Engine Exhaust Particle Sizer™

An Engine Exhaust Particle Sizer™ Spectrometer for Transient Emission Particle Measurements

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What is it?

Engine Exhaust Particle Sizer™

- A new instrument designed specifically for measuring engine exhaust particles
- Called Engine Exhaust Particle Sizer™ (EEPS™) Spectrometer
- Measures size distributions during transient engine emissions (10 measurements per second)
- Electrical mobility (current instrument is SMPS™ Spectrometer) is the recognized standard for combustion aerosol measurements.
- This new instrument builds on that electrical mobility technology
- Also incorporates technology developed in over 20 years of work at the University of Tartu in Estonia

Why is this instrument needed?

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- Engine Exhaust test cycles have fast changing size distributions on transient test cycles
- SMPS is the standard method for sizing stable engine exhaust aerosol
- SMPS can’t measure a size distribution when the distribution is changing rapidly
- Some customers use classifier at fixed size and collect concentration data with CPC and repeat for multiple particle sizes. This is time consuming and multiple runs aren’t necessarily repeatable enough to resolve fast changes.

What does EEPS measure?

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- Electrical Mobility measurement is similar to an SMPS measurement
- Time Response is much faster (10 Hz)
- Uses multiple electrometers to get multiple measurements simultaneously
- Size resolution of 16 channels per decade and two decades of size (32 channels total)
- Size range 5.6 nm to 560 nm
- Designed specifically for the Engine Exhaust market

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EEPS: Description

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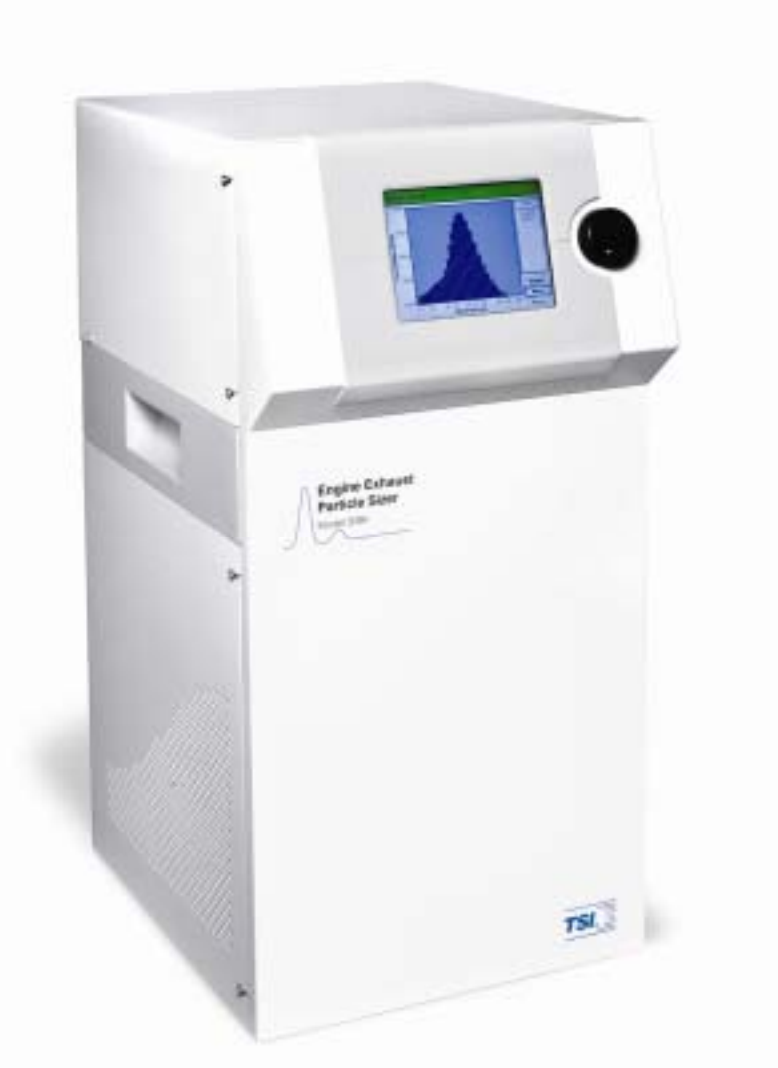

