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Paper/Poster-Abstract Form

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Title: Nanoparticle Measurements in Urban Routes with a Mobile Laboratory

Abstract: (min. 300 – max. 500 words)

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The use of fixed stations is the most usual methodology for ambient air pollution monitoring. Depending on the situation, the availability of suitable places for installation may prove challenging especially in close proximity to high traffic streets or commercial areas of a city where increased pollution levels occur. Given the fact that pollution episodes are characterized by temporal and spatial acuteness the need for mobile pollution monitoring can act complementary to an existing fixed station network and reveal more accurately the relevant pollution exposure levels, which are especially related to traffic.
In this paper we present the design, development and commissioning of a mobile laboratory able to monitor on-board along the exhaust line gaseous and particulate pollutants as well as measure these pollutants in the ambient environment around the vehicle. Results concern the vehicle emissions measurement along the exhaust line during steady state and transient engine operation as well as the ambient environment pollutants concentration in two European cities (well-known for their ambient air pollution problems): Thessaloniki (Greece) and Naples (Italy).
The vehicle used was a 2006 model year Mercedes-Benz Sprinter van (engine displacement: 2.2 L). The tailpipe emissions meet the Euro IV regulations. The emission control system includes a Diesel Oxidation Catalyst (DOC) and a Diesel Particulate Filter (DPF). Options that were necessary for the unhindered operation of the instruments, such as air condition for the load compartment, GPS antenna, high capacity battery, more powerful power generator, etc. have also been installed.
Three platforms of instruments were setup on the vehicle. The first platform concerned the ambient gas pollutants monitoring system, the second the exhaust gas pollutants monitoring system and the third the particulate pollutants

monitoring system, which would serve both for the ambient environment particulate measurements as well as the exhaust particulate measurements (by the installation of the appropriate mini dilution system). Two different sampling systems were installed on the vehicle: One for the ambient and one for the exhaust measurements.
The developed mobile laboratory proved to be able to measure efficiently both the engine vehicle particulate and gaseous emissions as well as the ambient air pollutants. It can be used to effectively evaluate exhaust emission control systems during real-word driving with respect to the emitted gases and particles.
The evaluation study presented in this paper, demonstrated that the exhaust emission reduction system installed by the vehicle's manufacturer is very efficient in the reduction of particulates, CO and HCs but on the other hand causes a significant increase in the vehicle's NO2 and SO2 emissions.
Valuable information can be extracted by the use of the MOBILAB for urban pollution monitoring. On-road pollutant concentrations can be largely different from the ones obtained from fixed stations in some cases (Naples ring-road). Moreover, the MOBILAB can be easily used for the study of temporal and spatial pollutant variations. A limited set of results for two different European cities seem to be equivalent regarding the effect of traffic density on the total particle number concentration and the mean particle size. The traffic density mostly causes an increase of the fine particle concentration (in the range of 50 to 150 nm). The number concentration of the larger particles seems to be independent of the traffic. Ultra fine particles (Dp<50 nm) also depend on the traffic conditions but can have a large variation depending on weather conditions, ground morphology and type of road network.

Short CV: **Dr. Athanasios G. Konstandopoulos** is the Founder and Director of the *Aerosol & Particle Technology (APT) Laboratory* at CPERI/CERTH (Thessaloniki, Greece), since 1996. He is also the Director of CPERI and member of the Board of Directors of CERTH. He is a specialist in combustion aerosols and nanoparticles, with extensive research and engineering consulting experience in the design, modeling and testing of emission control systems and monolithic reactors. He is the author of more than 100 scientific and technical papers, a Fellow of the Society of Automotive Engineers (SAE), and he is frequently an invited speaker in industry and scientific conferences. In 2006 he received the highest scientific award in the European Union, the Descartes Prize, as coordinator of the Hydrosol research team. Other awards include the 2006 International Partnership for the Hydrogen Economy (IPHE) Inaugural Technical Achievement Award and the Global 100 Eco-tech Award at the 2005 Expo in Aichi, Japan, both for his work on monolithic reactors for solar hydrogen production. He has a hybrid background in Mechanical (*Dipl. ME, Aristotle University of Thessaloniki, 1985; MSc ME Michigan Tech, 1987*) and Chemical Engineering (*MSc, MPhil, PhD, Yale University, 1991*).

