Measurement of PM_{10} Emission Factors from Paved Roads Using On-Board Particle Sensors

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NARSTO Workshop on Innovative Methods
Emission-Inventory Development and Evaluation
University of Texas, Austin
October 14-17, 2003

Bourns College of Engineering-Center for Environmental Research and Technology
University of California, Riverside

INTRODUCTION

- Quantifying PM Emissions from Paved Roads are Important Because:
  - Significant contributor to exceeding standard in many air basins
  - Estimated Inventories of Geologic PM are Higher than Measured Concentrations
  - Emissions due to paved roads are a major component of geologic emissions

- Emission Inventories are Difficult to Determine Because:
  - Fugitive nature leads to high uncertainties for emission factors
  - Current inventories are based on an empirical equation derived from upwind-downwind sampling from primarily industrial roads
  - Modeling is required to determine emission factors from upwind-downwind concentrations
  - PM concentration differences are small between upwind and downwind locations for most roads

OBJECTIVES

- Develop a More Accurate and Cost-Effective Approach for Measuring PM_{10} Emission Factors for Paved Roads
- Determine PM_{10} Emission Factors for Various Roadway Types in southern California

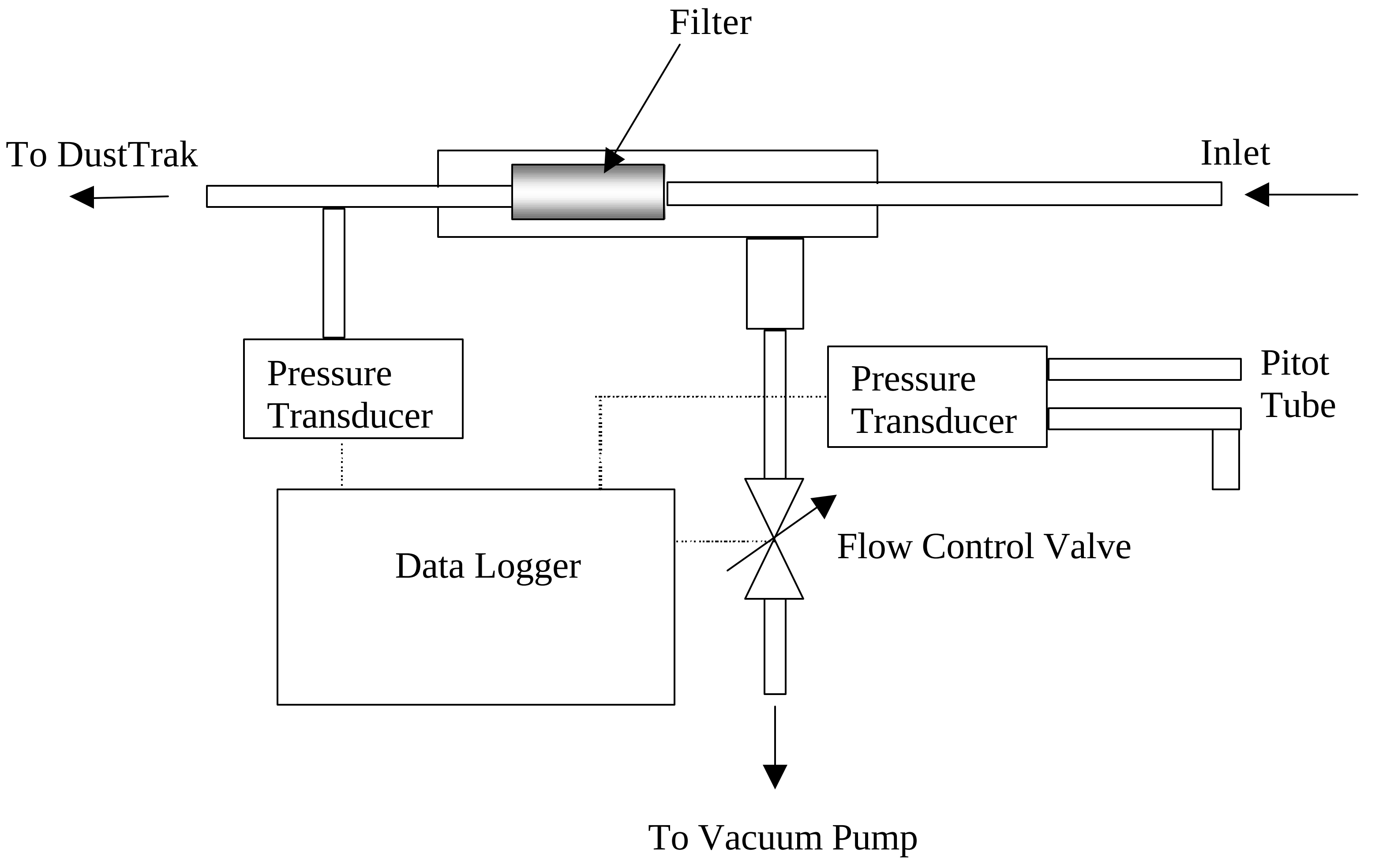
APPROACH

- Measure PM Directly in Front of and Behind a Test Vehicle with an Isokinetic Sampling Probe
- Use Real-Time Sensors to Accumulate Large Amounts of PM Data Quickly
- Determine the Variability of PM behind the Test Vehicle
- Determine Emission Factors Based on the Concentration Within the Vehicle’s Wake

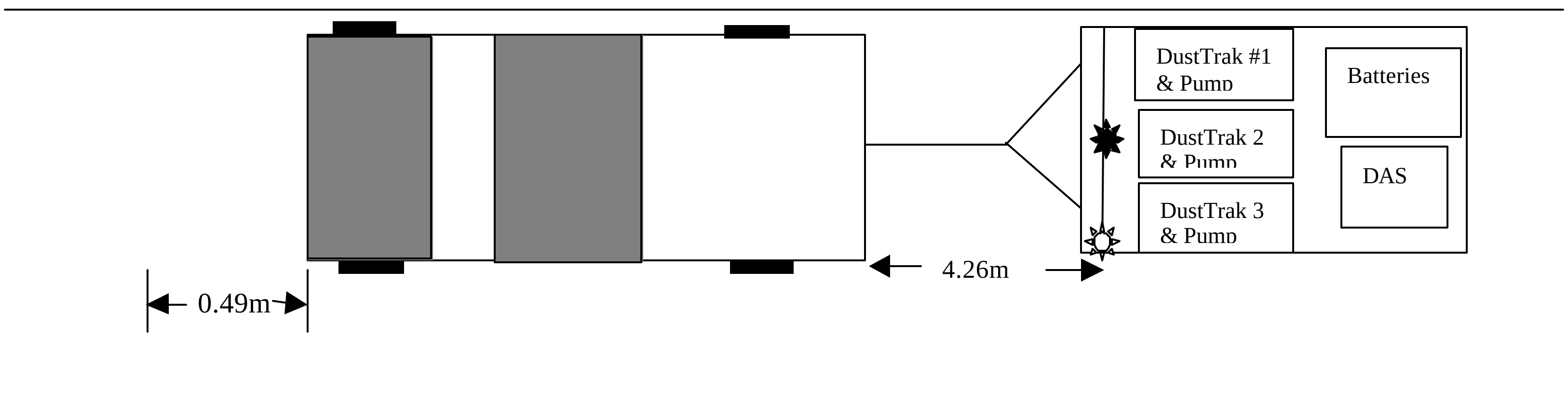
EXPERIMENTAL DESIGN

- DustTrak PM Optical Scattering Sensors
- Isokinetic Sampling Probe
  - Provide isokinetic sampling from 0-60 mph
  - Slow sample flow without creating a virtual impactor
- Inlets located in front of test vehicle and on small trailer towed behind it

