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# Fuel Sulfur: The Effects on Conventional and Future Emission Control Technologies

Partnership for Clean Fuels and Vehicles

Western Hemisphere Ad Hoc Meeting

San Diego

June 26-27, 2003

Manufacturers of Emission Controls Association

([www.meca.org](http://www.meca.org))



# *Presentation Outline*

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- Introduction
- Impact of Fuel Sulfur on Catalyst Emission Control Technology
  - Gasoline Technology
    - Conventional and Future
  - Diesel Technology
    - Conventional and Future
- U.S. Fuel Sulfur Levels
- Conclusions

# *Introduction*

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- Fuel Quality Is an Integral Part of a Complete Emission Control System for Both Gasoline and Diesel-Powered Vehicles
- Although Other Fuel Constituents Affect Engine-Out Emissions, Fuel Sulfur Is the Single Most Important Constituent for Catalyst-Based Emission Control Technology

## ***Introduction (cont.)***

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- Sulfur in Fuel Adversely Affects the Emission Control Performance of All Catalyst-Based Emission Control Technologies
- Near Zero Sulfur Levels Would Enable the Application of the Full Range of Control Technologies and Would Permit Each Technology to Be Optimized for Maximum Emission Control Performance

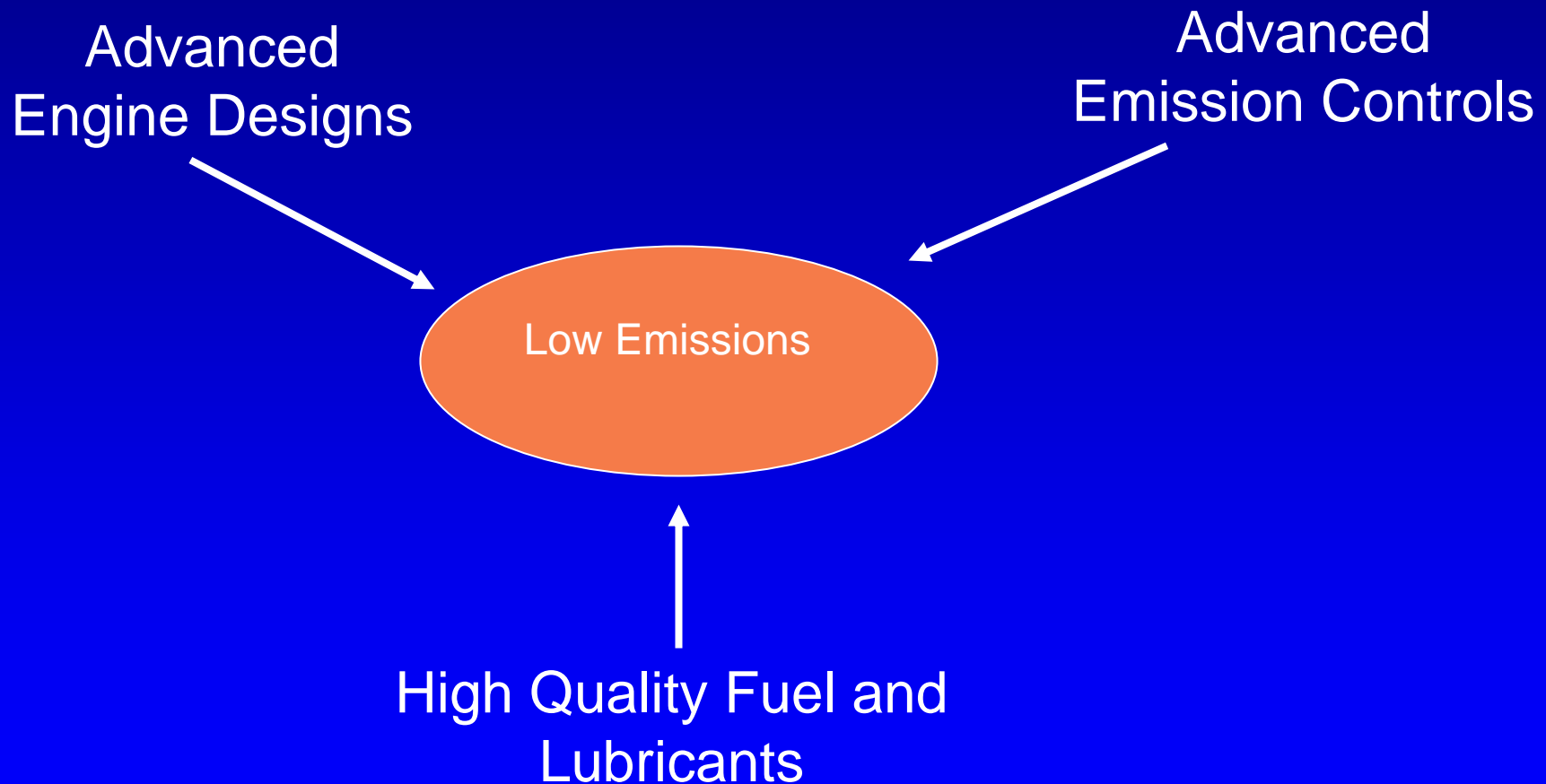
## *Introduction (cont.)*

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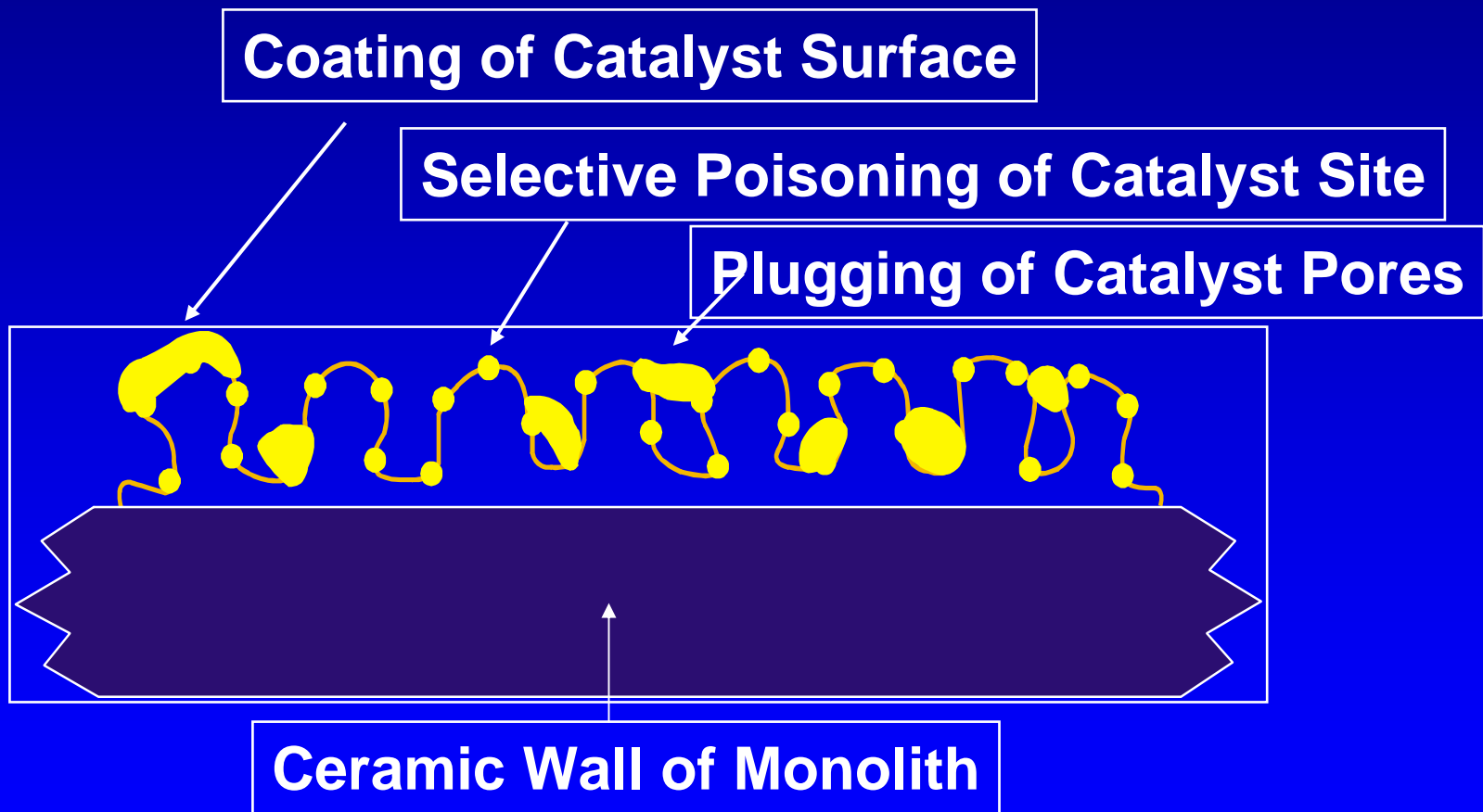
- The Appropriate Sulfur Limits Are Determined by Several Factors
  - The level of the standards
  - The test cycle
  - The durability requirements
  - The technology, or combination of technologies, that will be utilized
  - Climatic conditions

