15th ETH-Conference on Combustion Generated Nanoparticles
June 26th – 29th 2011

Paper/Poster-Abstract Form

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Title: Update of GASOLINE and Diesel I/M Programs

Abstract: (min. 300 – max. 500 words)

The prescribed official gasoline and diesel vehicle exhaust emission test in its current form – is no longer fully sufficient due to the rapid development of engine and emission technology in modern vehicles. The test should therefore be adapted to the current vehicle technology in regard to the test procedures and certification emission limit values.
Corresponding with the essence and objectives of emission inspection, only an official inspection which can provide reliable statements, e.g. with modern diesel vehicles equipped with diesel particle filters protects the environment and health.
As part of the on-board diagnostic, an electronic system for self-monitoring of the exhaust emission characteristic was introduced in new diesel vehicles in 2003. This sensible supplement cannot, however, reliably and at all times confirm adherence to the certification limit values, especially in respect of particulate emissions. Especially for modern diesel vehicles with diesel particle filters conclusive, meaningful tests which include direct measurement of tailpipe emissions must be employed to document and guarantee the efficiency of the emission after treatment over the entire service life of a vehicle.
An extensive field trial, conducted by the German Task Force "Emission 2010" (VdTÜV, DEKRA, ZDK, ASA Association), has tested over 1,000 diesel vehicles in workshops and at accredited inspection organizations to assess the effectiveness of measurement devices available to fulfil this testing. The field test project has confirmed the practical suitability of these instruments for in-use vehicle testing.
In addition, independent laboratory testing at a university institute has demonstrated levels of accuracy comparable to the laboratory instruments which are typically used for engine development and certification approval testing.
From CARB's final report for "Light Duty Gasoline PM: Characterization of High Emitters and Valuation of Repairs for Emission Reduction", August 2010:
PM emissions from light duty gasoline vehicles (LDGV) could contribute an increasingly larger portion on-road PM emissions, as after treatment systems for diesel engines become more commonplace. The most important fraction of the LDGV fleet for PM emissions is the worn or malfunctioning vehicles that can have PM emissions orders of magnitude higher than normal, well-maintained vehicles. While the Smog Check program in California implemented a check for visible smoke starting in January of 2008, it still does not include a direct measurement of PM.
The MAHA was able to distinguish the three high emitting vehicles from the remaining low emitting vehicles, as long as an appropriate calibration factor was applied. A linear regression between the MAHA and the PM mass showed a decent agreement with an R2 of 0.852.

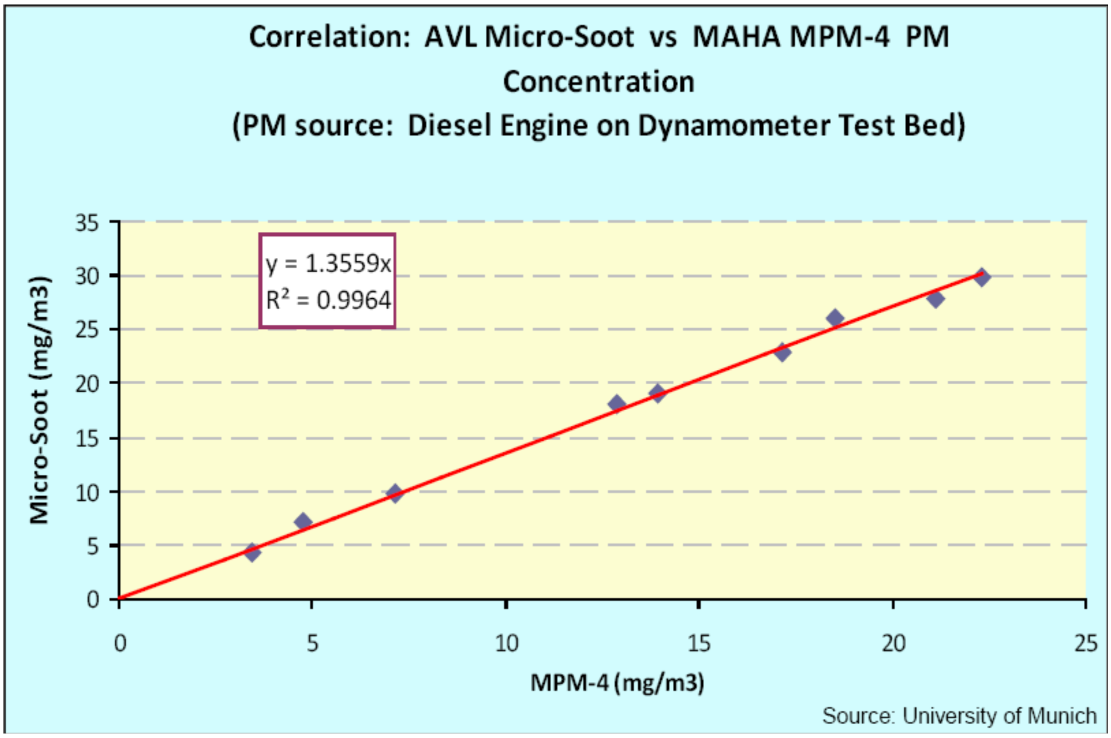
Short CV:

Antonio Multari is the Director Project Management for MAHA Maschinenbau Haldenwang GmbH & Co. KG in Haldenwang, Germany. Over the past 11 years, he has worked in several international emission programmes. Antonio has worked in several working groups, to realize emission projects. Currently he is working in the German project “Emission Check 2010”, CITA Working Group Emissions, European emission study “TEDDIE” and in the Californian pilot program with CARB, SCAQMD and FCCC.

OBD does not Effectively Identify high PM Emissions:

- **cannot even detect PM levels which would fail a pre-DPF car opacity (K-value) test!**
- **even a physically broken DPF could go undetected**

	PM [g/km] New DPF	**PM [g/km] Defect DPF**	PM [g/km] Threshold	K-Value [1/m] New DPF	K-value [1/m] Defect DPF	K – thresh. Limit [1/m]	**MIL – Lamp**
Car 1	0.0017	**0,043**	0,05	0,03	**1,62**	1,5	**off**
Car 2	0,0156	**0,014**	0,05	0,19	0,61	1,5	**off**
Car 3	0,0138	**0,018**	0,05	0,62	**2,72**	1,3	**off**
Car 4	0,0016	**0,051**	0,025	0,02	0,17	0,5	**off**
Car 5	0,0005	**0,019**	0,025	0,03	0,35	1,2	**off**
Car 6	0,0004	**0,006**	0,025	0,02	**1,12**	0,5	**off**
Car 7	0,0004	**0,023**	0,025	0,17	**3,1**	0,5	**off**



Update of Gasoline and Diesel I/M Programs

15th ETH-Conference on Combustion Generated Nanoparticles
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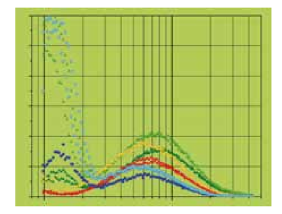
Presenter: Antonio Multari
Authors: Antonio Multari, Peter Anyon, Elmar Tschinkel



