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The Diesel exhaust aftertreatment (DEXA) cluster in the EC GROWTH program

5th ETH CONFERENCE ON NANOPARTICLE MEASUREMENT
Zurich Aug. 6-8, 2001

THE DIESEL EXHAUST AFTERTREATMENT (DEXA) CLUSTER IN THE EU GROWTH PROGRAMME

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ABSTRACT

The European Automotive Industry is currently facing increasing challenges to provide solutions that reduce transportation related environmental impact, conserve energy and advance social welfare without jeopardizing its major role as a prime contributor to economic growth (turnover of more than 400 billion Euro), major employer (1.7 million people directly employed and a ten-fold more indirectly affected) and important "defender" of European competitiveness (positive trade balance of 15 billion Euro).

As stated in the Workprogramme of the EU 5th Frame Work Programme on "Competitive and Sustainable Growth" (GROWTH) one of the aims of the Land Transport and Marine Technologies Key Action "*is the development of energy-efficient, ultra-low and near-zero emission, intelligent engines running on conventional or alternative fuels fulfilling requirements of maintainability, durability and manufacturability at competitive cost" and a "contribution to the reduction of 30% in CO_2 emissions for new car fleet average by 2008 to 2012 time period against the 1995 state of art technologies for consumption of equivalent classes"*. Improved fuel economy and emissions reduction has thus been recognized as a key target. Furthermore one of the aims of the Objective 6.2 in the Measurements and Testing Generic Activity of the GROWTH programme is "*Development of measurement and testing methodologies in support of quality:…to exploit techniques with potential to become the basis for new measurement techniques of industrial importance. RTD will focus on development of measurement and testing methodologies that are needed for (traditional, new and emerging) industrial products, processes and services, as well as for monitoring production and for controlling effluents and emissions"*

Meeting proposed emission levels (Euro IV in 2005 and beyond, "Euro V") for NOx and PM requires the development of a number of critical technologies, an important element of which is by advanced diesel exhaust aftertreatment (DEXA) technology, a need that has motivated the formation of the present ex-ante cluster of projects. The members of the present consortium include passenger car manufacturers, exhaust aftertreatment system suppliers, engineering research and development industries, instrumentation manufacturers, software vendors and research institutes/universities.

The currently running cluster projects on diesel exhaust aftertreatment, with emphasis on particulate matter, focus on three aspects:

- the component technology integration aspect (Project ART-DEXA)
- the system design aspect (Project SYLOC-DEXA) and
- the quality assessment/measurements aspect (Project PSICO-DEXA)

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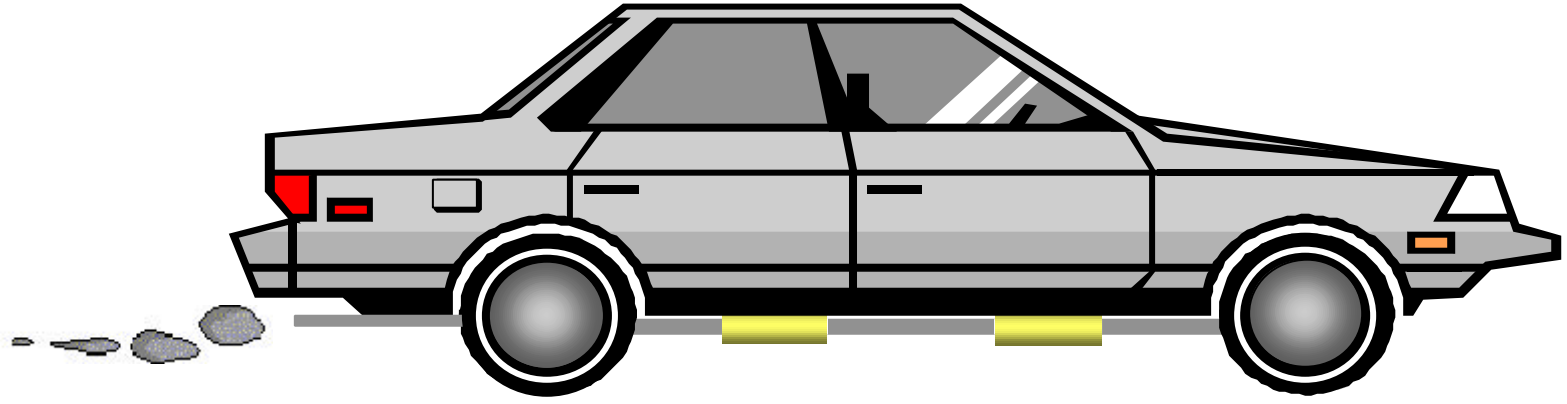
MOTIVATION:
A systems approach to diesel emission control