- Cyclone removes large particles at inlet
- Ions are generated in a diffusion charger
- Particles mixes with the ions and produce a predictable charge level versus particle size
- Particles are surrounded by sheath flow and flow down between a central rod and outer cylinder

Description (Continued)

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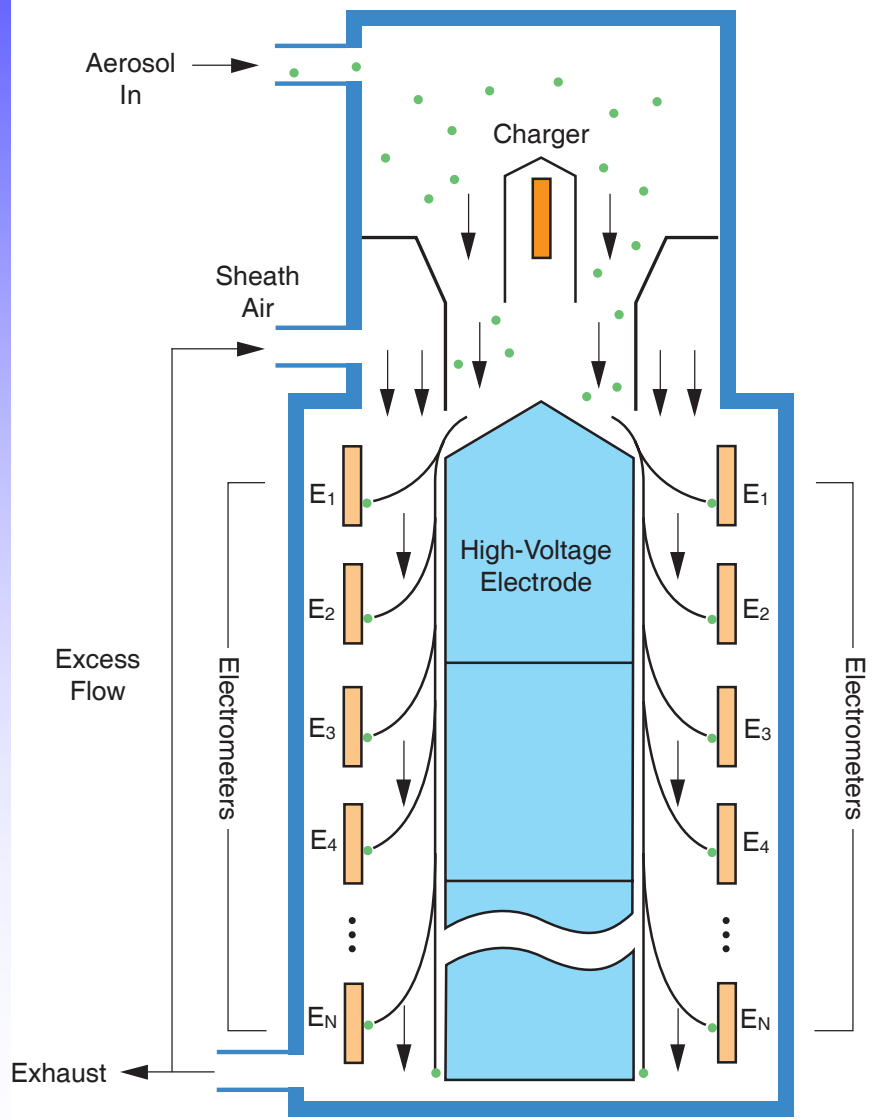

- Uses an electric field to repel the particles outward from a central rod. Inside-Out DMA.
- Charged aerosol particles are detected on a column of electrometers
- Electrometer currents are read 10 times per second
- Data needs to be inverted to get size information from the current readings

Data Inversion

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- This measurement requires a data inversion to convert electrometer current to particle size and concentration
  - Corrects for the time delay between stages
  - Compensates for the variable charge on the aerosol
  - Analyzes the multiple electrometers channels and applies a data inversion algorithm
  - Converts signals from 22 electrometers to 32 equally log spaced channels