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Nanoparticle Measurements in Urban Routes with a Mobile Laboratory

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Introduction

This work presents the development of a mobile laboratory (MOBILAB) with two-fold capabilities: On the one hand it is able to monitor urban air pollution by measuring the concentration of the major gaseous and particulate pollutants in the urban environment and on the other hand it is able to act as a mobile test center for automotive diesel engine exhaust aftertreatment systems (i.e. able to measure the engine exhaust gaseous and particulate pollutants concentration). Mobile ambient pollution measurement laboratories are getting increasing appreciation being able to monitor pollution episodes that are characterized by temporal and spatial acuteness. The importance of real-driving assessment of exhaust emission reduction systems is well-established among the developers of the relative technologies. Employing a test platform which combines ambient with exhaust measurements can enlighten the relation of vehicle emissions with the ambient air pollution levels and help in the design of sampling and measurement methodologies for better screening of the real-world conditions.

Set-up

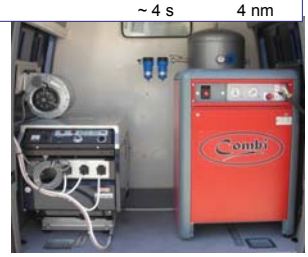
Vehicle: Mercedes-Benz Sprinter 315CDI (EURO IV)

Instrumentation:

Parameter	Instrument method/type	Time resolution	Detection Limit
Ambient gas pollutants monitoring equipment			
CO	HORIBA APMA-370 (NDIR absorption)	<60 s	0.02 ppm
NO, NO_2, NO_X	HORIBA APNA-370 (chemiluminescence)	<120 s	0.5 ppb
CO	HORIBA APMA-370 (NDIR absorption)	<60 s	0.02 ppm
SO_2	HORIBA APSA-370 (UV fluorescence)	<180 s	0.5 ppb
O_3	HORIBA APOA-370 (UV absorption)	<75 s	0.5 ppb
Exhaust gas pollutants monitoring equipment			
CO_2	Gasmet Cr-2000 (FTIR absorption)	1 s	0%
CO			1.1 ppm
NO, NO_2, NO_X			1 ppm
SO_2			1.2 ppm
HCs			1 ppm
O_2			0%
H_2O			0%
NH_3			1 ppm
Other			0.5-3 ppm
Particulate pollutants monitoring equipment (ambient and exhaust)			
Size distribution (15-660 nm)	TSI Inc. SMPS 3936 (3080L + 3776)	132 s	-
Number concentration	TSI Inc.CPC 3775	~ 4 s	4 nm


Ambient air gas analyzers


Particle measurement instruments and exhaust gas analyzer



Auxiliary equipment

Sampling system:

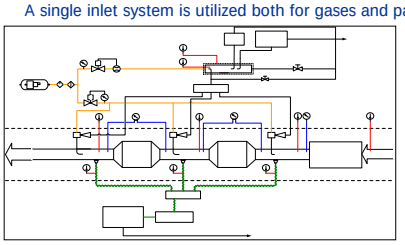
Two sampling systems are installed on the vehicle:

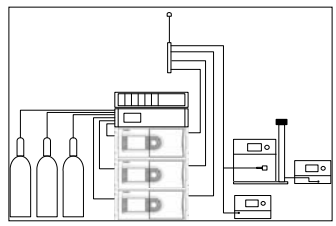
- Exhaust gas

  The exhaust sampling system contains two subsystems: One for the gases and one for the particles due to different demands in sampling flows and conditions. The exhaust gases are sampled through heated (190ºC) lines. The exhaust particles are sampled through insulated stainless steel pipes. A two-stage partial flow mini-dilution system is used (ejector type diluter followed by a mini dilution tunnel).