Fuel/Lube oil

→ Effects of Sulfur - content/composition on emissions and aftertreatment system

In-cylinder measures

→ Advanced Fuel Injection
→ Combustion mode



Real time soot nanoparticle measurement

→ Size/Composition
Raw vs. Dilute

Exhaust Aftertreatment System

→ Novel device designs (filters, catalysts)
→ CAE tools for system Design/Optimization/Control (traps, DeNOx system, Ox. Cat.)

OBJECTIVES OF DEXA CLUSTER

The present cluster of projects is aiming at providing a complete and integrated approach at the European level, on diesel exhaust aftertreatment, with emphasis on particulate emissions control, focusing on three aspects:

- component technology integration aspect (ART-DEXA)
- system design aspect (SYLOC-DEXA)
- quality assessment/measurements aspect (PSICO-DEXA)

CLUSTER MANAGEMENT

ART-DEXA

PROJECT Nº: GRD1-1999-10451
DURATION:1/2/2000-31/1/2003

Coordinator:
Gianmarco Boretto
CR FIAT

SYLOC-DEXA

PROJECT Nº: GRD1-1999-10588
DURATION:1/2/2000-31/1/2003

Coordinator:
Peter Prenninger
AVL List GmbH

PSICO-DEXA

PROJECT Nº: GRD1-1999-11154
DURATION:1/1/2000-31/12/2002

Cluster Coordinator:
Athanasios G. Konstandopoulos
CERTH/CPERI

DEXA CLUSTER PARTNERS (1)

INDUSTRIAL PARTNERS

◆CENTRO RICERCHE FIAT SCpA,	I
◆RENAULT RECHERCHE et INNOVATION	F
◆JOHNSON MATTHEY PLC	UK
◆AVL List GmbH	A
◆FEV MOTORENTECHNIK GmbH	D
◆ZEUNA STAERKER GmbH & CO KG	D
◆WIZARD ZAHORANSKY KG	D
◆OBERNOSTERER STRICKSTOFFE GmbH	A

DEXA CLUSTER PARTNERS (2)