# Meaningful Emission Control Reductions Requires a Systems Approach

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# Selective and Non-Selective Poisoning



# ***Summary of Influence of Fuel Sulfur on Diesel Exhaust Emission Control Devices***

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## **● *Control Technology***

- TWC
- Oxidation Catalyst
- Lean NOx Catalyst
- SCR with Urea
- Catalytic Filters
- NOx Adsorbers

## **● *Sulfur Effects***

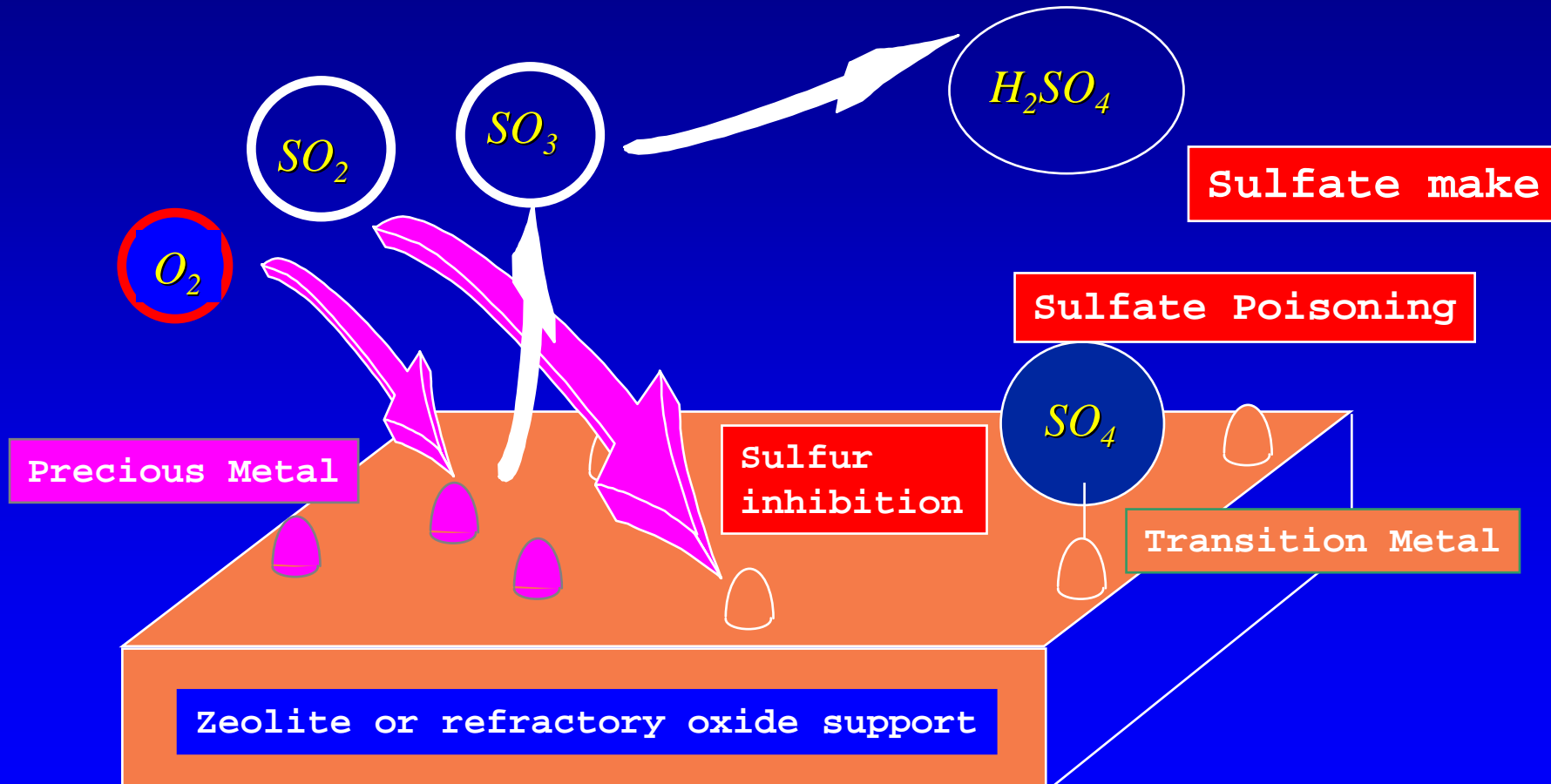
- Sulfur Inhibition
- Sulfur Inhibition, Sulfation
- Sulfur Inhibition, Sulfation
- Sulfur Inhibition, Sulfation
- Sulfur Inhibition, Sulfation
- Extreme Sulfur Inhibition

