
*Diesel Fuel Quality and Sulfur Effects on
Catalyst-Based Exhaust Emission Controls:*

Manufacturers of Emission Controls Association

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Presentation Outline

- Introduction
- Impact of Fuel Sulfur on Catalyst Emission Control Technology
 - Noble Metal Function
 - NO_x Control Technology
 - PM Control Technology
- Conclusions



Introduction

- 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
- Sulfur in Diesel Fuel Adversely Affects the Emission Control Performance of All Catalyst-Based Emission Control Technologies

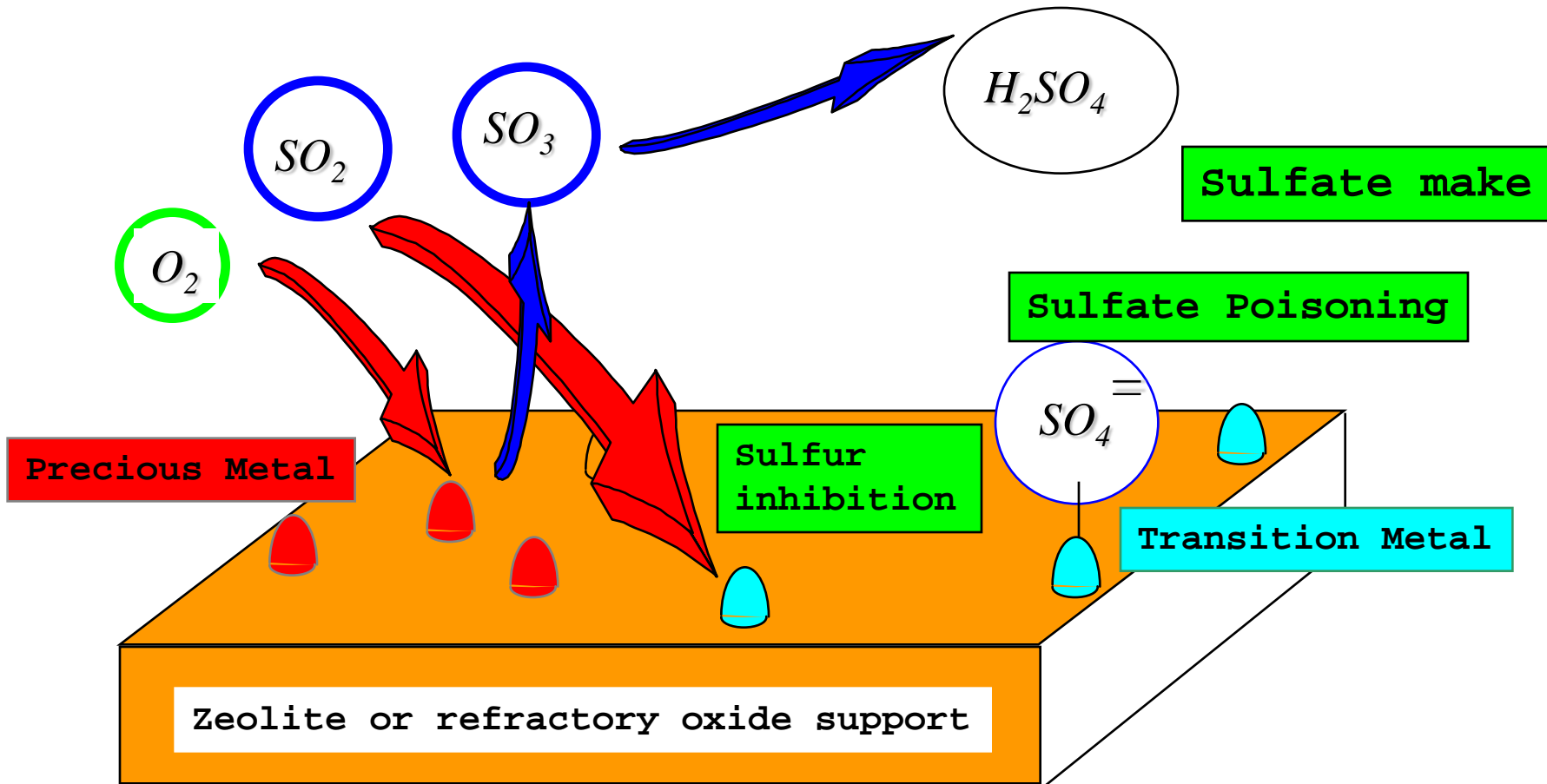


Introduction (cont.)

- Near Zero Diesel 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
- EPA Has Proposed Phase 2 On-Road HDE Standards of 0.2 g/bhp-hr NO_x and 0.01 g/bhp-hr Particulate to Take Effect in the 2007 Timeframe
- Fuel Sulfur Levels Will Be Instrumental in Meeting These Aggressive Targets