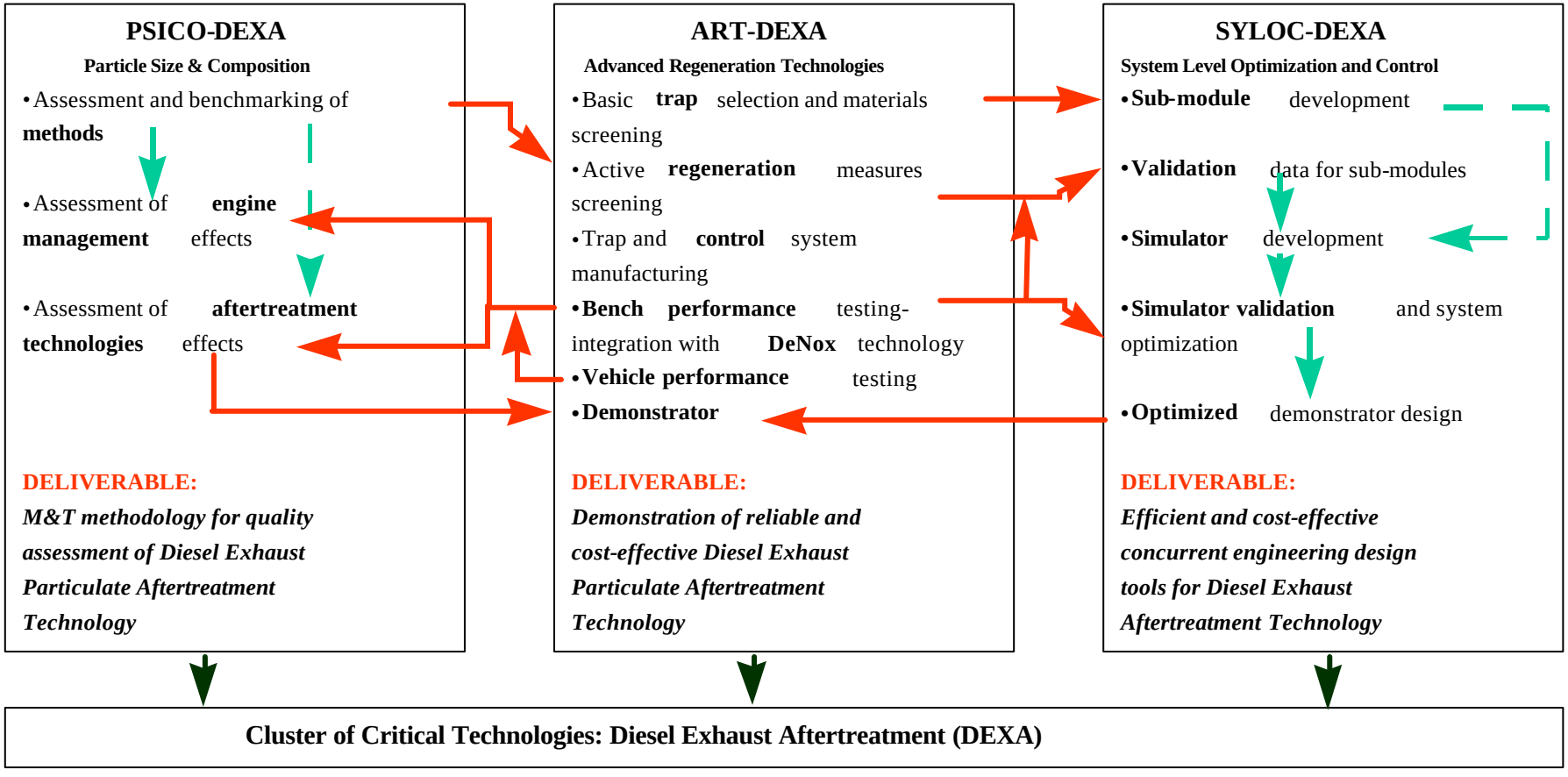
RESEARCH INSTITUTES

- CERTH/CPERI-Aerosol & Particle Technology Lab — EL
- CLAUSTHALER UMWELT TECHNIK-INSTITUT GmbH — D
- ISTITUTO MOTORI, National Research Council of Italy — I
- EC - JOINT RESEARCH CENTRE — NL

UNIVERSITIES

- UNIVERSITAET LEOBEN - Christian Doppler Lab — A
- POLITECNICO DI TORINO — I
- UN. DI NAPOLI “FREDERICO II” - Dept. Chem. Eng. — I

DEXA CLUSTER STRUCTURE



OBJECTIVES WITH RESPECT TO PARTICLE CHARACTERIZATION

- To develop, tailor, evaluate/screen and cross-calibrate size, composition and joint size- composition measurement techniques for diesel particulate emissions in the raw and diluted exhaust, with emphasis
  - on the evaluation of the effects of sampling conditions on measured size distributions
  - on the cross-comparison and validation of methods
  - on the deployment and assessment of real-time techniques
- To evaluate the effect of advanced Diesel engine combustion technology management under well defined boundary conditions applying the developed techniques and methodologies for particle characterization
- To evaluate the effect of advanced Diesel engine aftertreatment technology under well defined boundary conditions applying the developed techniques and methodologies for particle characterization