***All Catalyst Technologies***

***Adversely Affected***

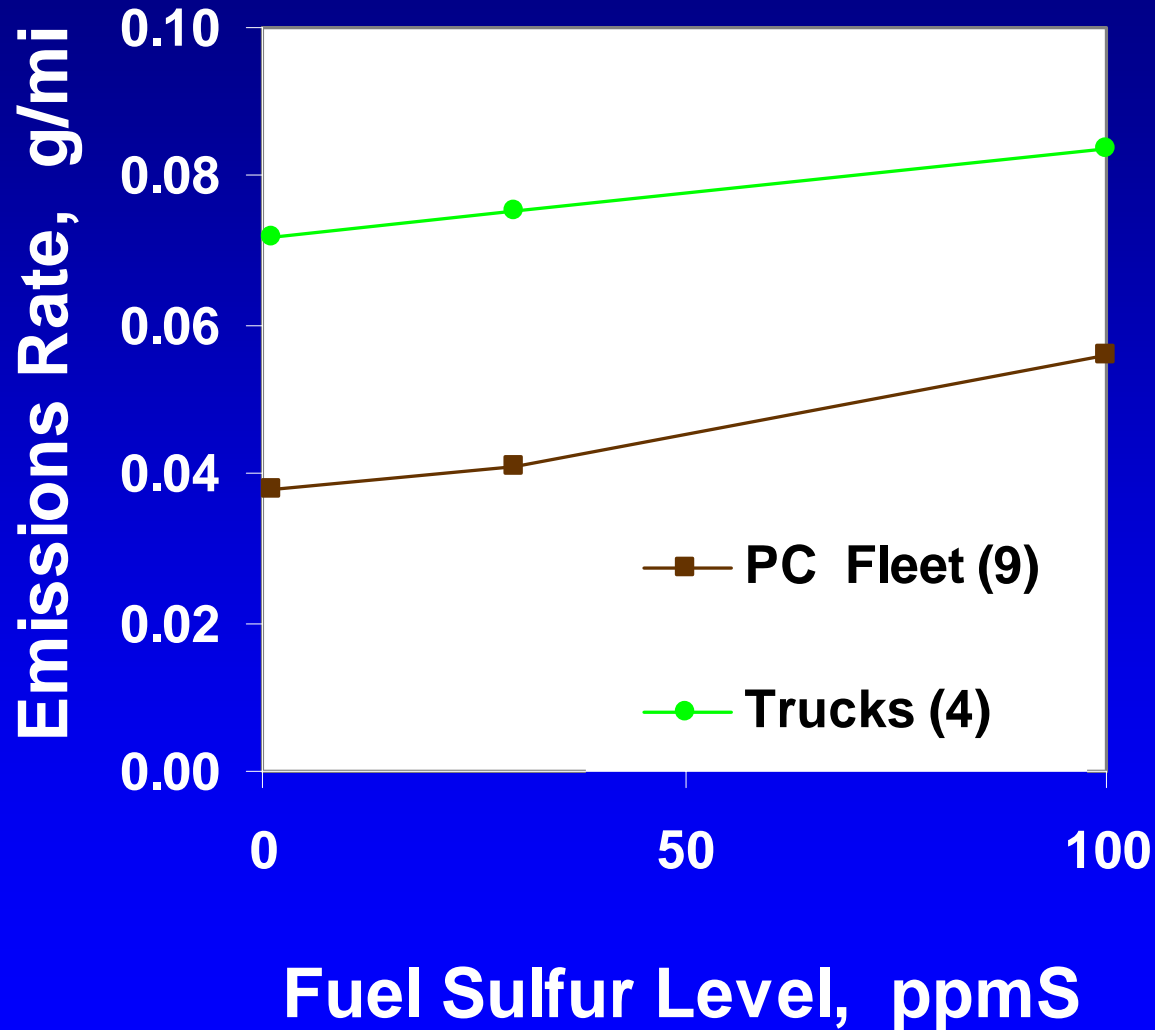


# Sulfur Effects



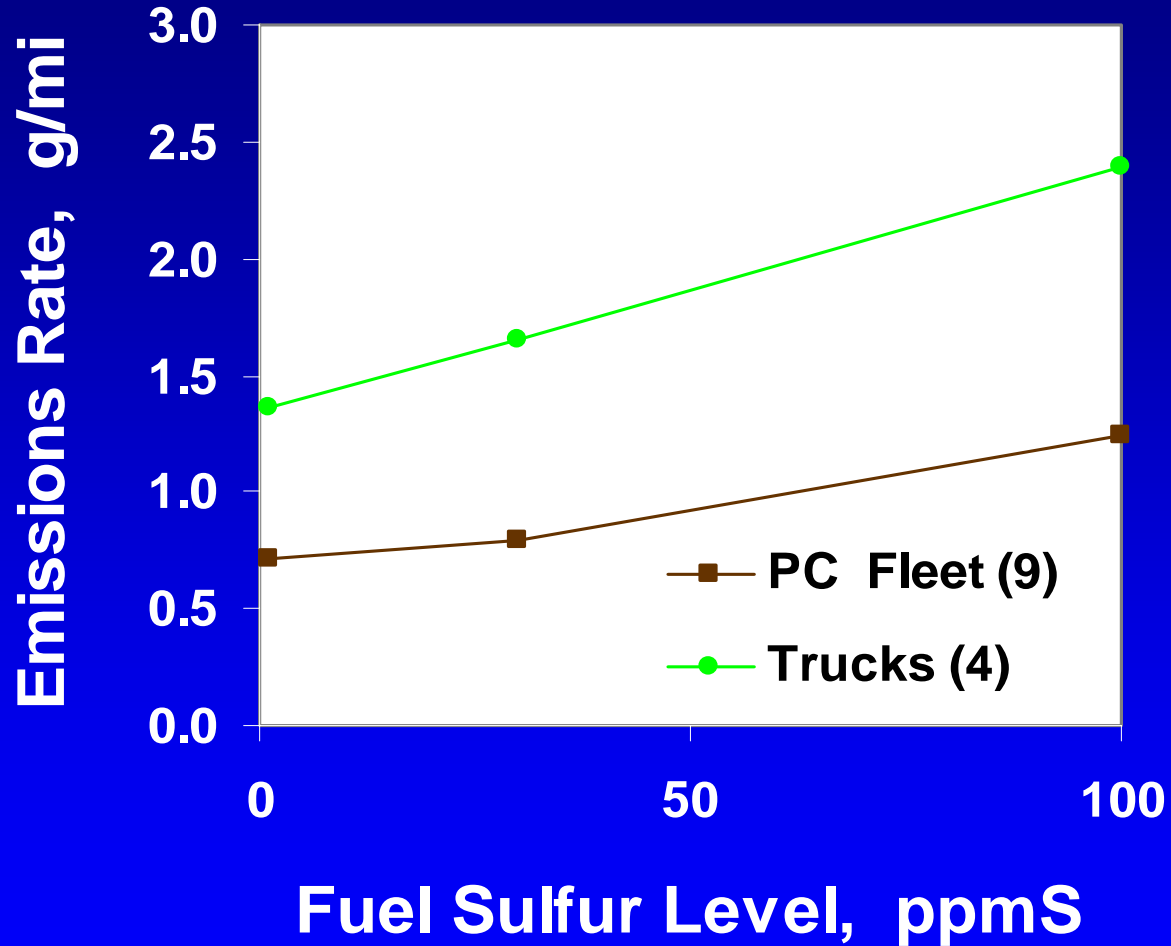
# Gasoline Sulfur Effects

## NMHC



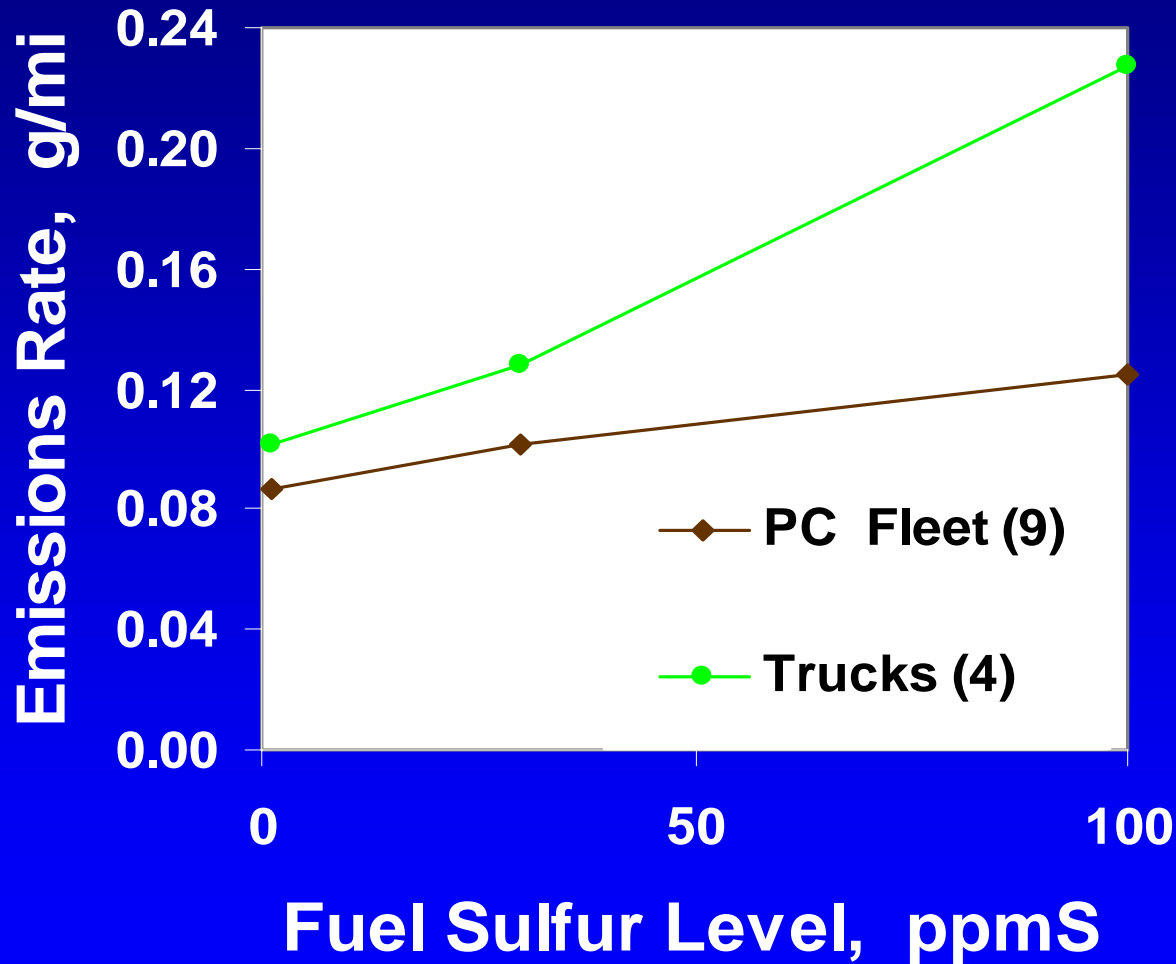
# Gasoline Sulfur Effects

## CO



# Gasoline Sulfur Effects

## NOx

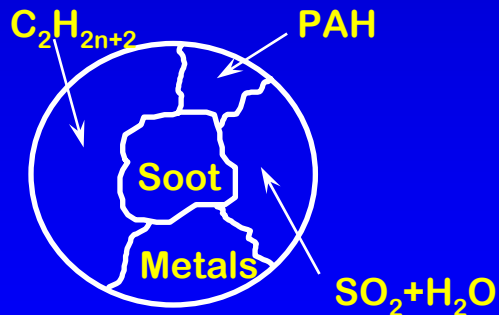
