

# **PARTICULATE MEASUREMENT FOR HEALTH EFFECTS ASSESSMENTS**

## *Summary of the Health Effects Institute Workshop on Particle Characterization*


**R. Sawyer, University of California at Berkeley,  
M. Costantini, The Health Effects Institute**

Airborne particulate has long been associated with adverse health effects, including death, especially at high concentrations. Historically, concerns for diesel particulate has been primarily associated with carcinogenic compounds attached to the particulate. More recently, epidemiological studies suggest an association between low levels of fine particulate, 2.5  $\mu\text{m}$  or less, and both acute and long term adverse health effects, including mortality and morbidity. While the mechanisms by which fine particulate may cause adverse health effects are not currently understood, it is likely that the size distribution and chemical composition of the particulate are important characteristics. Motor vehicles are important contributors to fine ambient particulate, both as primary (direct) and secondary (indirect) sources. Diesel engines emit fine particulate (soot) and oxides of nitrogen which are precursors to photochemical nitrate particulate. Information on the size distribution and chemical composition of fine particulate, both primary and secondary is limited. The Health Effects Institute recently conducted a workshop on particle characterization with the objective of bringing health effects, atmospheric, and engine researchers together to discuss the needs for particulate characterization and the current understanding of how particles are formed and the methodologies for their characterization.

At the workshop the relation between atmospheric particulate and adverse health effects

was reviewed. Hypothesized mechanisms of these effects were summarized. The physical and chemical processes leading to combustion generated particulate were explained. Engine particulate primarily has been measured in terms of mass emission rates, because this is what is currently regulated. From a laboratory study the reduction in mass emissions from some modern diesel engines appears to have been accompanied by a large increase in the numbers of fine particles emitted. The consequences of this change could prove adverse if the health effects turn out to be associated with particle numbers or surface area rather than mass, as suggested by some investigators. Laboratory, on-road, tunnel, and ambient measurements all provide insight into the characteristics of motor vehicle generated particulate. Both emitted and secondary particulate are subject to atmospheric transformations which affect both size distributions and compositions. Health effects researchers face problems in generating and characterizing particulate for animal experiments. The researchers from the diverse fields share common problems in characterizing fine particulate.

The HEI Workshop on Particle Characterization is reported in more detail in the publication: "Formation and Characterization of Particles in Emissions: Summary of the 1996 HEI Workshop," Health Effects Institute Communications Number 5, August 1997, which can be obtained from the Health Effects Institute, 955 Massachusetts Ave., Cambridge MA 02139.

 **1997 Diesel Engine Emissions  
Reduction Workshop--Session II  
Human Health Effects of Diesel Exhaust**

**PARTICULATE MEASUREMENT FOR  
HEALTH EFFECTS ASSESSMENTS--**

*Summary of the Health Effects Institute  
Workshop on Particle Characterization*

**Robert F. Sawyer**

Professor, University of California at Berkeley  
Research Committee, Health Effects Institute

**Maria Costantini**

Senior Scientist, Health Effects Institute

**San Diego, 28 July 1997**

UCB/LBNL COMBUSTION

 **HEI PARTICLE  
CHARACTERIZATION WORKSHOP**

● **Cambridge MA, 3-4 December  
1996**

● **Bring together workers in**

- Health effects
- Atmospheric chemistry and physics
- Engine emissions

● **Review current understanding,  
characterization methodology,  
research needs**

UCB/LBNL COMBUSTION



## HEI WORKSHOP REPORT

HEI Communications, Number 5, August 1997, *Formation and Characterization of Particles in Emissions: Summary of the 1996 HEI Workshop*

- Current understanding of the health effects of particles and the characteristics that determine dose or effect, *J. Mauderly and G. Oberdorster*
- Particle formation in combustion, *J. Howard and G. Hunter*
- The EPA particle emission testing procedure, *J. Somers*

UCB/LBNL COMBUSTION



## HEI WORKSHOP REPORT

- Results of characterization of particulate matter and vapor-phase organic compounds from motor vehicles exhaust

Diesel and gasoline engines, *D. Kittelson, J. Johnson, K. Schindler, M. Maricq, M. Hawkins*

Motor vehicles in-use, *G. Cass, W. Pierson, S. Cadle*

- Atmospheric aerosol transformation, *S. Pandis*
- Generating particles for experimental Studies, *Y.-S. Cheng, and P. Koutrakis*
- Summary, *R. Sawyer and M. Costantini*
- Issues and research needs for particle characterization