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Example of Data

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- Generated Test Aerosols
  - Oil from Nebulizer switched on and off with a valve
  - Time Response with Spark Particle Source
- Engine at Center for Diesel Research (CDR at University of Minnesota)
  - Constant load tests (engine noise) – Comparison to CPC
  - Transient engine behavior
  - Comparison to SMPS at stable load conditions

Testing instrument response with switched aerosol

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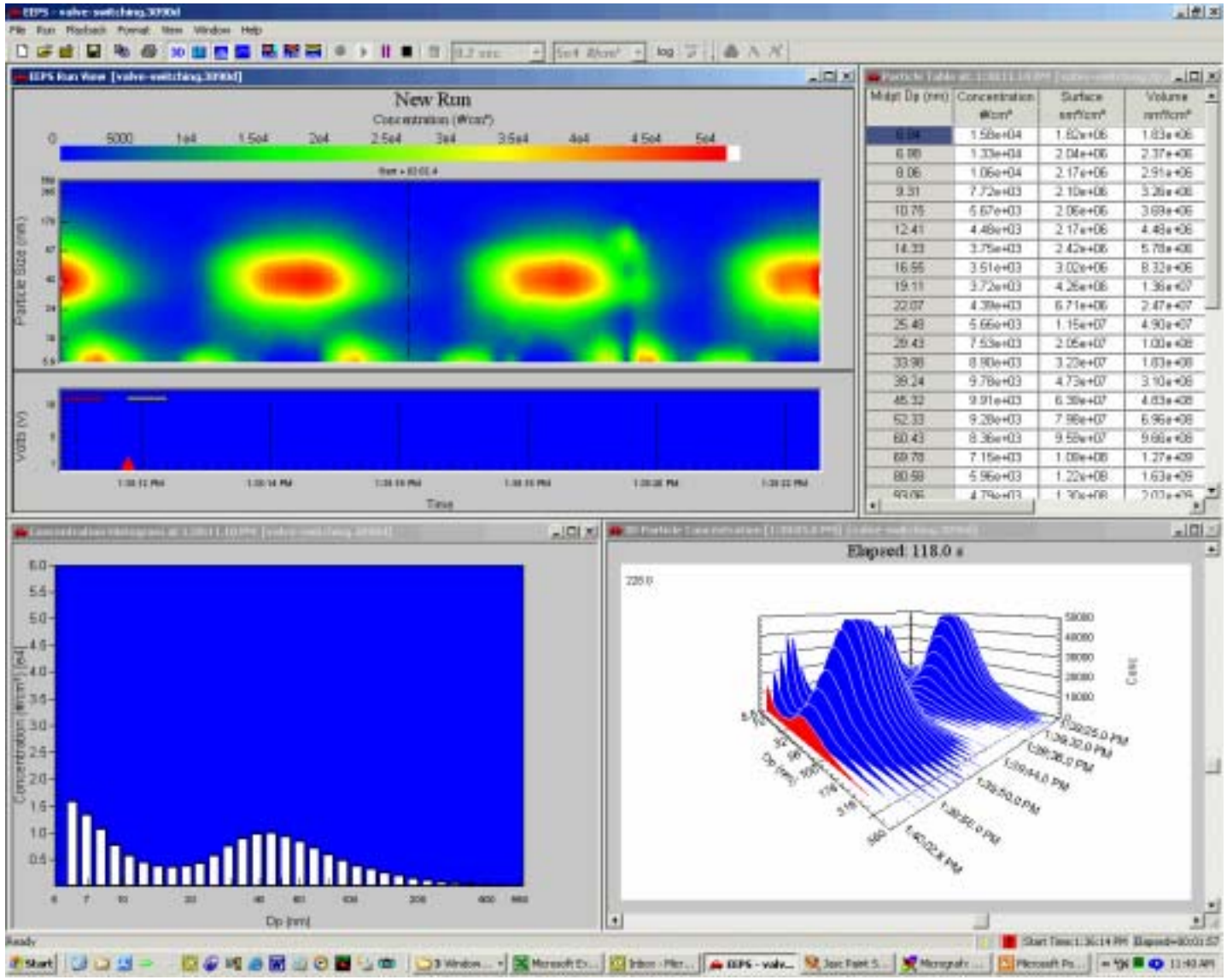

