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Evaluation of the European PMP Methodologies during On-Road Testing

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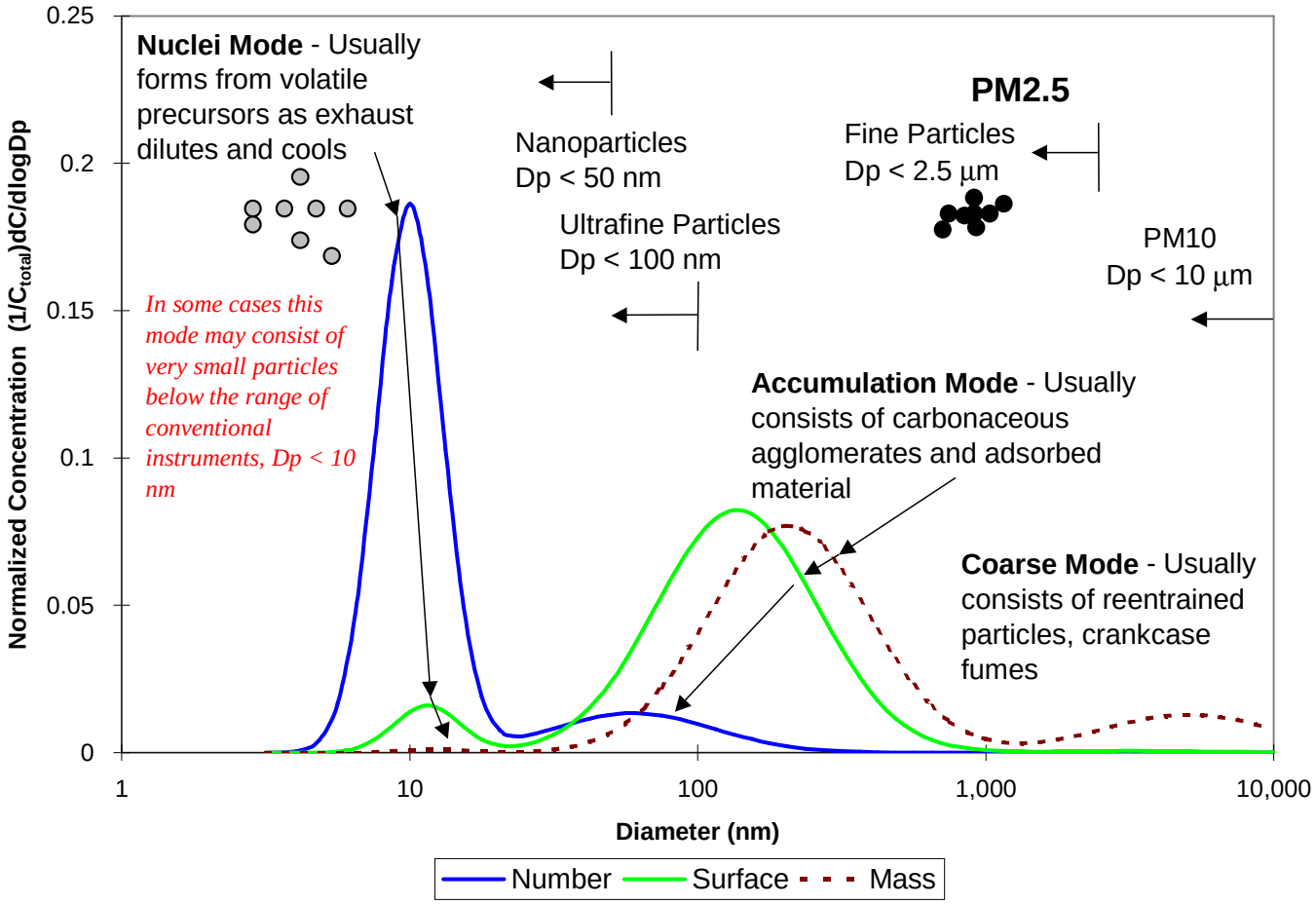
Overview

- Diesel particle size distribution
- Background
- Objectives
- Experimental setup
- Results
- Conclusion

Typical diesel particle size distributions

Number, surface area, and mass weightings are shown.



Courtesy of David Kittelson

Background

- Diesel Particulate Filter (DPF) is essential to meet current diesel PM (Particulate Matter) regulation.

- Current gravimetric method will have increasing difficulty quantifying PM mass emissions.

Background

- Particle Measurement Programme (PMP) is an extensive multi-nation research initiative under the auspices of the United Nation's Economic Commission for Europe.

- Driving forces for PMP are health effects and measurement.

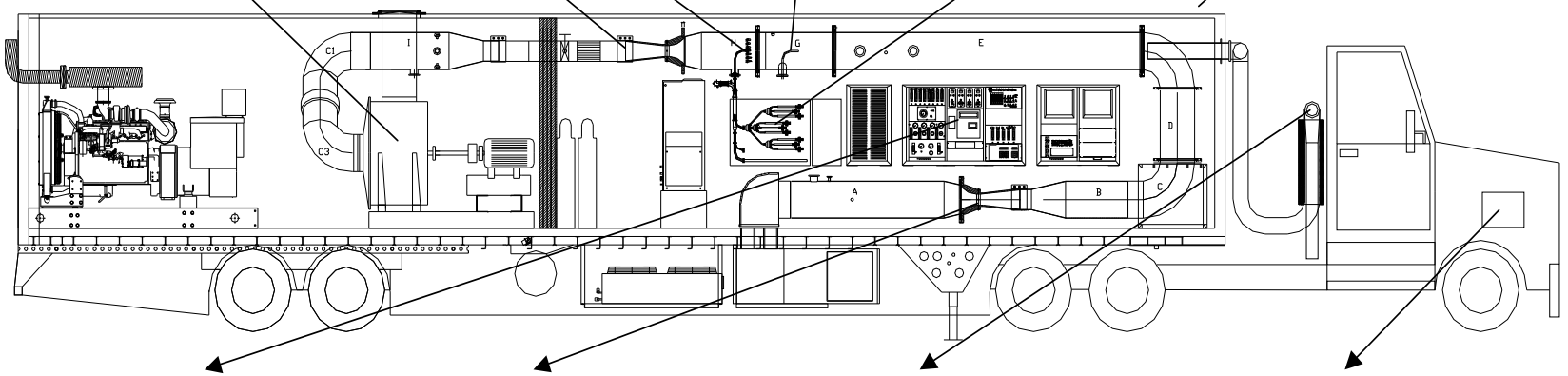
Sensitivity and transient response.

Objectives

- Critical evaluation of the proposed European PMP method for determining particle emissions from heavy-duty diesels and its potential in California for PM measurement and in-use screening.

- Particle mass vs particle number.

CE-CERT's Mobile Emisssion Lab (MEL)



Diluted Exhaust: Temperature, Absolute Pressure, Throat ΔP, Flow.

GPS: Pat, Long, Elevation, # Satellite Precision.

CVS Turbine: 1000-4000 SCFM, Variable Dilution.

Secondary Probe.

Gas Sample Probe.

Secondary Dilution System* PM (size, Mass).

Drivers Aid.

Gas Measurements: CO_2 %, O_2 %, CO ppm, NO_x ppm, THC ppm, CH_4 ppm.