UCB/LBNL COMBUSTION



## HEALTH EFFECTS OF PARTICLES

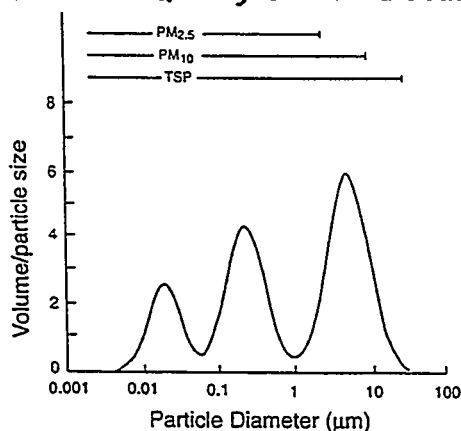
- Epidemiology establishes an association between acute and chronic mortality, morbidity and particles
- Mechanism not known
- Important particle characteristics not known--mass, size, surface area, number, chemical composition, physical shape?

UCB/LBNL COMBUSTION



## PARTICLE AREA DISTRIBUTION BY AERODYNAMIC DIAMETER,

*USEPA Air Quality Criteria Document, 1996*



UCB/LBNL COMBUSTION



## PARTICLE FORMATION

- Laboratory combustion of pure hydrocarbons, *Howard*
  - Condensation
  - Accumulation
  - Oxidation
  - Fragmentation
- Engine combustion of real fuels, *Hunter*
  - Pyrolysis, condensation, accumulation to carbonaceous particles (soot)
  - Sulfates, ash (metal oxides), adsorbed hydrocarbons
  - Particle burnout--NO<sub>x</sub> tradeoff

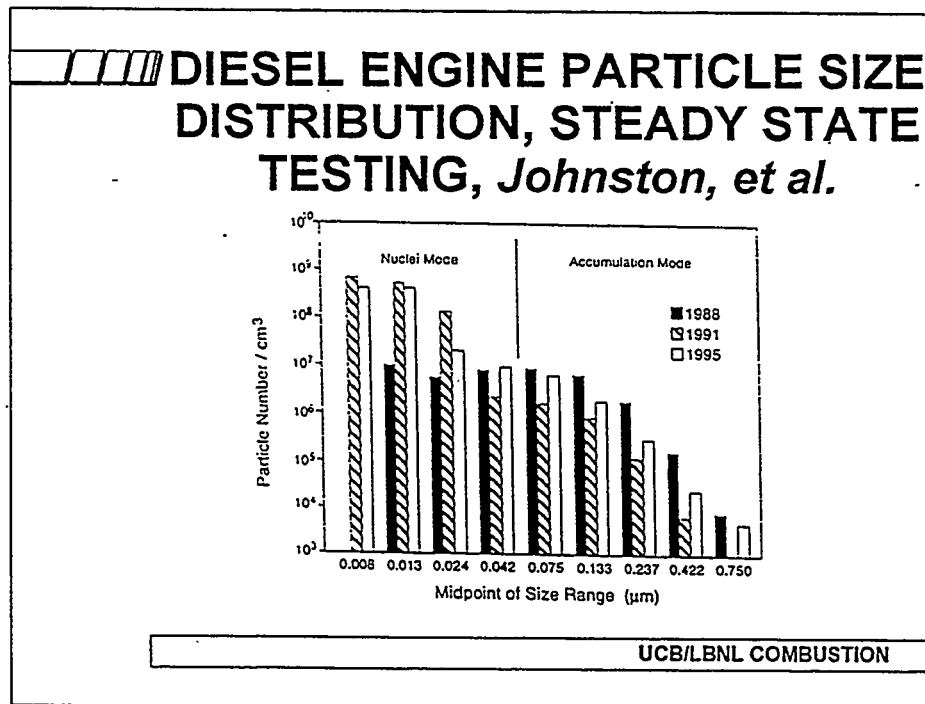
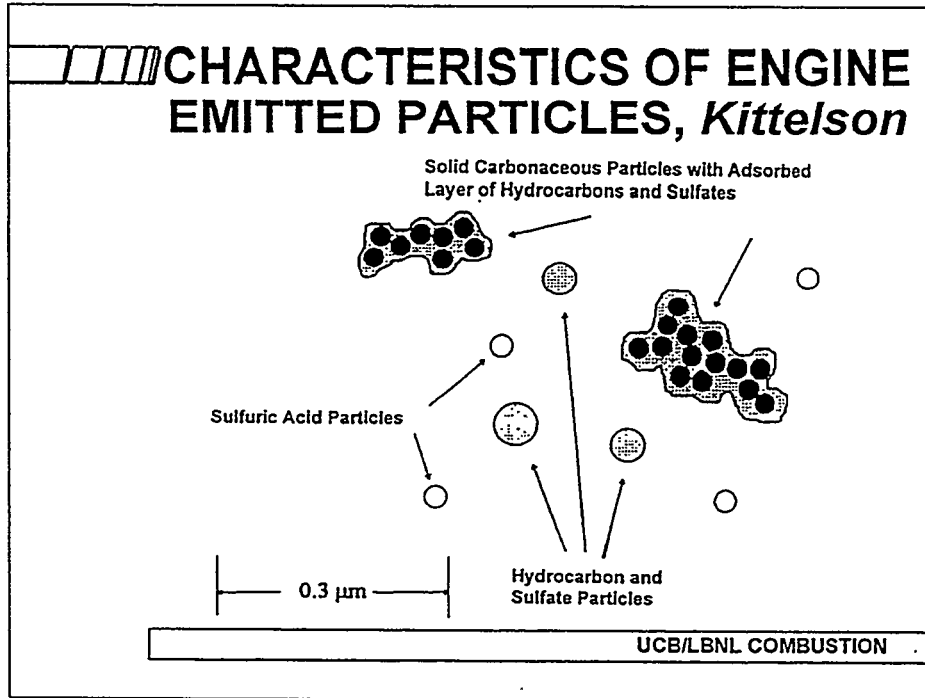
UCB/LBNL COMBUSTION