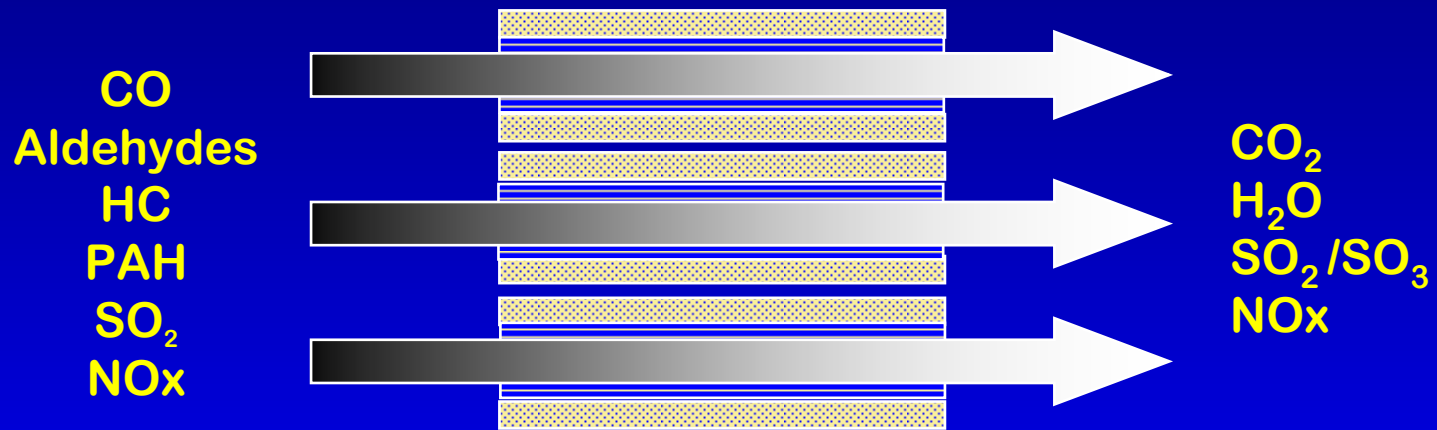


## *Emerging and Future Technologies*

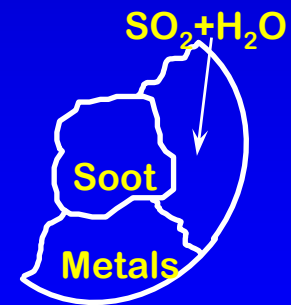
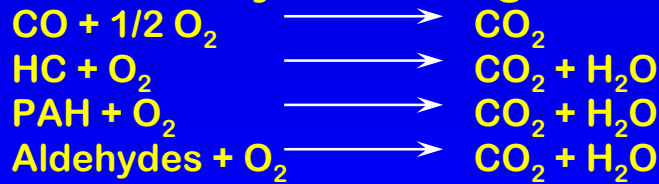
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- Diesel Oxidation Catalysts
- Diesel Particulate Filters
- NOx Adsorbers for Diesel and Lean-Burn Gasoline
- Selective Catalytic Reduction for Diesel

