

THE DIESEL ENGINE CHALLENGE

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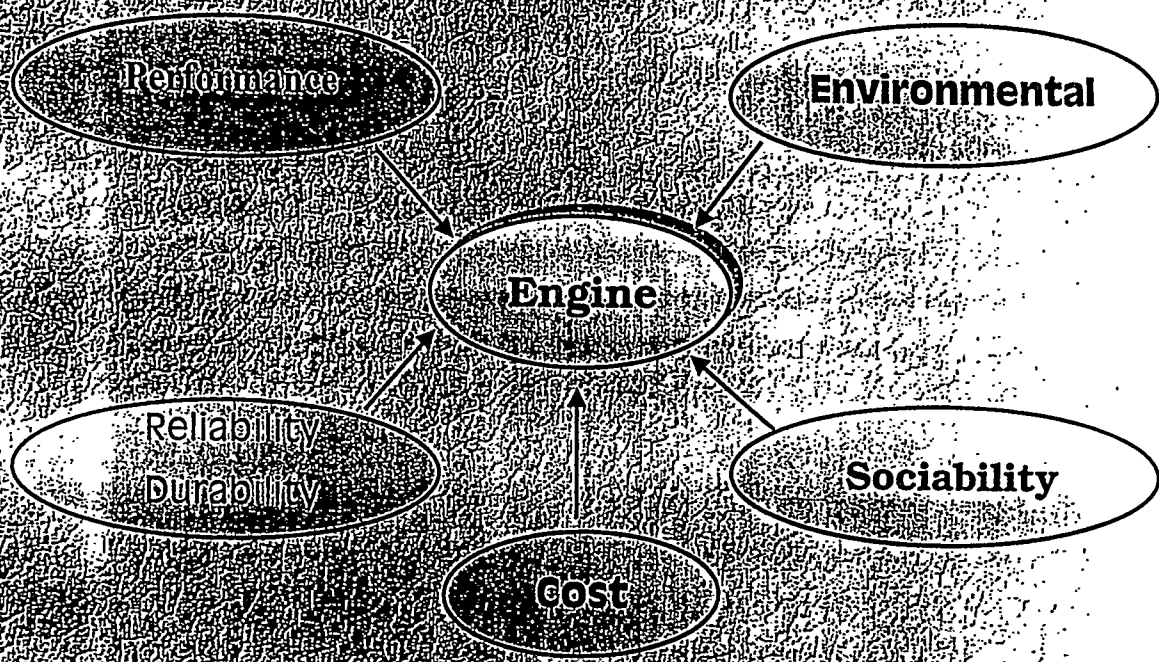
USDOE/NREL Workshop

EXPLORING LOW EMISSIONS DIESEL ENGINE OILS

Scottsdale, Arizona, January 30 - February 1, 2000

Outline

- § Introduction
- § Requirements for State-of-the-Art Engine
- § Benefits and Challenges of Diesels
- § Progress in Reducing Diesel Emissions
- § Emission Challenges beyond 2000
- § Further Development (System Approach)
- § Clean Fuel - Technology Enabler
- § Conclusions