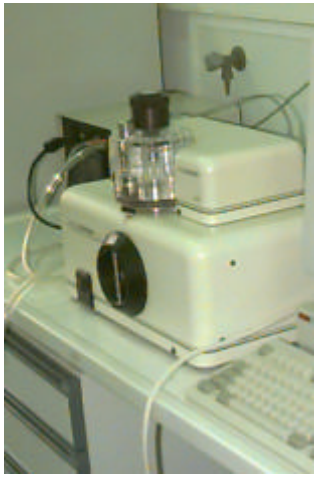
Particle Measurement Techniques Employed (1)

Berne Low Pressure Impactor and Electr. Low Press. Impactor (ELPI)

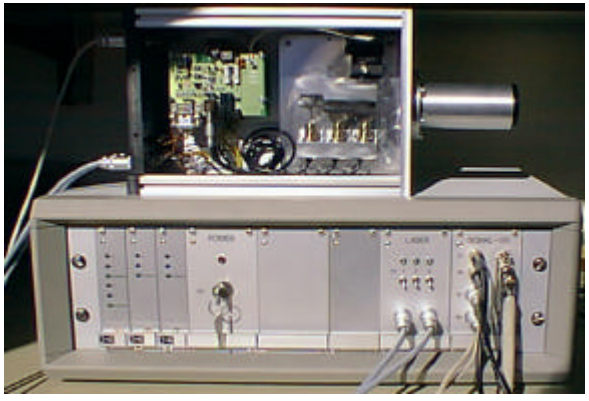
Scanning Mobility Particle Sizer (SMPS) and Transient Mobility Particle Sizer (TDMPS)

Nano DMA and Dual DMPS

Nanomet Particle Measuring System



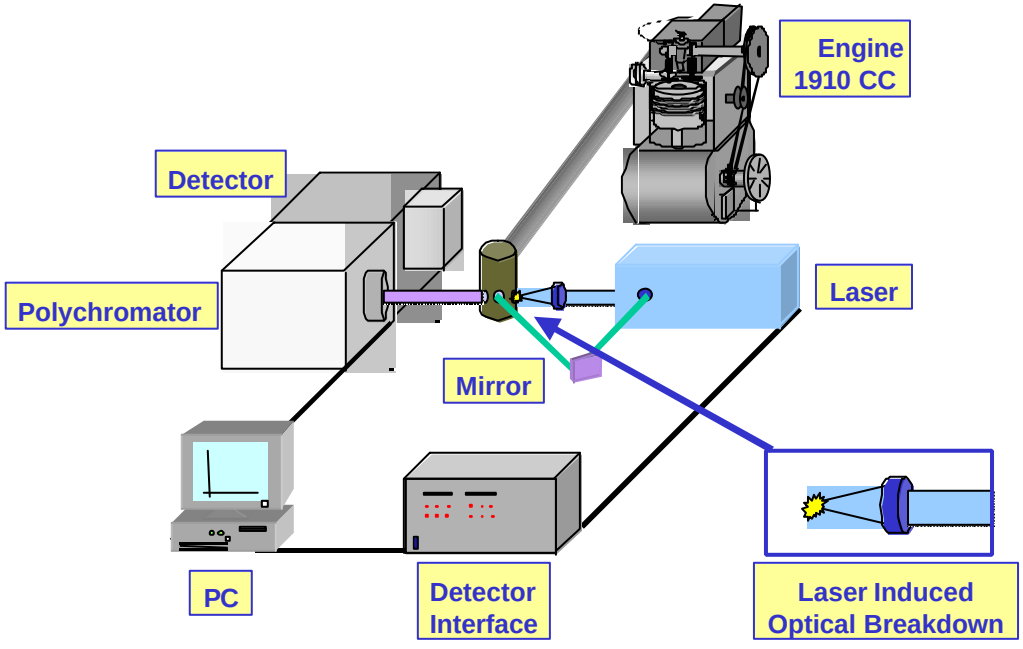
API Aerosizer (TOFPS)