- 2D Contour Graph
- Concentration Table
- 2D Size Graph
- 3D Isometric Graph

Time Response

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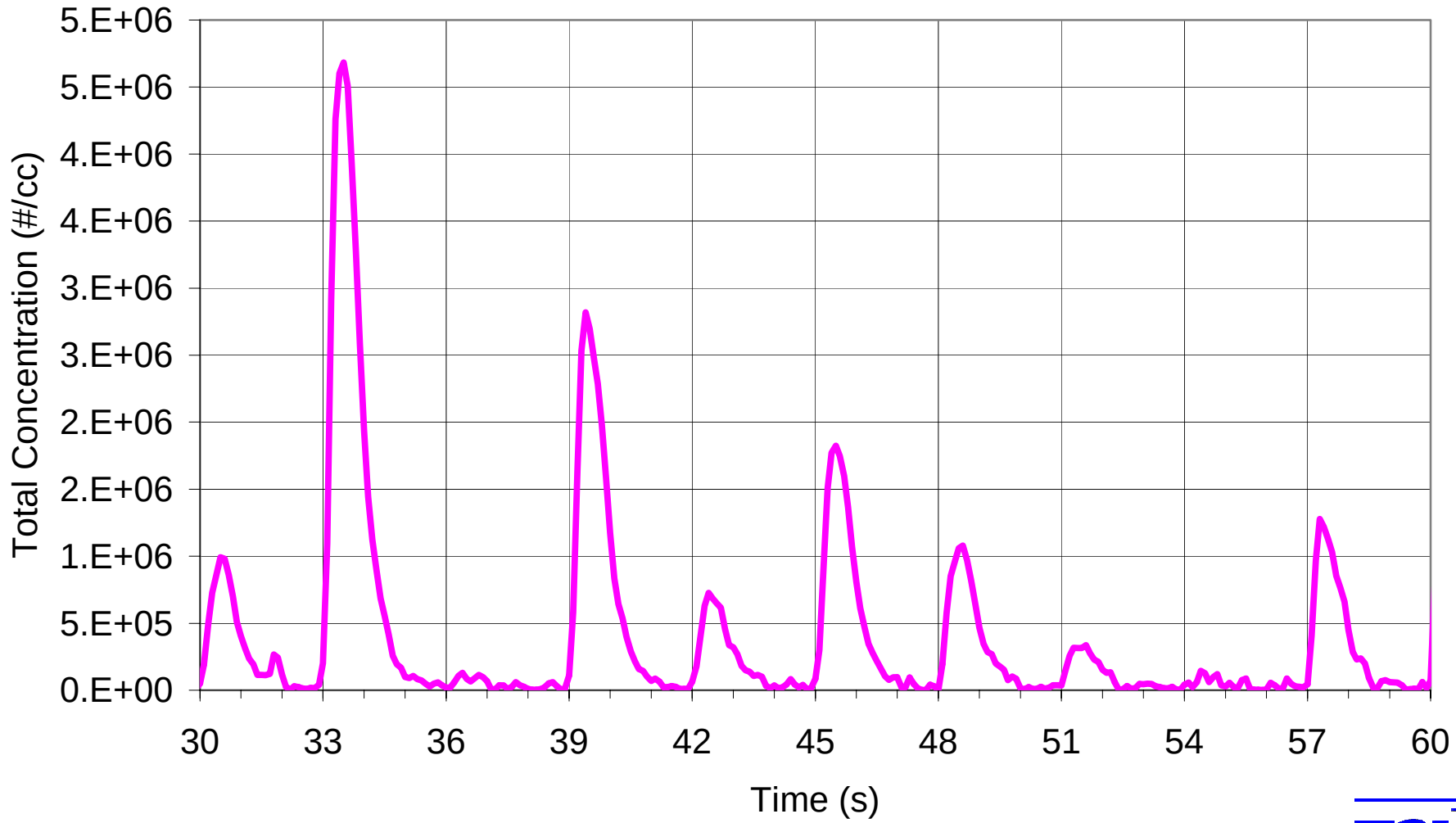
Spark Generator
EEPS response to 0.1 sec carbon spark every 3 seconds