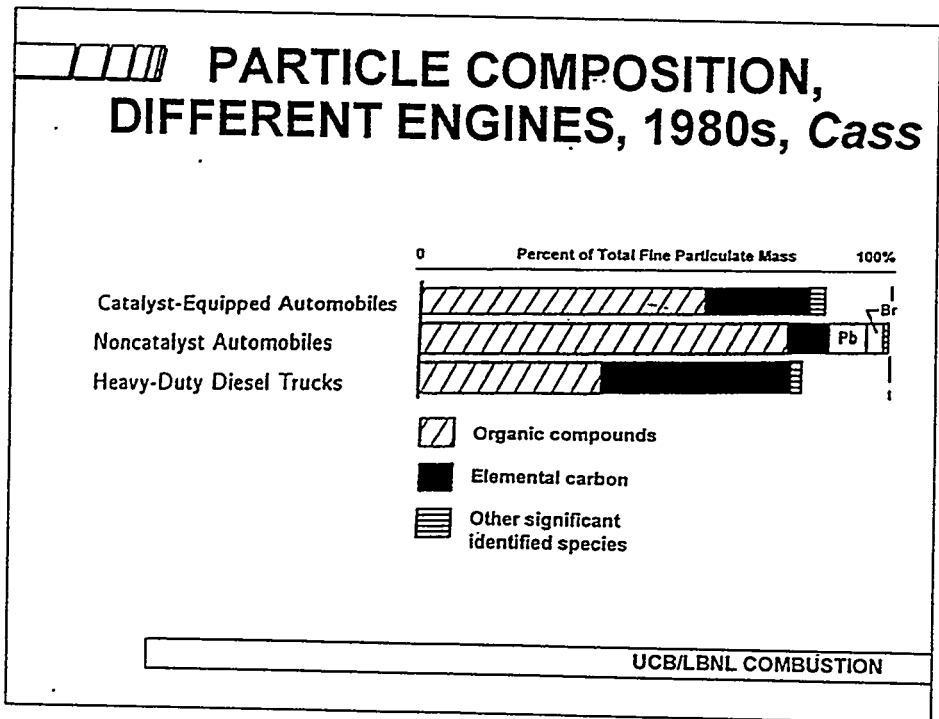
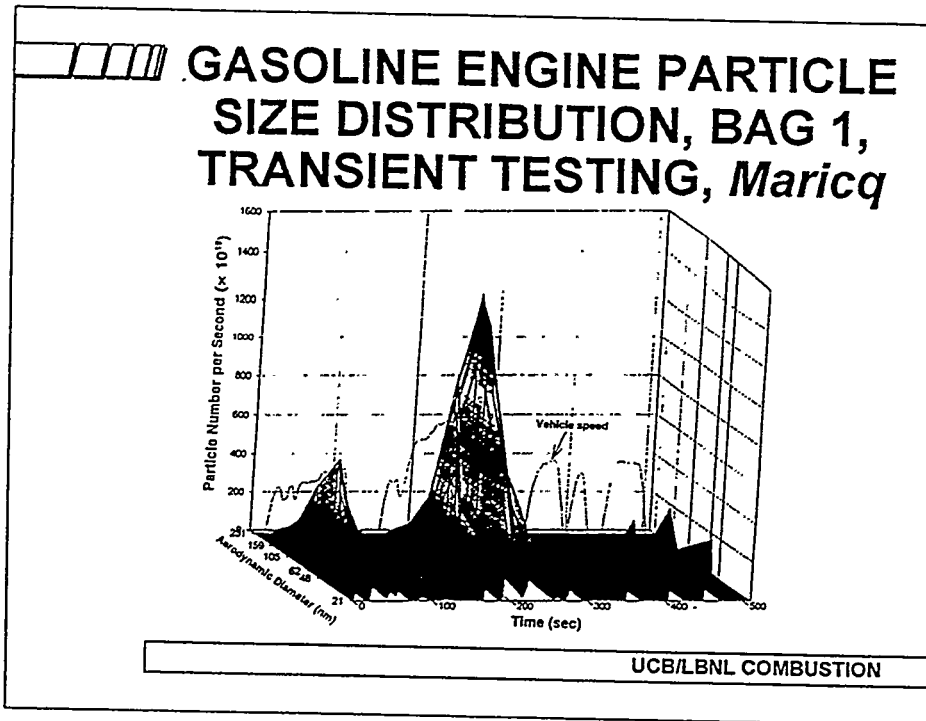


