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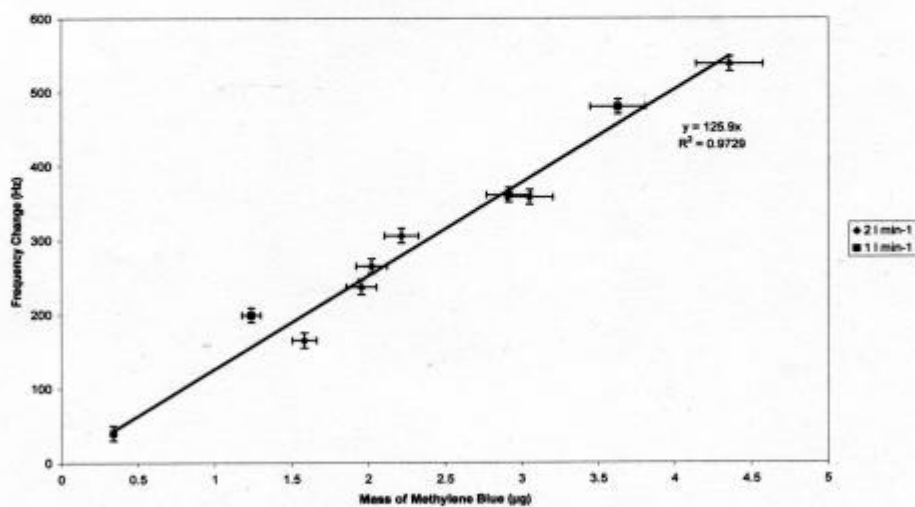
**Real-time particle characterization of diesel  
and gasoline particulate mass**

# Calibration

## Experimentally Determined Sensitivity

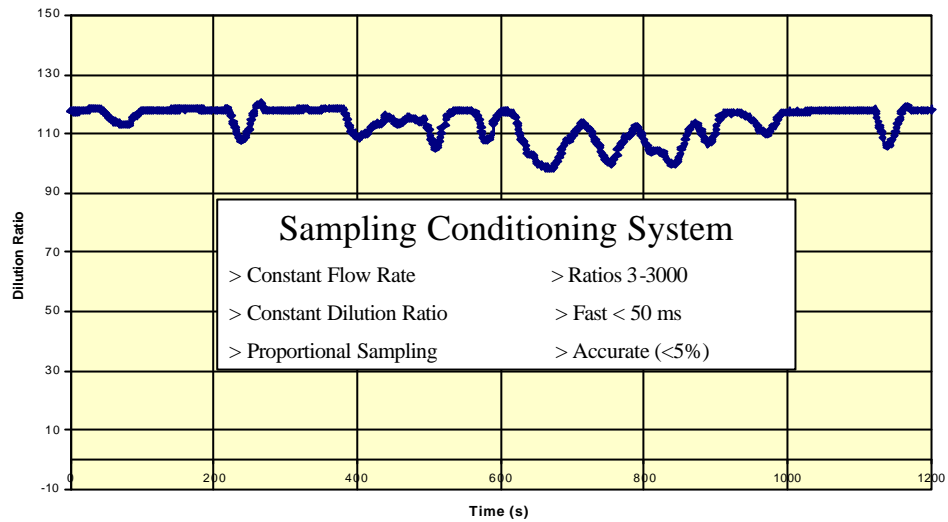
Calibration aerosol:  
Nebulised solution of methylene blue in methanol ( $2.4 \text{ mg g}^{-1}$ )  
MMAD:  $1.4 \mu\text{m}$ , GSD: 1.36

Flow Rate ( $\text{l min}^{-1}$ )	Measured Mass of Methylene Blue ( $\mu\text{g}$ )	Recorded Frequency Change (Hz)
1	1.239	199
1	3.629	480
1	2.917	361
2	2.022	265
2	1.585	165
2	0.339	40
2	1.956	237
2	2.217	306
2	3.052	358
2	4.357	538