REQUIREMENTS FOR THE STATE-OF-THE ART ENGINE

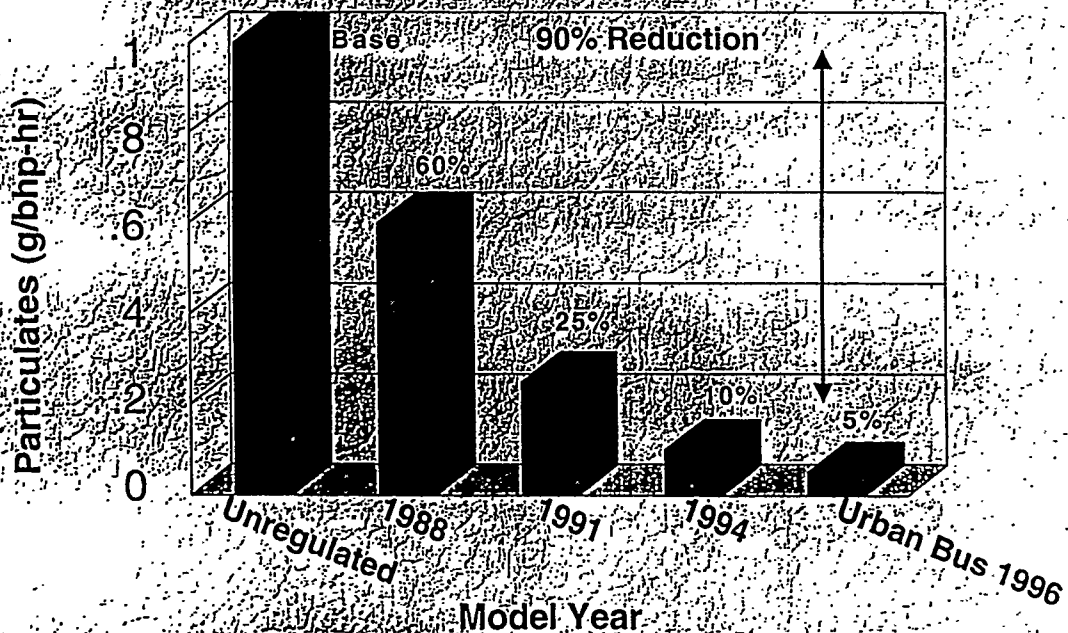
Diesel Engine Benefits

- § **Energy Use**
- § **Fuel Efficiency and CO₂ Emissions**
- § **Durability and Reliability**
- § **Safe Fuel Handling**