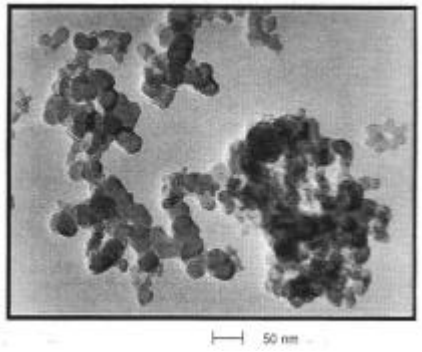
Multiwavelength Extinction Sensor

Particle Size Measurement Techniques Employed (2)

Broadband UV-vis. Extinction and Scattering



Thermophoretic Sampling and Transmission Electron Microscopy



Particle Composition Measurement Techniques

- Standard dilution tunnel mass-based methods and TGA/DSC for soluble/insoluble fractions, solids/volatiles, etc
- Neutron Activation Spectroscopy for trace species analysis
- Spectral absorption in UV-vis and fluorescence
- Fast extraction for PAH analysis
- Nanomet Photoelectric Aerosol Sensor + Diffusion Charger
- Mass-Spectrometer in conjunction with DMA/thermal denuder for size specific composition
- Analytic Electron Microscopy

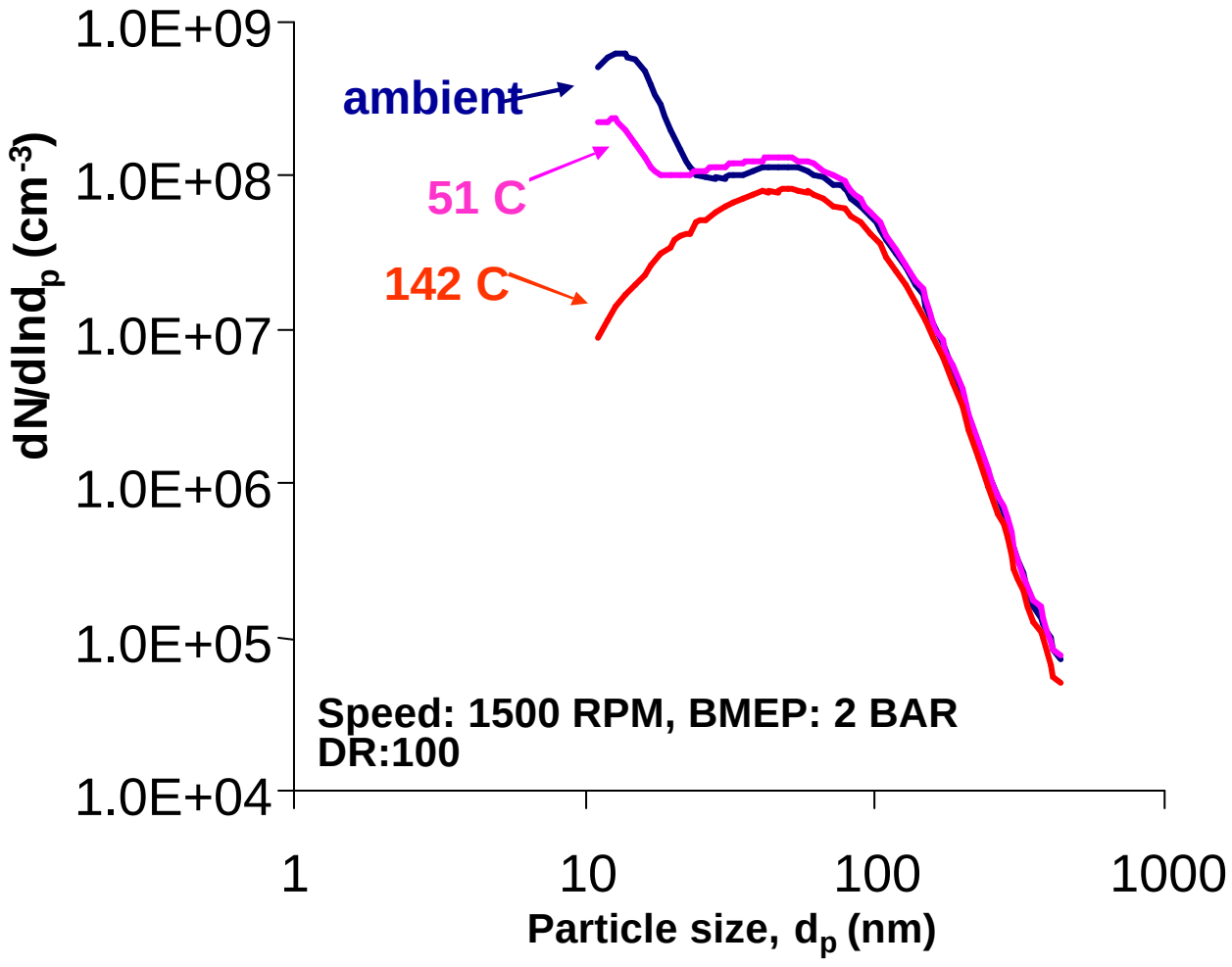
DEXA CLUSTER STATUS

- Midterm assessment meeting to be held in September 2001
- A web-site is operational with 3 levels of access confidentiality: Intra-project, intra-cluster, public
- Brief status of all projects follows