Sampling Setup for Engine Test

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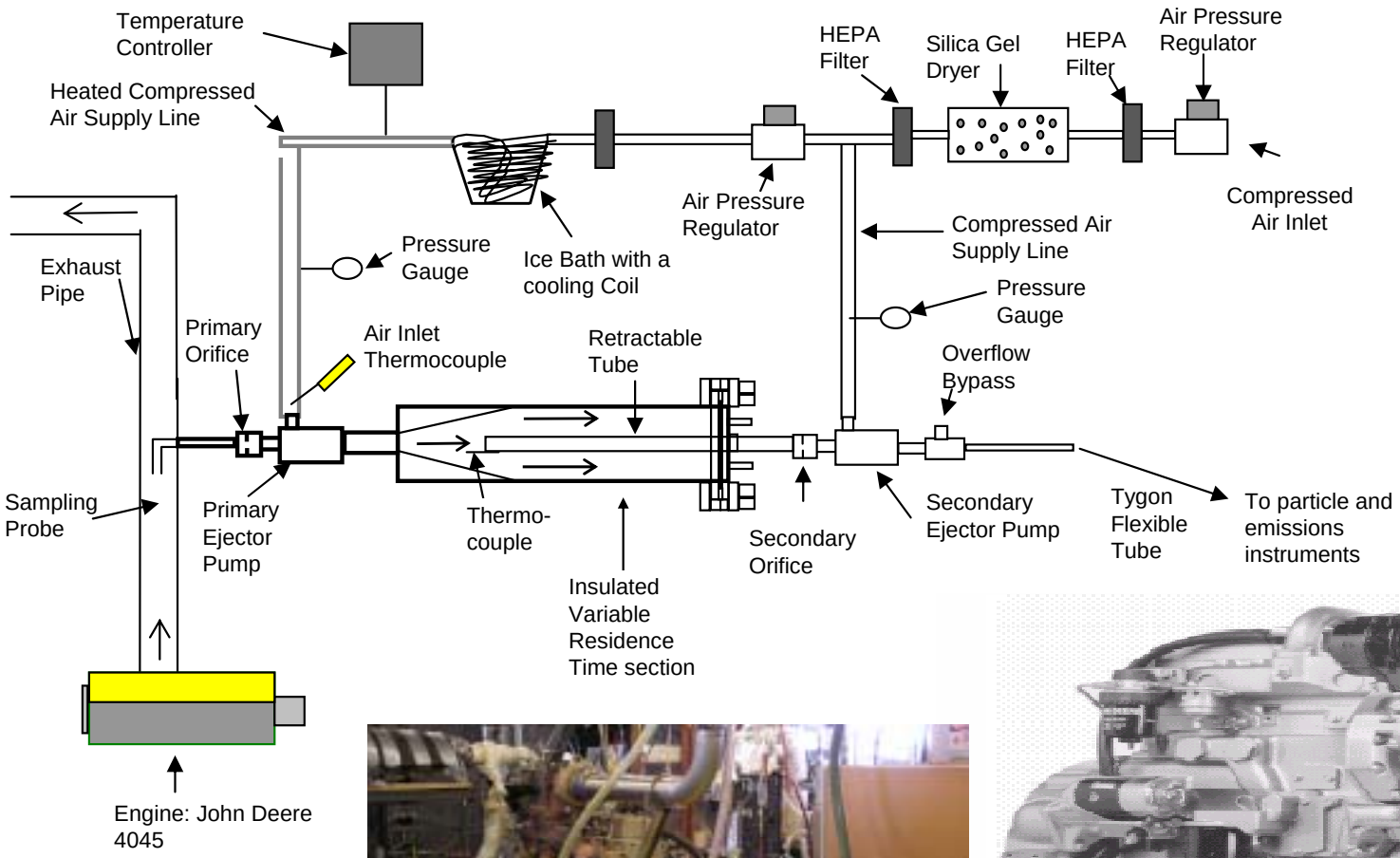

