Improved Soot Measurements with an ENGINE EXHAUST PARTICLE SIZER

5th International Exhaust Emissions Symposium:
BOSMAL,
Bielsko-Biala (Poland)
May 19 -20 , 2016

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Introduction

The Engine Exhaust Particle Sizer™ spectrometer (EEPS, Model 3090, TSI Inc.) is widely used to measure the size distribution of fast changing exhaust particles at ambient pressure in engine research and development. It can provide particle size, number and mass at different locations in the combustion process. The EEPS records particle size distributions (PSD) at a rate of 10 Hz, allowing for the measurement of transient events. TSI offers three different inversion matrices to improve the PSD agreement between EEPS and reference Scanning Mobility Particle Sizer Spectrometer™ (SMPS) measurements, especially for aggregated particles and at larger particle sizes.

Working principle

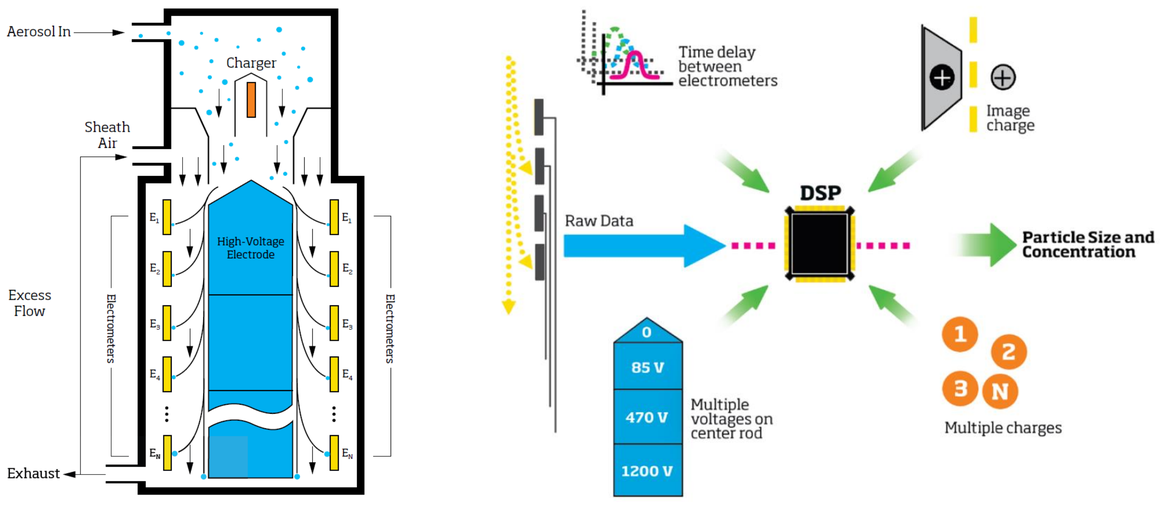

Fig. 1: Schematic diagram and data inversion of the EEPS.

- Unipolar diffusion charging by two corona chargers
- Differential electrical mobility separation under flow and electric fields
- Electric charge detection by 22 parallel electrometers
- Data inversion to obtain size distribution.

Soot inversion matrix results

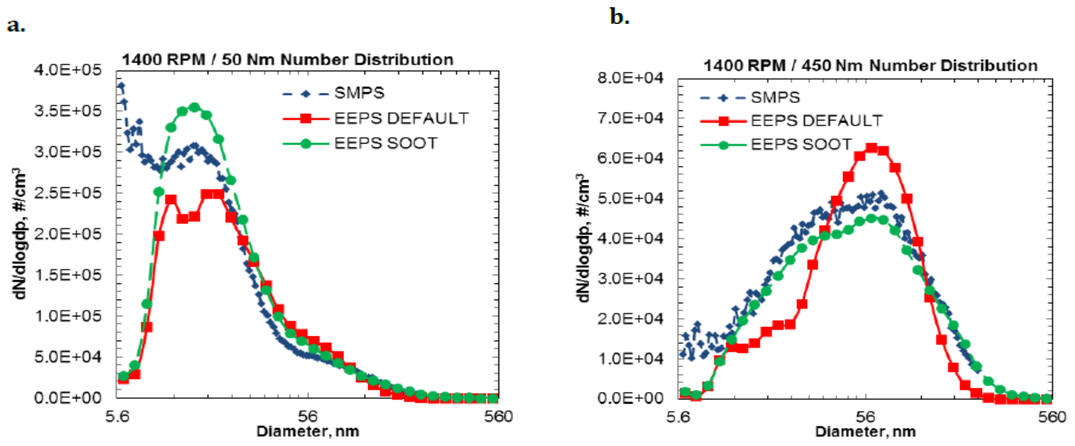

Fig. 2: Default and Soot matrices compared to SMPS for HD diesel engine running at 1400 RPM, 50 Nm (a) and 450 Nm (b)

- Matrix developed in conjunction with the help of X. Wang of Desert Research Institute (Wang et al. 2016).
- Soot matrix significantly improved agreement between EEPS and SMPS.
- More details in TSI application Note EEPS-005
- 3 inversion matrices available:
  - ✓ **Default**
  - ✓ **Compact** : Nearly spherical aerosols
  - ✓ **Soot** : Agglomerate aerosols
- Compact and Soot matrices developed using combination of calculations and experimental measurements.