PSICO-DEXA Executive Summary :

- **Definition of test conditions and procurement of fuel**
  - Low sulfur diesel fuel (<50 ppm)
- **Size measurement techniques (SMPS, ELPI, TOFPS)**
  - SMPS results insensitive for Dilution Ratio > 100
  - Losses in ELPI with standard plates
  - TOFPS measures only particles > 0.3 μm
  - Multiwavelength light extinction is promising
  - Optimized sampling for simultaneous operation
- **Composition measurement techniques**
  - Mini diluter for filter sampling and TGA/DSC
  - Nanomet system (PAS + DC)
  - Neutron activated Gamma-ray spectroscopy
- **Joint size-composition measurement techniques**
  - Size specific thermal desorption/oxidation
- **Assessment of Engine Management & Aftertreatment Effects**
  - Measurement protocols and parameters defined
  - Aftertreatment technologies defined & procured

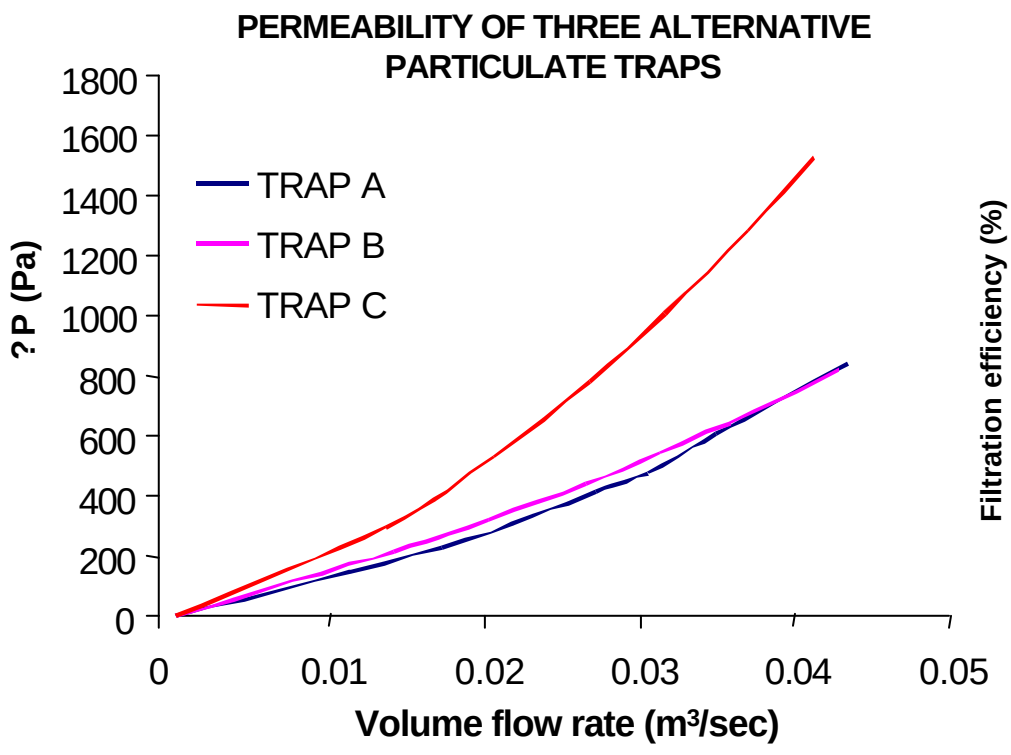
Influence of Diluter Temperature on Size Distribution (SMPS)