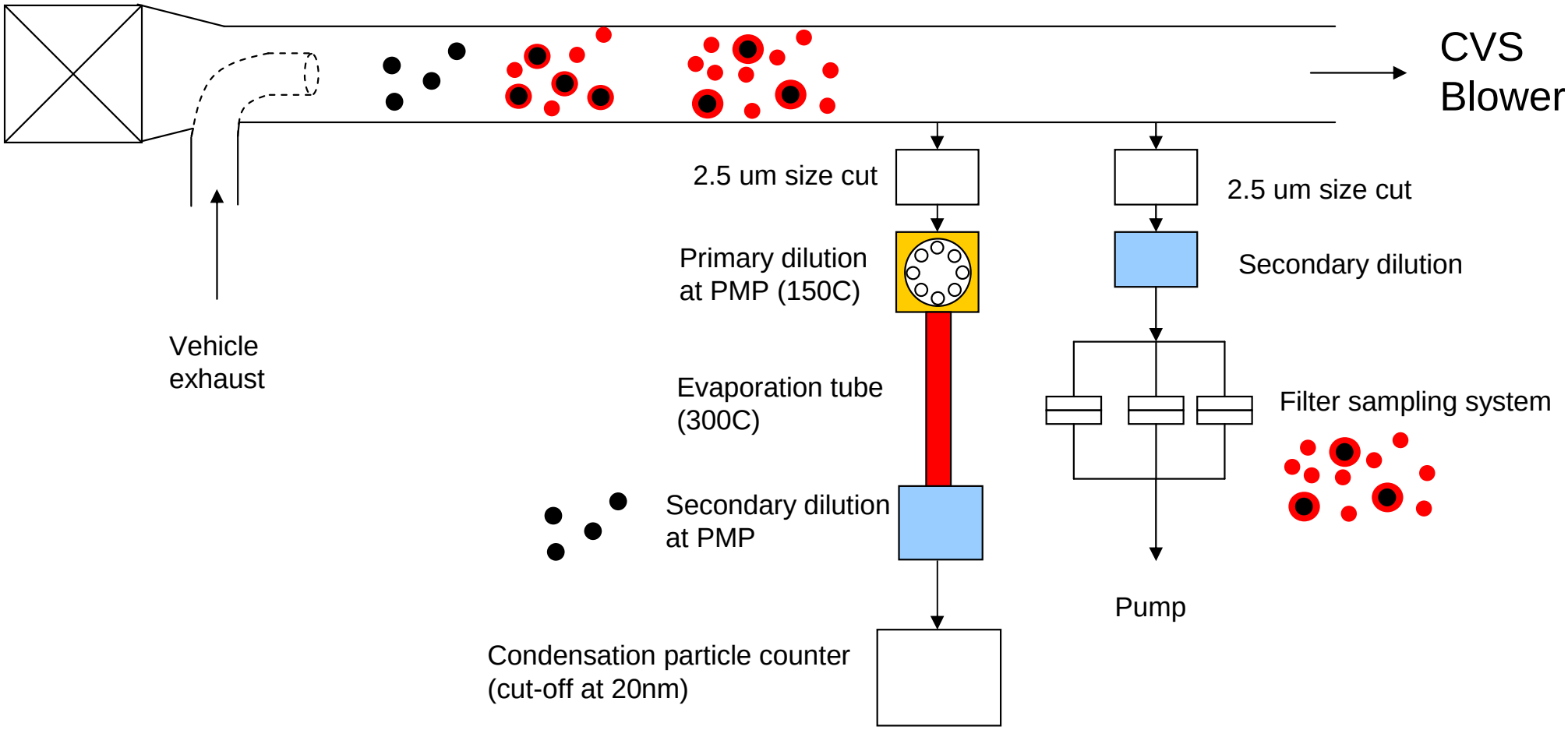
Other Sensor: Dew Point, Ambient Temperature, Control room temperature, Ambient Baro, Trailer Speed (rpm), CVS Inlet Temperature.

Dilution Air: Temperature, Absolute Pressure, Throat ΔP, Baro (Ambient), Flow, Dew Point (Ambient).

Exhaust: Temperature, ΔP (Exhaust-Ambient), Flow.

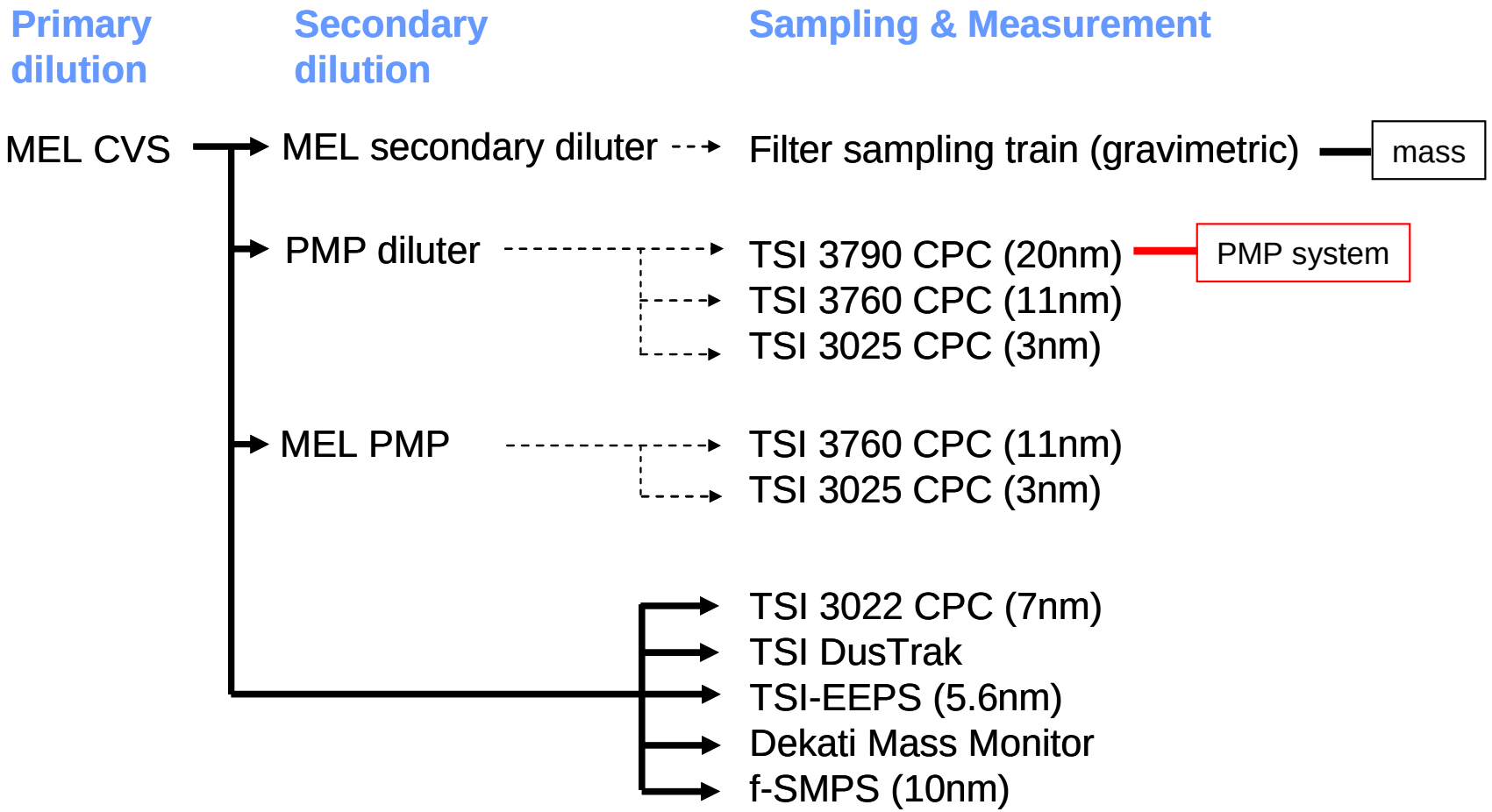
Engine Broadcast: Intake Temperature, Coolant Temperature, Boost Pressure, Baro Pressure, Vehicle Speed (mph), Engine Speed (rpm), Throttle Position, Load (% of rated).