Sulfur Effects

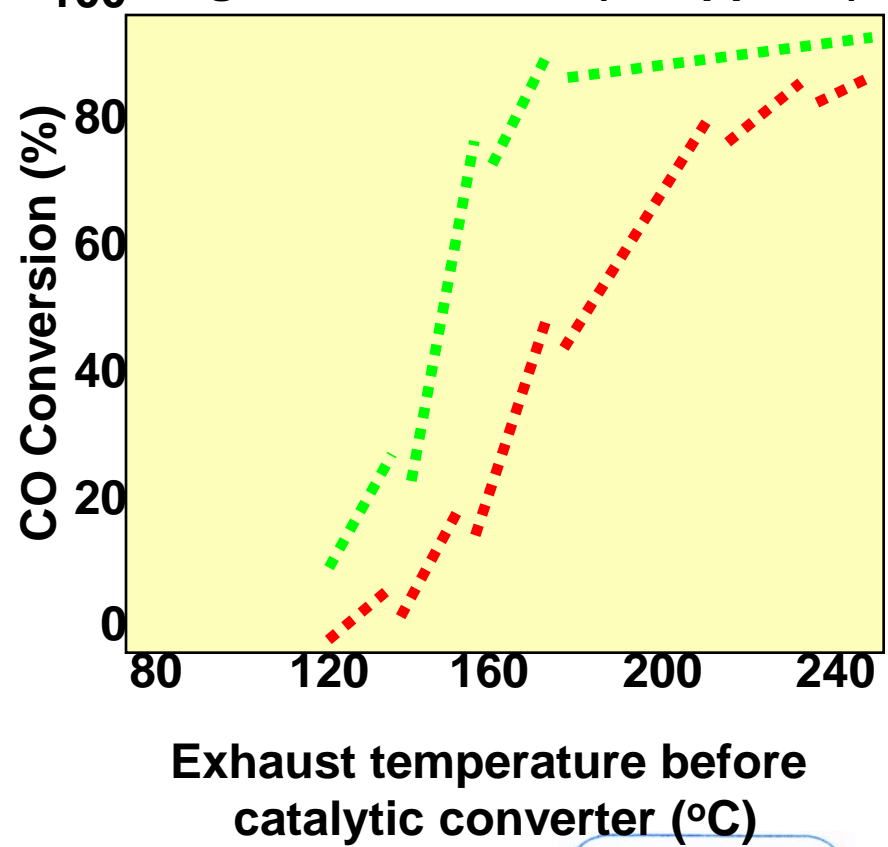
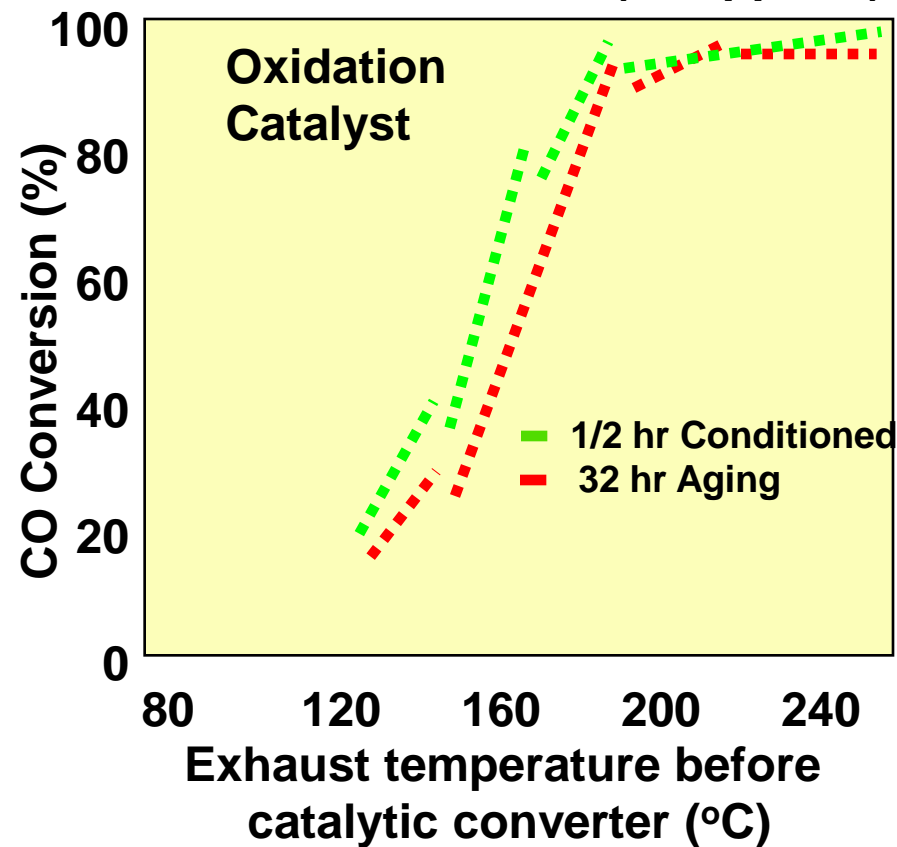


Noble Metal Function: Sulfur Increases Light-Off Temperature and Reduces Peak Conversion