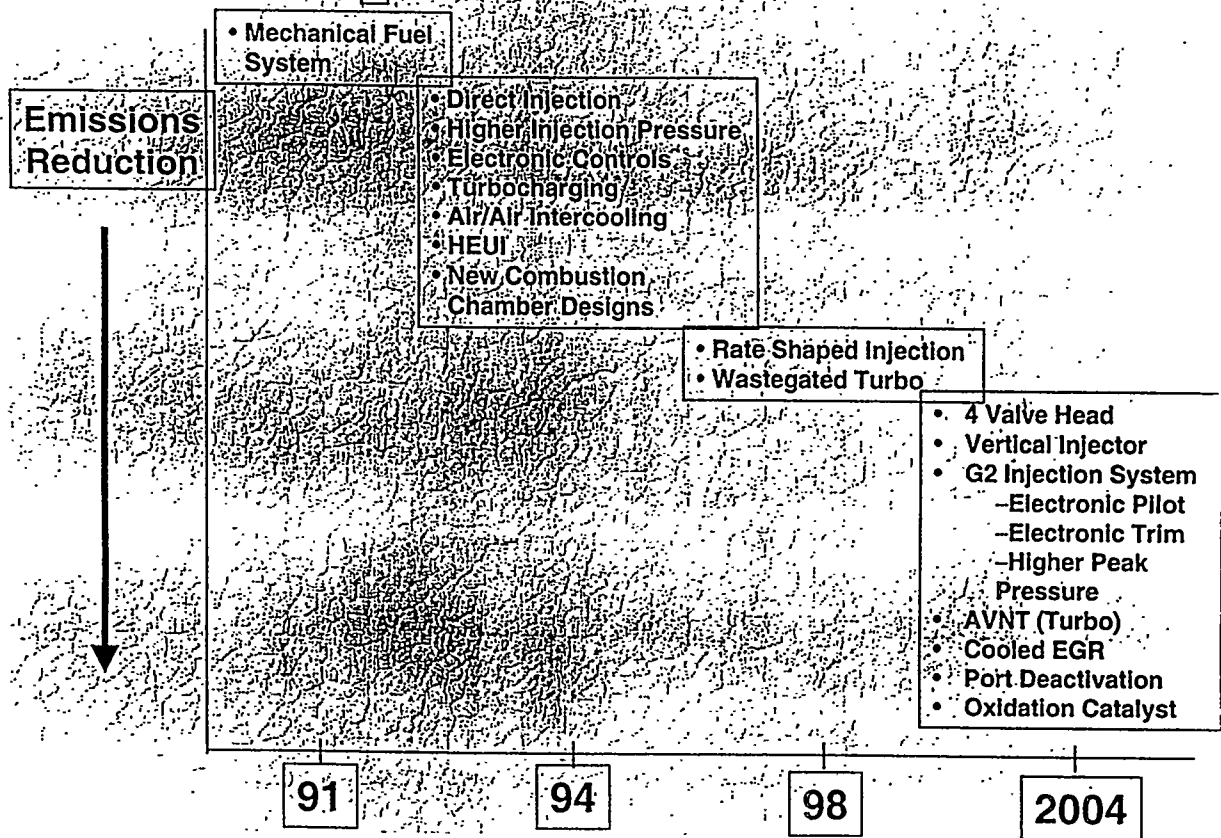
Diesel Engine Challenges

- § Benchmark against Gasoline Engine
- § NOx Emissions Profile
- § Particulate Emissions
- § Nox/Particulate Trade-off

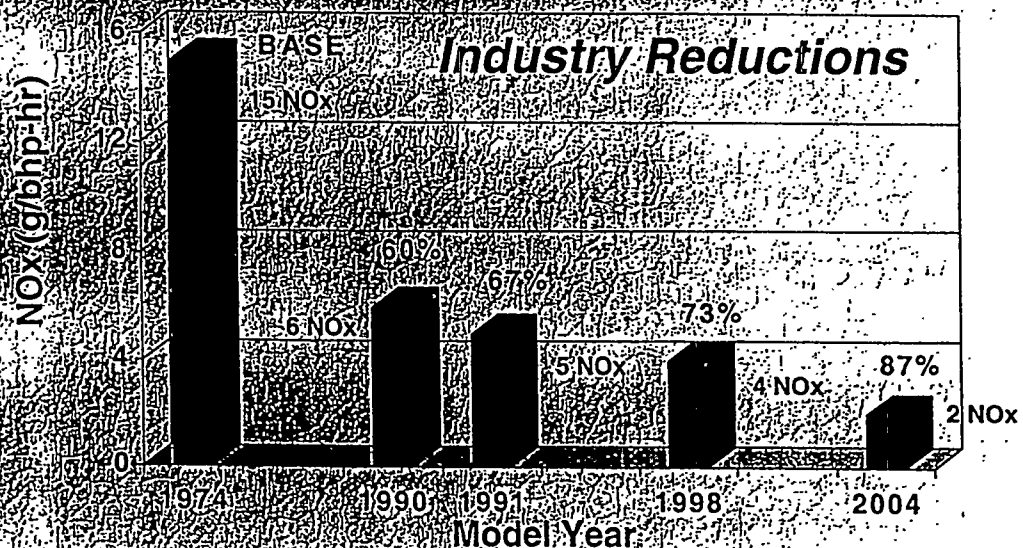
Progress In Reducing HD Truck PM Emissions