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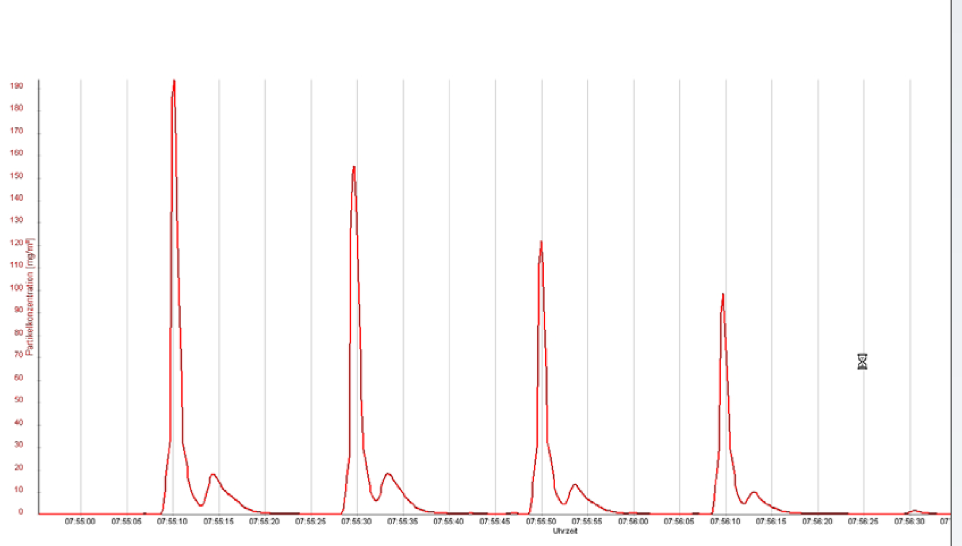
Gasoline Direct Injection – High PM Emissions



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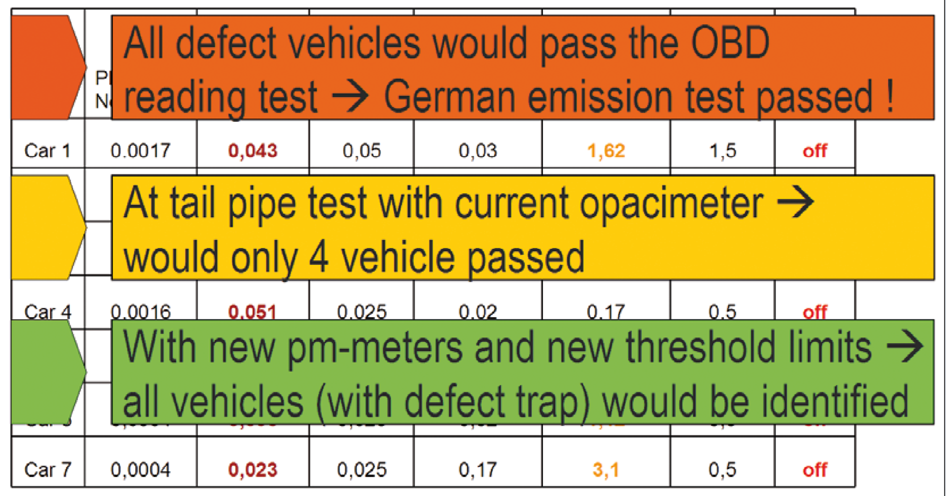
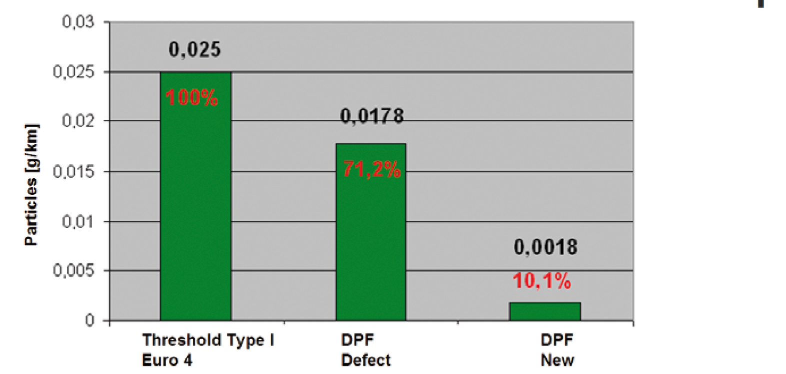


Measurement Procedure: Car with Defect Trap



Even a 10 time higher emissions result does not give any objection!