- Ambient air

  A single inlet system is utilized both for gases and particles.


Exhaust sampling system


Ambient sampling system

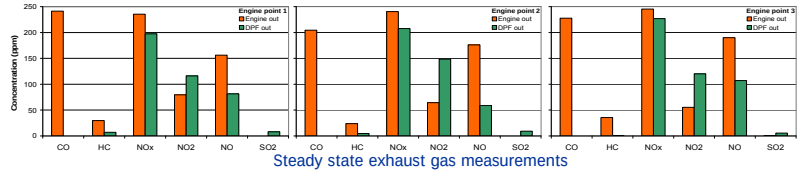
Indicative Results

Engine Exhaust Measurements

Steady state and transient engine operating conditions were examined for the exhaust measurements. The tests were performed with the vehicle driven on a chassis dynamometer. The sulphur content of the fuel used was 50 ppm.

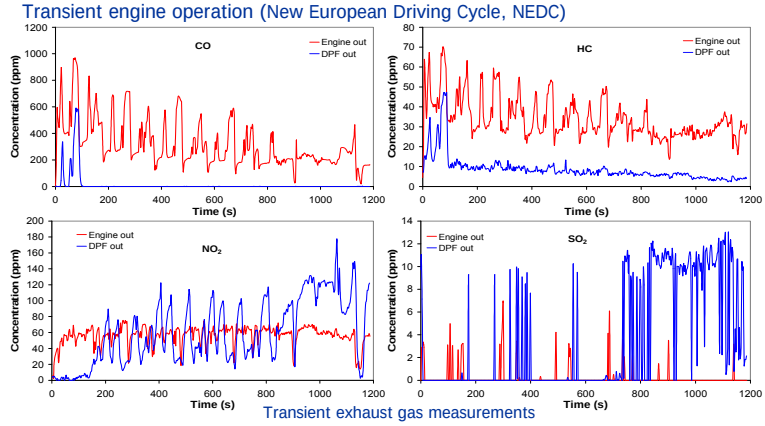
Steady state engine operation:

Engine point	1	2	3
RPM	1700	2150	3000
Engine load (%)	35	50	65
Exhaust mass flow (g/s)	28.5	40	62.4
Exhaust temperature (ºC)	160	237	345
Vehicle speed (km/h)	30	70	120



Steady state exhaust gas measurements

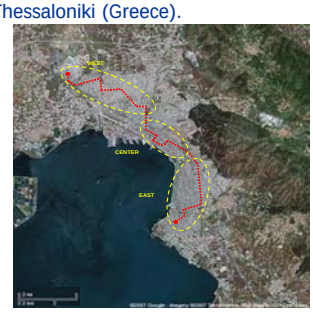
Transient engine operation (New European Driving Cycle, NEDC)



Transient exhaust gas measurements

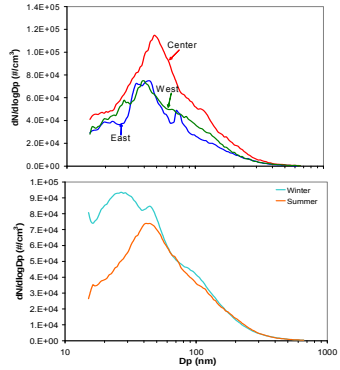
Ambient Air Measurements

The MOBILAB performed measurements at two European cities: Naples (Italy) and Thessaloniki (Greece).

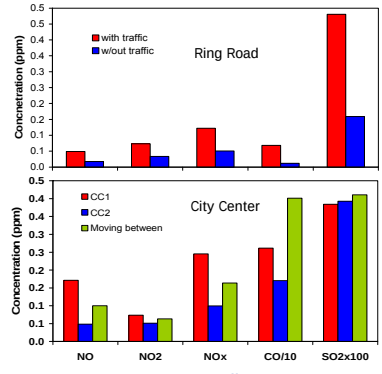


Thessaloniki measurement campaign

Naples measurement campaign



Particle size distribution measurements in Thessaloniki



Gaseous pollutants measurements in Naples

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