

Sub-23 nm particle contribution from DI spark ignition engines fueled with gasoline and ethanol blends: PMP compliant measurement and digital filtering

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Several studies evidenced a large presence of sub-23 nm particles at the exhaust of internal combustion engines. The particle nature, size and concentration are strongly influenced by the engine configuration and operation condition and above all by the fuel.

This work focuses on the sub-23 nm particles emitted from a 250 cc single cylinder SI engine equipped with direct injection (DI) system at different operating conditions with gasoline and ethanol both pure and in a blend at 25 % v/v (E25). Particle number and size were measured by an Engine Exhaust Particle Sizer (EEPS). A PMP compliant system was used for the sampling and conditioning of the sample. The measures were performed in both PMP than in not-PMP sampling conditions. The last configuration was aimed to promote nucleation and condensation phenomena in order to distinguish the volatile fraction by comparing the distributions measured in both configurations. Quantitate metrics based on the shift ratio calculated as $GMD_{NO\ PMP}/GMD_{PMP}$ revealed inception of nucleation particles for $SR < 1$ (Figure 1-a) and condensation onto particles for $SR > 1$. Alternative methods to achieve results comparable to PMP measurements were developed, one of these is the Digital Filtering of the linear approximation of the particle size distribution function, which was initially proposed by Leach et al. [1]. It is based on the application of counting efficiency function, based on the structure of a Wiebe, to the particle size distribution function. Pfau et al. [2] developed a function suitable for the counting efficiencies proposed by the new regulation that will take in to account the particles from 10 nm. The Digital Filters proposed by Leach (Filter #1) and Pfau (Filter #2) were applied to PSD measured by EEPS. Linear regression yields good fits for both filters (Figure 1-b). Higher contribution of sub-23 nm particles for higher particle number (N_p) is evident from stronger reduction with Filter #1. The little reduction by applying Filter #2 reveals a smaller contribution of sub-10 nm particles overall.

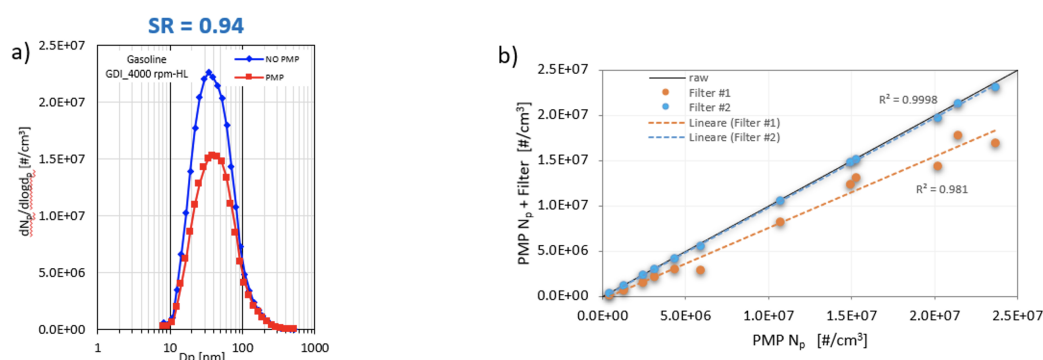


Figure 1. a) PSDF measured at both PMP and NO PMP conditions, b) Digital Filter application

[1] Leach F, Lewis A, Akehurst S, Turner J, Richardson D. Sub-23 nm Particulate Emissions from a Highly Boosted GDI Engine. SAE Tech Pap 2019;2019-Sept. <https://doi.org/10.4271/2019-24-0153>.

[2] Pfau SAM of S-23 nm PE from GE: AC of PM, Hafftnr-Staton E, La Rocca A. Measurement of Sub-23 nm Particulate Emissions from GDI Engines : A Comparison of Processing Methods. SAE Tech Pap 2019.