British Colombia Clean Air Research Fund 2009 / 2010

There is very little available data relating to the PM emissions from in-use light-duty vehicles. In 1999 a project was undertaken by Environment Canada at the AirCare Research Centre, to collect PM emissions data from in-use gasoline vehicles. It used the established gravimetric method of collecting PM samples on filter papers. A total of 62 light-duty vehicles were tested. Since then, we are not aware of any further work aimed at characterising the PM emissions of the BC in-use fleet.

For this project the AirCare Research Centre used its unique ability to solicit appropriate volunteer vehicles, together with its in-house chassis dynamometer/CVS emissions testing system to develop a way to collect PM mass emission data from in-use light-duty gasoline and diesel vehicles. The PM measurements were obtained using a MAHA MPM4 light-scattering analyser that gives a continuous measurement of exhaust PM concentration (mg/m3). The purpose of this project was to collect PM emissions data from a sample group of light-duty diesel and gasoline vehicles in order to characterise the PM emissions of the in-use fleet. The resulting data will be used for emission factor development; in developing mitigation strategies; and to support evaluation of the effectiveness of mitigation strategies.

The inconvenience of gravimetric PM measurement has created a situation where new vehicle PM emissions are regulated in units of grams of PM per km or per bhp-hr, but in-use inspections have been limited to measuring opacity. Although opacity remains a reliable and affordable way of identifying diesel vehicles that are in need of repair, it is not a surrogate for PM measurement. Opacity is more of a qualitative test and the correlation between opacity measurements and PM measurements is poor. This means that opacity data can not be used to develop a picture of the PM emissions of the in-use fleet, or to help develop emission factors for inventory purposes.

The MAHA MPM4 is a light-scattering PM analyser, and is intended for routine vehicle emission inspection. This means that it is more affordable, and more convenient to use, than equipment intended for a purely research environment. Measurements were made in real time at a frequency of 1Hz, which is enough to track the effects of transient vehicle operation. So, as well as delivering overall mg/km emissions over a set driving cycle, the data also indicates which driving modes produce more PM, and any transient relationships between PM, NOx and other emissions. This is something that is impossible with filter collection methods.

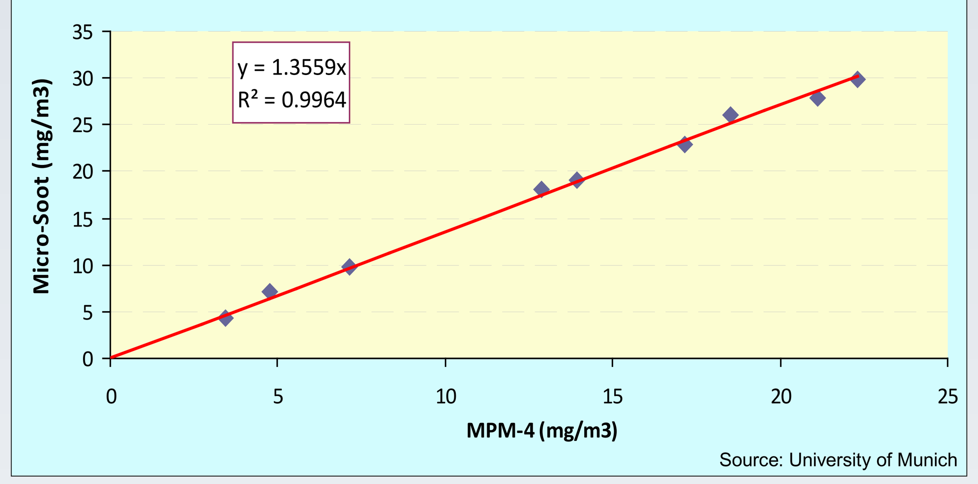
The results presented in this report for gasoline vehicles are comparable to those obtained by Environment Canada in 1999. However, they also include diesels, which were not included in the EC work, and also include vehicles up to model year 2010, reflecting advances in emission control technology. The data also highlight the range of emissions from old and new vehicles and the effect of oil-burning on the rate of PM emissions.