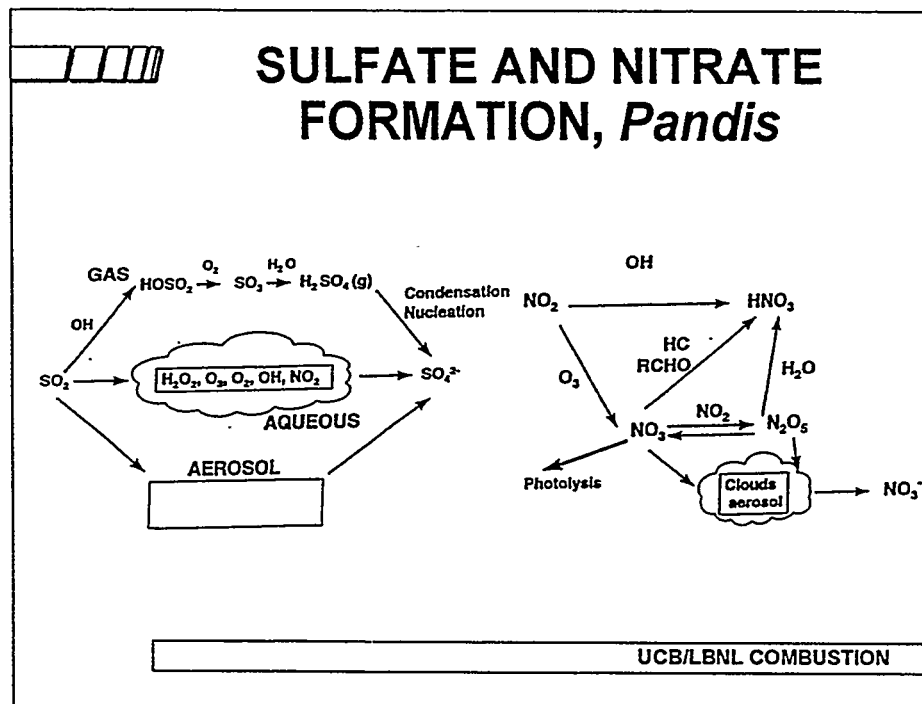
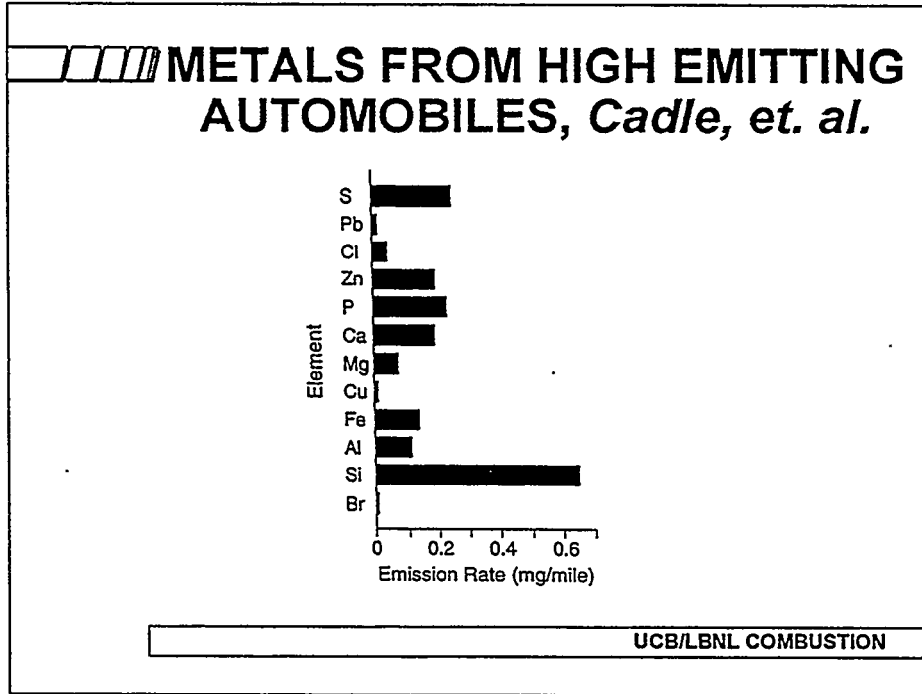
## EPA PARTICLE EMISSION TESTING PROCEDURE, *Somers*