Gravimetric vs PMP measurements



Courtesy of W. Robertson for MD-19 diagram

Flow diagram of PM measurement system off the CVS tunnel



Experimental condition

Chassis: Freightliner

Engine: 2000 EPA Certif CAT C15 475 Hp

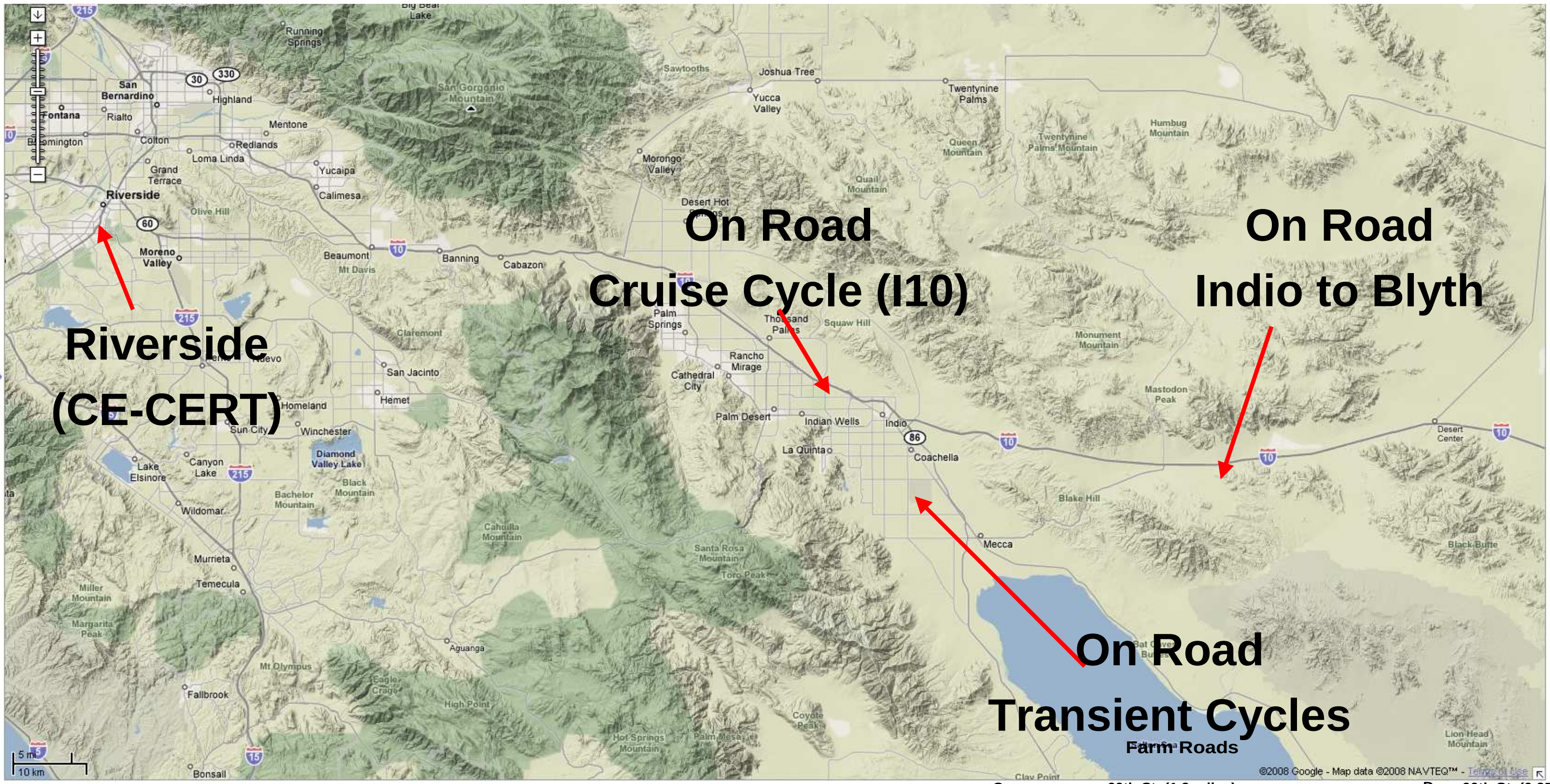
Certification NOx: 3.7 g/bhp-hr (US EPA)

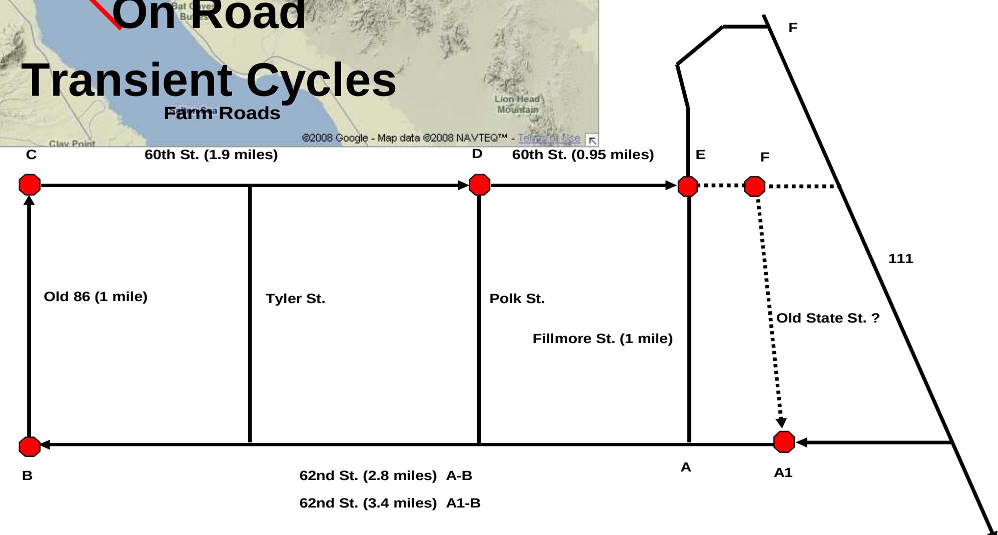
Certification PM: 0.08 g/bhp-hr (US EPA)

