Overview

- Concerns With Motor Vehicle Emissions
- Progress To Date
- Major Remaining Problems
  - New Diesel Vehicles & Engines
  - Existing Diesels
  - Non Road Vehicles & Engines

Global Trend In Motor Vehicles

What pollutants are of concern?

- Greenhouse Gases
- Haze
- Ozone (ROG + NOx)
- Particles (PM10/PM2.5)
- Toxics
  - Diesel particles
  - Benzene
  - Chromium
  - Asbestos
- Carbon monoxide (CO)

Health Impacts of Air Pollution

Health Effects

- Different Pollutants have Different Effects
  - Carbon Monoxide - circulatory system, heart
  - Ozone - respiratory system, lung
  - Nitrogen Dioxide - respiratory system
  - PM - lung, potential effects on heart
  - Diesel, Air Toxics - cancer, respiratory effects
- There are potential effects of the Mixture
- Some Populations more sensitive than others
  - elderly
  - people with heart and lung disease
PM – The Most Serious Health Concerns

- High levels of PM (e.g. 500 µ/m²) known to cause premature death
- e.g. London 1952
- Recent studies in US, Europe, Asia, South America have found association of PM with premature death at much lower levels
- no evidence of a “threshold” (safe level)

PM - The Epidemiology Studies

- A Number of Epidemiology Studies

PM10 Study in Europe

(Lancet Medical Journal – September 2, 2000)

- ~6% of all deaths from PM10
- ~40,000 deaths per year in Austria, France, Switzerland; 2 times traffic fatalities
- Motor Vehicles Responsible For ~50%
- People in Cities Die ~18 Months Earlier Than They Otherwise Would
- Over 300,000 cases of chronic bronchitis; 500,000 asthma attacks; 16 million lost person days of activity
- Health Costs From Traffic Pollution ~1.7% of total GDP

Proximity To Truck Traffic Linked To Lung Function in Children

Brunekreef, Epidemiology 1997; 8: 298-303

New Car Emissions Standards in the US – Pre Control to Present

Chronology of Motor Vehicle Regulations In California

- Catalytic Converters and Unleaded Fuel
- Required use of TWC and computer-based emission control
- On-Board Diagnostics
- Low Emission Vehicle I + Phase I Gasoline
- Roadside Truck Inspections
- Phase II Gasoline
- Gasoline Trucks
- Diesel Trucks
- Low Emission Vehicle II
- On-Road Motorcycles
- Urban Transit Buses
- Diesel Trucks
Great Progress: Reduction of Ozone in Los Angeles

California Air Quality vs. Growth
Percent Change 1980 to 1999
Greater Los Angeles Area


Percent Change in Air Quality Across The US

But Significant Problems Remain

Current 8-hour Ozone and PM2.5 Nonattainment

US Tier 2 Standards
California’s Goal: “Zero” Emissions

Emissions From Gasoline Cars In Europe

Emissions From Diesel Cars In Europe

Close Linkage Between Vehicle Emissions Standards and Fuel Sulfur Levels

Special Problem: Diesels Must Be Cleaner
Diesel Particulate Matter

Increased Risk of Premature Mortality Due To 10 µg/m³ PM₂.₅

Journal of the American Medical Association, March 2002

Cancer Studies in Railroad Workers HEI, 1995

Relative Cancer Risks in Los Angeles

Typical engine exhaust mass and number weighted size distributions shown with alveolar deposition
Comparison of PM10, PM2.5, and Ultrafine PM

- PM10 (10 μm)
- PM2.5 (2.5 μm)
- Ultrafine PM (0.1 μm)

Human Hair (60 μm diameter)  Relative size of particles

Vehicles Are A Major Source of Ultrafine Particles

ARB In-Vehicle Study
Real-Time Fine Particle Counts
(L.A. Freeway; AM Rush Hour; Vent Open)

Time (120 minutes)
- Outside Vehicle 1
- Inside Vehicle 1

Concern Over Ultrafine PM Reinforced
- Daily Mortality in Erfurt Germany
- Health Effects of Ultrafine & Fine PM Comparable
- Effects of Ultrafines Depend on Number and Surface Area
- Since 91/92 PM Mass Has Declined
- Since 91/92 very small particles (.01-.03) increased