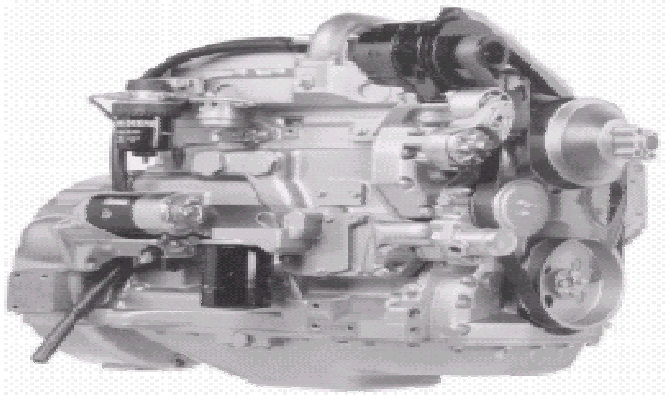

Engine Test Results

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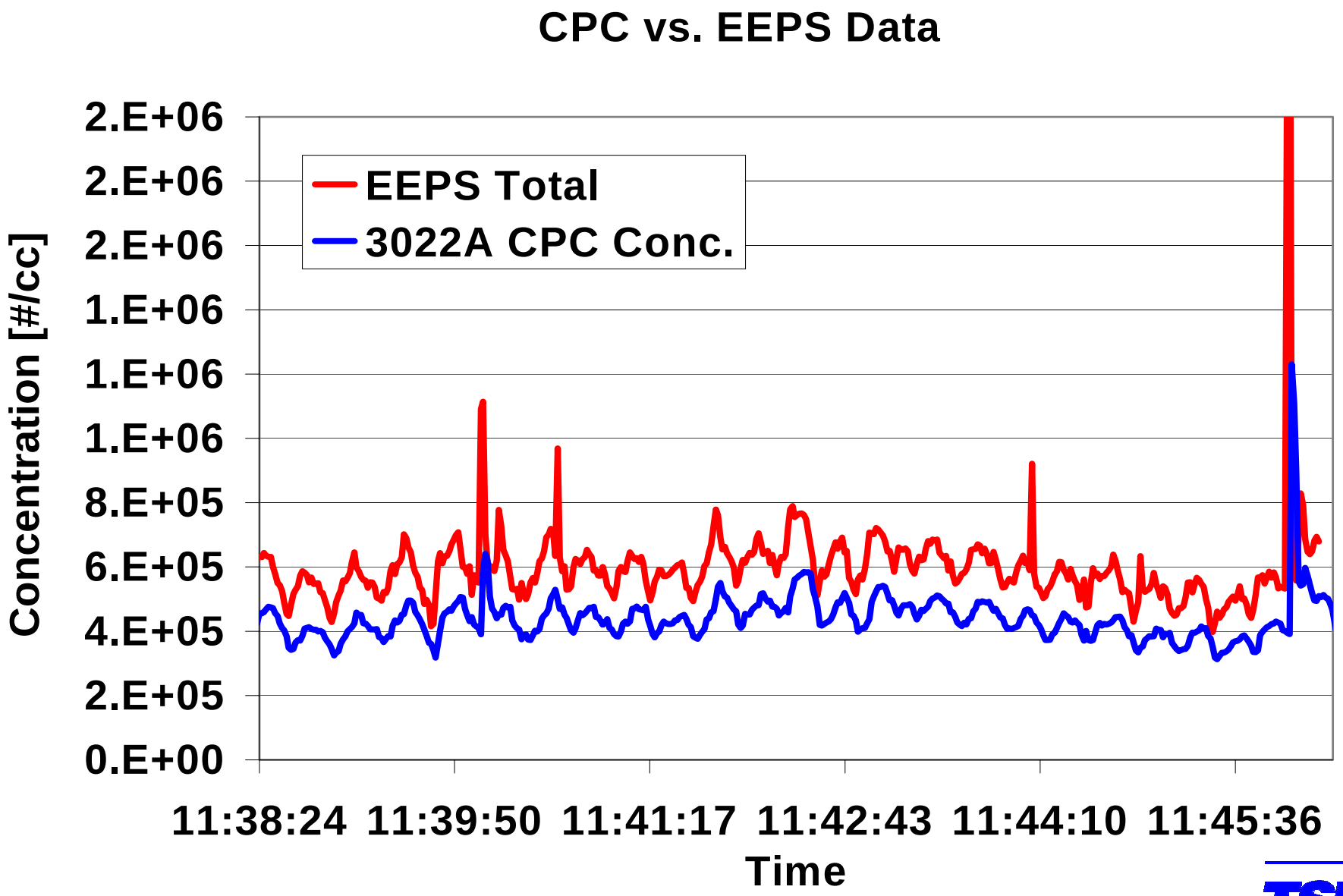

