

# Comparison study of PMP instrument candidates at EMPA

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## Background GRPE PARTICLE MEASUREMENT PROGRAMME (PMP)

### 1. INTRODUCTION

Current medical evidence indicates that particle emissions, measured as PM10, are associated with increased mortality. However, a growing number of medical experts consider that nanometer size particles, that may be insignificant to the total mass of particulates, may be more significant in terms of health effects. New engine/vehicle technologies offer levels of particulate emission control that are considered to be approaching the effective measurement limits of the current legislative systems. It is therefore necessary to consider the development of new systems of particulate measurement that can be recommended for adoption into international regulations governing these emissions.

The GRPE Particulate Measurement Programme (PMP) is a collaborative programme operating under the auspices of the UNECE WP29/GRPE Group. Its focus is on the development of a new approach to the measurement of particles in vehicle exhaust emissions, which may be used to replace or to complement the existing regulated mass based system. PMP is open to contributions from governments, industry and NGOs who are members of the GRPE. Each contributor to the programme will undertake and fund their own research and deliver the results in accordance with the schedule of the two-year programme. Interim and final results of the national research programmes will be shared with all members of the programme, to enable the development of a PMP consensus report.

### 2. AIM

The aim of PMP is to recommend to the regulatory authorities a new particulate assessment and measurement system for application during type approval testing of light-duty vehicles and heavy-duty engines for particulate emissions. This recommended system would permit the development of new emission standards, which would, in turn, promote the adoption of new emission reduction technologies. In this context "system" comprises a description of the test procedures, sampling equipment and measurement instrumentation. The system will enable accurate and repeatable measurement of particles present in the exhaust stream and at stringency levels below those currently set down in legislation. The output will be draft text for use as a proposal that may replace or supplement the current systems set out in UNECE Regulations 83 and 49.

To assist in the setting of future limit values for light-duty vehicles and heavy-duty engines, the programme will provide data on the emissions of particles from engines employing a range of advanced technologies, and in particular from different diesel particle filters (DPF), measured using the new PMP recommended test system.

Informal Document No ①  
(GRPE 42nd, 29 May – 1 June 2001, agenda Item 2.)  
Transmitted by the Expert from the United Kingdom.

## GRPE PARTICLE MEASUREMENT PROGRAMME (PMP)

### What?

Collaborative programme operating under the auspices of the UNECE WP29/GRPE Group

### Who?

National authorities, Industrial associations, Research institutes, Instrument manufacturers

### Goal?

Recommendation a new/additional measurement system for particles during type approval testing that permit the development of new emission standards

### Schedule?

Finished by a final report in 2003

## COMPARISON STUDY OF PMP INSTRUMENT CANDIDATES AT EMPA

### Features of the test programme

- open to everybody, no pre-selection of participants
- measurement in responsibility of instrument manufacturers
- simultaneous measurements on future emission levels
- basic data evaluation by participants with guidance of EMPA
- advanced evaluation & statistic analysis by EMPA
- report by EMPA

## EMISSION SOURCES

**HD-engine** 7 l, 6 Cyl., TC, IC, EURO 3, (provided by Volvo)  
equipped with particle filter (CRT-System)

### *Emission levels*

- 100% of exhaust flow through particle trap
- part of exhaust flow through bypass of particle trap that about 40% below Euro 4 level

### *Fuel*

- Diesel fuel, CEC-RF-06-99  
8 ppm sulphur, 17% aromatic compounds

### *Lubricant oil*

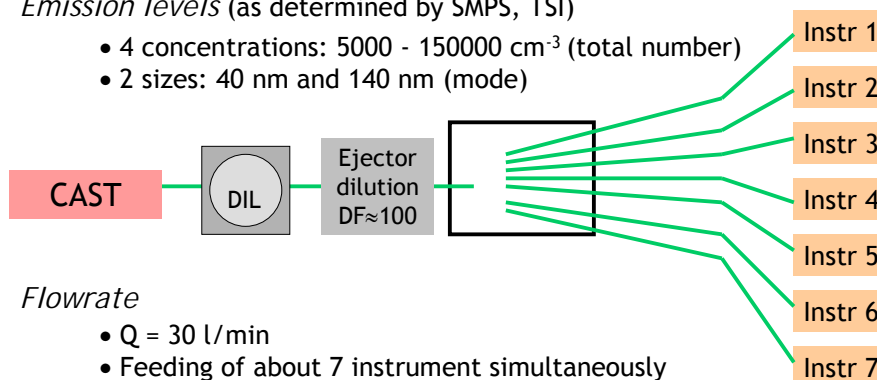
- high quality, 10W40, 3900 ppm sulphur (Shell Myrina)