- Light duty--FTP cycle
- Heavy duty--transient engine dynamometer
- Off-road--8 mode steady state
- Dilution tunnel, 125°C, fluorocarbon filter
- Total mass

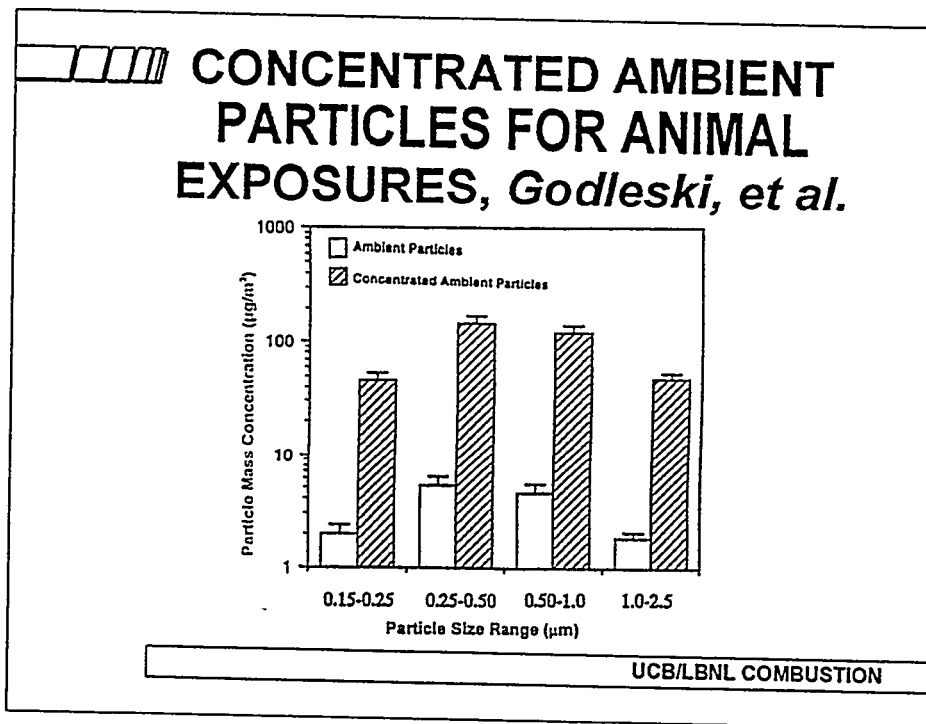
UCB/LBNL COMBUSTION











- ### RESEARCH NEEDS FOR PARTICLE CHARACTERIZATION
- Ambient particles: size distribution, chemical and physical properties
    - to assist epidemiology
    - to identify sources
  - Indoor and outdoor particle characteristics
    - to aid in estimating exposure
  - Atmospheric generation and transformation processes
    - modification of primary particles
    - formation of secondary particles
- UCB/LBNL COMBUSTION



## RESEARCH NEEDS FOR PARTICLE CHARACTERIZATION

- Chemical and physical properties by size of emitted particles under real-world appropriate conditions
- Equivalency or relationship of different particle sampling methods
- Equivalency or relationship of different particle sizing methods
- Methods of generating, delivering, and characterizing particles for animal and human clinical studies relevant to real- world conditions

UCB/LBNL COMBUSTION



## SOME OBSERVATIONS AND COMMENTS, Sawyer

- PM<sub>2.5</sub> air quality standard may be changed before controls are implemented
- Engineers need to follow particle health research to ensure they are measuring and controlling particles appropriately
- The current EPA specified engine particle measurements are probably not appropriate
- Need particle number--size distributions; chemical and physical characteristics by particle size

UCB/LBNL COMBUSTION