Engine Test Results: Transient Behavior

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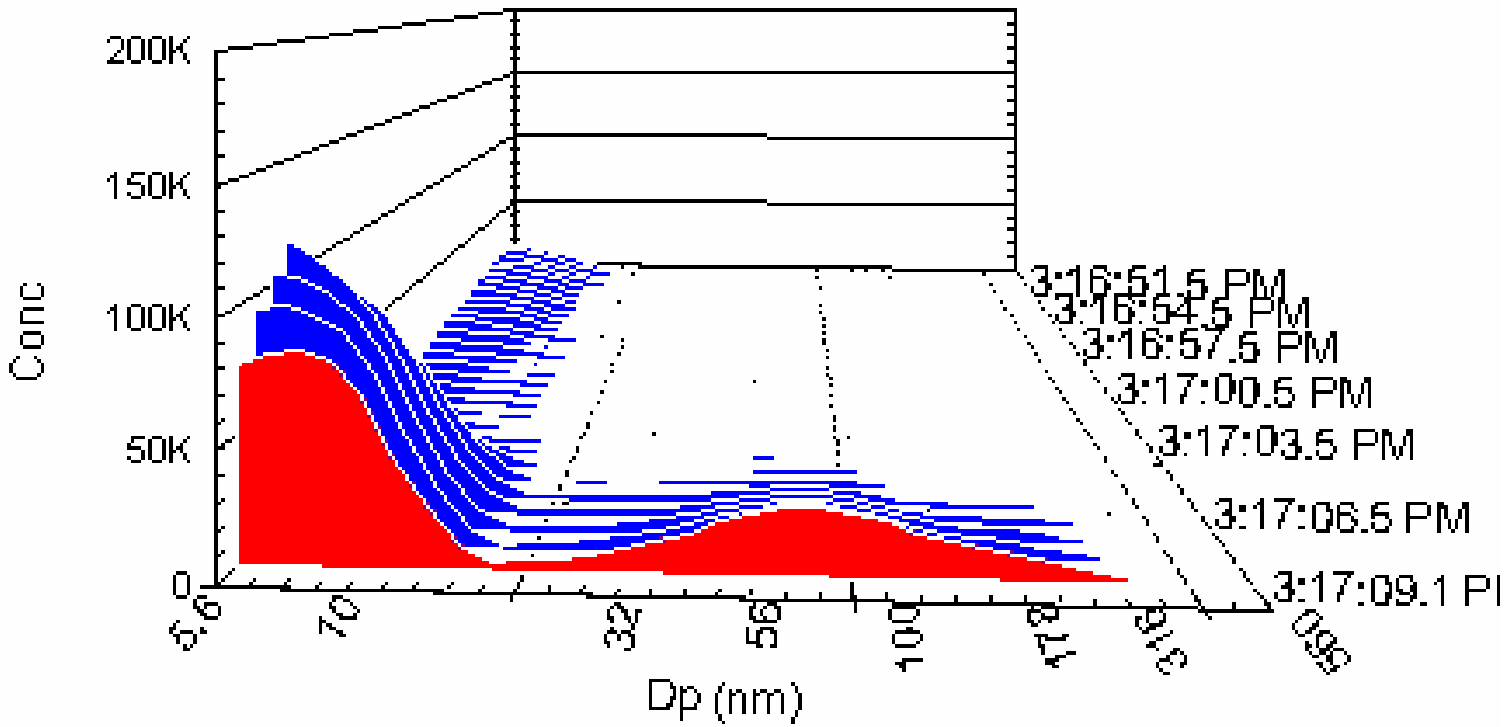
10% to 75 % load