The project has confirmed the suitability of the MAHA analyser for routine PM data collection, and has verified the methodology developed to combine the PM concentration measurements with CVS modal data in order to derive PM mass emission factors in units of mg/km.

Although this report marks the end of this specific project, the work of data collection will continue, and the next phase is to deploy an analyser in an inspection lane where it would be used for every vehicle brought through for regular inspection. This approach has already been used for NOx measurement of diesels: A Horiba diesel NOx analyser was first used in the CVS lab and then moved out to Lane #1 at the Abbotsford inspection centre. This lane tests about 100 diesels per month as well as many more gasoline vehicles. The PM analyser will be deployed to the same lane.

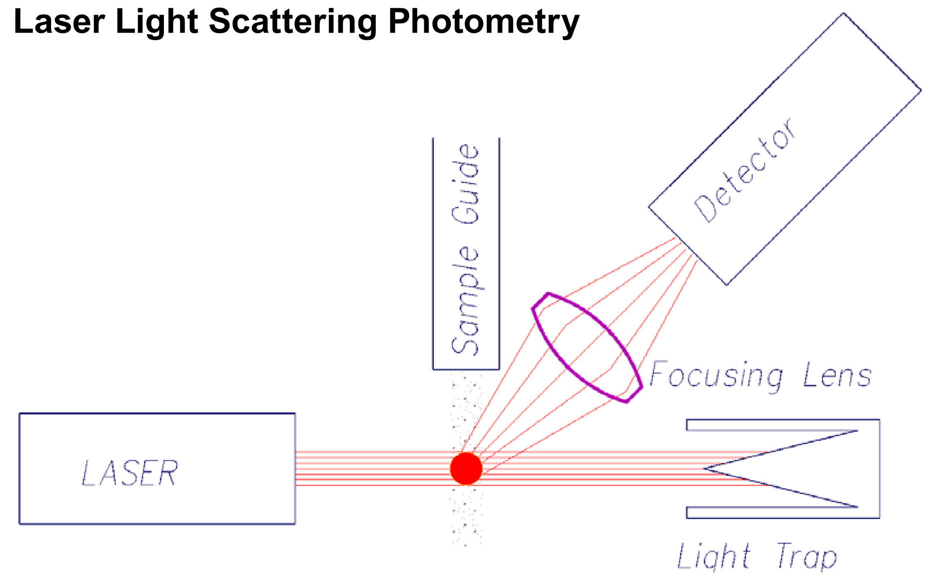
PVTT
Dr Stephen J Stewart

Correlation: AVL Micro-Soot vs MAHA MPM-4 PM Concentration
(PM source: Diesel Engine on Dynamometer Test Bed)