Technology Trail



Progress in Reducing HD Truck NOx Emissions



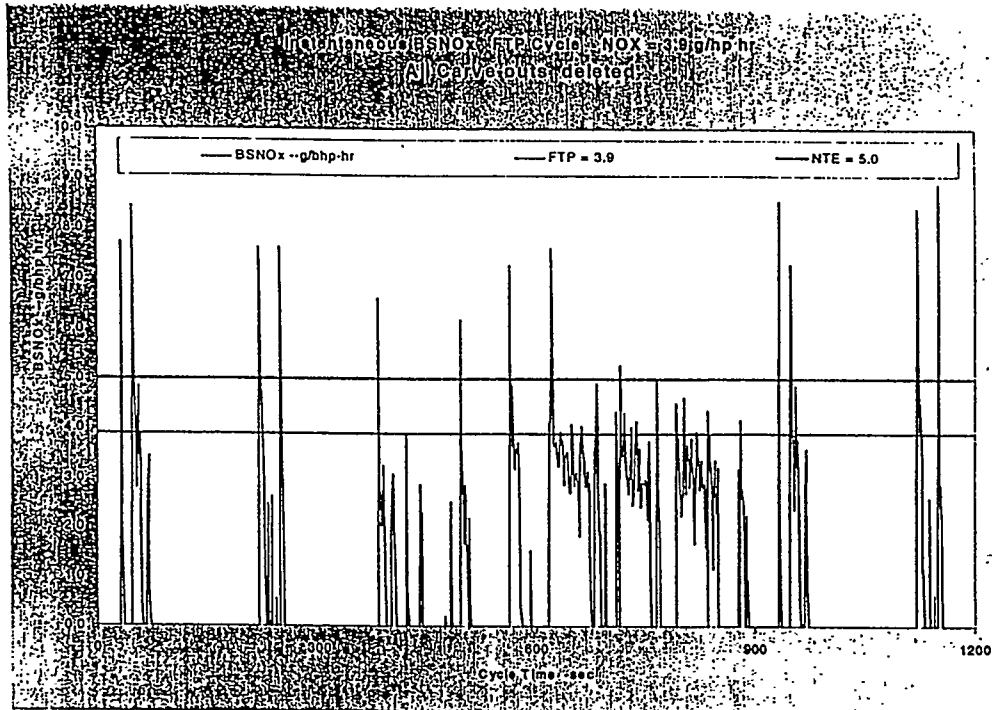
EPA Proposal Adds Stringency to 2004 Regulation

- § Requires compliance over a wider range of ambient conditions
- § Requires Compliance over a wider range of engine operating conditions
- § Requires Not To Exceed Limits
(Flatter Emissions Maps)

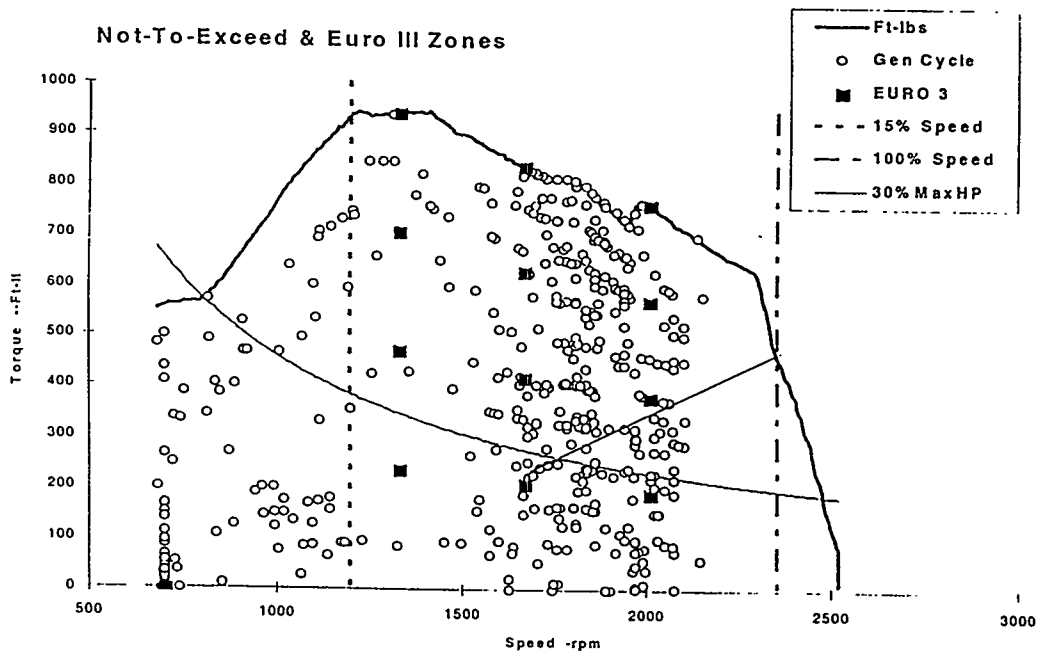
Compliance Over Wider Range of Ambient Conditions