Isokinetic Sampling Probe



Sampling Design for Wake Characterization



☼ DustTrak #1 Inlet (1.98 or 2.59 m above ground)

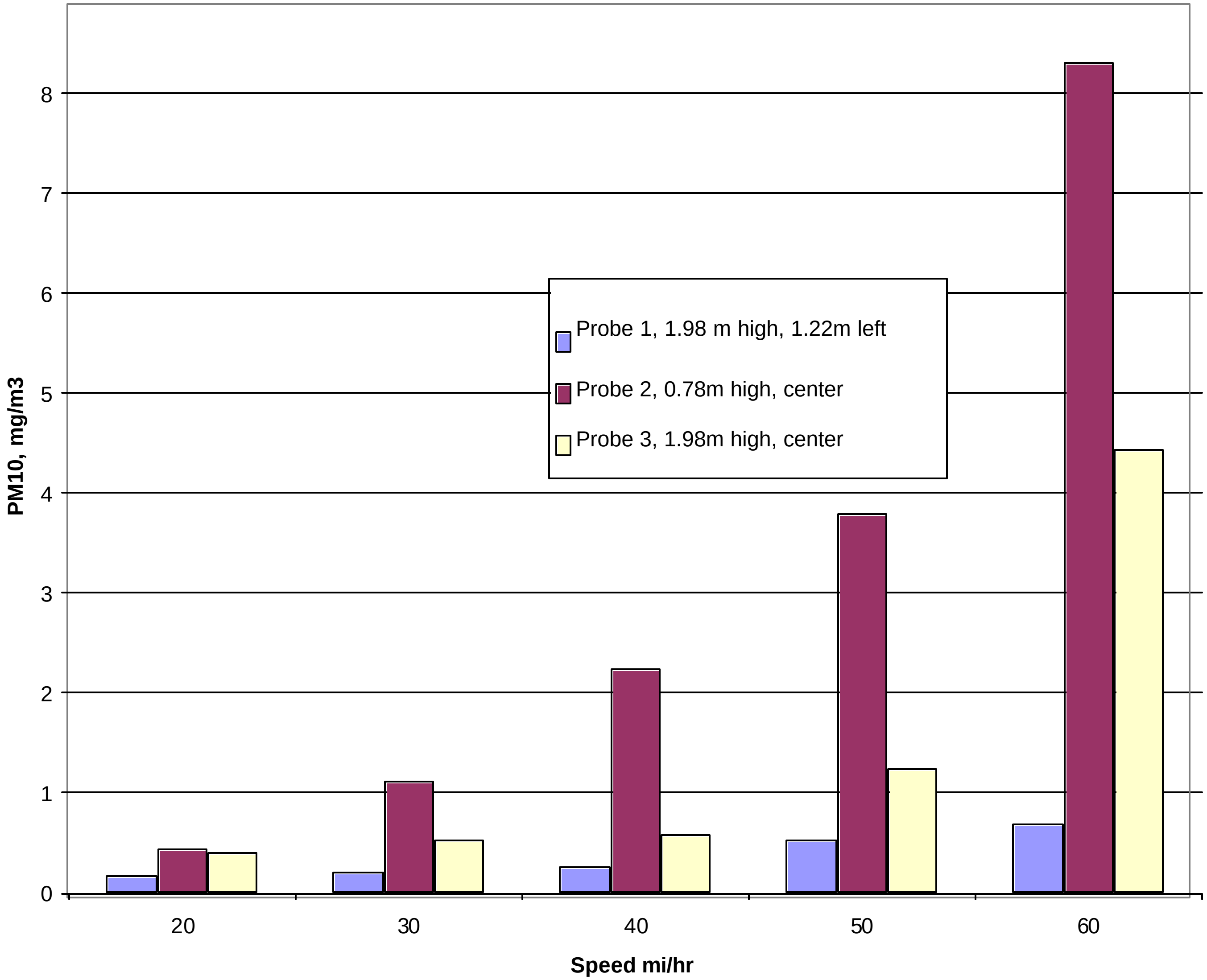
✸ DustTrak #2 & #3 Inlets (0.78 & 1.98 or 2.59 m above ground)