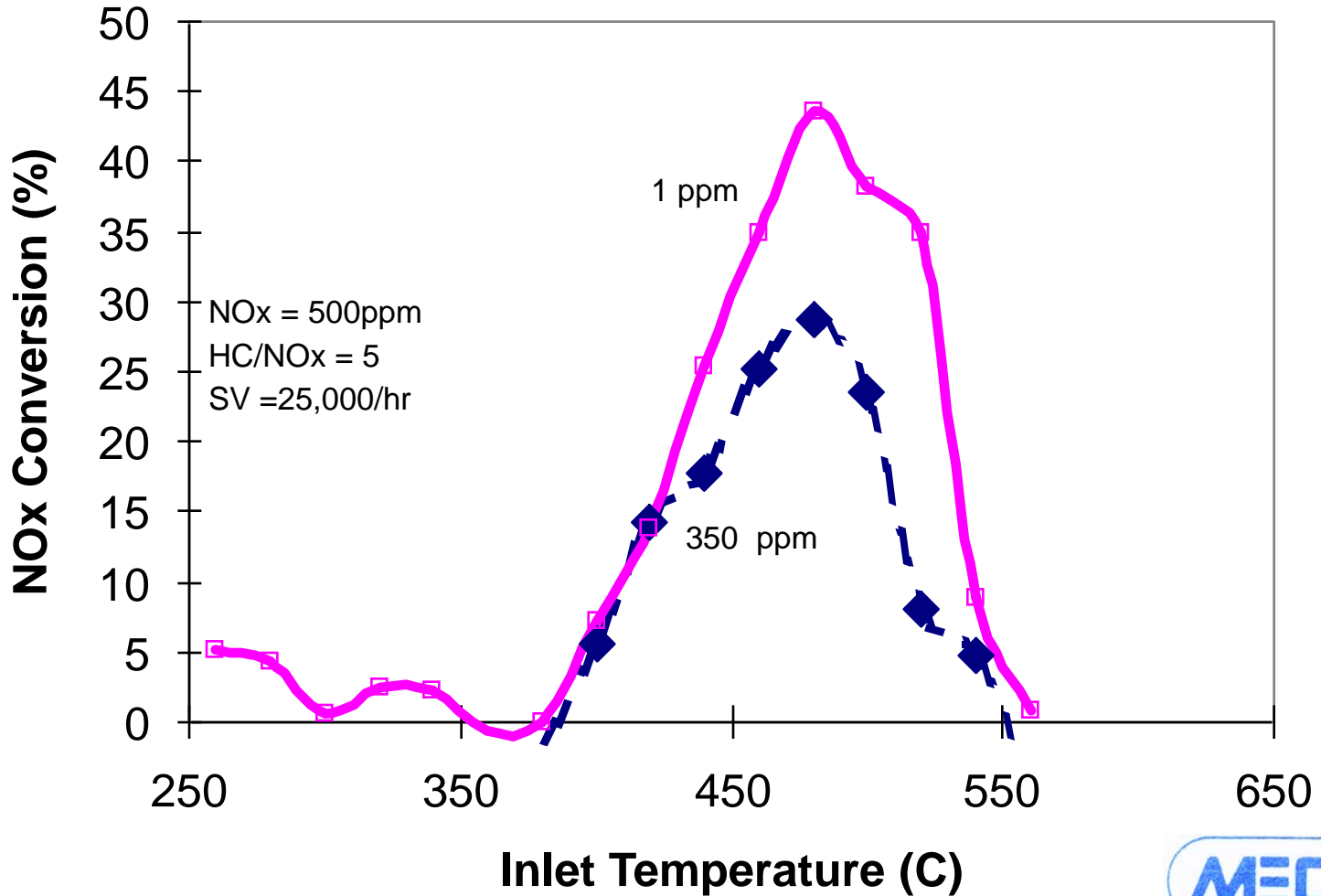
Test procedure: Engine test bench, partial load, 1.9 L TDI engine

Sweden Diesel fuel (<10 ppm S)

100 Regular Diesel fuel (350 ppm S)



Sulfur Adversely Affects Non-Precious Metal Lean NOx Catalysts

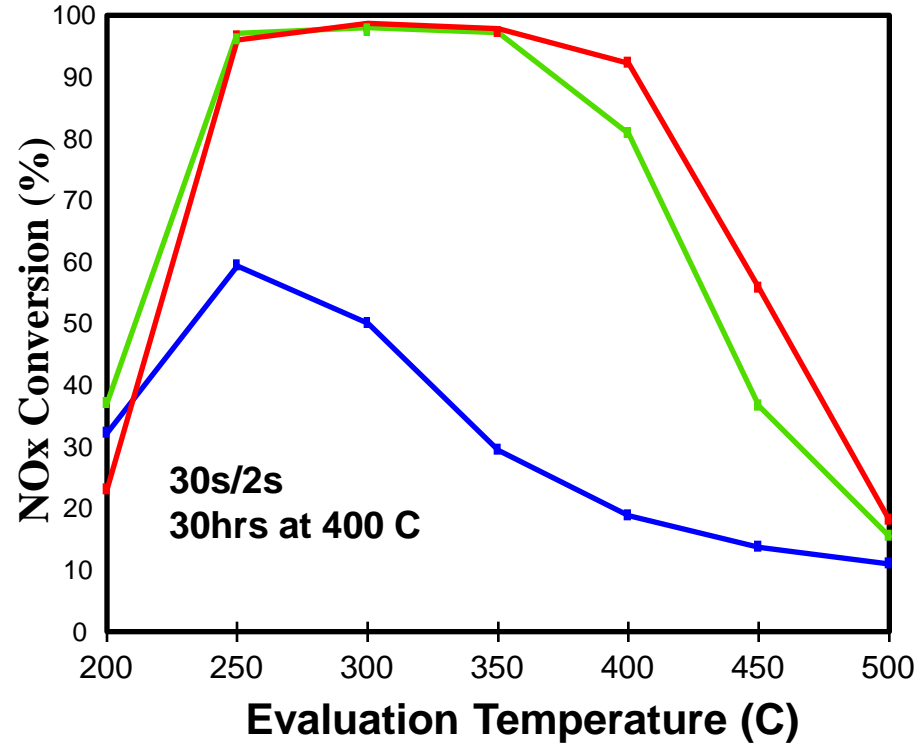
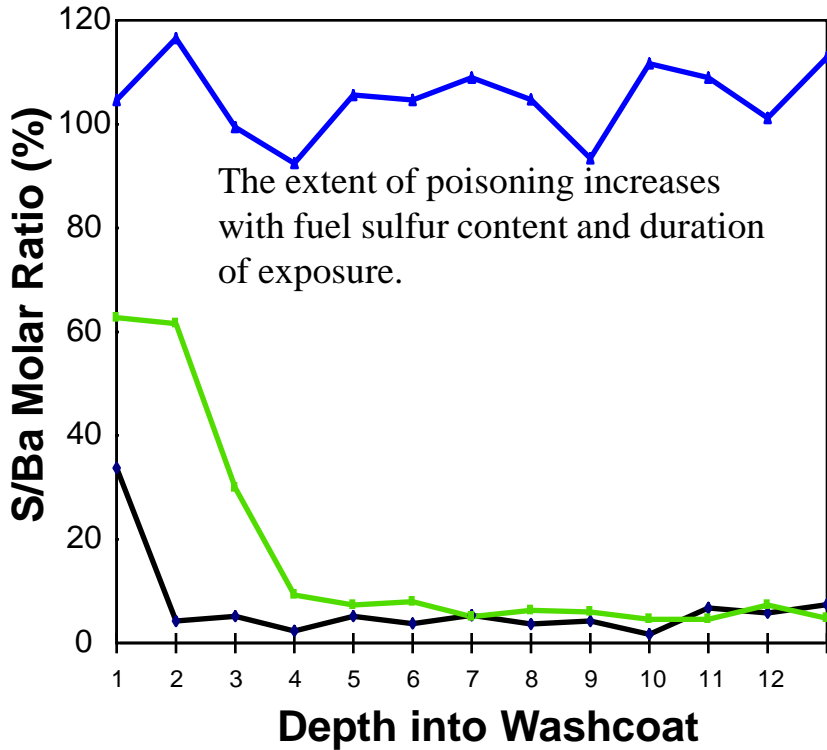