Source: University of Munich

Laser Light Scattering Photometry

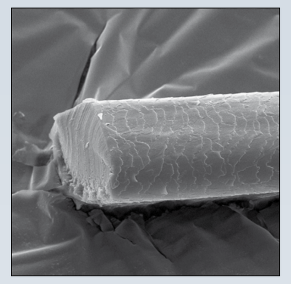


Principal of Operation

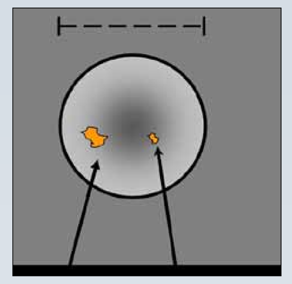
Invisible Danger

Diesel Particle

In order to understand the depth of danger that the smallest particles in diesel engine emission represent, we need to try to think in the tiniest dimensions. The most common measure of comparison is the human hair. It measures 70,000 nm in diameter. A typical diesel particle measures only 250 nm diameter. More than a million of these particles can be found in a volume of cm3 which corresponds with a normal concentration. When inhaling, particles in the range of 5,000 to 10,000 nm get into the nose and throat with smaller particles between 3,000 and 5,000 nm reaching into the air pipe. Even smaller particles with a diameter of 2,000 to 3,000 nm can advance forward into the bronchial tubes. Particles with a diameter of 1,000 to 2,000 nm can reach the bronchiole area. And the smallest diesel particles with a diameter of only 100 to 1,000 nm attack the pulmonary alveoli in the lungs. This then opens the path for particles to enter the bloodstream. It does not take all too much fantasy to imagine the damage that they can cause there. For this reason it is of paramount importance that vehicles with heavy particle emission be identified in the framework of the official emission inspection using state-of-the-art measurement technology. Our health also depends on this.



Human hair has a diameter of 70,000 nm.



Typical diesel particles are much smaller than the diameter of a human hair.

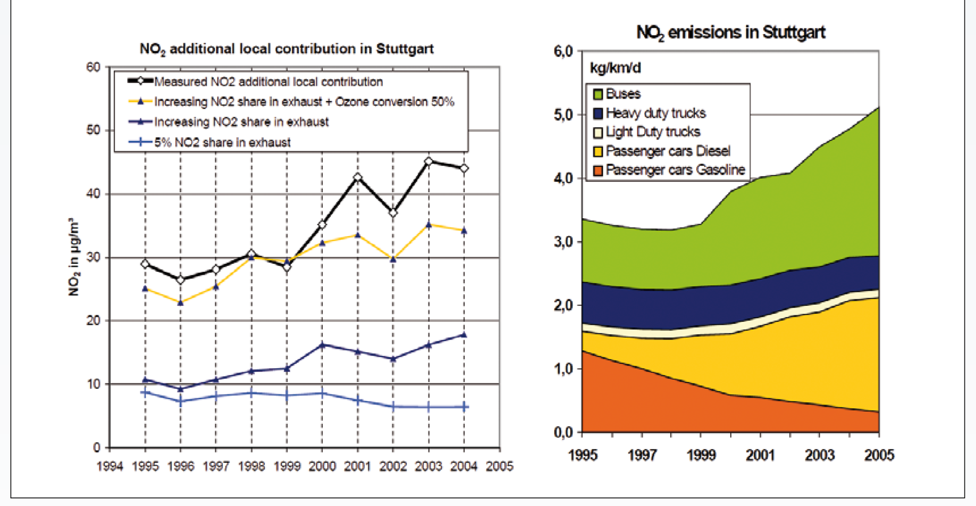
Extremely fine diesel particles can enter the bloodstream through the lungs.

Some Pilot Programs Worldwide

Technical Data MET 6.3

Gas Analyzer	
Gas	HC, CO, CO_2, O_2, NO_x ($NO+NO_2$), NH_3 Lambda
Measurement principle: - Infrared - Electro chemical - Chemical	 HC, CO, CO_2 O_2, NO NO_2, NH_3
Power supply	110 – 230 V/ 50/60 Hz 10 – 32 V
Measurement accuracy class	0 OIML
Dimensions (L x W x H)	406 x 225 x 160 mm
Weight	5 kg
PM / Opacity Analyzer	
Measurement principle	Laser Light Scattering
Measurement range PM	0,01 – 700,00 mg/m³
Measurement range Opacity	0-100 % (0-9,99 k value)