HEI Research Report 98, November 2000

Comparison of Particle Emissions from SMPS.7: All Vehicles and Fuels - 50kph

- Conventional Diesels
- Direct Injection
- Gasoline
- Trap Equipped Diesels
- MPI and LPG Gasoline
- PSA’s DPF System for Diesel Passenger Cars
Exposure Information is Limited in US

- Only existing ultrafine PM network is in southern California
- Freshly emitted ultrafine PM concentrations do not correlate well with PM10 or PM2.5 mass concentrations
- Freshly emitted ultrafine PM concentrations decrease rapidly with distance from source

\[1 \text{ Sioutas et al, 2002}\]

Intriguing Health-Related Findings

- Ultrafine PM exposure associated with mortality effects strongest for respiratory disease followed by cardiovascular disease
- Individuals with airway obstruction receive greater dose of ultrafine PM than healthy individuals
- Ultrafine particles pass rapidly into the circulatory system
- Ultrafine PM is more potent than fine or coarse PM towards inducing cellular damage

\[1 \text{ Wichman et al, 2000; 2Brown et al., 2002; 3Nemmar et al., 2001; 4Li et al., 2002}\]

In Germany, Diesels Actually 7 times More NOx Than Otto

Diesel Passenger Car Standards In The US, EU and Japan

- Current and Future Heavy Duty Diesel Standards in US, EU & Japan
- New Vehicles Standards Will Take Many Years To Have Full Effect: Must Address Existing Vehicles
  - They Will Be Around For Many Years
  - Retrofit Programs Are An Effective & Cost-Effective Solution
  - Low Sulfur Fuel Makes Filters Attractive

\[\text{Intriguing Health-Related Findings}\]
Health Impacts of Diesel in California

<table>
<thead>
<tr>
<th>Impacts Of Diesel PM</th>
<th>2.5</th>
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<tbody>
<tr>
<td>Deaths</td>
<td>2,900</td>
</tr>
<tr>
<td>Chronic Bronchitis</td>
<td>2,590</td>
</tr>
<tr>
<td>Hospital Admissions</td>
<td>2,790</td>
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<tr>
<td>Lower Lung Symptoms</td>
<td>95,400</td>
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<tr>
<td>Loss of Days Work</td>
<td>621,000</td>
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Annual

California Diesel Risk Reduction Program

- Target: Require PM Filters on All New & Most Existing Diesels (On & Off Road)
- Aiming for 90% Reduction in Total PM Emissions From 1.25 Million Engines
- Full Implementation By 2010
  - PM Traps
  - Low Sulfur Fuel
  - In Use Emission Testing
  - Alternative Fuels

Rest of the US

- EPA’s Target is Commitment For 180,000 Retrofits By End of 2003
- ~130,000 To Date
  - New York
  - Seattle
  - Texas
  - Others

Status of US EPA’s Voluntary Diesel Retrofit Program

Other Retrofit Efforts

- On & Off Road in Sweden
- London
- German Cities
- Switzerland
- Hong Kong
- Tokyo
- Other

New York City Retrofit Experience
**Swedish Retrofit Program**

All Trucks Above 3.5 Tons

Very Low Sulfur Fuel Dominates The Market

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**Retrofit PM Reduction Required in Tokyo**

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**Mobile Source PM**

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**Proposed Engine Standards – 2 Step Fuel Program**

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**PM tons / year**

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Potential Benefits of Non Road Rule (PM Only)

Avoided Incidences Per Year
Thousands

Non Road | Heavy Duty On Road

0 | 1,100
1 | 1,090
2 | 1,080
3 | 1,070
4 | 1,060
5 | 1,050
6 | 1,040
7 | 1,030
8 | 1,020
9 | 1,010

Premature Mortality
Chronic Bronchitis
Hospital Admissions, Pneumonia
Hospital Admissions, COPD
Hospital Admissions, Asthma
Hospital Admissions, Cardiovascular
Emergency Room Visits, Asthma

Conclusions
- Great Progress Has Occurred To Date in Reducing Motor Vehicle Pollution
- PM Remains A Major Concern
- Special Concerns With Diesel PM
  - Small Size
  - Toxicity
- Stringent New Diesel Standards and Low Sulfur Fuel Standards Spreading
- PM Filters Seen As Key To Control
- Non Road & Retrofit – Unfinished Agenda