Engine Test Results

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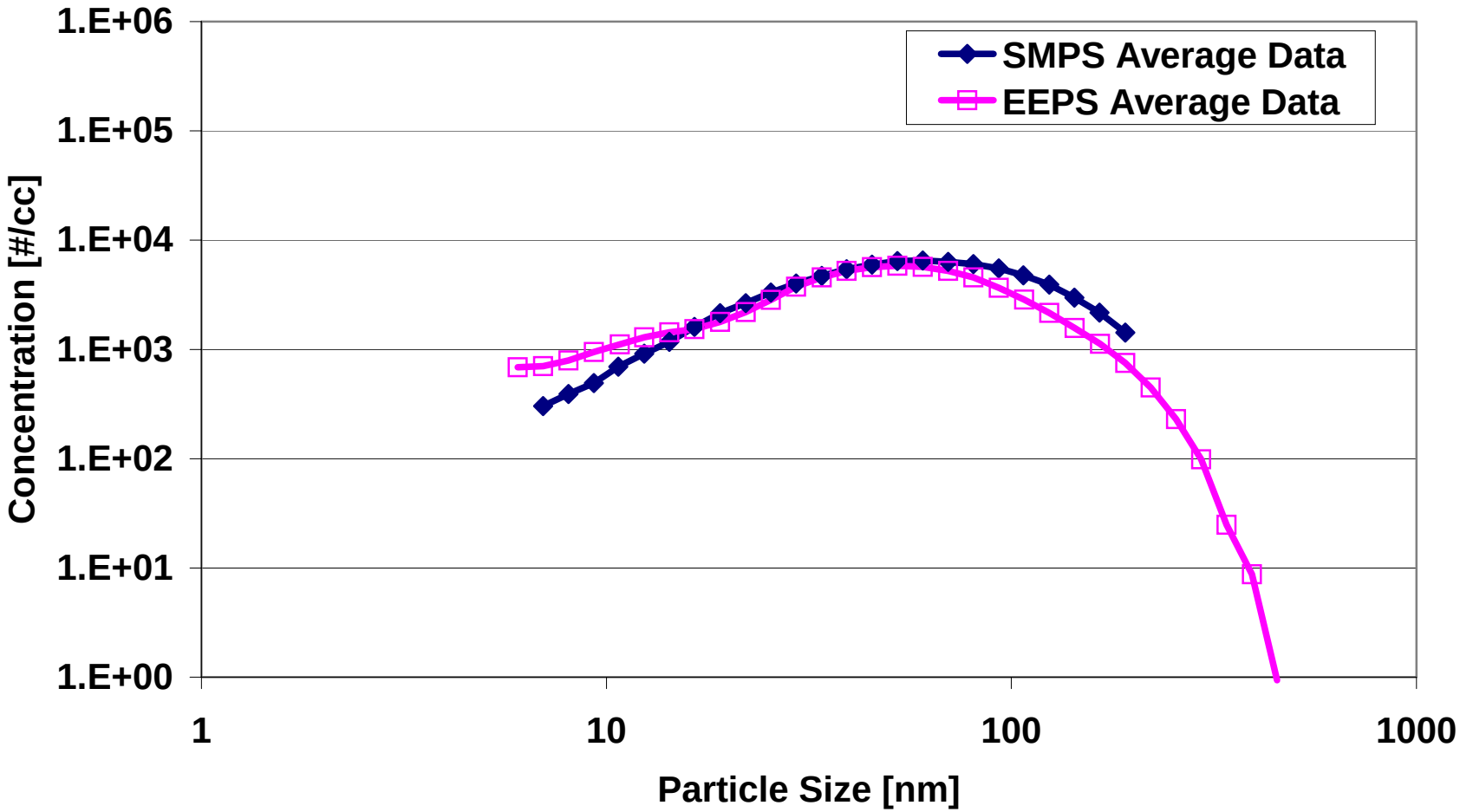
75% Load Diesel Engine -Comparison of SMPS (average of 9 histograms) and EEPS Data (average of 6000 histograms)



Summary

Engine Exhaust Particle Sizer™

- New instrument capable of measuring size distributions of transient nucleation and accumulation mode particles
- Fast Response allows for the measurement of transient signals
- Faster response than a CPC but tracks well with CPC concentrations
- Size distributions correlate well with SMPS results
- Covers size range of interest for engine exhaust measurements (5.6-560 nm)
- Makes possible size distribution measurements of transient engine emissions