- § No timing compensations for temperatures over 55°F
- § No timing compensations for altitudes below 5 500 ft contrary to current practices.

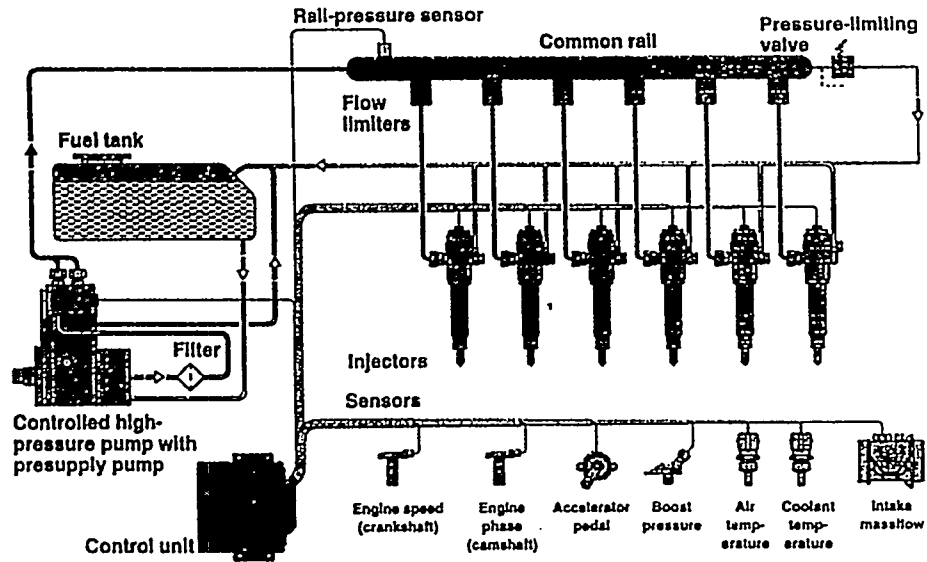
Flat Emissions Map



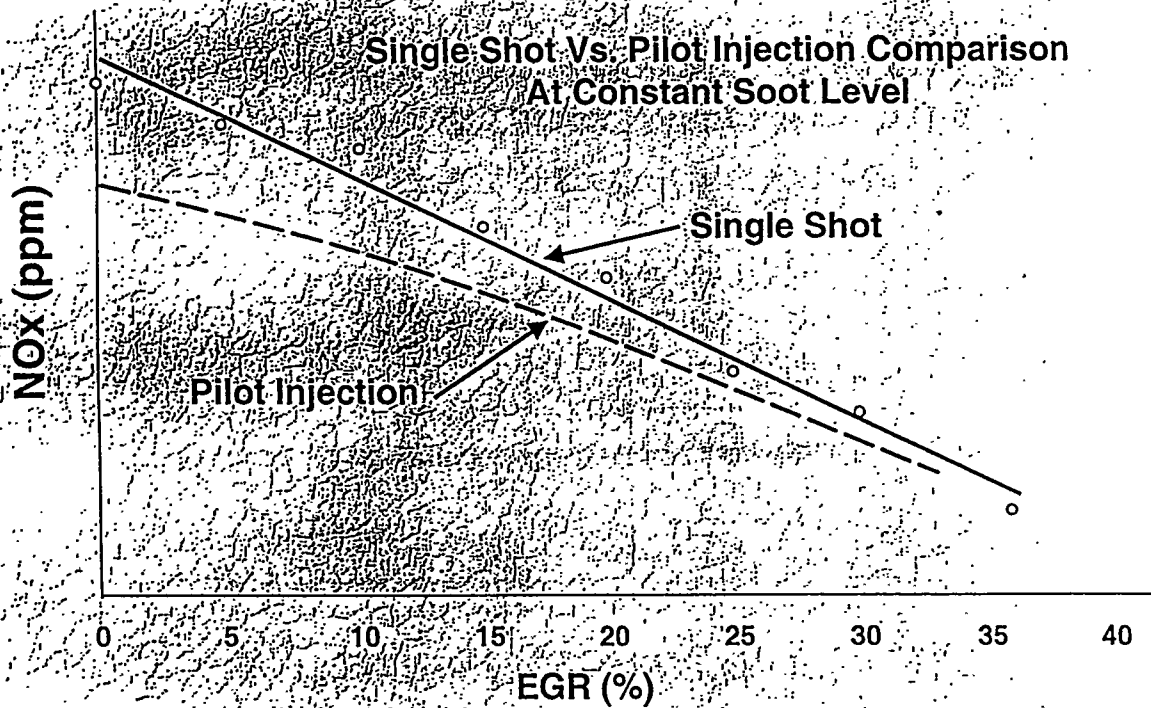
Compliance Over Wider Range of Engine Operating Conditions