## EMISSION SOURCES

**Combustion aerosol generator (CAST)**  
provided and operated by METAS

### *Emission levels* (as determined by SMPS, TSI)

- 4 concentrations: 5000 - 150000 cm<sup>-3</sup> (total number)
- 2 sizes: 40 nm and 140 nm (mode)



### *Flowrate*

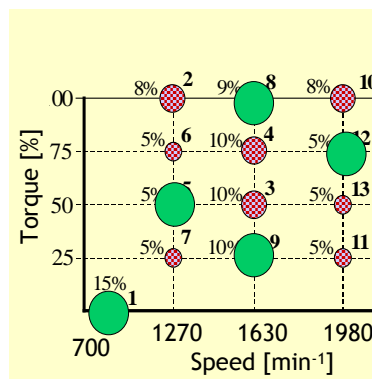
- Q = 30 l/min
- Feeding of about 7 instrument simultaneously  
=> 3 groups of instruments

## TEST CYCLES

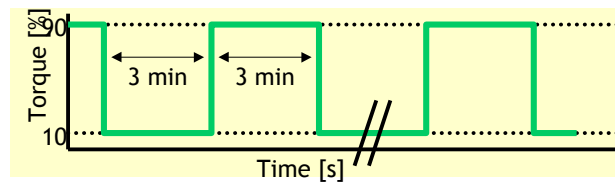
- Transient test cycle ETC
- Steady state tests 5 single modes: B100, C75, A50, B25, idle ESC
- Step change test (SCT) (own definition)  
repeated load change at 1630 rpm speed  
10% → 90% → 10% → 90% → ...
- Background

## TEST CYCLES

SM / ESC



SCT



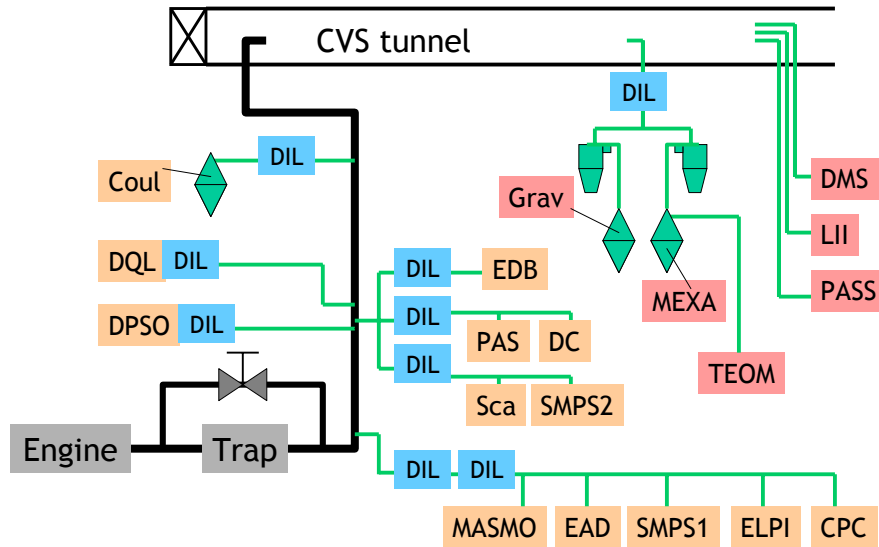
## INSTRUMENT MANUFACTURERS

- Assembly Technology & Test Ltd, GB
- Cambustion Ltd., GB
- Dekati Ltd.; Finland
- Esytec GmbH, Germany
- Grimm Aerosol Technik, Germany
- Horiba, Japan
- Matter Engineering, Switzerland
- Rupprecht & Patashnick Co, USA
- Sensor Inc., USA
- Techn. University Munich, Germany
- TSI Inc., USA
- Wizard Zahoransky KG, Germany