# Diesel Oxidation Catalyst

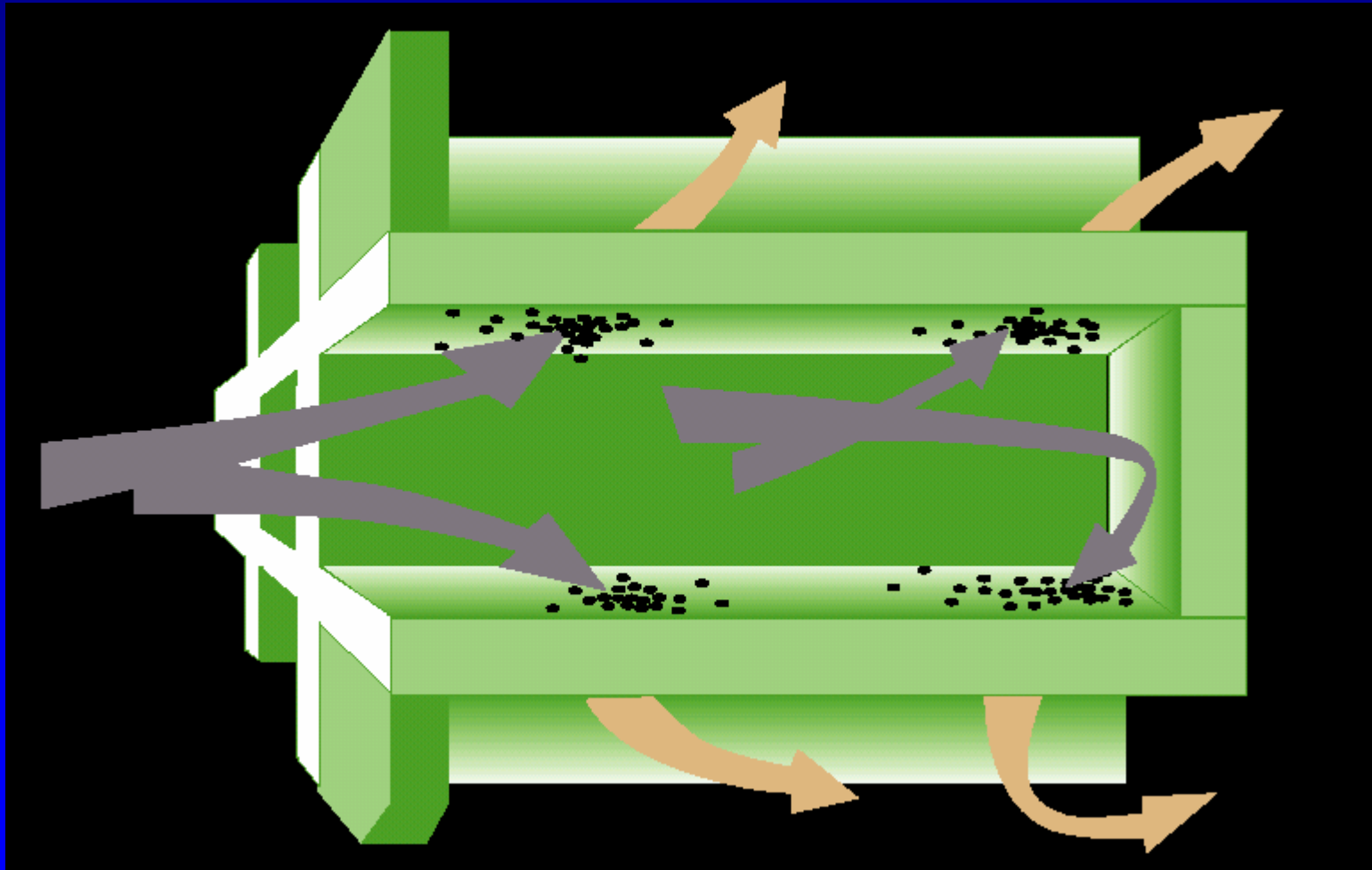


Flow through monolith  
with catalytic coating



# Diesel Particulate Filter

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# *Filter from Bus Application*

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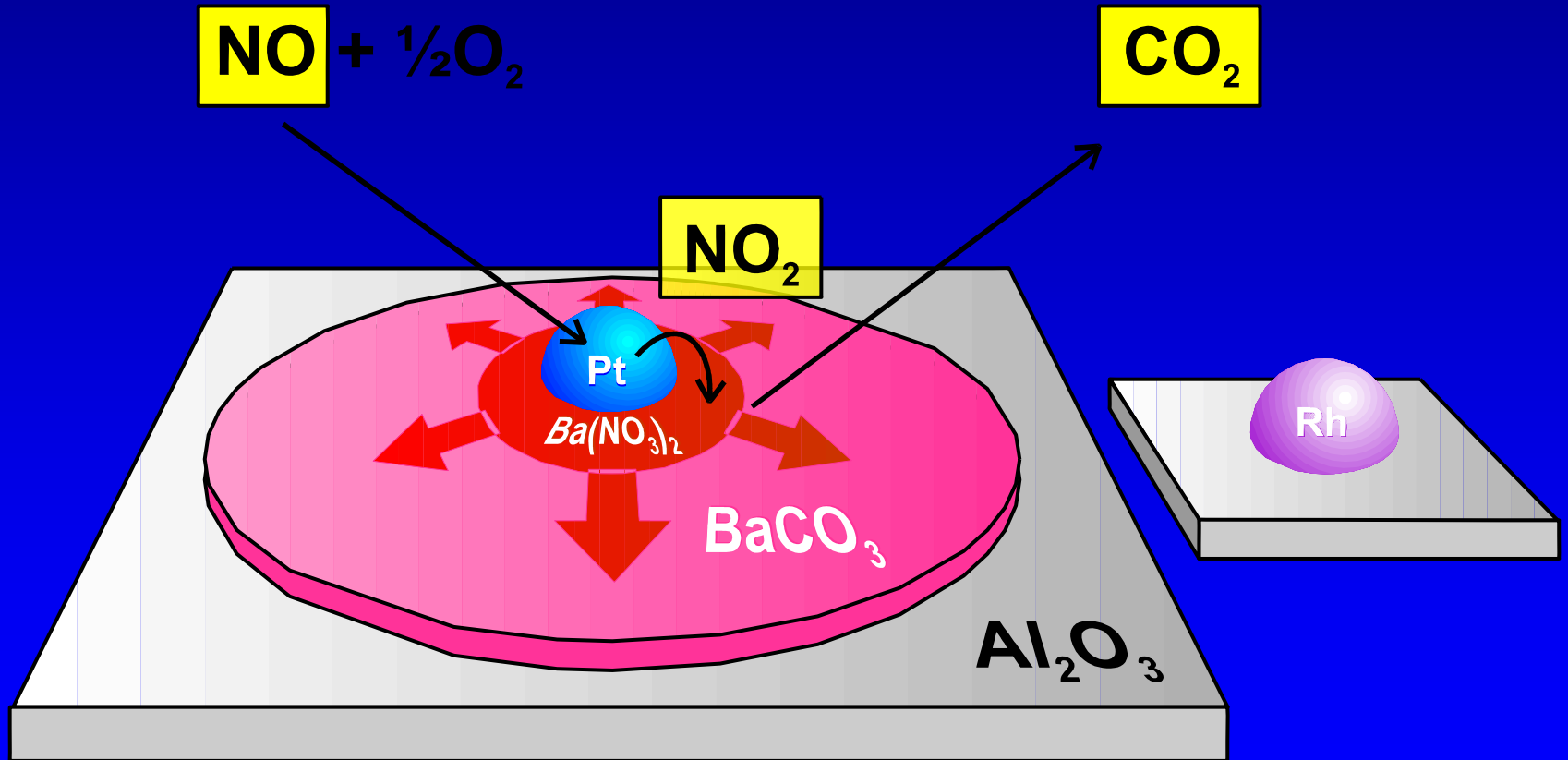
**Filter Inlet Section**