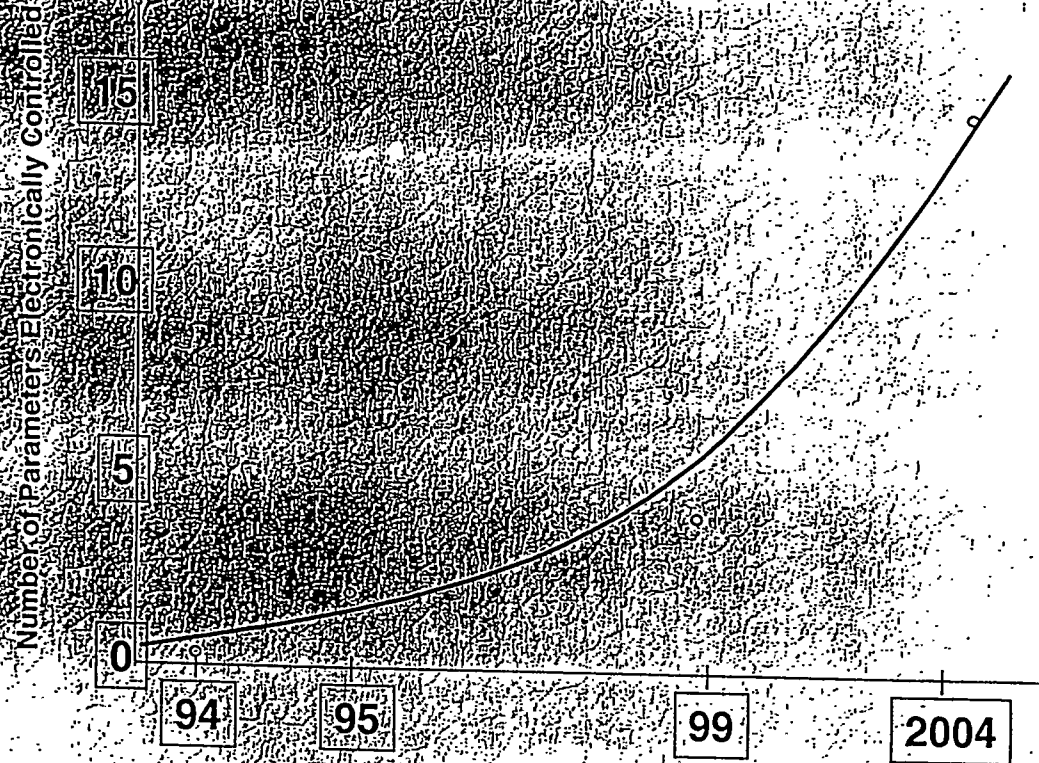
High Pressure Fuel Common Rail Comparison System Schematic



NO_x Reduction as a Function Of EGR



Evolution Of Electronic Controls



Message:

Engine Industry is working diligently to develop cost-effective 2004 complying engines that will provide the performance and durability that meets our customer needs.

