Retrofit Emission Control Technologies for On-Road, Off-Road, and Stationary Diesel Engines

Manufacturers of Emission Controls Association

May 2000
Presentation Outline

- Introduction
- Background
- Retrofit Control Technologies
- Elements of a Retrofit Program
- Cost Effectiveness
- Conclusion
Introduction

- Diesel Engines Are a Major Source of NOx, PM, and Toxic Emissions
- Even with the Prospect of Tighter Emission Standards in the Future, Existing, High-Emitting Diesel Engines Will Be in Use for the Next 10 to 20 Years
- Retrofitting Existing Diesel Engines with Exhaust Control Technologies or Converting Diesel Engines to Natural Gas Are Available Strategies to Reduce Emissions
  - This Presentation Will Focus on the Exhaust Control Retrofit Strategy
Available Retrofit Technologies

- PM, CO, HC and Toxics
  - Diesel Oxidation Catalyst (DOC)
  - Diesel Particulate Filters (DPF)
  - Enhanced Combustion Modifications (e.g., cams, coatings, superchargers)
  - Crankcase Emission Controls
Available Retrofit Technologies (cont’d)

- NOx
  - Selective Catalytic Reduction
  - Lean NOx Catalyst Technology
  - Systems Strategies (e.g., engine modifications to reduce NOx plus PM exhaust controls)
Retrofit Experience

- Mining
- Materials Handling
- Truck and Bus
- Marine Vessels and Locomotives
- Stationary Diesel Engines
Diesel Oxidation Catalysts Are Efficient and Have Excellent Operating Experience

- Oxidation Catalyst Operating Experience
  - >20,000 Urban Buses in the U.S. and Europe
  - >6,000 HD Vehicles in Mexico
  - Hong Kong Is Retrofitting 2,000 Urban Buses
  - >250,000 Off-Road Engines
  - >1,500,000 Class 1 & 2 Vehicles (Pick-Ups)
Diesel Particulate Filters Are Efficient and Are Developing an Impressive Track Record

- Filter Operating Experience
  - Over 15,000 Systems Have Retrofitted to Vehicles Worldwide
  - Peugeot Will Offer Filter-Equipped LDVs in 2000
  - Over 10,000 Non-Road Engines Equipped (Both OE Installed and Retrofit)
SCR Has Been Used Successfully on Stationary Sources and Is Now Used for Mobile Sources

- SCR Operating Experience
  - 18 HD Trucks Demonstrated in Europe since 1995 with Mileage Exceeding 200,000 miles
  - Over 20 Marine Vessels since mid-1990s
  - Some Use on Locomotives
  - Several Off-Road Applications
Air Enhancement Technologies Can Be Used to Reduce Emissions on Existing Vehicles

- Electronic Supercharger Operating Experience
  - 250 Units Installed on Urban Buses in the U.S.
  - Installed on HD Vehicle Applications in the U.S., Canada, Mexico, England, Germany, France, Russia, Brazil, and New Zealand
Other Retrofit Options Can Be Used to Reduce Emissions on Existing Vehicles

- Heat Recuperator Combined with Catalyst Technology for Reductions in CO, HC, Toxics, NOx, and PM
  - Currently Being Demonstrated in California
Overview of Retrofit Programs

- U.S. EPA Mandatory Urban Bus Retrofit/Rebuild Program
- U.S. EPA Voluntary Retrofit Program
- ARCO/ARB/CEC Low Sulfur Demonstration
- Sweden’s Clean Cities Retrofit Program
- London Bus and Truck Program
New York City Retrofit Demonstration Program

NESCAUM/NEP/MECA Nonroad Equipment Pilot Demonstration Program

Boston Central Artery/Tunnel Project Retrofit Program

German Central City/Tunnel Clean Diesel Program
Overview of Retrofit Programs (cont’d)

- Retrofit of Tunnel Construction Equipment in Germany, Austria and Switzerland
- Retrofit Programs in Korea, Taiwan, Mexico, El Salvador, Nicaragua, and Hong Kong
- Filter Program Started In Paris
- SCAQMD - School Bus Program Starting Up
- SCAQMD - Off-Road Program In Planning Phase
Elements of a Proper Retrofit Control Program

- **Size**
  - Properly Sized Control Technologies Ensure Low Backpressure and Maximum Performance

- **Vehicle Integration**
  - An Important Aspect of Control Technology Retrofit, but Has Been Successfully Accomplished on Both On- and Off-Road Vehicles (muffler replacement or in-line installation)

- **Fuel Quality**
  - For PM Control, <10 ppm Allows for Maximum Emission Control Performance and Best Filter Regeneration Characteristics
  - Oxidation Catalysts Can Be Formulated to Minimize Sulfation, but at the Expense of Some Reduced Emission Control Performance
  - Some Technologies Can Be Applied to Certain Applications Using Fuels with Higher Sulfur Levels
Current Cost Effectiveness

- **Filter Technology**
  - Depends on Engine Size -- Approximately $10 - $20/bhp
  - 2-4 Hours for Installation
  - Ash Removal at ~60,000 Miles

- **Oxidation Catalyst Technology**
  - Approximately $1,000 - $3,000 per Vehicle Depending on Type of Vehicle Integration
  - 2 Hours for Installation
  - No Maintenance
Current Cost Effectiveness (cont.)

- SCR
  - Approximately ~$20,000 - $30,000 per Vehicle Assuming a Fleet Operator Equips a Number of Vehicles
  - 2 Days for Installation
  - Reagent Consumed at 6% of Fuel Consumption (depending on conversion efficiency, engine type, etc.)

- MECA Is Currently Carrying Out an Independent Cost Study

- Costs for Filters, Oxidation Catalysts and SCR Will Decrease as Sales Volumes Increase
Filter System Retrofitted to a Truck
Filter System Retrofitted to a Bus
Filter System Retrofitted to a Bus
Filter System Retrofitted to a Refuse Truck
Direct Fit In-line Converter
Integrated Converter Muffler
Both Oxidation Catalysts and Diesel Particulate Filters Have Been Extensively Retrofitted to This Type of Mining Vehicle
Both Oxidation Catalysts and Diesel Particulate Filters Have Been Extensively Retrofitted to This Type of Mining Vehicle

ST8-B Scooptram
Testing of An Oxidation Catalyst on a FEL
Central Artery/Tunnel Project (Big Dig)

Filter System
Conclusions

● Existing Heavy-Duty Diesel Engines Are a Significant Source of NOx, PM, and Toxic Emissions

● A Variety of Demonstrated Retrofit Technologies Are Available to Significantly Reduce PM, NOx, HC, CO, Toxic, Smoke and Odor Emissions from Existing HDDEs

● A Growing Number of Retrofit Programs Are Being Successfully Implemented