PM Control: JM CRT retrofit

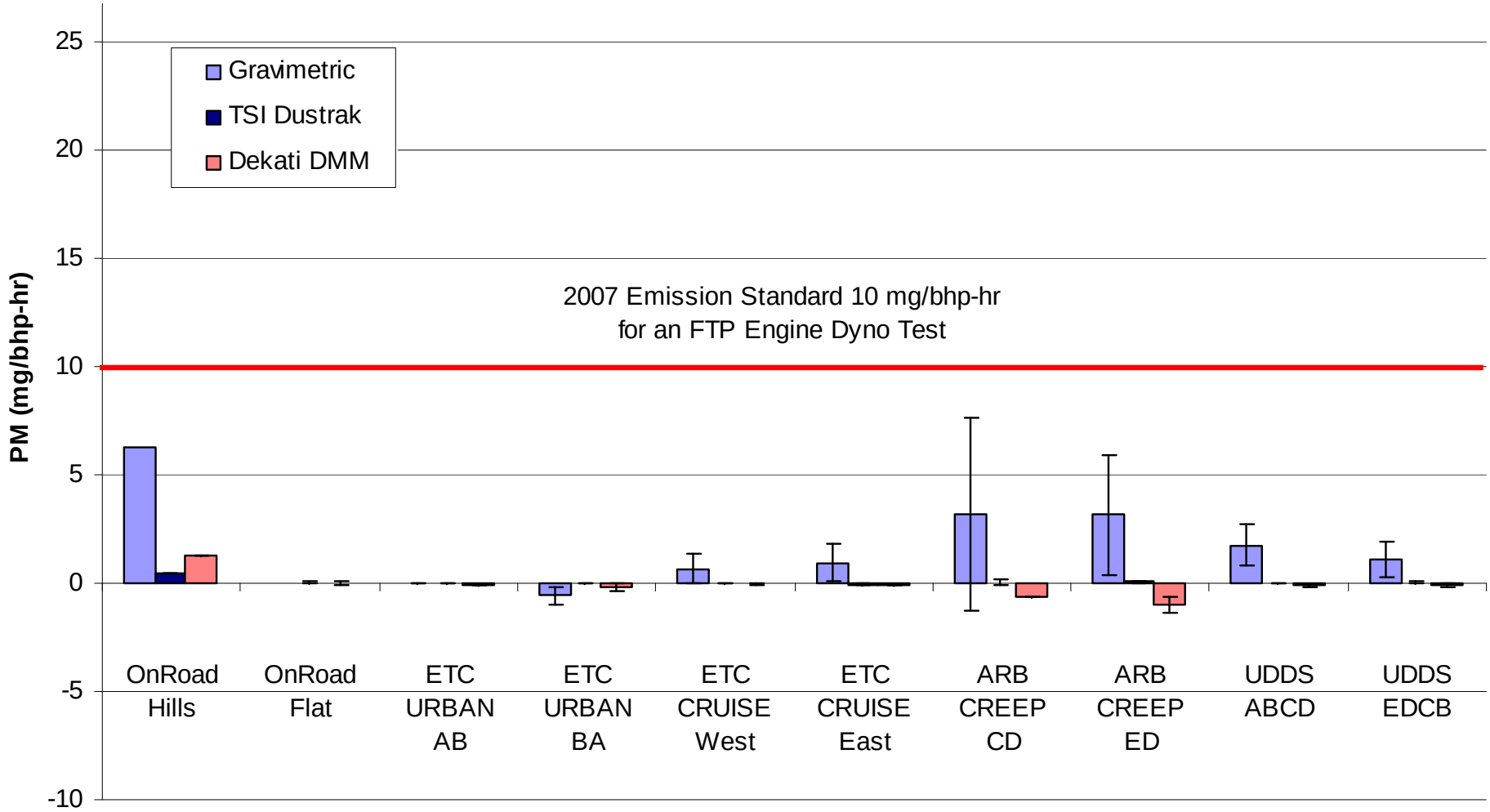
NOx Control: No Catalyst

Location

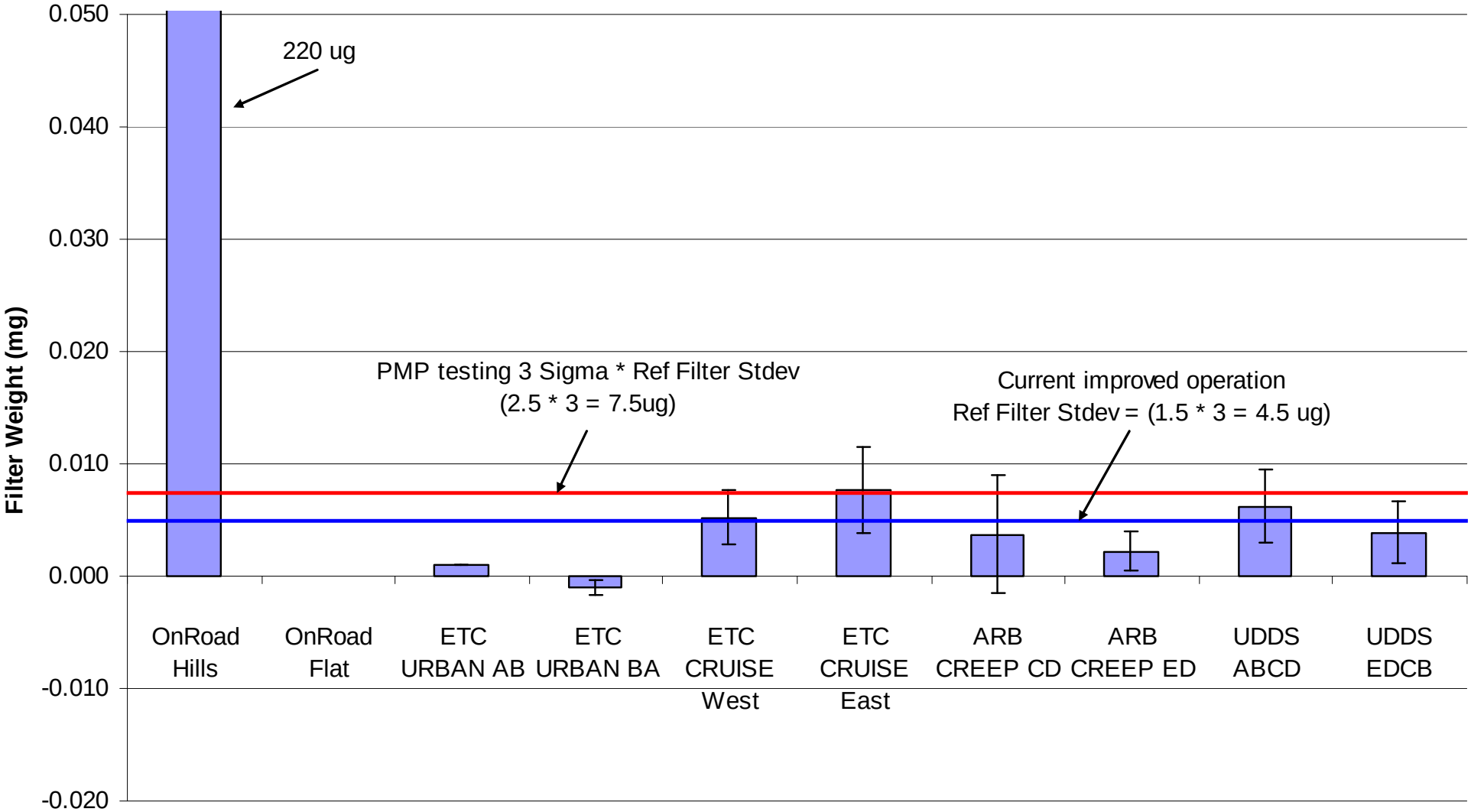

On Road
Cruise Cycle (I10)
On Road
Indio to Blyth
Riverside
(CE-CERT)
On Road
Transient Cycles
Farm Roads
©2008 Google - Map data ©2008 NAVTEQ™


F
C
60th St. (1.9 miles)
D
60th St. (0.95 miles)
E
F
111
Old 86 (1 mile)
Tyler St.
Polk St.
Fillmore St. (1 mile)
Old State St. ?
B
62nd St. (2.8 miles) A-B
62nd St. (3.4 miles) A1-B
A
A1