NOx Adsorbers: Sulfur Effects

- Sulfur Poisoning and Inhibition
 - Inhibits Conversion of Unregulated Emissions (e.g. toxic HC emissions)
 - Prevents NOx Conversion
 - Increases Fuel Economy Penalty
- Sulfate Make



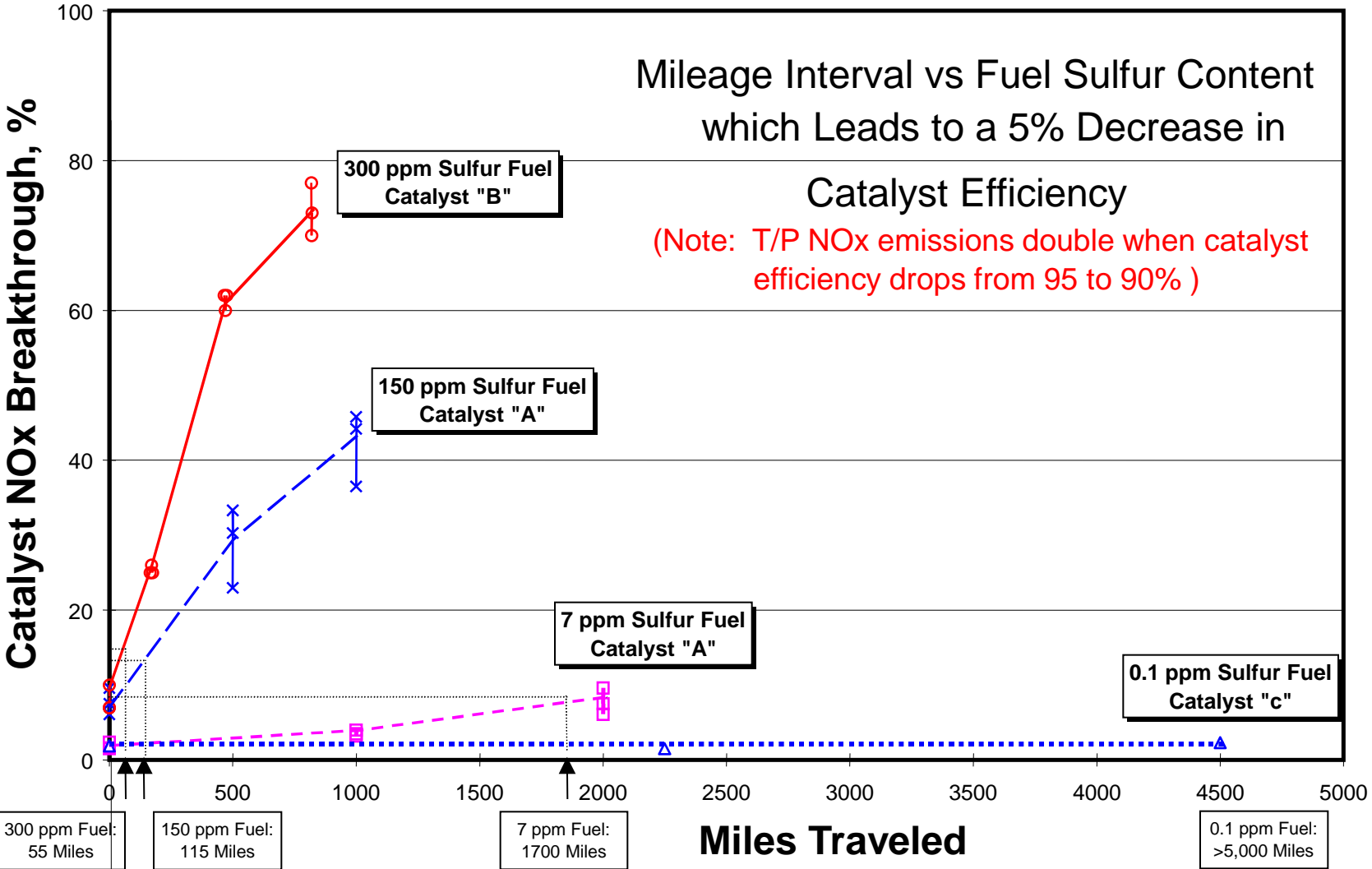
Sulfur Poisons NOx Adsorbers Storage Sites