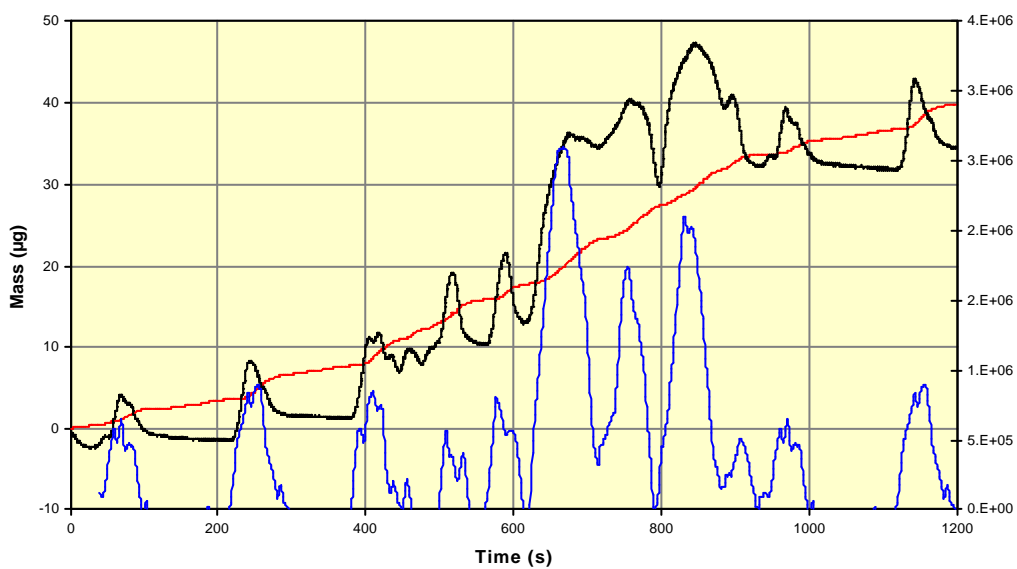


Sensitivity  $125.9 \text{ Hz } \mu\text{g}^{-1}$

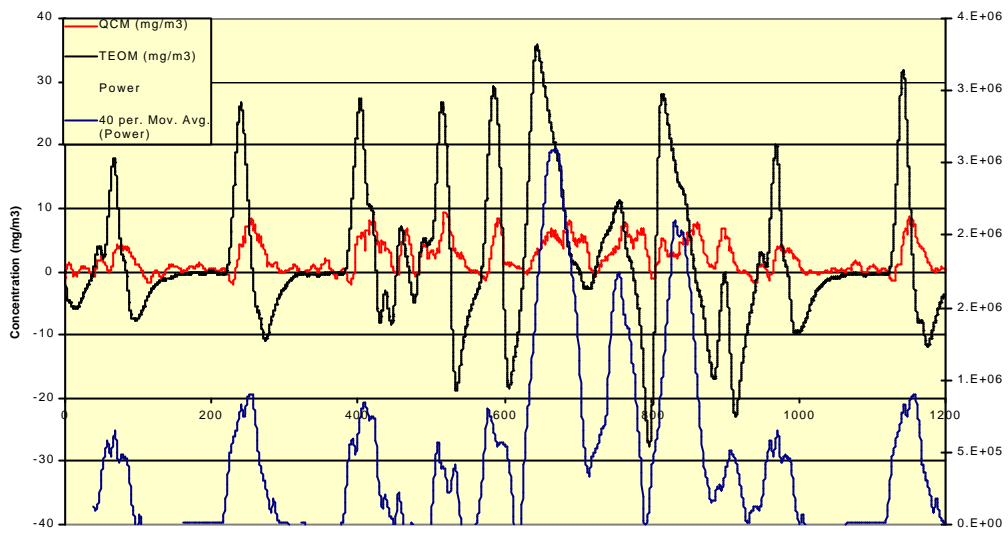
## QCM Fitted with an Advanced Dilution System (SCS)