PM mass results on mg/bhp-hr

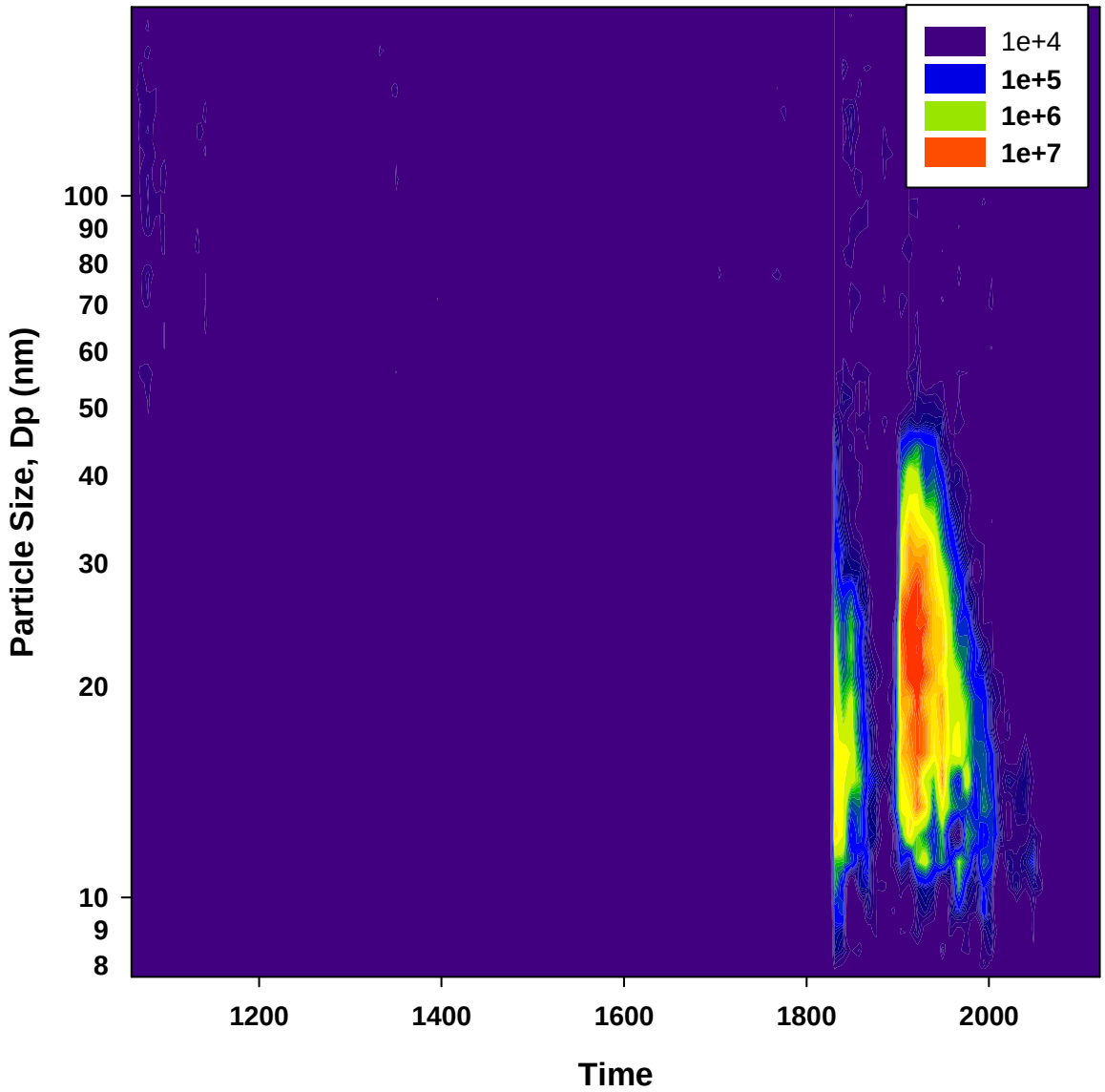


PM mass results on filter weight basis



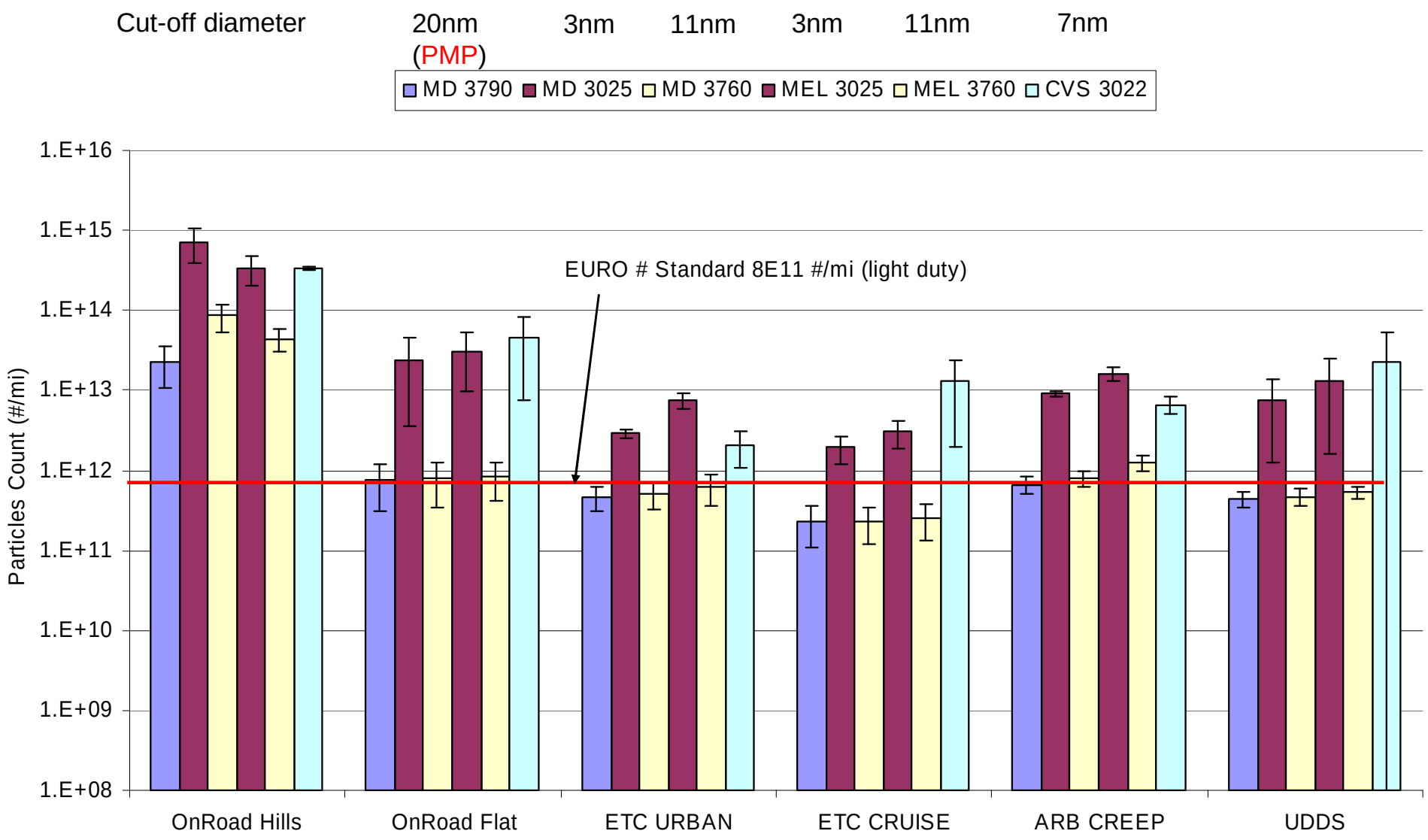
Particle size distribution

Urban dynamometer driving schedule (UDDS)