■ 200 ppm
 ■ 100 ppm
 ■ 40 ppm
 ■ 0 ppm
 equivalent fuel sulfur content

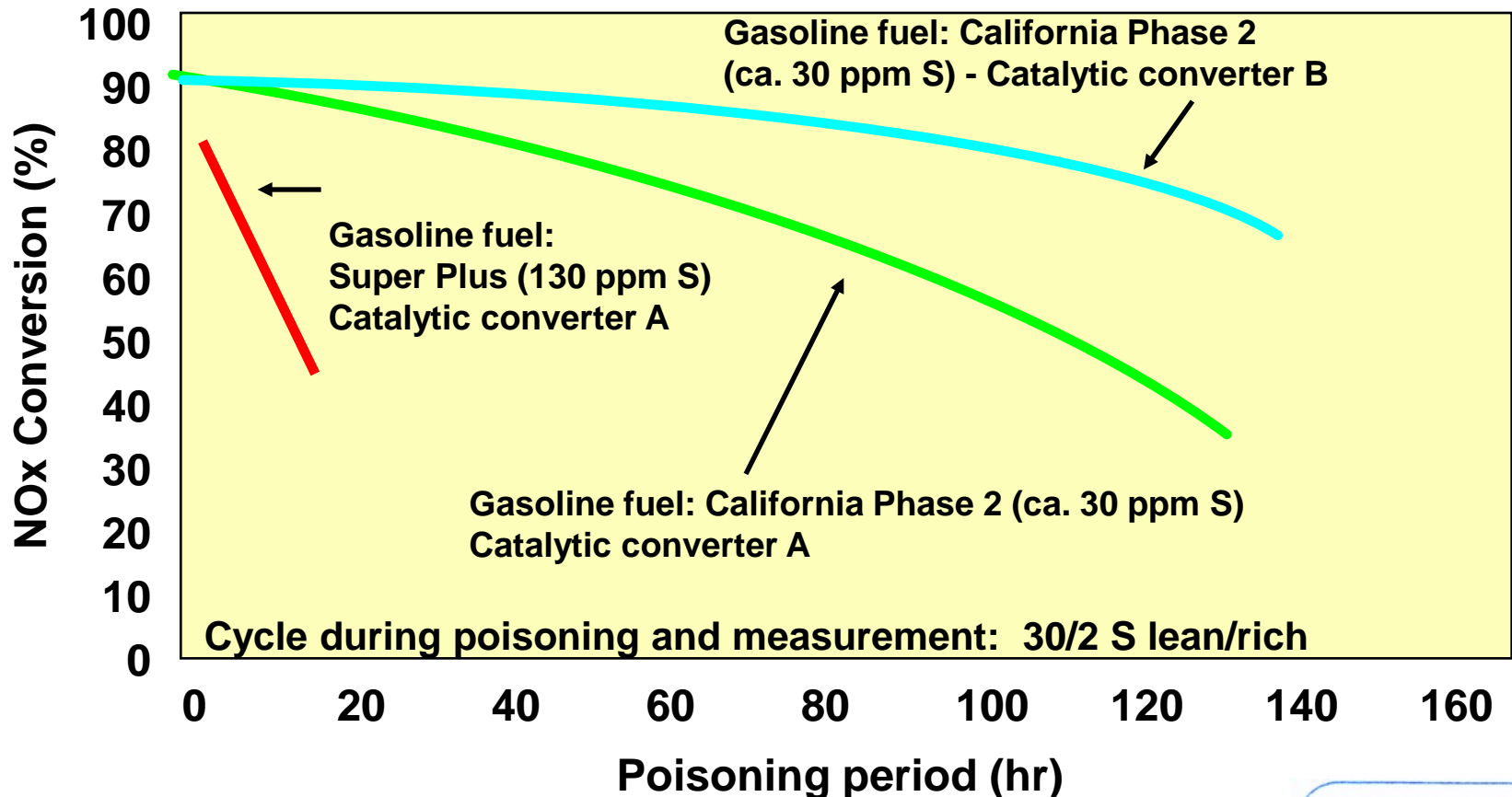


Low Levels of Sulfur Are Needed to Maintain NOx Adsorber Catalyst Efficiency



Advances in NOx Adsorber Sulfur Resistance

Test Procedure: Engine test bench, partial load operation



Catalytic Particulate Filters: Sulfur Effects

- Sulfur Poisoning and Inhibition
 - Inhibits Control of Unregulated Emissions
 - Increases Regeneration Temperature
- Formation of Sulfate