Critical Questions Concerning 2004 Engines

- § Fuel Economy?
- § Oil Drain Intervals?
- § Engine Durability?
- § Engine Costs?

Tier 2 Standards for LD Applications

- § Proposal affects Passenger Cars and LD trucks (under and over 6000 lb.)
- § 0.07 gr/mi Nox; 0.01g/mi Particulates (fleet average emissions)
- § gradual phase-in 2004-2007
- § Standards are fuel neutral
- § Proposal represents about 90% reduction in emissions from today's level

Engine System Development

- § Engine
- § Aftertreatment of exhaust
- § Fuel
- § Lubricant

Aftertreatment Options

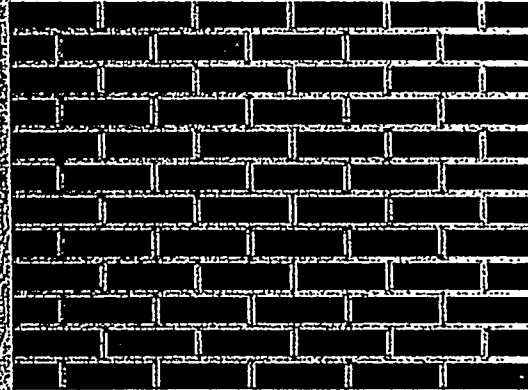
- § Diesel Oxidation Catalysts
- § Diesel Particulate Filters
- § Non-Catalysed Particulate Filters w/
Fuel Borne Catalyst
- § Lean NO_x Catalyst
- § Selective Catalytic Reduction

The Barrier

§ 2004 Truck compliance

- HD problematic
- LD unlikely

§ Needs 30 ppm sulfur national fuel

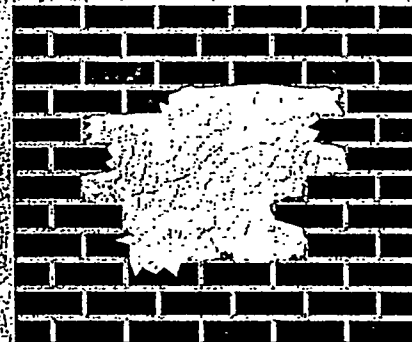


The Breakthrough To The Next Level!

§ The development of adv. aftertreatment devices, (Lean NOx catalyst & NOx Adsorber)

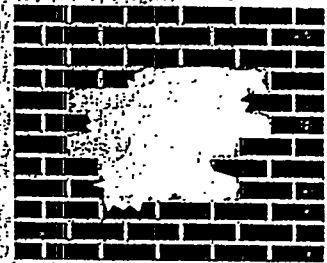
§ We need ultra-low national sulfur fuel