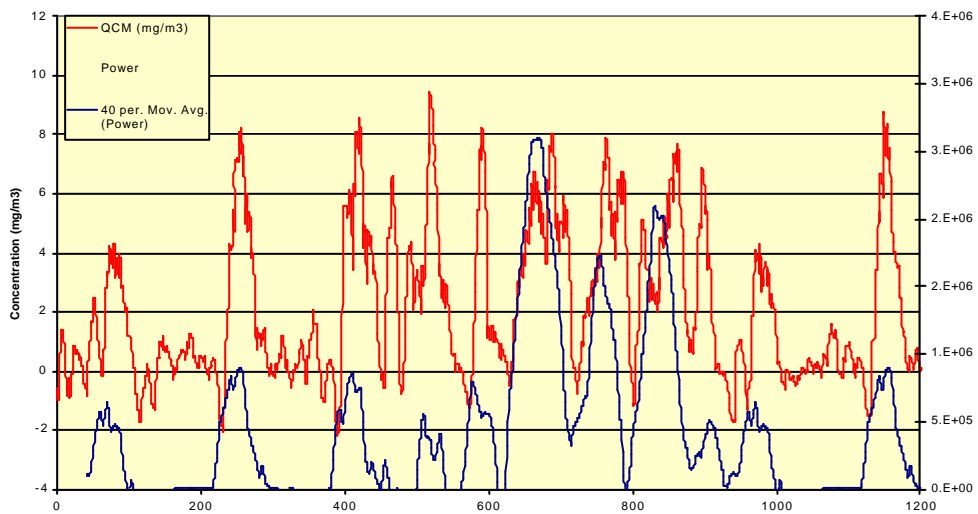
## FTP – Mass – Power Curves



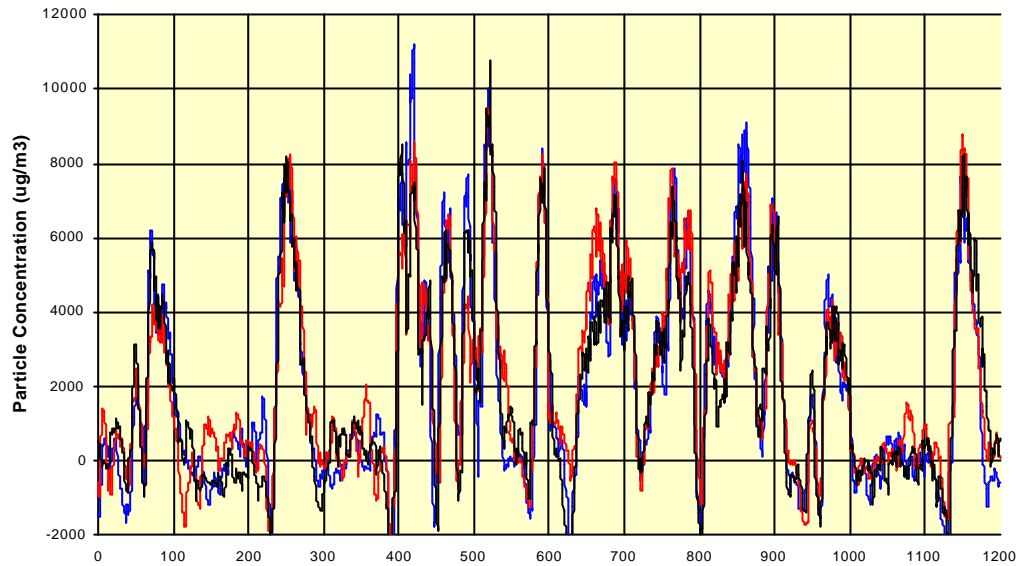
# FTP – Concentration – Power



# FTP – Concentration - Power



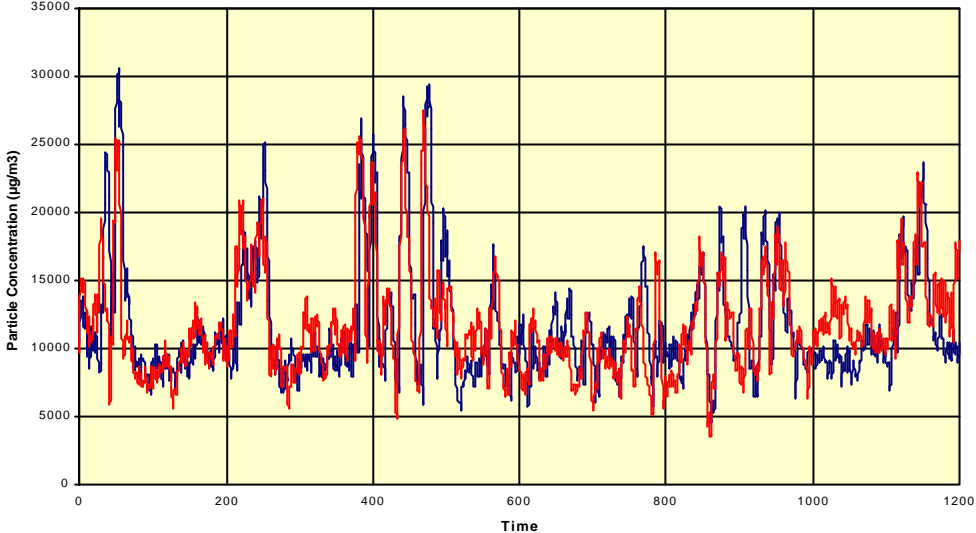
## *FTP – QCM Repeatability*



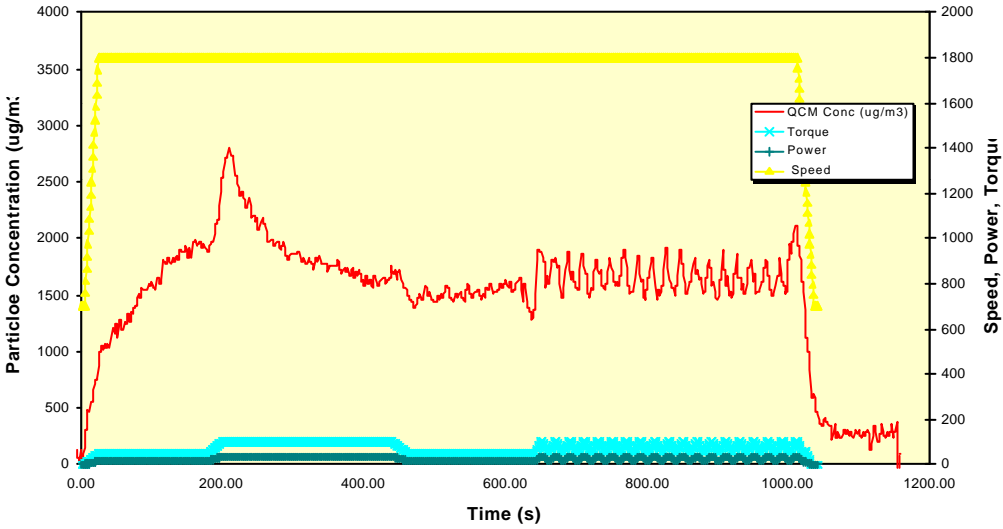