**Filter Outlet Section**

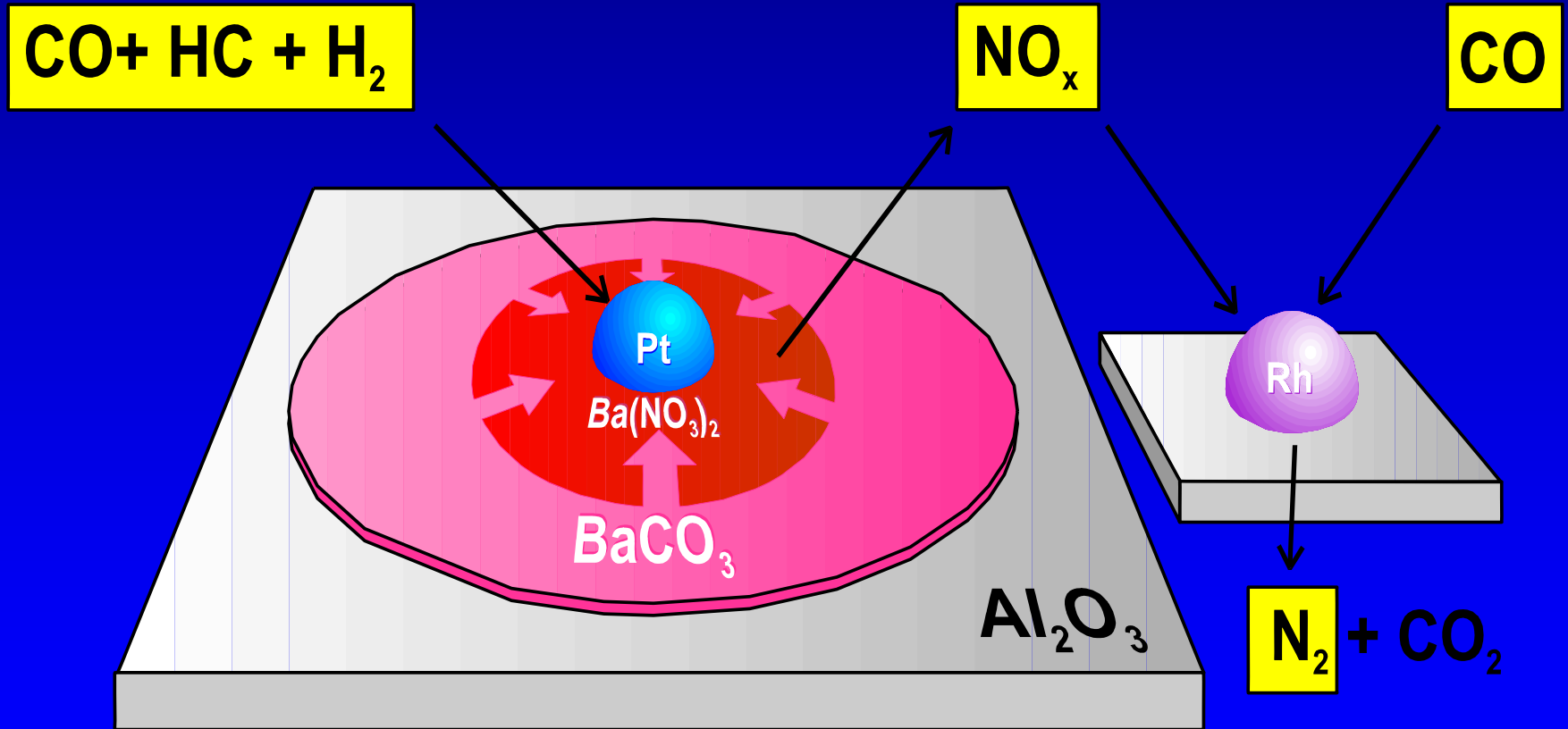
# NOx Traps

Lean Conditions



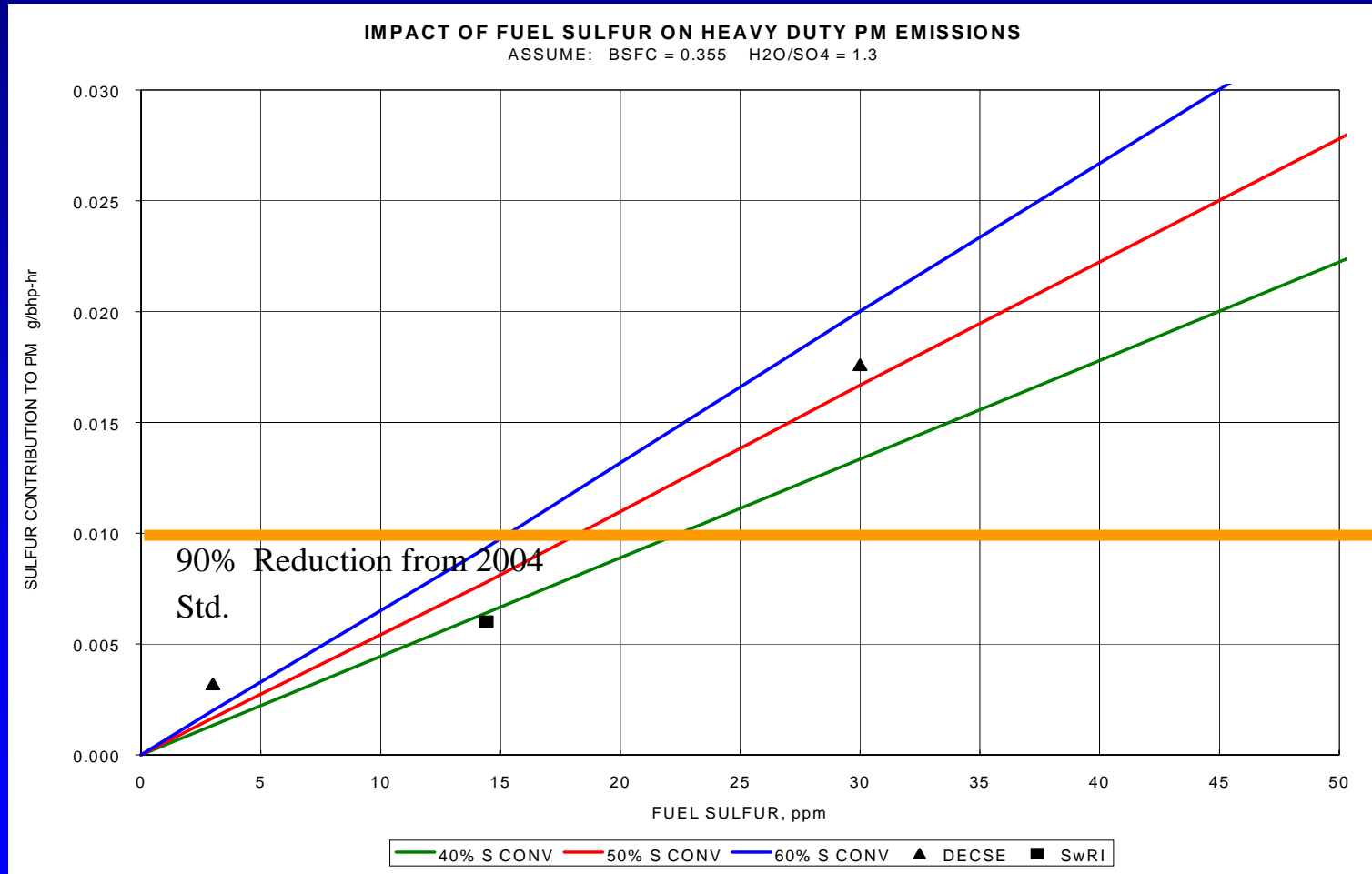
# NOx Traps

Rich Conditions

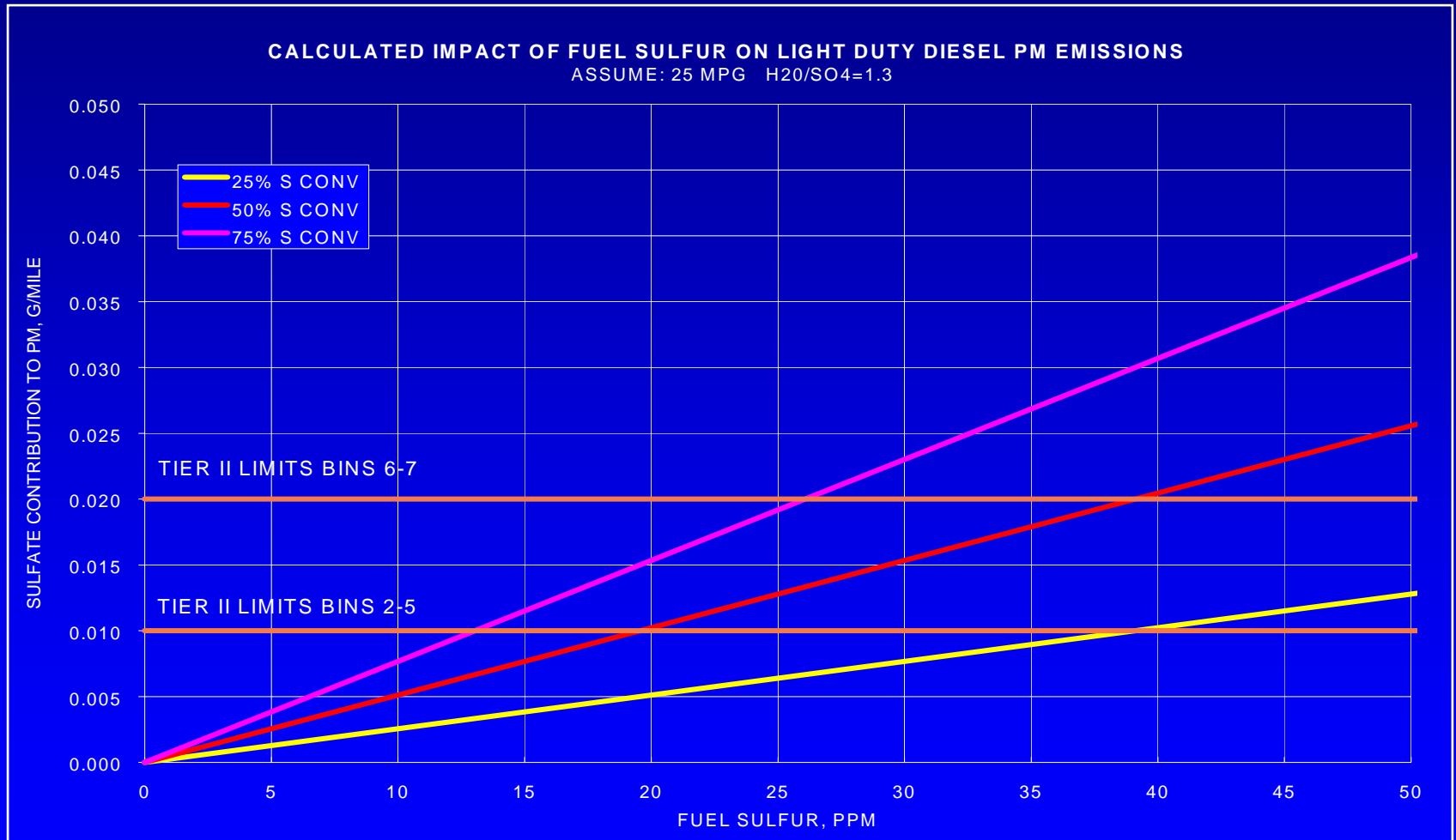




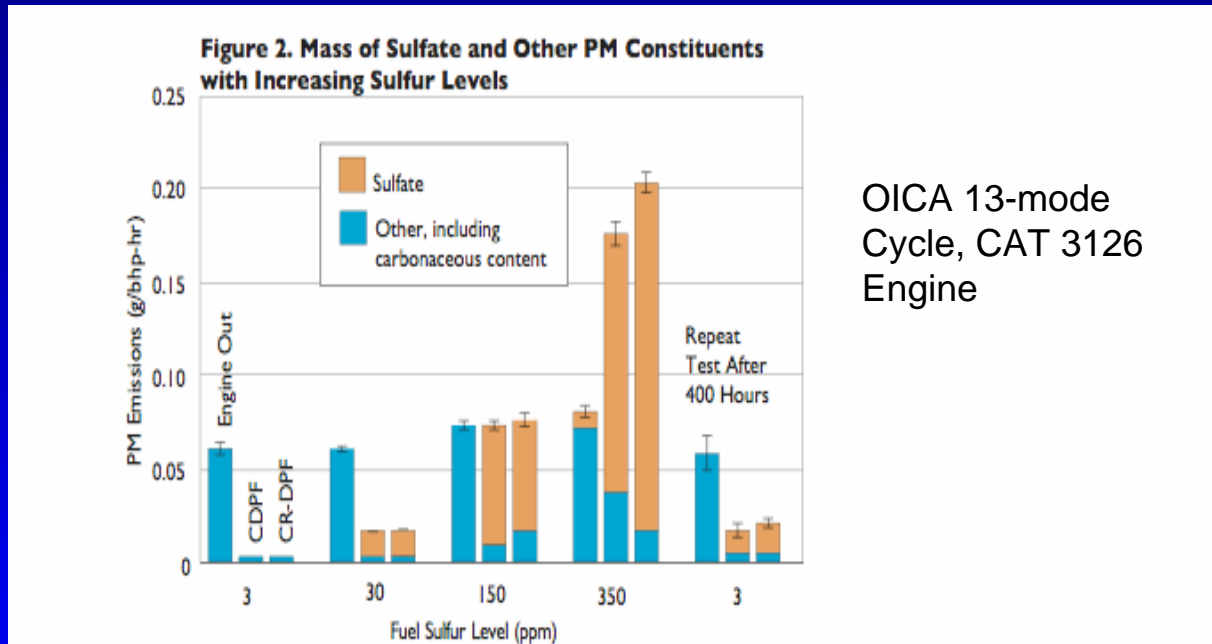
# Impact of Diesel Sulfur on Heavy-Duty PM Emissions



# Impact of Sulfur on Light-Duty PM Emissions



# The DECSE Study