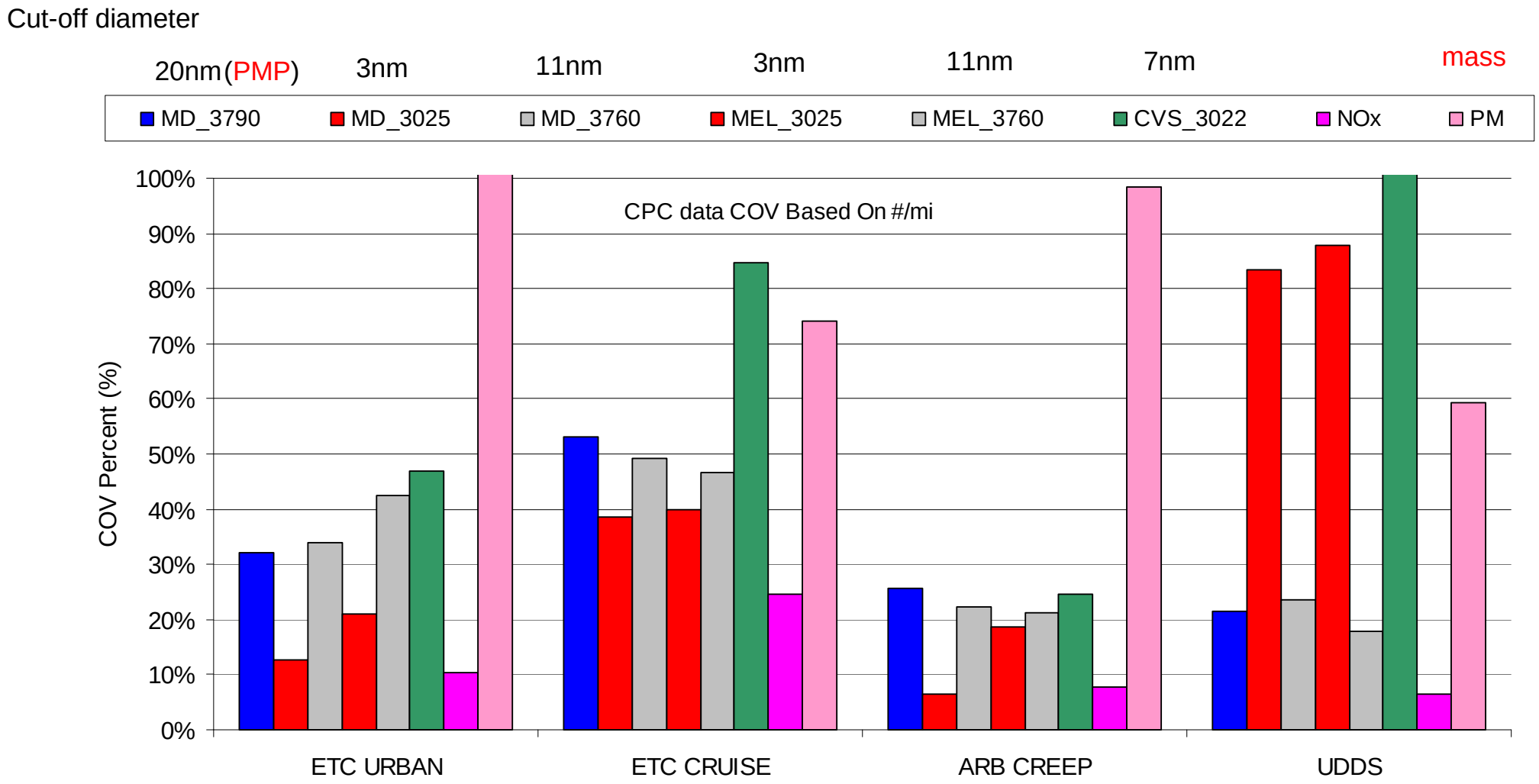


Fast-SMPS data

Particle number rate (#/mile) on driving cycles



Coefficient of variation for all CPCs and PM mass on driving cycles



Conclusion

- Gravimetric PM filter mass measurements were near detection limits for most of driving cycle, which makes it desirable to explore new PM measurement protocol.

- The CPC particle number count levels follow a trend that is consistent with the size cuts of the respective instruments. The 3022 CPC, which was connected to the primary tunnel as opposed to below the PMP system, also showed higher counts than the other CPCs below the PMP system when volatile nucleation particles formed.

- The particle number measurements using PMP method showed a lower coefficient of variation than the PM filter mass measurements. One potential advantage of particle number measurements is better repeatability at low mass levels.

Acknowledgements

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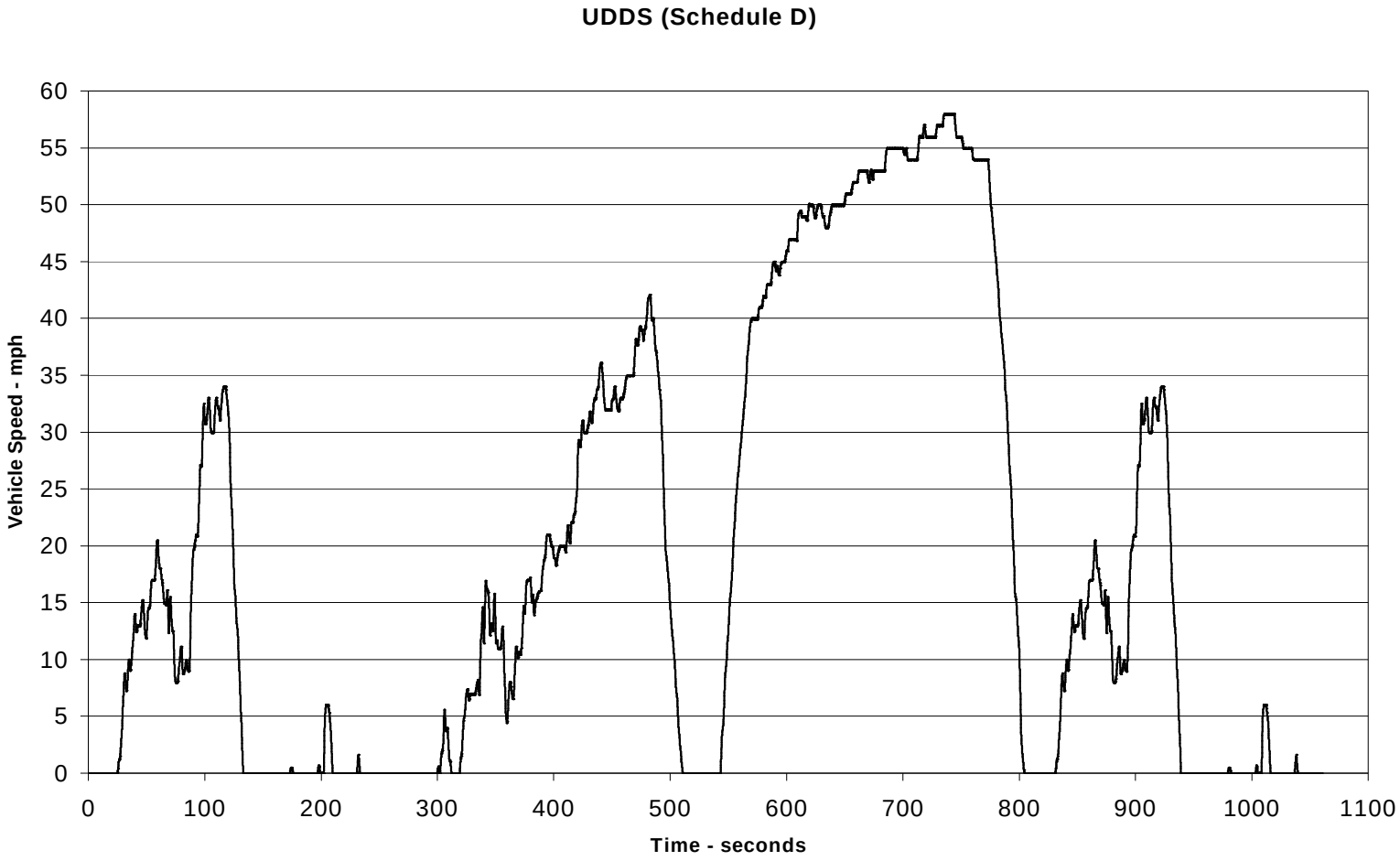
  - Dr. Marcus Kasper of Matter Engineering Inc.
  - Mr. Jon Andersson of Ricardo
  - Dr. Andreas Mayer of Technik Thermischer Maschinen (TTM).
  - for their assistance in developing the test plan procedures, in carrying out the experiments, and in analysis of the data.
  - Mr. Donald Pacocha, for his contribution in setting up and executing this field project, the data collection and quality control.
  - Joint Research Center (JRC) of the European Commission

Thank you!

