ELPI in the Automotive Emission Measurements

Tikkanen, J., Tuomenoja, H., Mikkanen, P. & Niemelä, V.
Dekati Ltd. Osuusmyllynkatu 13, FIN-33700 Tampere, FINLAND

Introduction

ELPI™ (Electrical Low Pressure Impactor, Dekati Ltd. Finland) measures particle size distribution and concentration in real-time. The instrument operation is based on particle charging in a corona charger, size classification in an inertial impactor and current measurement with a sensitive multichannel electrometer. ELPI gives information on the particle concentration and size distribution in the size range of 7nm-10um. In this paper, ELPI results from automotive emission measurements during different measurement campaigns are presented.

Methods and results

ELPI has been used in several different applications including ambient and indoor air quality measurements, power plant emission monitoring, particle charge measurements and different automotive applications such as engine exhaust, blow-by gas and brake wear debris measurements. Experiences from more than ten years of measurements and research on the ELPI have added several new features into the instrument including two sample flow rate versions, Outdoor Air ELPI model for independent operation, filter stage to extend the measurement range down to 7nm and the sintered collection plates for longer measurement periods. The latest development has been in the user interface of the ELPI, the ELPIVI software. The new user-friendlier version ELPIVI 4.0 enables e.g. controlling of two ELPI units using only one software and data transfer via TCP/IP connection into external systems. In addition more choices are provided for the data presentation during the measurement.

During the last couple of years, several measurement campaigns have been organised to harmonise the methods for particle measurements in engine exhaust emissions and also in emissions from stationary sources (e.g.CRAFT project CEMPM - Continuous Emission Monitoring of Fine Particulates PM10/PM2.5). ELPI has taken part in many of these programs with excellent performance. In the GRPE PMP (Particle Measurement Programme) measurements organised by EMPA, Switzerland, ELPI was used to measure particle number concentration and the instrument was shown to have a very good repeatability, sensitivity and also correlation with other instruments. The Particulates program (Characterisation of Exhaust Particulate Emissions from Road Vehicles, program organised under the European Commission -DG TREN 5TH Framework Programme) was organised to develop a harmonised method for measuring engine emissions so that results between different measurement laboratories could easily be compared. The instruments were required to have low enough sensitivity for future emission levels, and good repeatability to get comparable results from different laboratories. ELPI was shown to produce comparable results even between laboratories, and the results correlated well with other particle counting methods.

Conclusions

ELPI was successfully applied to engine emission measurements from both light- and heavy-duty engines. ELPI showed good correlation with other particle counting methods such as the CPC, but at the same time provided information on the size distribution as well. Very good repeatability and reproducibility of the ELPI results was found in several measurement campaigns. New features including a new software have been added to the system to further improve the instrument capabilities and usability.

Acknowledgements

The authors would like to acknowledge the DG TREN Particulates Programme for providing the data.

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Introduction

ELPI™ (Electrical Low Pressure Impactor, Dekati Ltd. Finland) measures particle size distribution and concentration in real-time. The instrument operation is based on particle charging in a corona charger, size classification in an inertial impactor and current measurement with a sensitive multichannel electrometer. The operational range of the ELPI is 7nm-10μm and the operating principle is presented in Figure 1a.

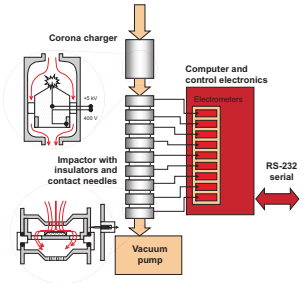


Figure 1a. Operating principle of ELPI.

Figure 1b. ELPI.

Methods

ELPI has been used in several different applications including ambient and indoor air quality measurements, power plant emission monitoring, particle charge measurements and different automotive applications such as engine exhaust, blow-by gas and brake wear debris measurements. Experiences from more than ten years of measurements and research on the ELPI have added several new features into the instrument including two sample flow rate versions, Outdoor Air ELPI model for independent operation, filter stage to extend the measurement range down to 7nm and the sintered collection plates for longer measurement periods. The latest development has been in the user interface of the ELPI, the ELPIVI software. The new user-friendlier version ELPIVI 4.0 (Figure 2) enables e.g. controlling of two ELPI units using only one software and data transfer via TCP/IP connection into external systems. In addition more choices are provided for the data presentation during the measurement.