New application: Brake emission measurements

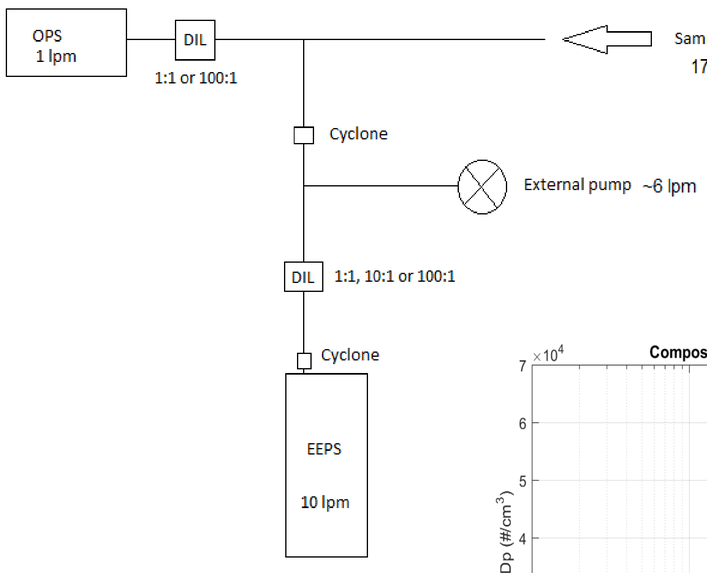

Fig. 4: Wide Range Fast Sizer system with EEPS and OPS.

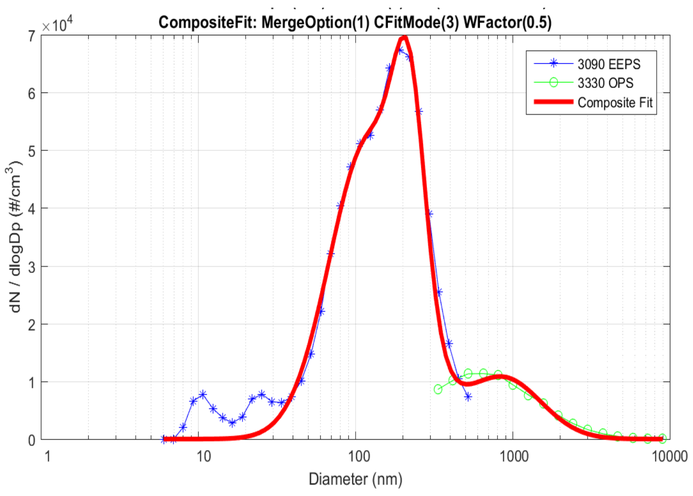

Fig. 5: Particle number size concentration from brake event.

- Highly transient aerosol
- Wide size range from 5 nm up to 10 µm at 10 Hz
- Wide concentration range over several orders of magnitude

Application: Engine exhaust measurements

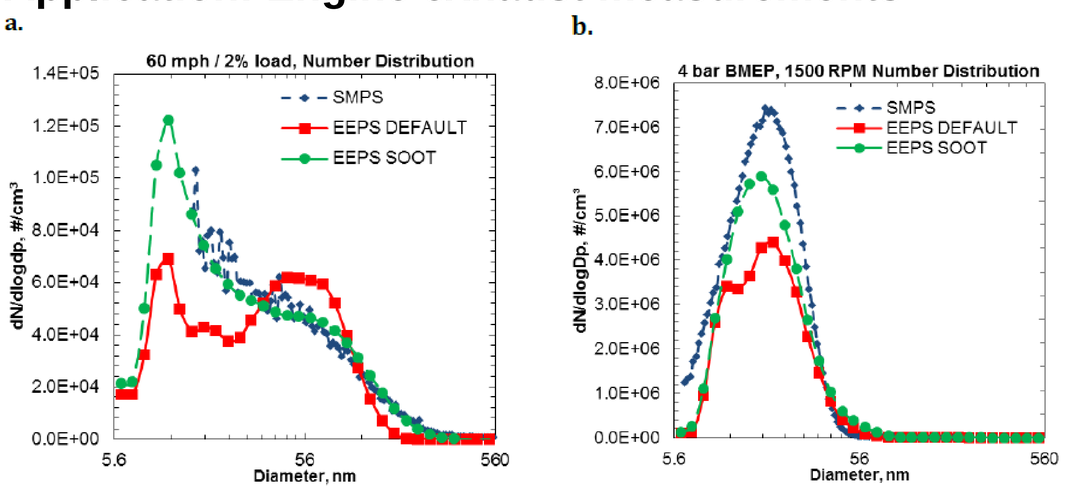

Fig.3: Default and Soot matrices compared to SMPS for a GDI vehicle (a) and light duty diesel engine (b)

- The right selection of the matrix matters – otherwise can lead to discrepancies in size and number as shown in Fig.3
- The Soot matrix allows to measure particle size distributions either on GDI vehicle, light duty diesel engine and heavy duty diesel engine (Fig.2)

Conclusions

- Ideal measurement of diesel and gasoline engine exhaust PSD at 10 Hz
- Multiple applications also beyond engine exhaust measurements e.g. brake wear.

References

Wang, X et al. 2016, "Improvement of Engine Exhaust Particle Sizer (EEPS) size distribution measurement – I. Algorithm and Applications to Compact Aerosols," J Aerosol Sci, 92: 95–108

Wang, X et al. 2016, "Improvement of Engine Exhaust Particle Sizer (EEPS) size distribution measurement – II. Engine exhaust particles," J Aerosol Sci, 92: 83–94