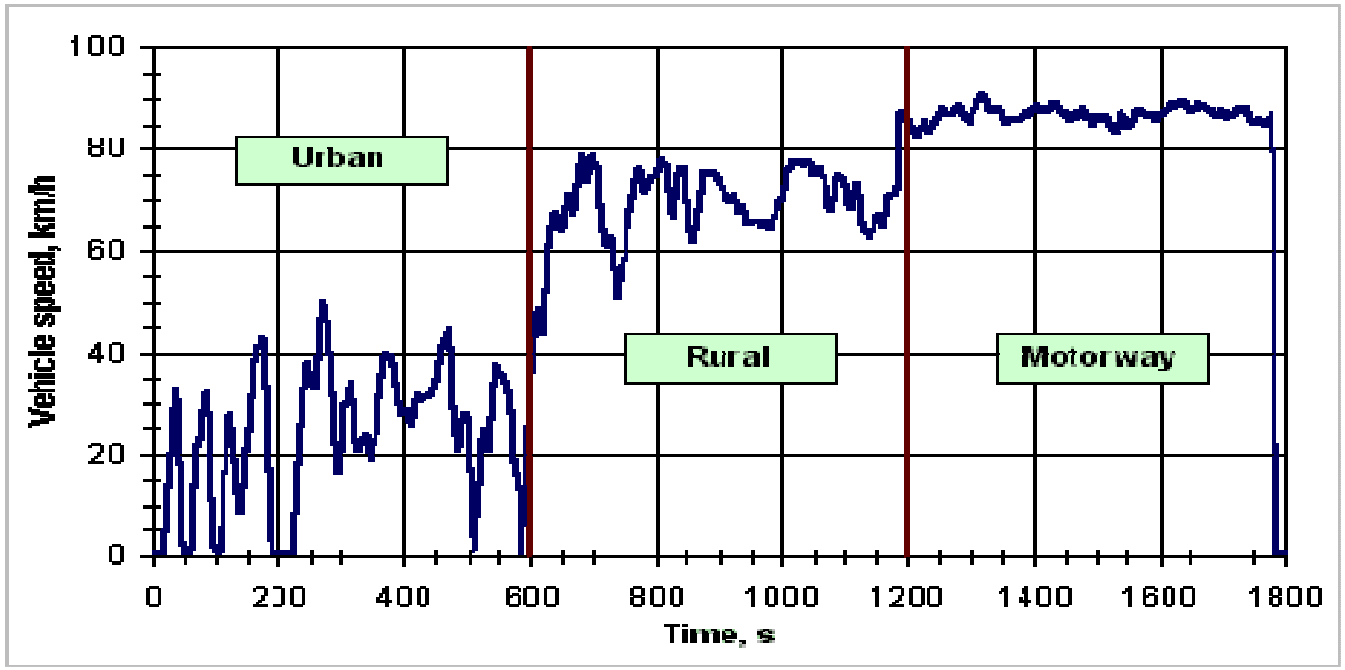
Questions?

Backup slides

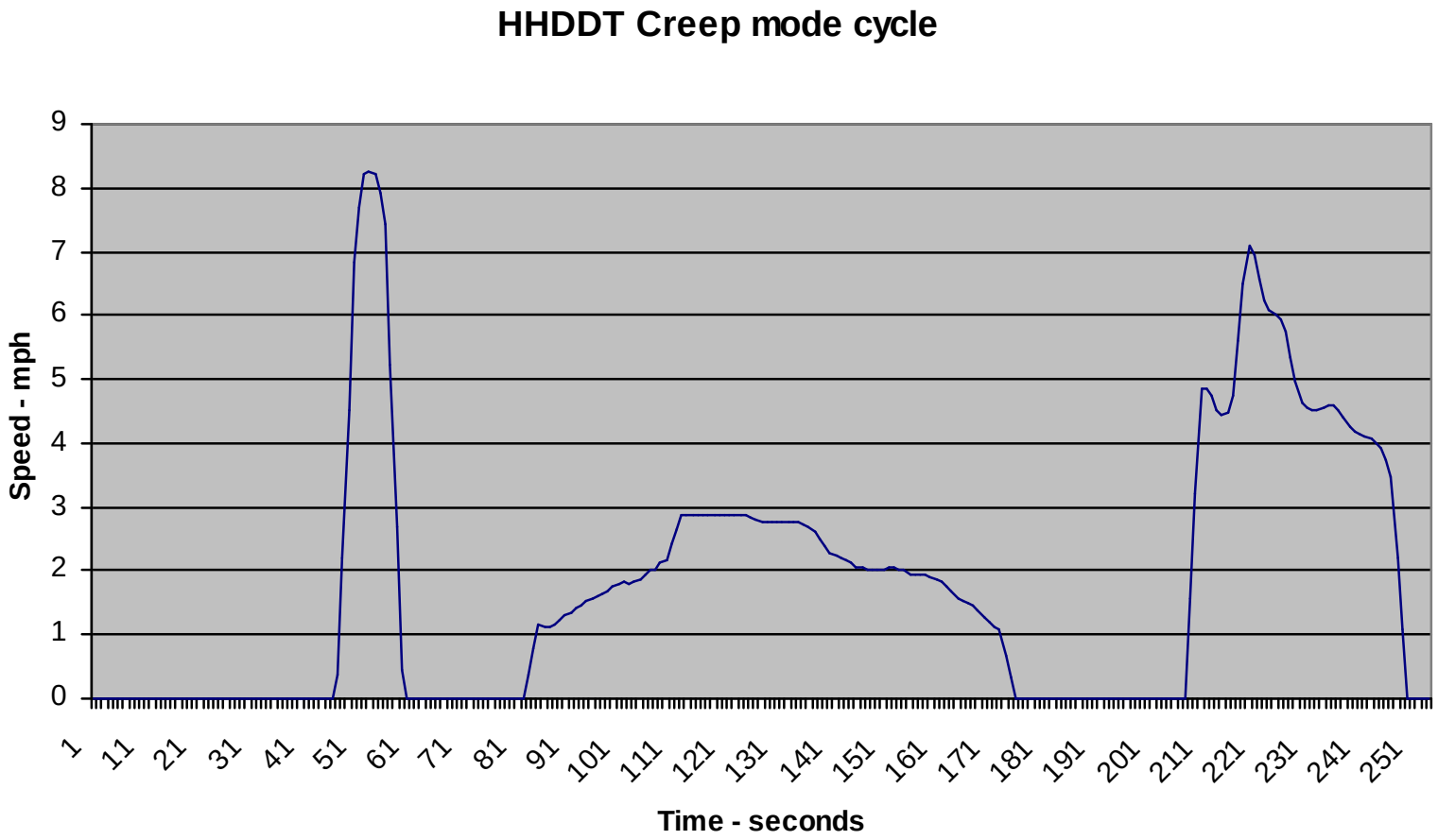
Driving cycle (UDDS)