## *FTP Test Summary*

Filter (mg/m3)	TEOM (mg/m3)	Error (TEOM)	QCM (mg/m3)	Error QCM
1.76	1.98	13	1.91	9
1.84	1.96	7	1.74	-5
1.9	2.03	7	2.04	7
2.34	2.38	2	2.14	-9
1.93	1.96	2	1.84	-5
1.98	1.78	-10	1.93	-3
1.9	1.95	3	1.73	-9
Average		3		-2

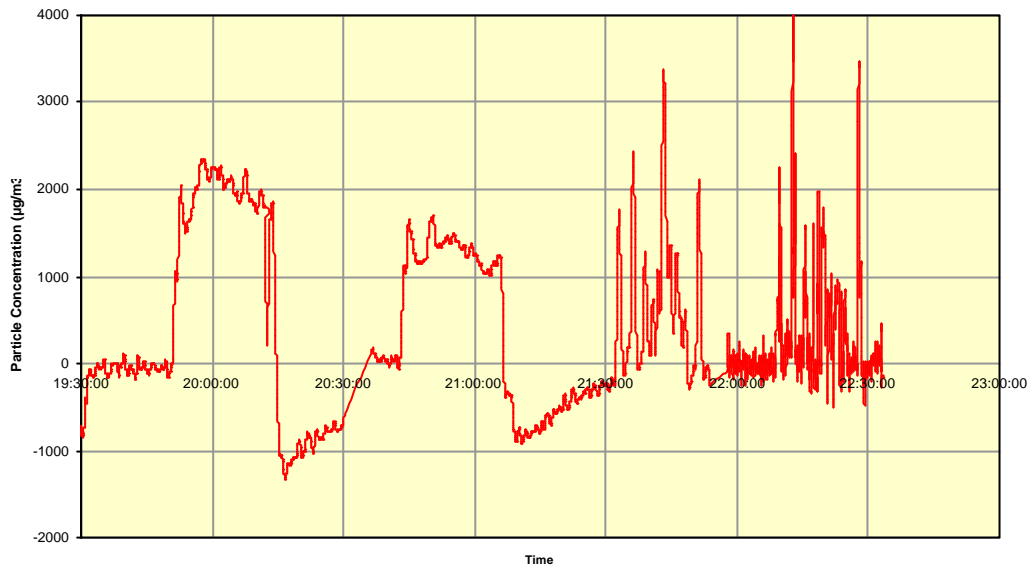
# Raw Exhaust Measurements (MEMS)