Test Trailer and Isokinetic Sampling Probes

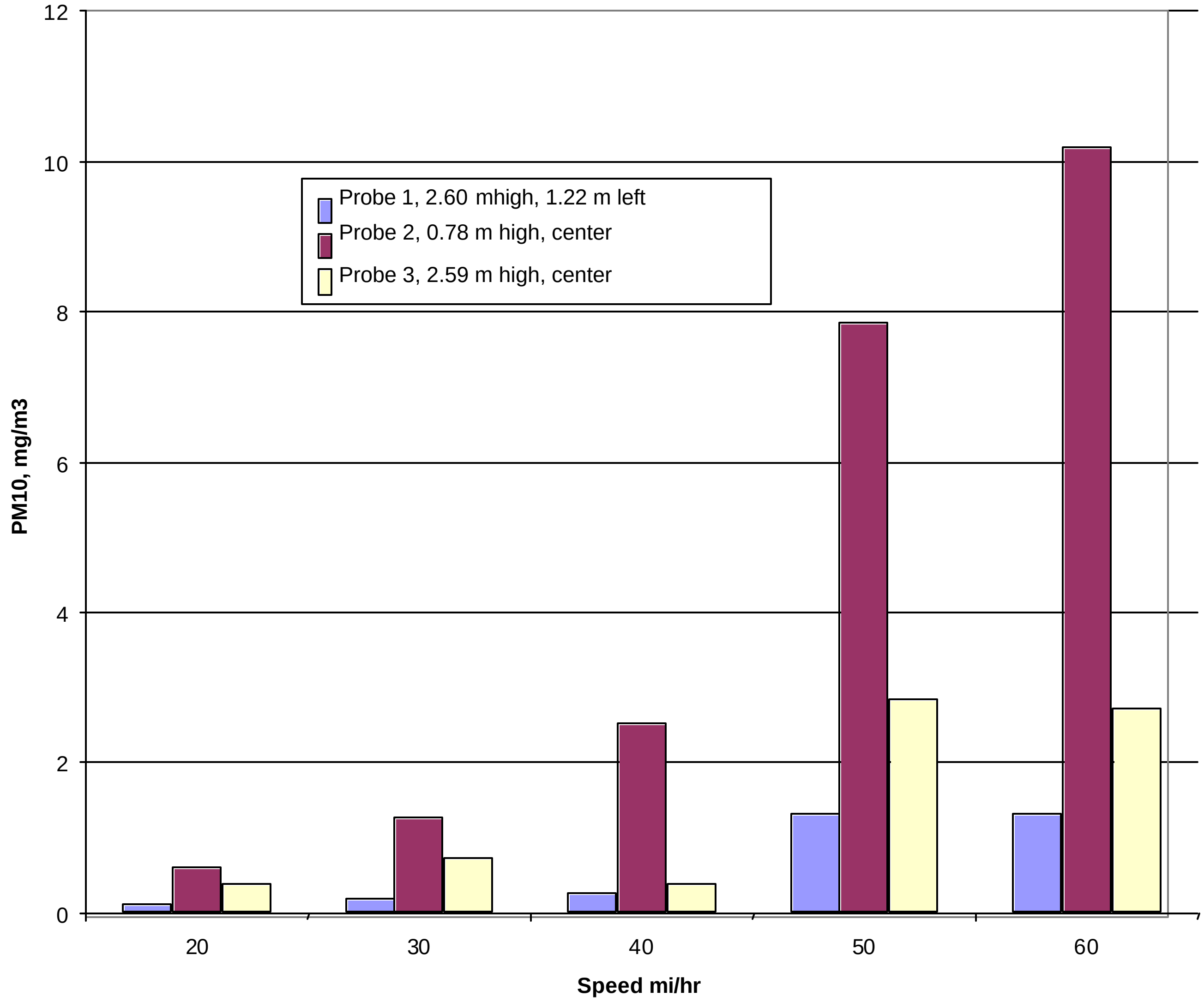
Wake Characterization

- Test on Unused Deteriorating Paved Road to Provide High PM Concentrations
- Measured PM Concentrations at a Variety of Test Points On the Trailer Relative to a Reference Test Point
- Fully Characterized the Wake PM Concentrations at Speeds from 10-60 mph