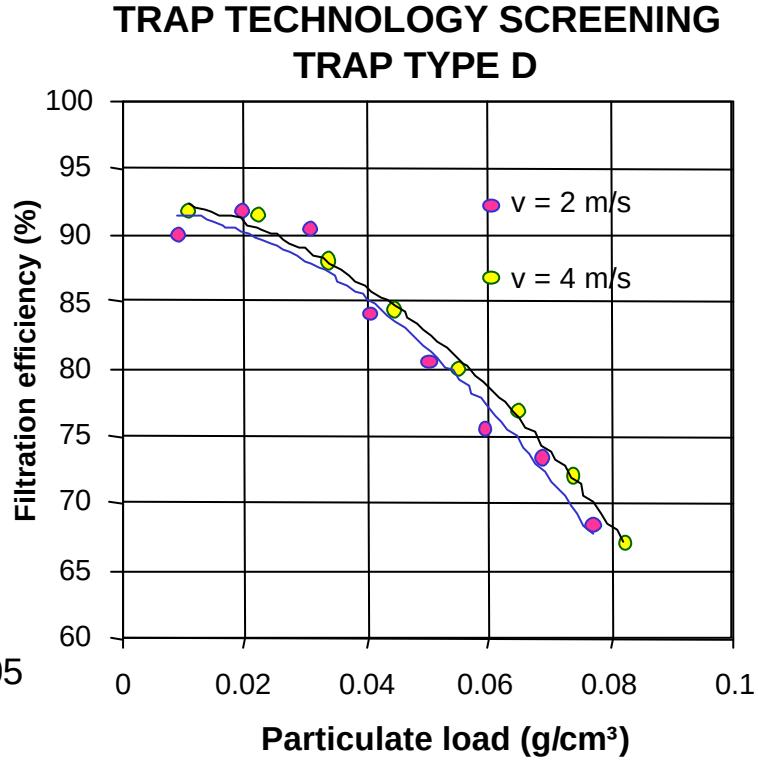


ART-DEXA Executive Summary :

- **Basic Trap Selection and Material Screening**
  - Different trap concepts have been investigated both internal and external to the project
  - Three component technologies have been selected for further development for demonstrators. Evaluation of new components will continue for 6 more months.
- **Active Regeneration Measures Screening**
  - Active engine management leading to regeneration potential and its effect on fuel consumption and driveability has been studied
- **Trap and Control System Manufacturing**
  - Filter operation, diagnostics and control algorithms have been developed and programmed
  - Control system manufacturing is in progress