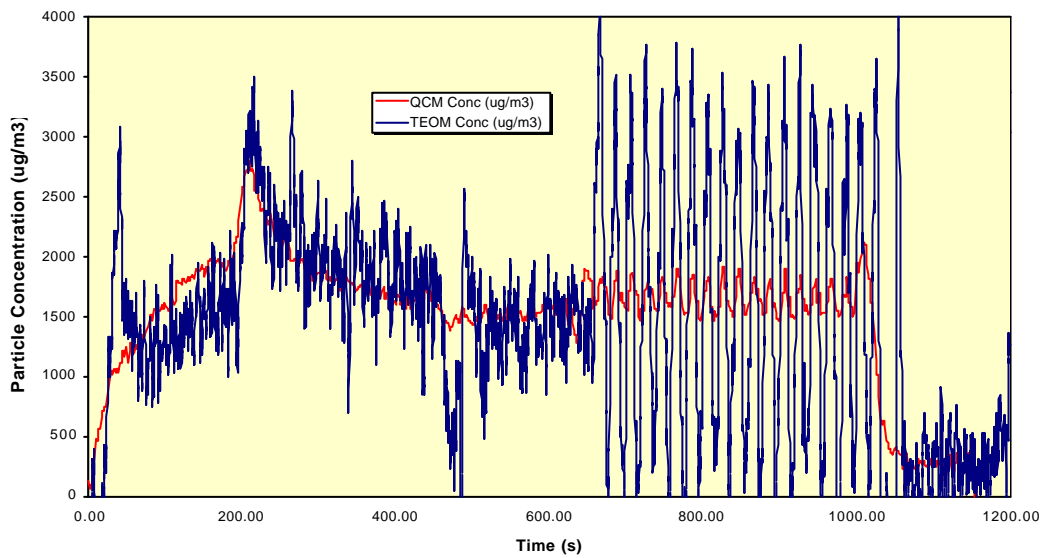
# Development - Test Cycle



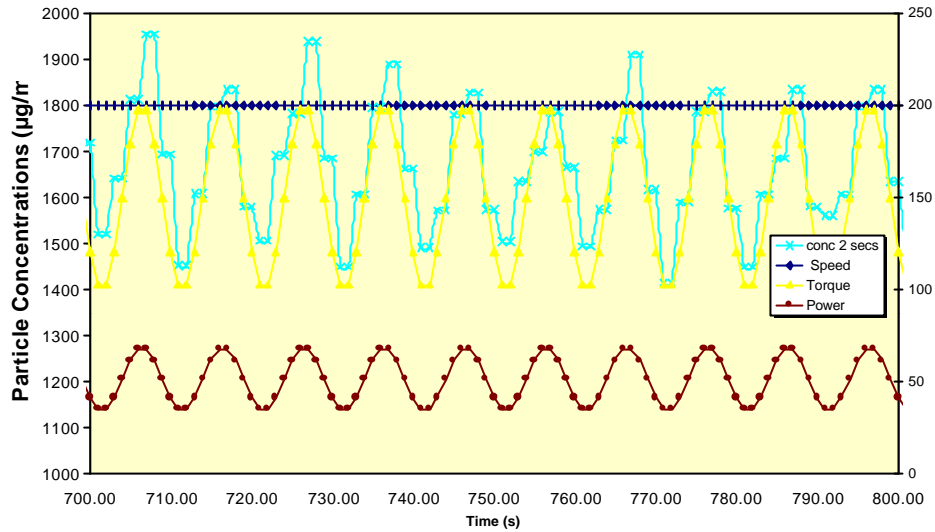
## *Steady-State – Transient Volatility Issues – Lube Oil Consumption*