Wake Characterization Results



Wake Characterization Results



Wake Characterization Results

- The precision of the measurement (with all three DustTraks sampling from the same point).
- The homogeneity of the PM within the vehicle's wake with respect to the vehicle's speed.
- The vertical and horizontal extent of the plume as a function of vehicle speed and cross wind.
- The optimum sampling position.

EMISSION FACTOR MEASUREMENTS

- Performed Repeated Measurements Over Test Loops
- Tested All Types of Roadways and Speeds
  - Freeway
  - Arterial
  - Collector
  - Local
- Calculated Emission Factors Based on Frontal Area (Wake Size) For Various Road Type Segments

Summary of Results

DustTrak #1[a] (mg/m^3)	DustTrak #2[b] (mg/m^3)	DustTrak #3[b] (mg/m^3)	Difference DustTrak #2-#1 (mg/m^3)	Difference DustTrak #3-#1 (mg/m^3)	Road type	DustTrak #2-#1 emission factor[d] (mg/km)	DustTrak #3-#1 emission factor[d] (mg/km)	PM
0.019	0.040	0.040	0.021	0.021	Local	68.7 +/- 4.9	68.0 +/- 4.8	10
0.044	0.057	0.053	0.013	0.009	Collector	43.2 +/- 3.1	30.7 +/- 2.2	10
0.059	0.088	0.073	0.030	0.015	Arterial	98.4 +/- 7.0	48.6 +/- 3.5	10
0.056	0.089	0.061	0.033	0.005	Freeway	79.3 +/- 5.6	14.9 +/- 1.1	10
0.012	0.031	0.032	0.019	0.020	Local	61.1 +/- 4.3	64.9 +/- 4.6	2.5
0.074	0.084	0.079	0.010	0.005	Collector	31.7 +/- 2.3	15.4 +/- 1.1	2.5
0.048	0.058	0.058	0.013	0.011	Arterial	41.5+/- 3.0	35.7 +/- 2.5	2.5
0.026	0.035	0.038	0.009	0.013	Freeway	29.4 +/- 2.1	41.3 +/- 2.9	2.5

Comparison With Other Studies

Study	Road Type	Emission Factor (g/VKT)	Emission Factor (lbs/VMT)
This Study	Freeway-local	0.06 – 0.13	0.00022-0.00047
Venkatram and Fitz, 1998 [4]	Freeway-local	0.1-0.3	0.00036-0.0011
Cahill et al., 1995 [19]	Intersection	<0.3	<0.001
Claiborn et al., 1995 [8]	Freeway-local	0.5 to 34	0.0018-0.12
Harding Lawson, 1996 [6]	Freeway-local	0.03 to 180	0.00011-0.65
AP-42 Default[a]	Arterial-local	0.08-0.53	0.00030-0.0019
ARB Default	Arterial-local	0.10-0.61	0.00036-0.0022

a: From silt loadings measured in southern California, assuming 2 ton vehicles

CONCLUSIONS

- On-Board Real Time Measurement is a Viable Method to Characterize PM Emissions form Vehicles on Paved Roads
- Measurements in Southern California were Lower than Those Predicted by the AP-42 Empirical Equation
- Advantages of the Method are:
  – Low Cost
  – No Modeling Required
  – Ability to Collect Large Amounts of Data
  – Ability to Determine PM “Hot Spots”