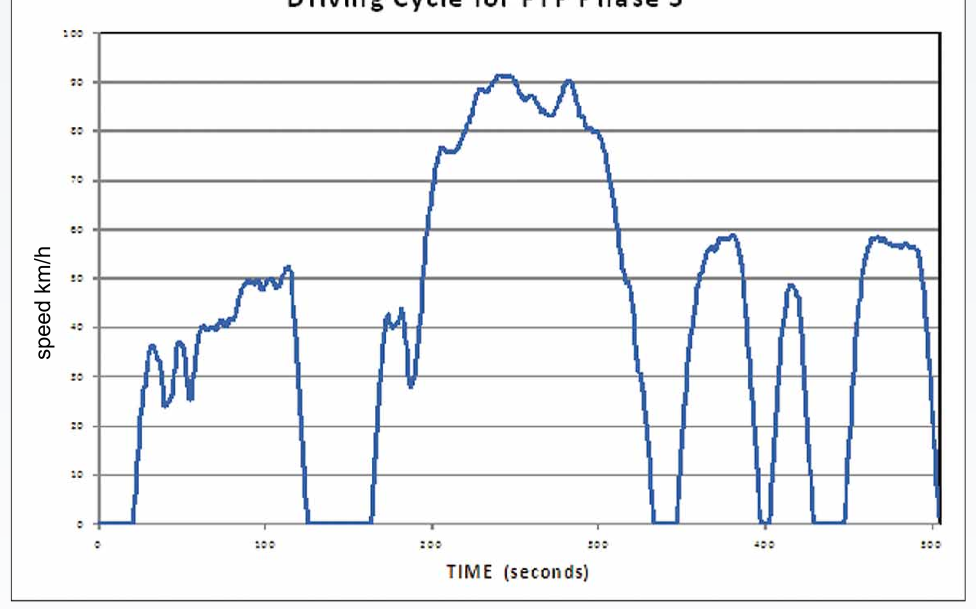
NO_2 exceeding limits in Stuttgart
caused by buses with DPF and cars with DOC



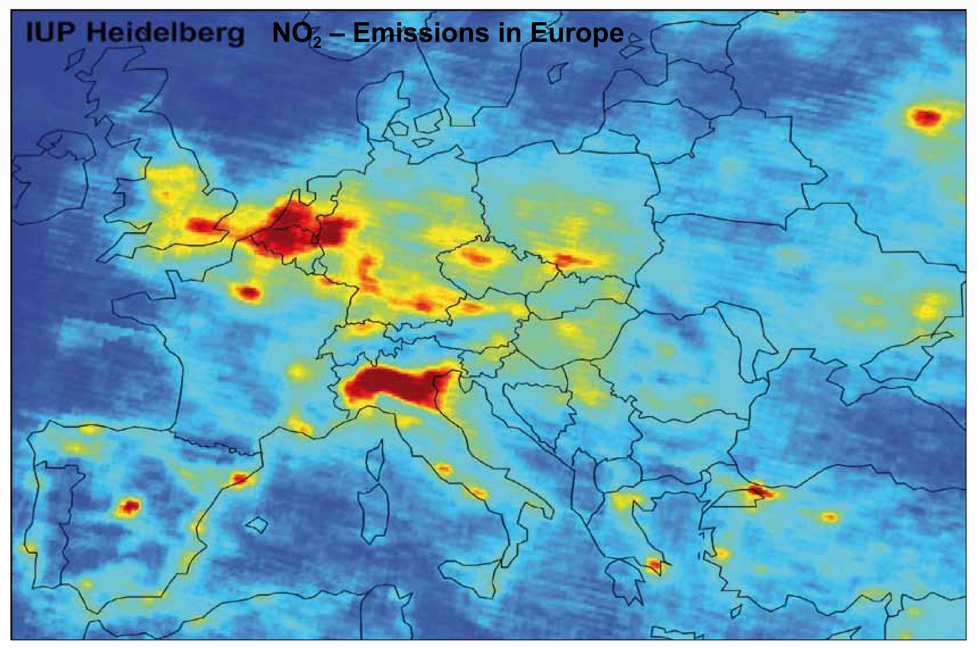
A Modern Diesel/Gasoline Emission Test for Vehicles is

1. Necessary
2. Technology is available
3. Cost effective

Driving Cycle for FTP Phase 3



IUP Heidelberg NO_2 – Emissions in Europe



PM Concentrations - Test Number 6112