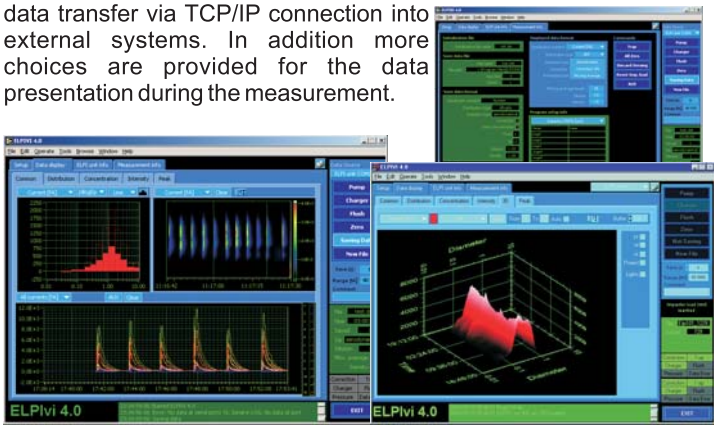


Figure 2. Screenshots of the new ELPIVI4.0 software.

During the last couple of years, several measurement campaigns have been organised to harmonise the methods for particle measurements in engine exhaust emissions and also in emissions from stationary sources (e.g.CRAFT project **CEMPM** - Continous Emission Monitoring of Fine Particulates PM10/PM2.5). ELPI has taken part in many of these programs with excellent performance. In the **GRPE PMP** (Particle Measurement Programme) measurements organised by EMPA, Switzerland, ELPI was used to measure particle number concentration and the instrument was shown to have a very good repeatability, sensitivity and also correlation with other instruments. The **Particulates** program (Characterisation of Exhaust Particulate Emissions from Road Vehicles, program organised under the European Commission -DG TREN 5TH Framework Programme) was organised to develop a harmonised method for measuring engine emissions so that results between different measurement laboratories could easily be compared. The instruments were required to have low enough sensitivity for future emission levels, and good repeatability to get comparable results from different laboratories.

Results

Comparison results for particle number concentration between ELPI and CPC (Condensation Particle Counter model 3022A, TSI Inc.) over a cold NEDC test are presented in Figure 3. The measurements have been made during the Particulates Programme, and a good correlation between the instrument is found

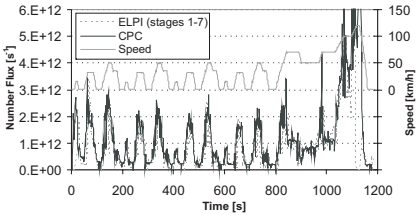
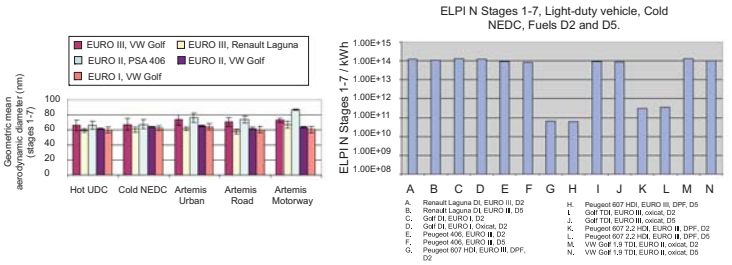


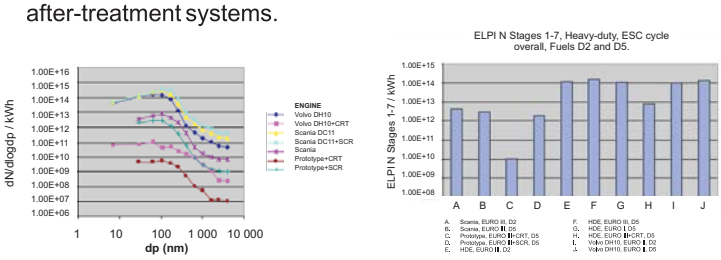
Figure 3. Example of ELPI comparison data over a cold NEDC cycle measured during the Particulates Programme. VW Golf TDI 1.9l.

More results from the Particulates programme are shown in Figures 4a and 4b where ELPI results from different measurement laboratories were compared with each other when light-duty engines were measured. As can be seen from the Figure, good correlation was found for both particle size and concentration.



Figures 4a and 4b. Results from the Particulates Programme. Left: ELPI geometric mean diameter over several driving cycles measured in different laboratories. Right: Particle number results measured by ELPI in different laboratories.

More results from the Particulates programme are shown in Figures 5a and 5b. In this study ELPI has been used to study the emissions from different Heavy-Duty engines equipped with different type of after-treatment systems.



Figures 5a and 5b. Results from the Particulates Programme. Left: ELPI Particle Number Size Distributions over the ETC cycle with different after-treatment systems. Right: Total particle number concentration measured by ELPI.

Conclusions

The ELPI has been successfully applied to engine emission measurements from both light- and heavy-duty engines. Very good repeatability and reproducibility has been found in several measurement campaigns. New features including a new software have been added to the system to further improve the instrument capabilities and usability.

Acknowledgements

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