Catalytic Filter Regeneration Is Adversely Affected by Sulfur

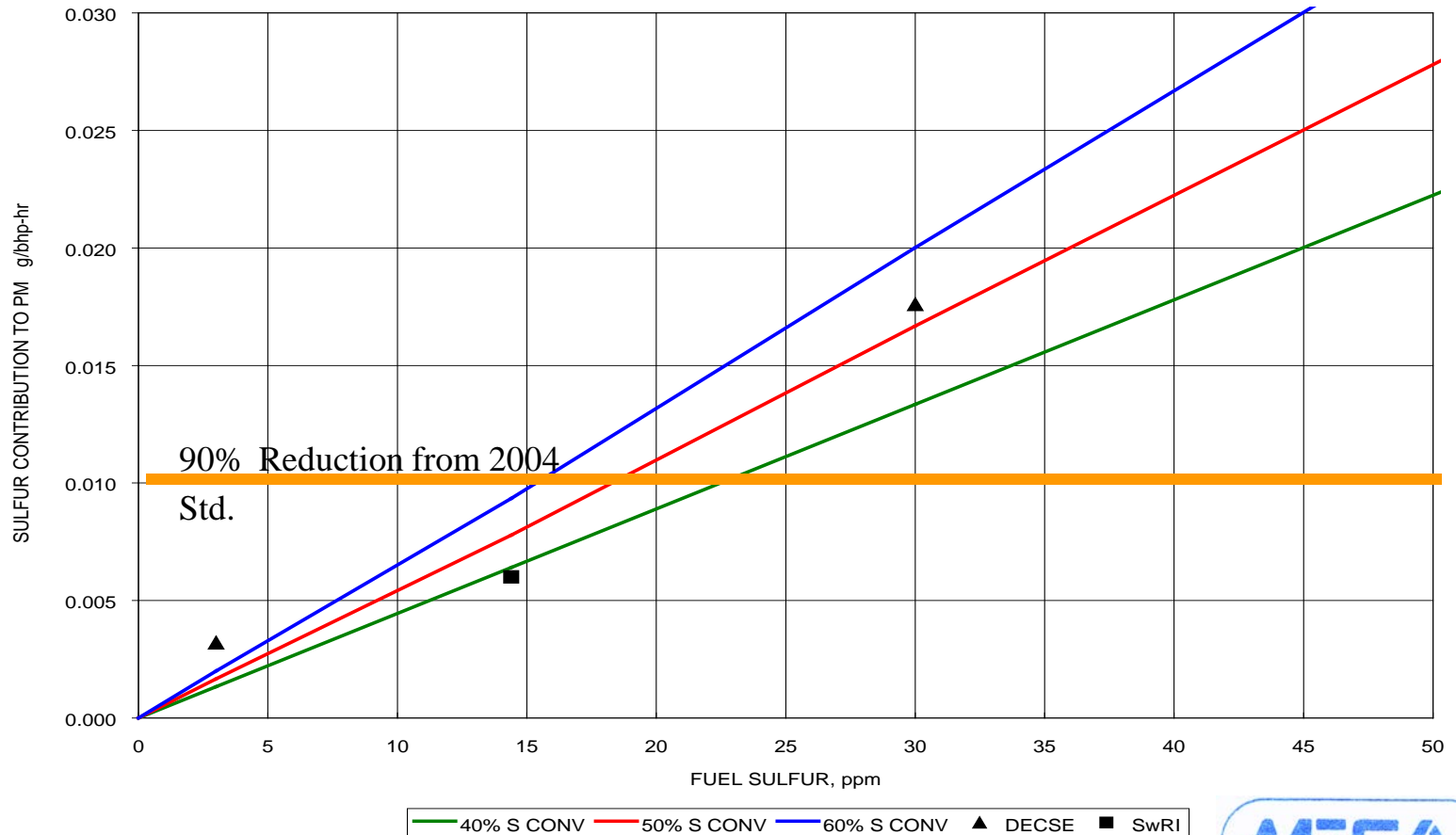
- A Low Regeneration Temperature Insures Reliable Catalytic Filter Operation and Durability
- A Low Regeneration Temperature Allows Filter Technology to Be Applied to a Broad Range of Vehicle Applications
- Higher Sulfur Levels in Diesel Fuel Increase a Catalytic Filter's Regeneration Temperature
 - In the DECSE Program, Increasing the Fuel Sulfur Content from 3 ppm to 30 ppm Increased the Regeneration Temperature of Two Different Catalytic Filter Systems by 23 to Over 30 °C.
- Experience in Countries Characterized by Very Cold Temperatures, e.g. Sweden, Indicates that There Have Been No Durability Problems with Systems Having Accumulated in Excess of 475,000 km when Diesel Fuel with <10 ppm Is Used