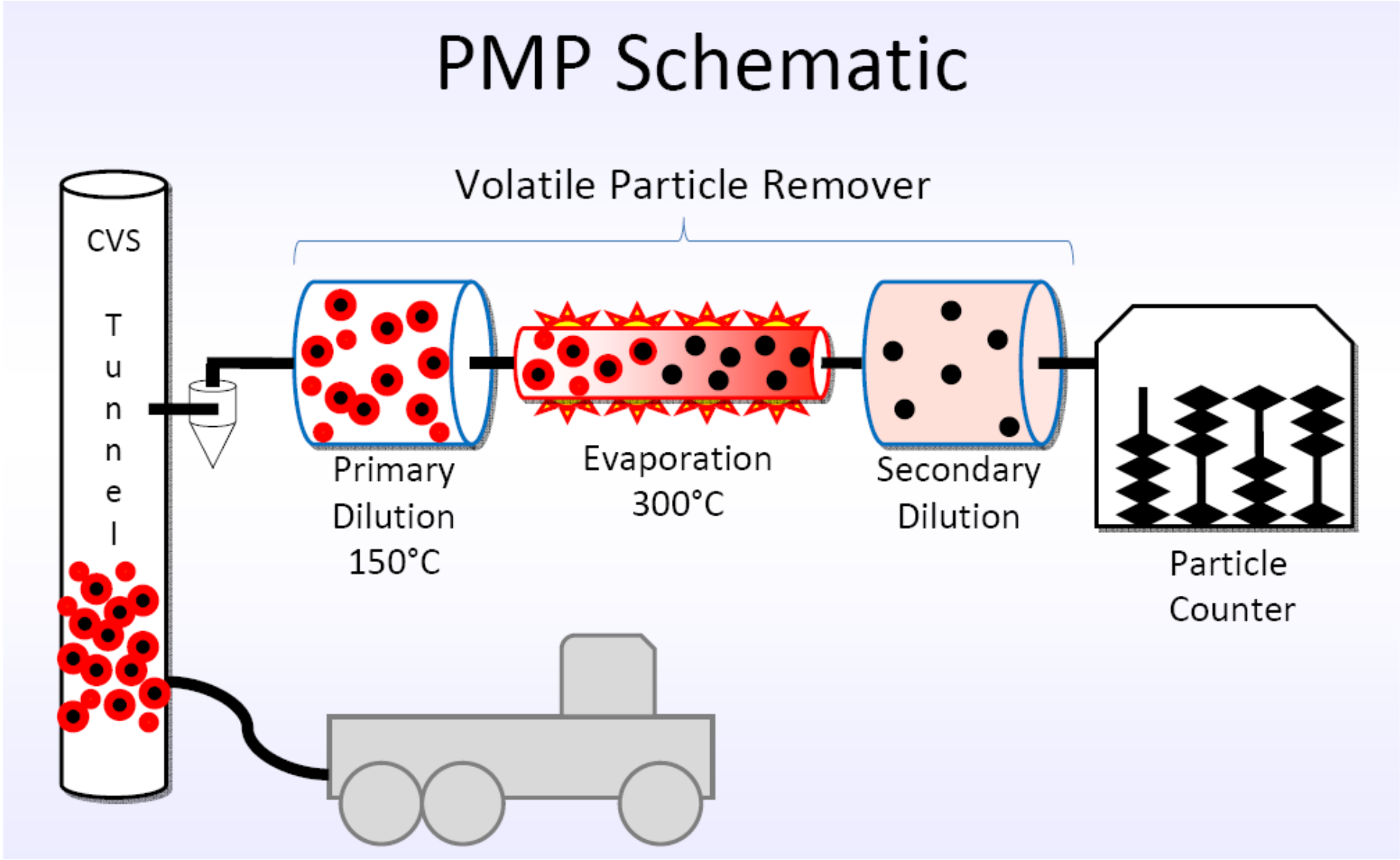
ETC (European Transient Cycle)



ARB Creep cycle



PMP Schematic



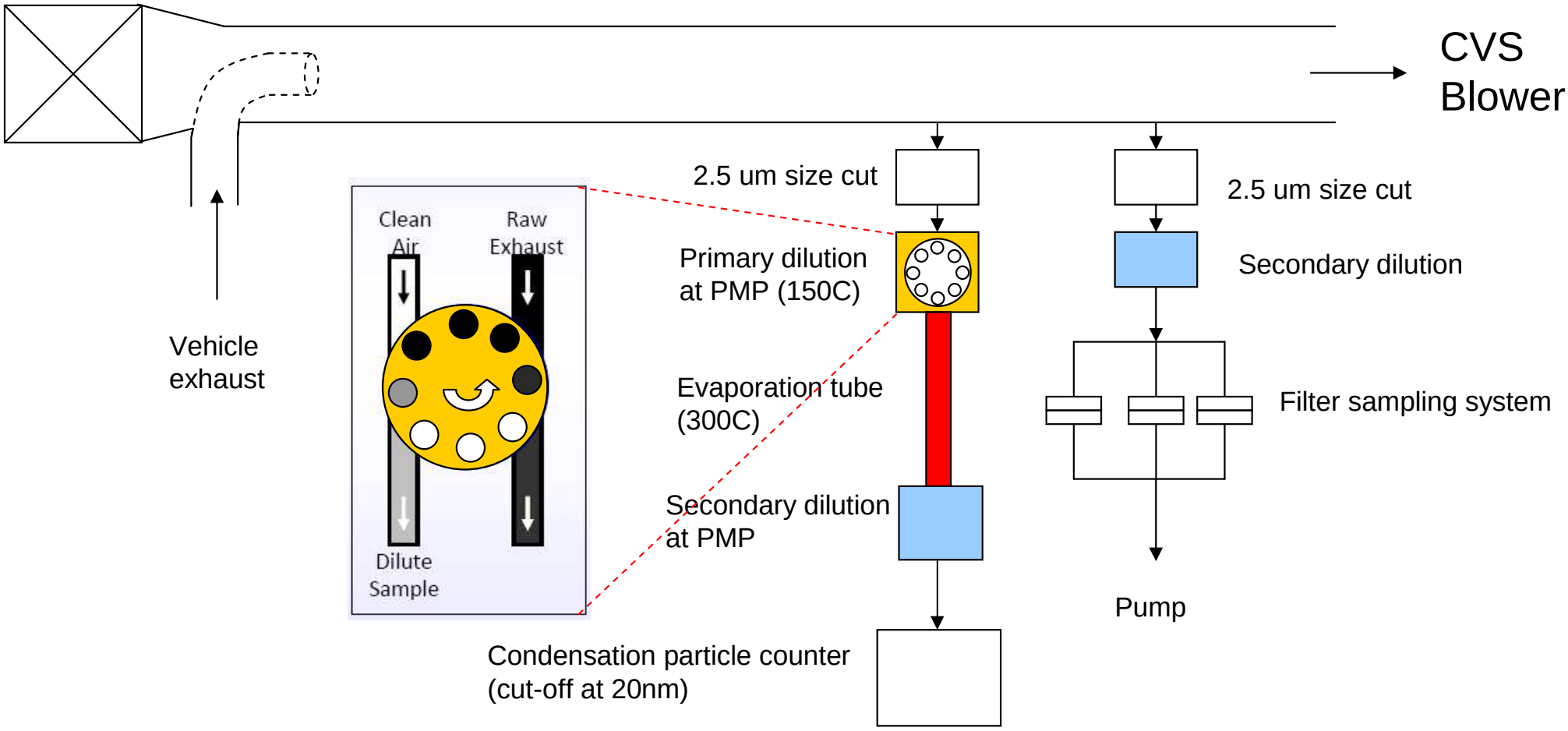
Courtesy of W. Robertson at CARB

Particle health effects

- PM mass will continue to be an important metric.
- Ultrafine PM and metals are important via oxidative stress mechanism.
- Elemental carbon (EC) has long-term effects (lung cancer)

From PMP report: Final report of Phase 1 of Module 1

Gravimetric vs PMP measurements



Courtesy of W. Robertson for MD-19 diagram