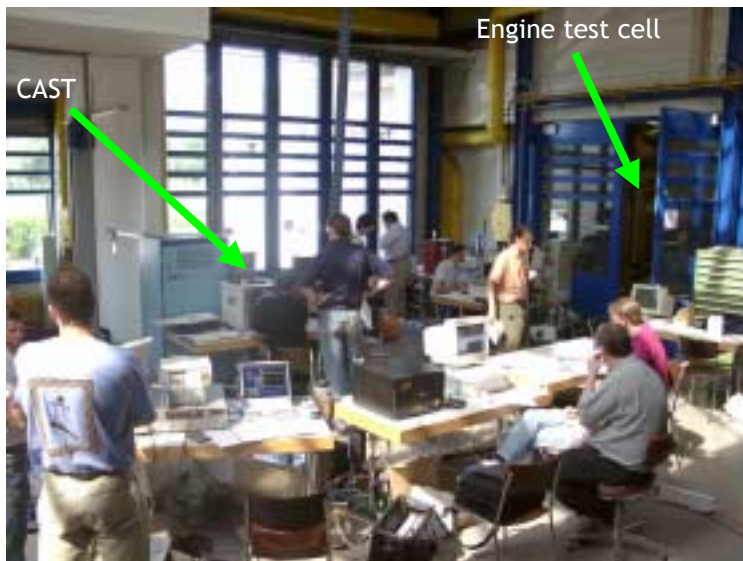
## MEASUREMENT TECHNIQUES

Method	Instrument	Size
• light extinction	DPSO(B), DQL(L)	yes
• light scattering	CPC(L), Dust monitor(L), PM-300(L)	no/yes
• LII	LI2SA	yes
• photoacoustic	PASS	no
• electr. mobility	DMA, DMS, MASMO	yes
• aerodyn. mobility	MASMO, ELPI	yes
• electr. charging	DC, DMS, EDB, ELPI, MASMO, PAS	
• diffusion mobility	EDB	yes
• oscill. Microbalance	TEOM	no
• IR absorption	Mexa 1370PM	no
• titration	coulometry	no
• balance	gravimetric filter method	no

## EXPERIMENTAL SET-UP



## MEASUREMENT HALL



## WHAT WE HOPE TO LEARN

- **Robustness**  
tight measurement programme of two weeks duration
- **Repeatability**  
subsequent tests and day-to-day variability
- **Linearity**  
Measurements at 4 emission levels set by CAST
- **Time response**  
Time-resolved measurements during 2 emission levels
- **Detection sensitivity**  
Measurements of background & different concentration levels
- **Size sensitivity**  
Measurements of two defined particle size distribution  
(mode at 40 nm und 140 nm) set by CAST

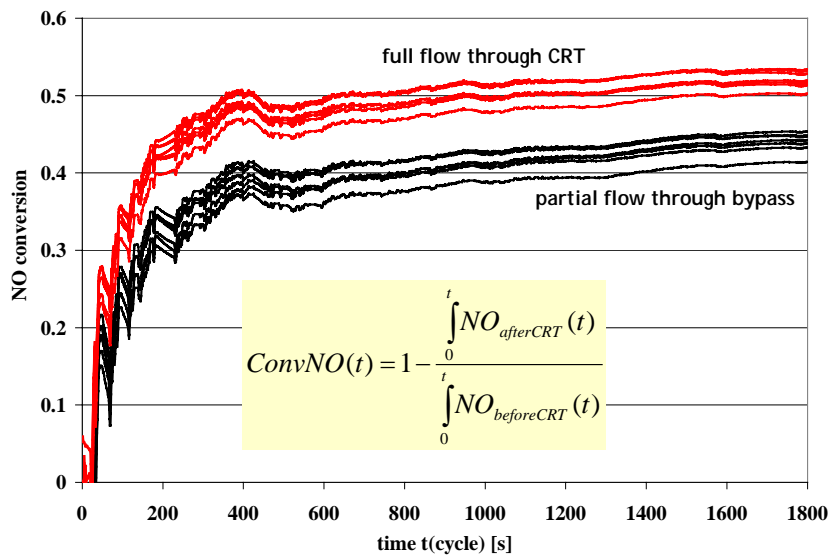
## WHAT IS NOT INTENDED ?

- to evaluate a complete future test procedure for particle measurement
- to characterise the engine and the particle trap
- to determine universally applicable correlation factors between the different measurement methods

## WHAT IS INTENDED ?

- to get an overview of advanced particle measurement techniques
- to produce a data basis of comparable results of different particle systems
- to evaluate the potential of the participating systems for a future type approval suitability

## ENGINE AND FLOW SPLIT STABILITY



### Funded by

- ASTRA
- EMPA
- BUWAL
- Manufacturers (instruments operation)
- METAS (CAST operation)
- R&P (cyclones & filter holders)
- SUVA (coulometry)
- VOLVO (engine)

### Thanks to my EMPA colleagues

- Sepp Rütter
- Roland Graf
- Rolf Ziegler
- Urs Lehmann
- Daniel Schreiber
- Hans-Christian Opstad