Showed That Low Sulfur Diesel Is Critical to Achieving a 0.01 g/bhp-hr PM Standard



OICA 13-mode  
Cycle, CAT 3126  
Engine

**95% filtration efficiency at 3 ppm sulfur**  
**74% filtration efficiency at 30 ppm sulfur**

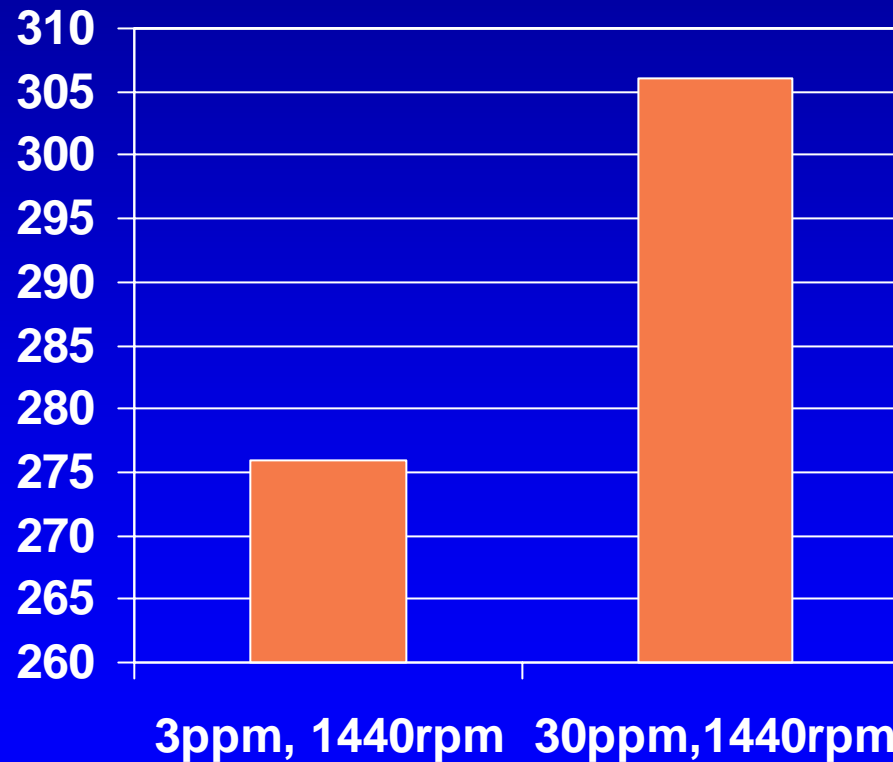
From DOE website: Diesel Emission Control - Sulfur Effects;  
Sponsored by DOE, EMA, MECA, and National Labs