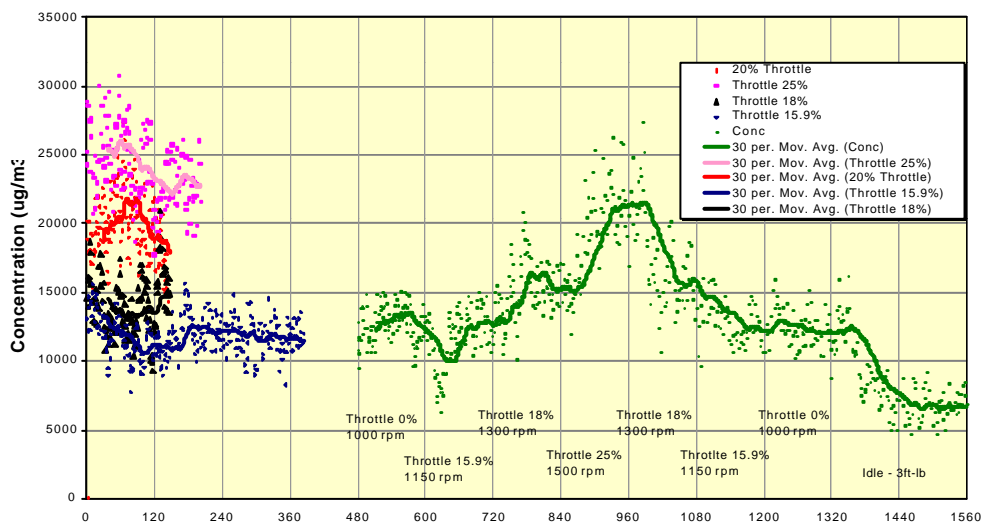
## *Development Test Cycle*



# Development Test Cycle



# Steady State Tests – 80-ft-lb Torque



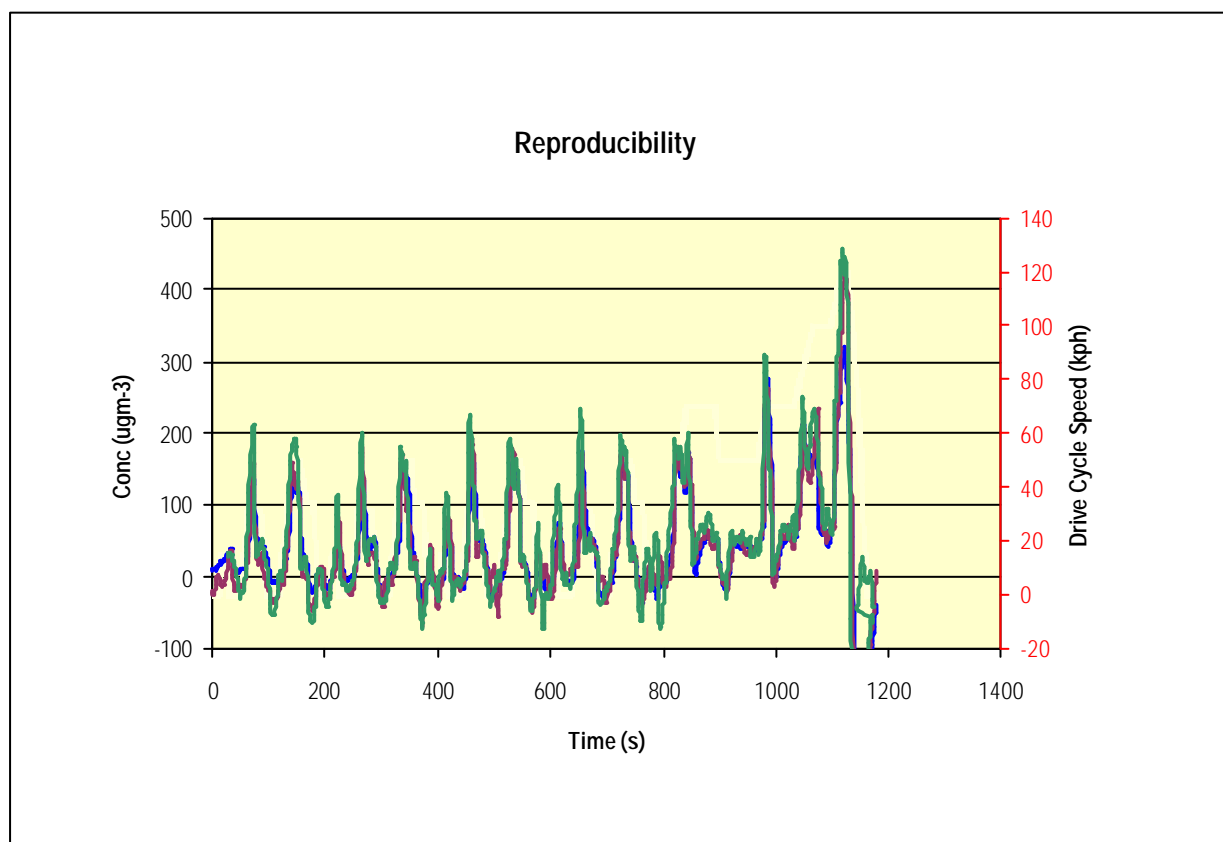


# Light - Duty Tests

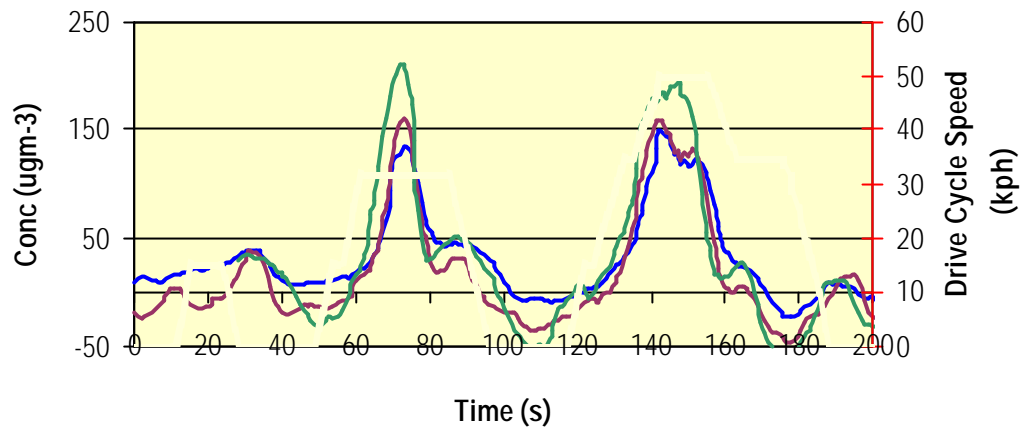
## Objective

Reproducibility, Repeatability

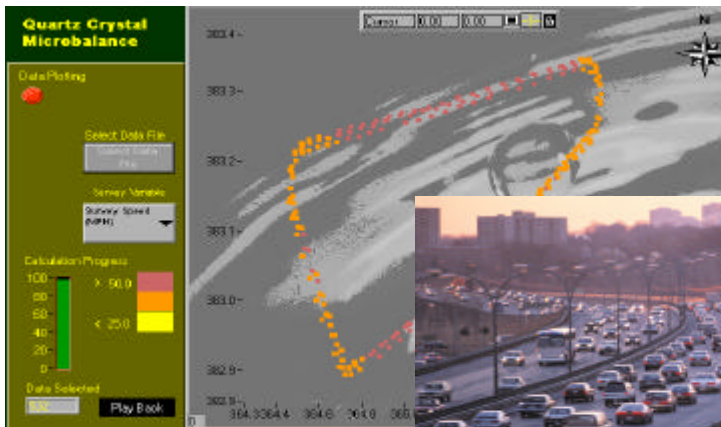
- ▼ EUDC Tests
  - Dilution Tunnel
- ▼ Chase Studies