Impact of Sulfur on Heavy-Duty PM Emissions

IMPACT OF FUEL SULFUR ON HEAVY DUTY PM EMISSIONS

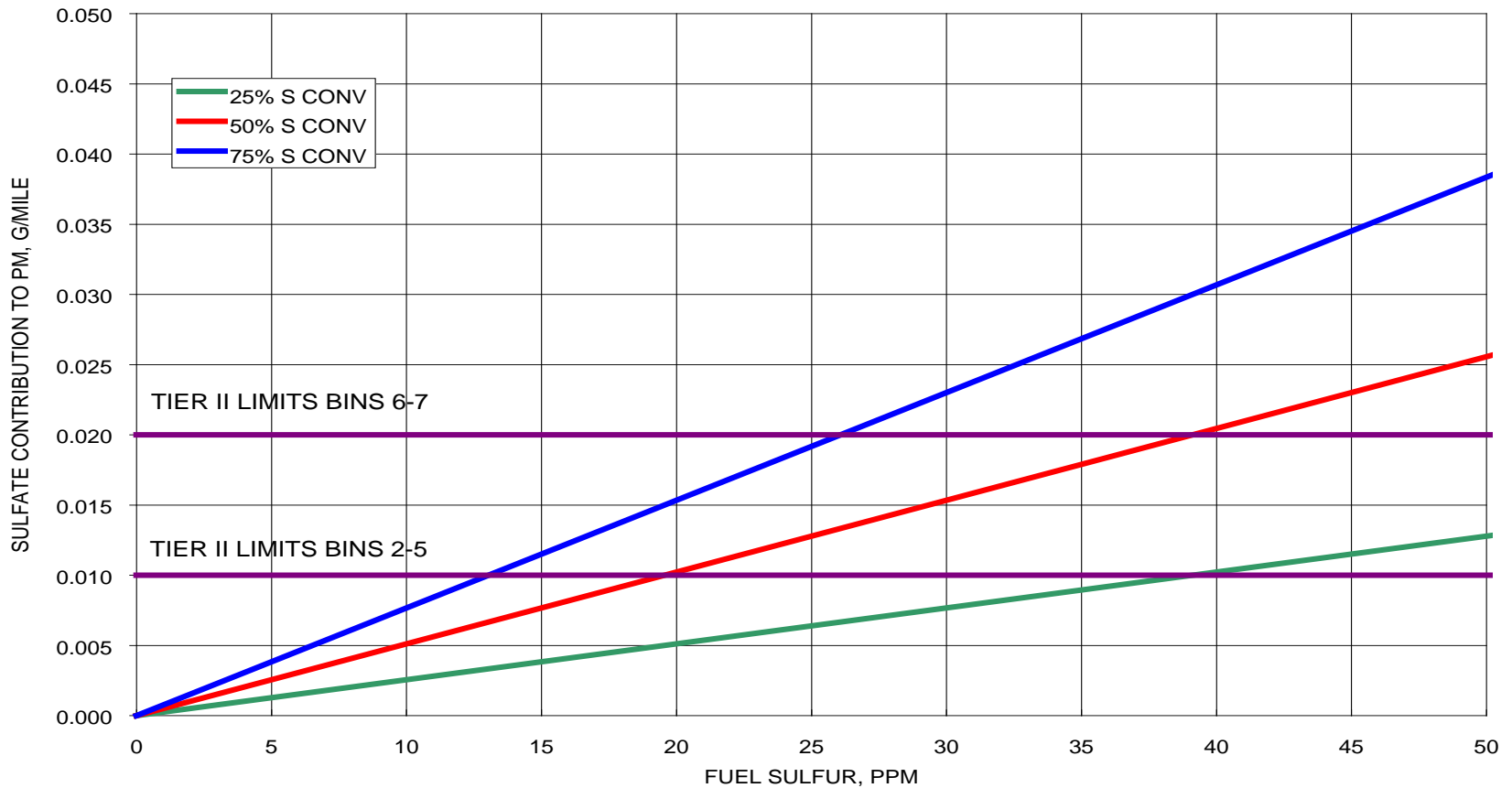
ASSUME: BSFC = 0.355 H₂O/SO₄ = 1.3



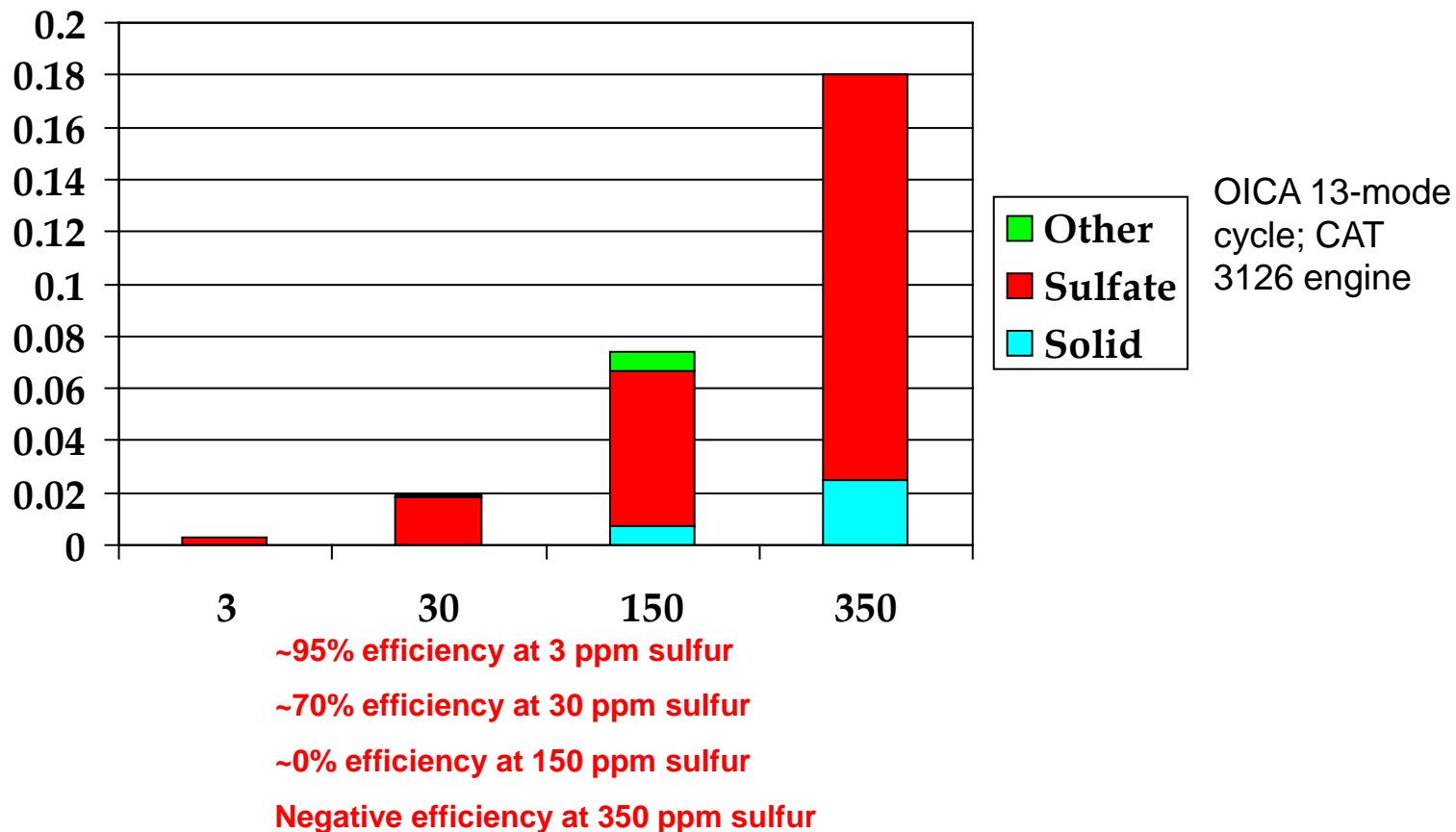
Impact of Sulfur on Light-Duty PM Emissions