# Effect of Catalyst Efficiency Loss due to Sulfur on Diesel Particulate Filters

The Increase in Balance Point Temperature Jeopardizes Reliability and Durability

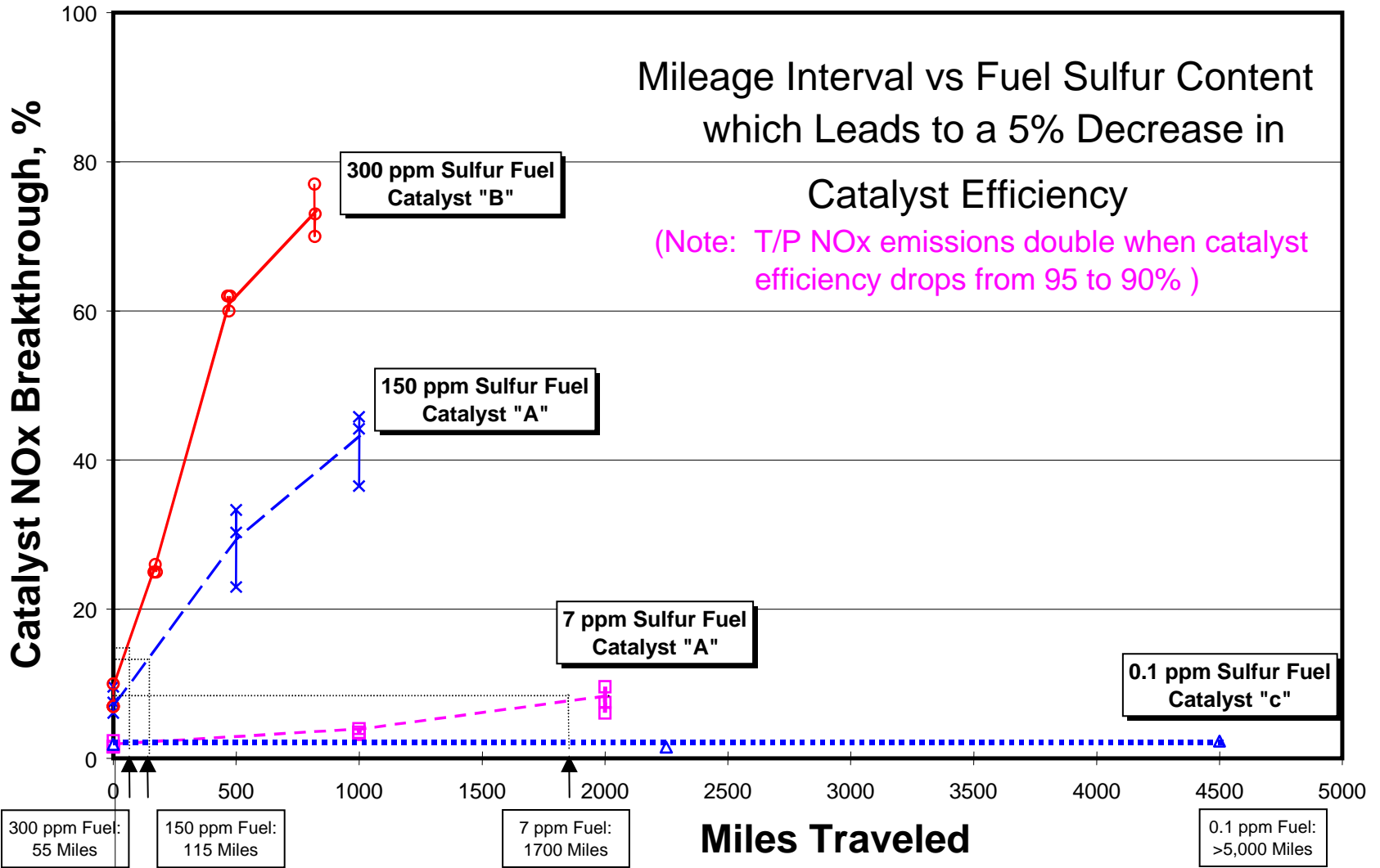
Balance Point Temperature (oC)



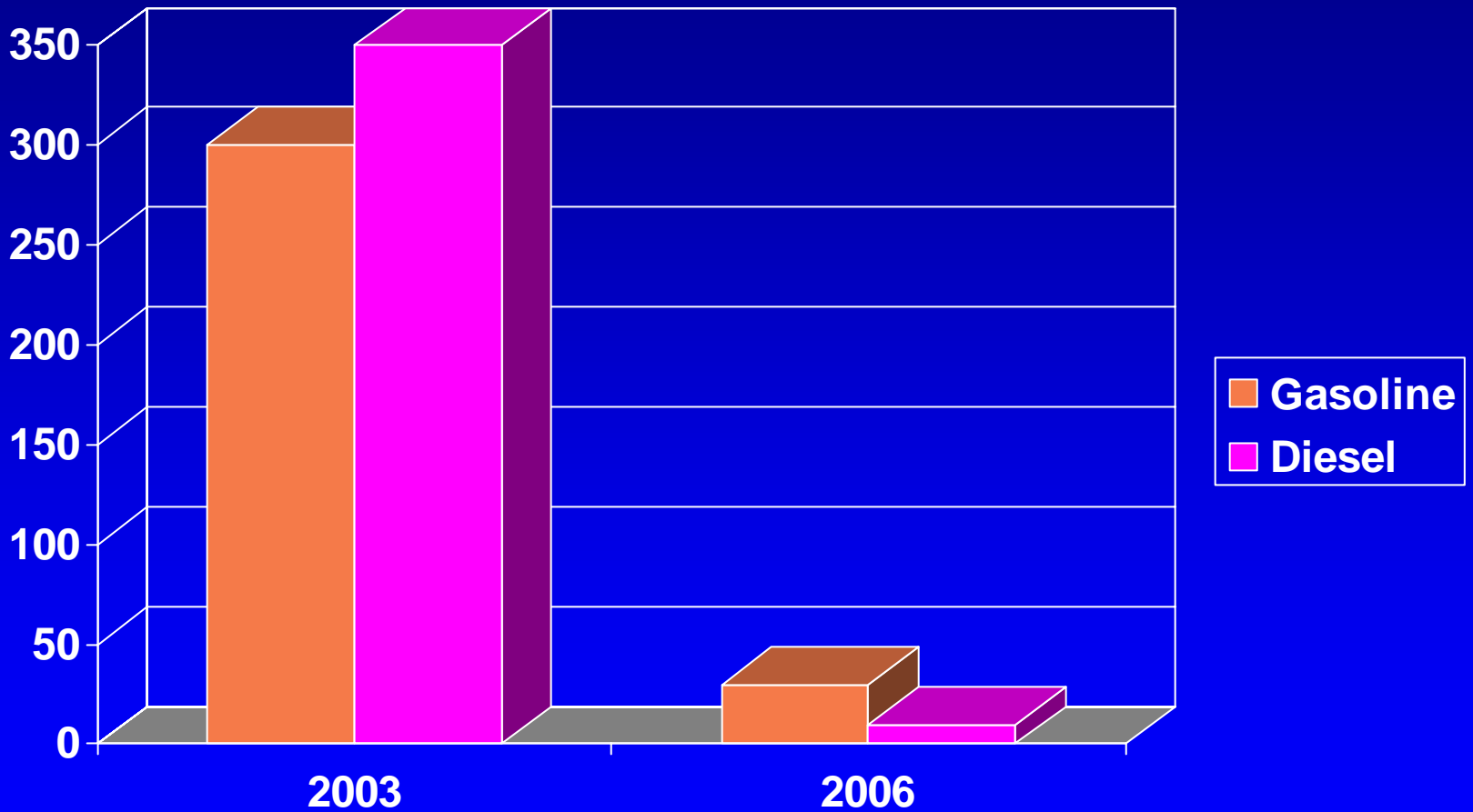
Source:DECSE



# Sulfur Significantly Affects NOx Adsorber Catalyst Efficiency



# U.S. Fuel Sulfur Levels (ppm)



# Conclusions

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- Fuel Quality Is an Integral Part of a Complete Emission Control System for Both Gasoline- and Diesel-Powered Vehicles
- Using a Systems Approach with Ultra-Low Sulfur Fuel, Cars, Trucks, and Buses Will Emit 99% Less Pollution As Compared to Vehicles in the 1960s
- Although Other Fuel Constituents Affect Engine-Out Emissions, Fuel Sulfur Is the Single Most Important Constituent for Catalyst-Based Emission Control Technology
- The Ultimate Solution to Significantly Reducing Emissions from Vehicles Requires a Systems Approach Utilizing Advanced Engine Designs, Advanced Integrated Emission Control Technology, and Low Sulfur Fuel
- Eventual Goal for Both Gasoline and Diesel Fuel Should Be Near Zero Sulfur Levels (<10 ppm), With Sulfur Reduced to The Maximum Level Feasible During the Interim