Basic Trap Selection and Material Screening

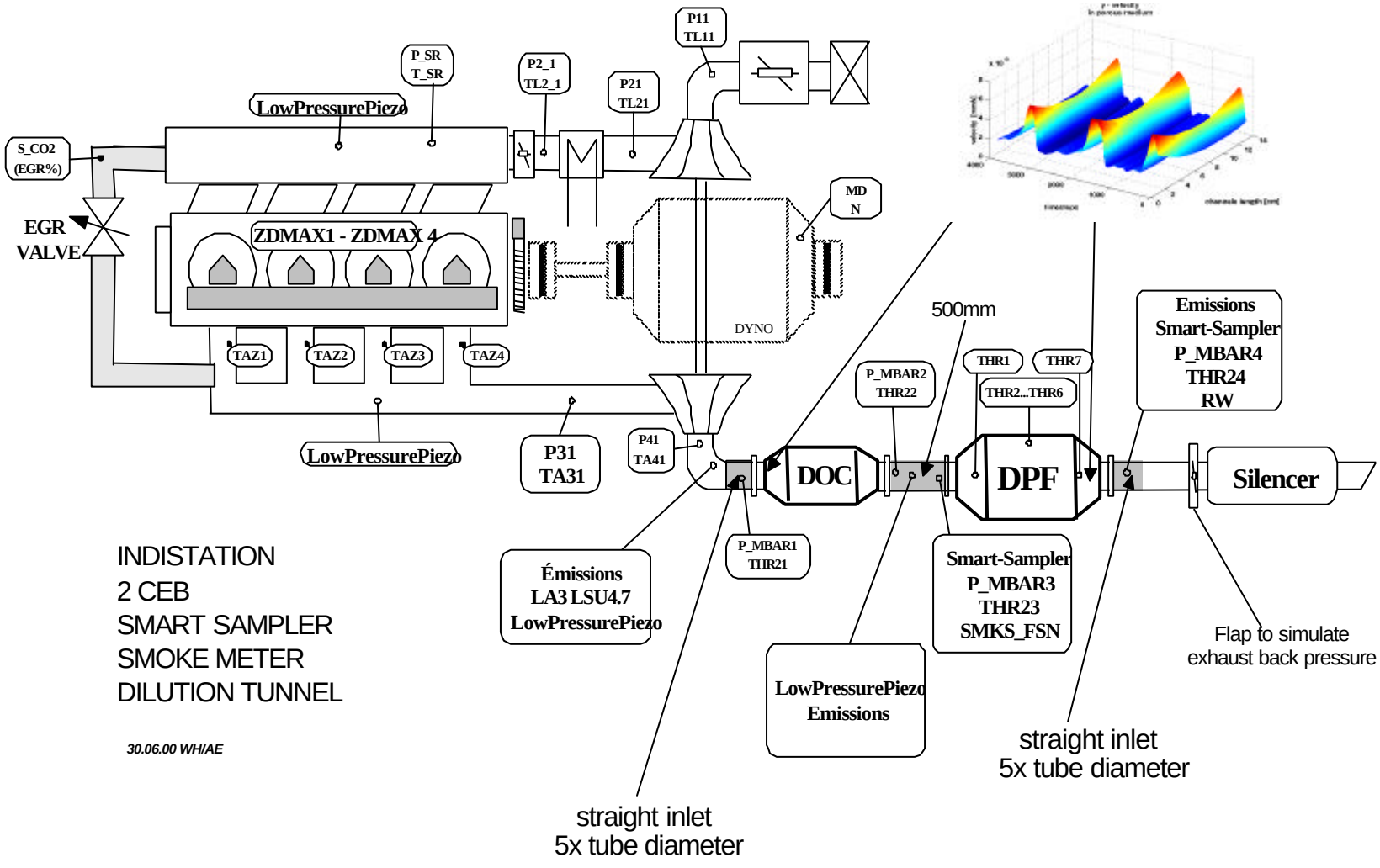




SYLOC-DEXA Executive Summary :

- **Submodel procurement is completed**
  - Filters
  - Catalysts
- **Database of component technologies is in place**
  - Exhaust system layouts
  - Filter materials and configurations
  - Catalysts
- **Computational interfaces/platforms defined**
  - Engine cycle simulation
  - Exhaust pipe CFD
  - Filter/Catalyst parameters
- **Validation Data procurement in progress**
  - Emission control components procured
  - System lay-out completed

System Layout for Validation Data



INDISTATION
2 CEB
SMART SAMPLER
SMOKE METER
DILUTION TUNNEL

30.06.00 WH/AE