## Reproducibility



## Particle Mass -Pollution Surveys



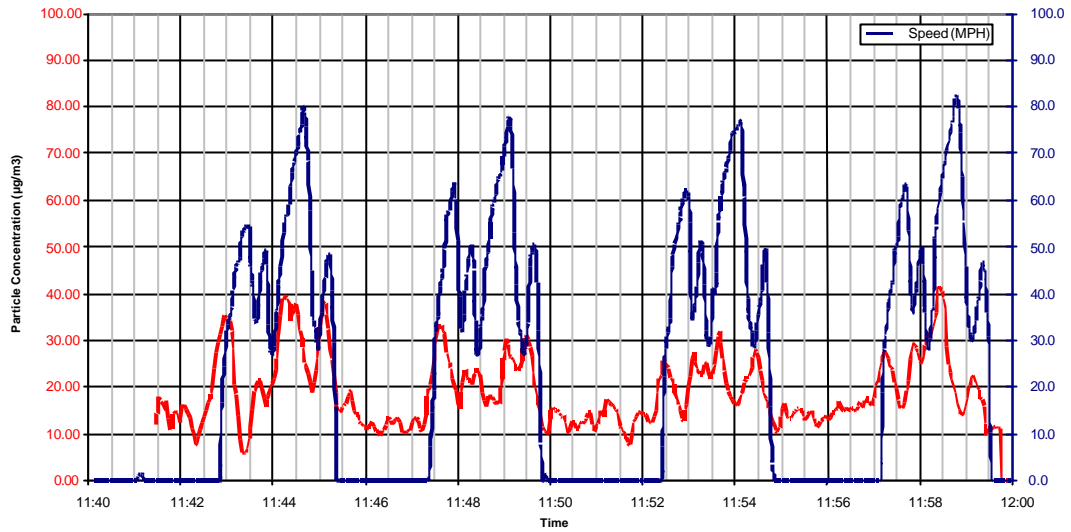
Test Track

Environmental Surveys



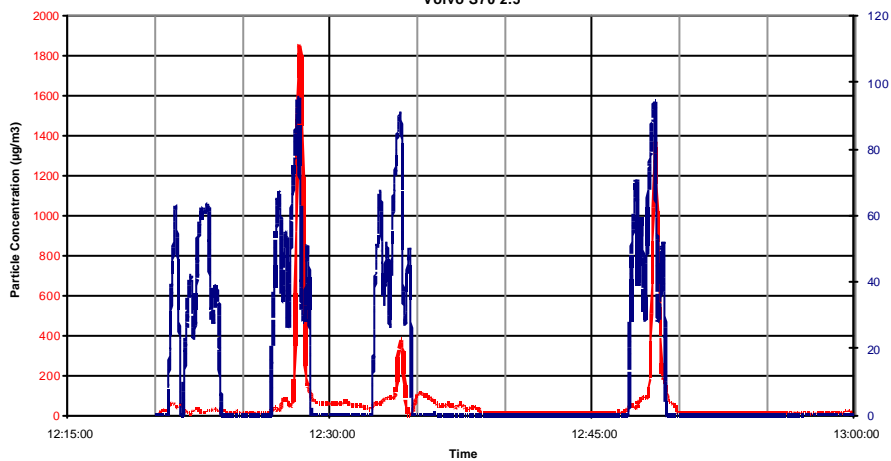
# Modern Engine – Raw Emissions

Raw Exhaust Particulate Sampling  
Volvo S70 2.5

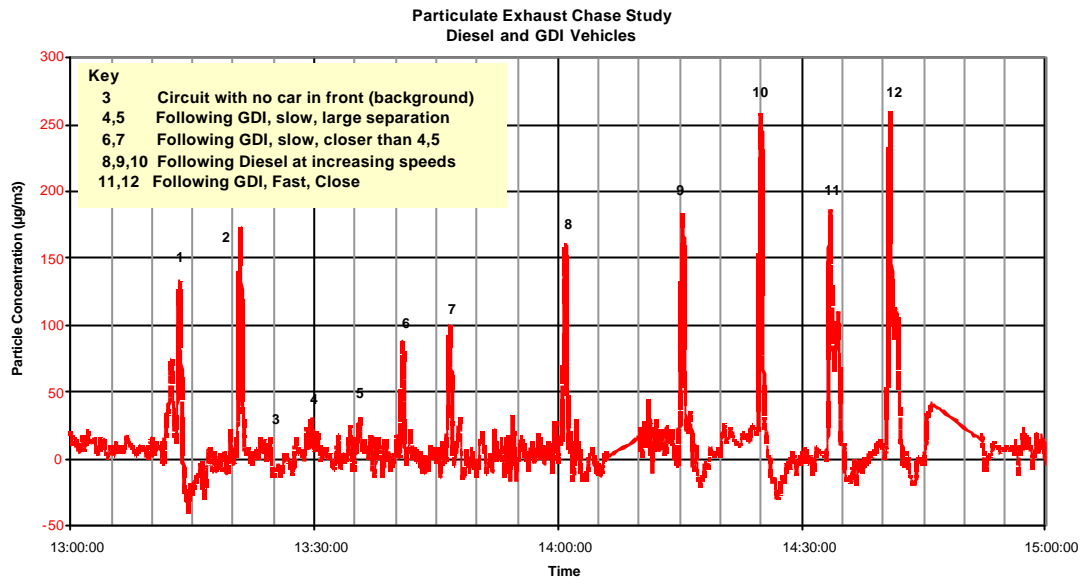


# High Load – High Particulates

Raw Exhaust Particulate Sampling  
Volvo S70 2.5



# Chase Studies



## SUMMARY

### Objective

Reproducibility, Repeatability, Filter Equivalence  
and TEOM Intercomparison

- QCM good Candidate For Real-Time Mass Monitoring of both Light-Duty and Heavy Duty Vehicle Emissions

