total number and size distribution. Since 2009, communication with the host computer in the test cell via the AK protocol is also available. Upgrades of current units in operation to the DMM-230a hardware can be provided on request. The new software that provides particle number results is available for downloading at the Dekati Internet site free of charge.

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