§ Potential to achieve added 90% reduction of NOx & PM emissions

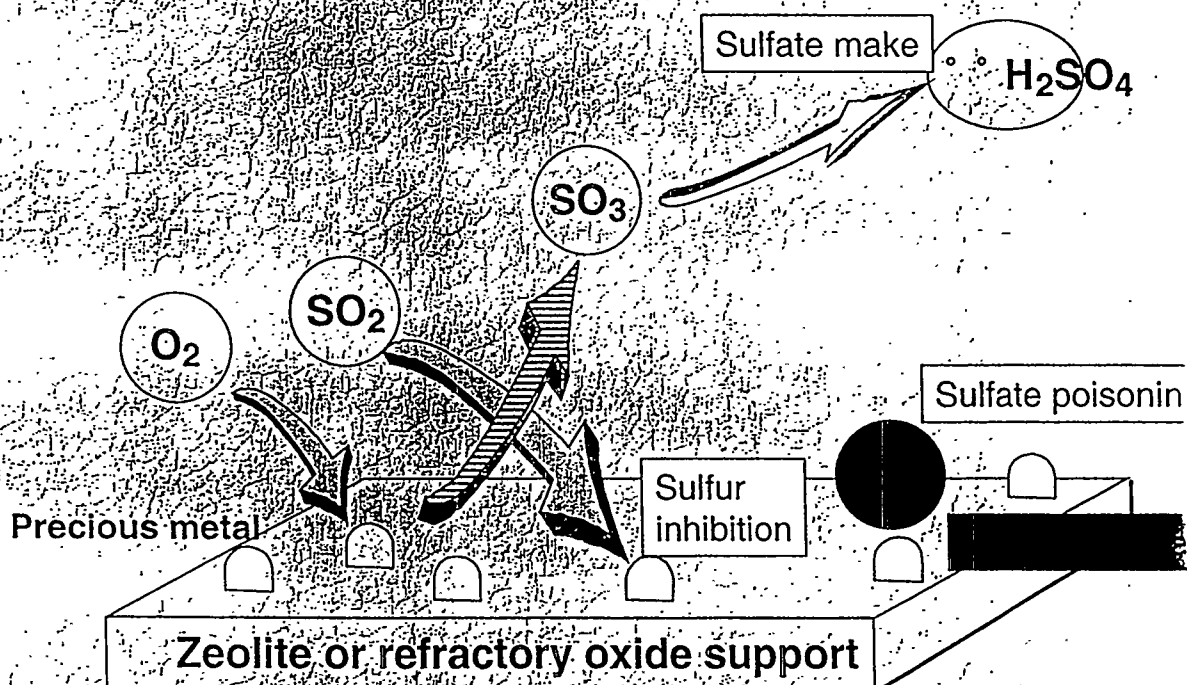


Why Breakthrough the Barrier?

- § Eliminate Health Concerns
- § Maximize Potential of “Green” Diesel Technology
- § Provide best overall value to Heavy-Duty & Light-Duty Customers



Impact of Fuel Sulfur on Aftertreatment



Impact of Fuel Sulfur

- § Sulfate Generation
- § Catalyst Inhibition
- § Catalyst Poisoning

Diesel Fuel Quality Sulfur Content

§ 30PPM Sulfur

- Required for Utilizing DeNOx Catalysts
- Required for Aggressive Oxidation Catalysts

§ 5PPM Sulfur

- Nox Adsorber
- Particulate Trap

Why A National Low Sulfur Diesel Fuel?

- § Reduces PM inventory by reducing SO₄ emissions from all diesels
- § Enables the introduction of advanced aftertreatment devices

Navistar Supports

- § Fuel Neutral Standards
 - Subject to Clean Fuel Availability
- § Phased Approach to Reducing Emission of NO_x and Particulates
 - Technology Advancements of Base Engine
 - Leverage of Catalytic Aftertreatment
 - Sulfur Reduction in Fuel
 - Development of Adequate Lubricants

Conclusions

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- § Diesel Emissions Regulations which are Challenging but Technologically Feasible will Drive Investment in Diesel Technology
- § Low Sulfur Fuel is a “Technology Enabler” which will Allow Diesels to meet Stringent Fuel Neutral Standards

Conclusions (cont'd)

- § Diesel is the only Technology that can Provide Short Term and Long Term Greenhouse Gas Benefits
- § Light Duty Diesel Technology will be Applicable to Heavy Duty Engines

Conclusions (cont'd)

- § Lubricant plays an Increasing Role in Catalytic Emission Control System. The Development of Advanced Lubricants Should be Pursued.

Conclusions (cont'd)

- § Diesel is the only Technology that can Provide Short Term and Long Term Greenhouse Gas Benefits
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