### Future Developments

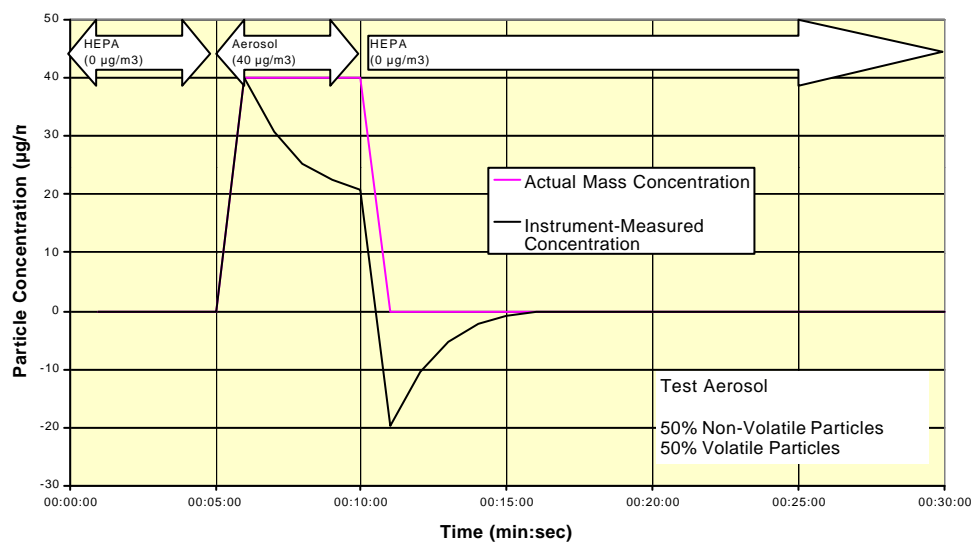
- Methodology to address Volatility / Hygroscopicity issues is being developed.

# Methodology Development Principle



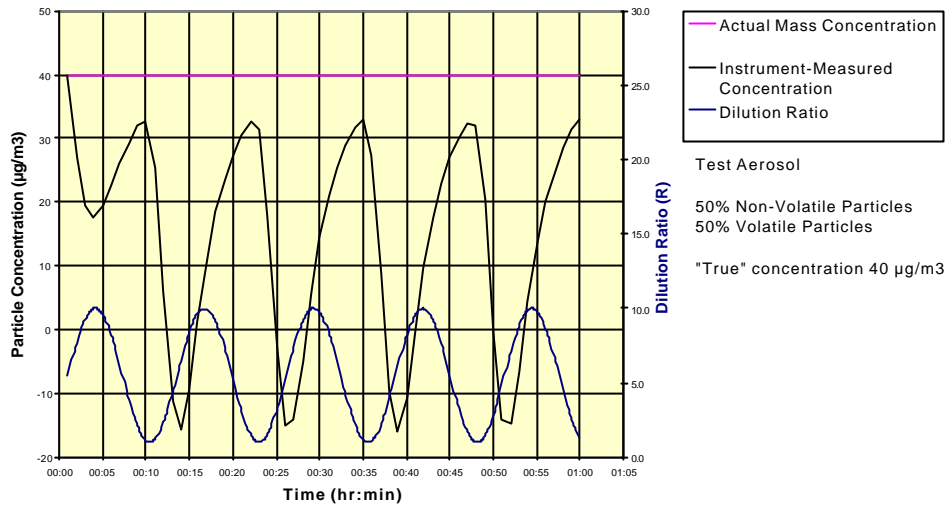
$$M_{\text{total mass}} = M_{\text{non-volatiles}} + M_{\text{volatiles}} - M_{\text{volatiles evaporated}} + M_{\text{chemical reaction}} + M_{\text{etc}}$$

## Basic Sampling Methodology



# Instrument Response

$1 < R > 10$ , 50% Volatiles,  $40 \mu\text{g m}^{-3}$



## Hardware Solutions