CALCULATED IMPACT OF FUEL SULFUR ON LIGHT DUTY DIESEL PM EMISSIONS

ASSUME: 25 MPG H₂O/SO₄=1.3



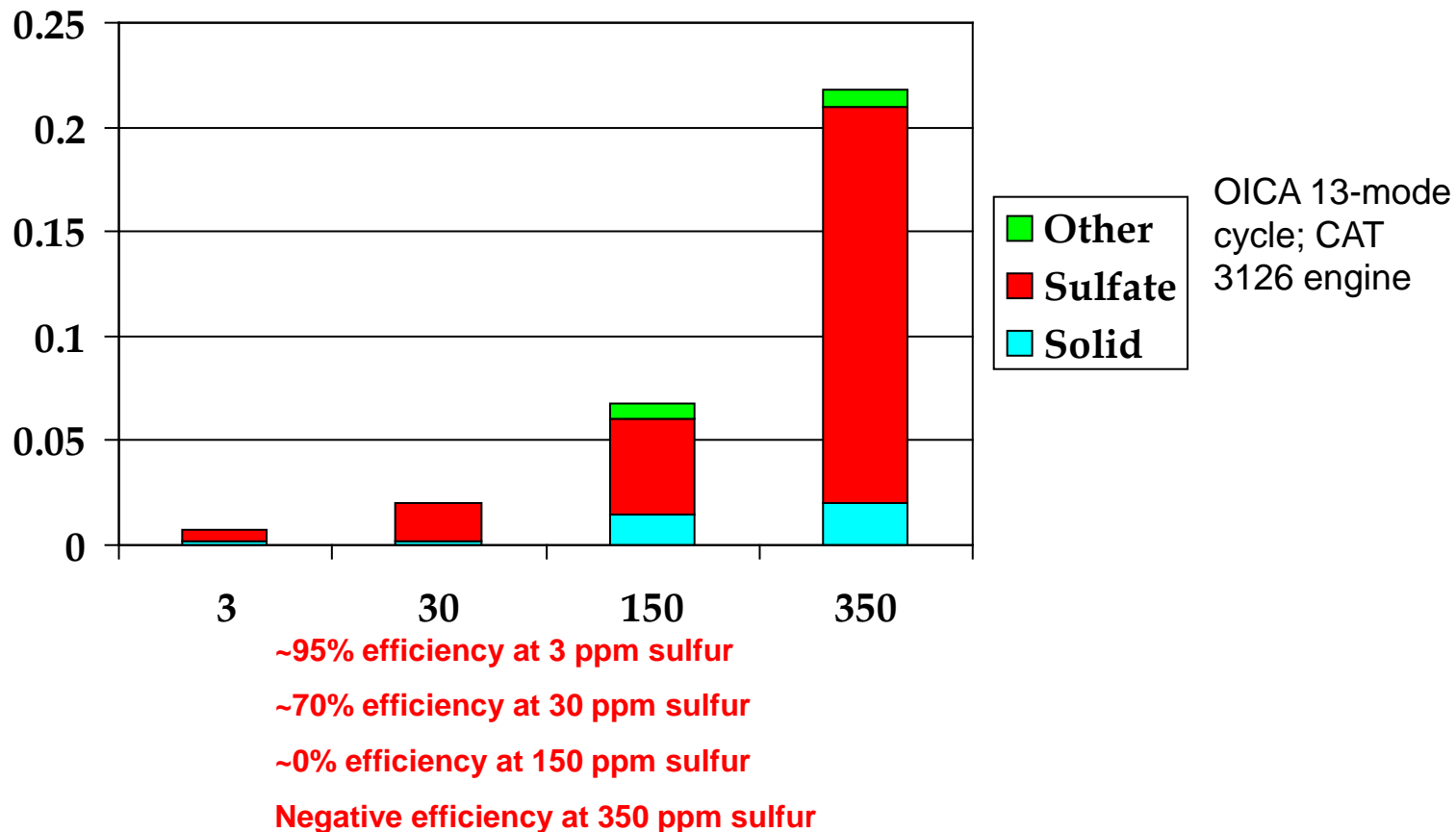
The DECSE Study Is Showing That Low Sulfur Is Critical to Achieving a 0.01 g/bhp-hr PM Standard (System 1)



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



The DECSE Study Is Showing That Low Sulfur Is Critical to Achieving a 0.01 g/bhp-hr PM Standard (System 2)



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



Status of Reducing Impacts of Sulfur on NOx Adsorbers

- MECA Members Continue Research Efforts in Decreasing Sulfur Sensitivity
- ***BUT,***
 - Desulfurization Frequency Needs to Be Minimized for Commercial Viability of NOx Adsorbers
 - Minimize Fuel Economy Penalty
 - Maximizes the Opportunity for Operating Conditions Conducive to Desulfurization to Be Met Under Normal In-Service Operation
 - To Meet Very Low Emission Levels Only an Approximately 5% Decrease in Performance Can Be Tolerated
 - Control of Unregulated Emissions Is Inhibited
 - Off-Cycle Emissions During Desulfurization
 - Inhibition of the Performance of Other Emission Control Devices
 - Sulfur Inhibition Is Cumulative



Status of Reducing Impacts of Sulfur on Catalytic Particulate Filters

- MECA Members Continue Research Efforts in Decreasing Sulfur Sensitivity
- ***BUT,***
 - Sulfur Significantly Increase the Balance Point Temperature Due to Sulfur Inhibition which Adversely Affects Filter Regeneration
 - Control of Unregulated Emissions Is Inhibited
 - Cold Climatic Conditions Exasperate the Effects of Sulfur Inhibition
 - Sulfur Inhibition Is Cumulative



Conclusion

- To Help Insure that Diesel Fuel Remains Competitive with Other Fuels, It Is Incumbent on the Engine Manufacturers, the Emission Controls Industry, and the Fuel Providers to Work Together to Provide a “Truly Clean” Diesel Engine so that the Public Accepts the Fuel As an Environmentally Friendly, Safe, and Efficient Means to Meet the Nation’s Transportation Needs

