

# *EPA 2007 Clean Diesel Program*

*International Symposium of the Vehicle Emission Regulations  
US EPA Office of Transportation and Air Quality  
February 3, 2004*



# *Presentation Overview*

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- Diesels and Air Quality
- Key Elements of the Program
  - Engine Standards
  - Fuel Provisions
- Health Benefits of the Program
- Engine Technology
- HD2007 Progress – What's Happening Now?



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# *Diesels and Air Quality*



# *Air Quality Need & Public Health Concerns*

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- Diesel trucks and buses comprise 28% NO<sub>x</sub> and 20% PM mobile source emissions in the United States
- Contributions are even higher in some regions of the U.S. with serious air quality problems
- In addition, diesel exhaust has been implicated in an increased risk of lung cancer and respiratory disease
- U.S. EPA has concluded that diesel exhaust is a likely human carcinogen
- PM and NO<sub>x</sub> from diesel also contribute to asthma and other serious respiratory health problems

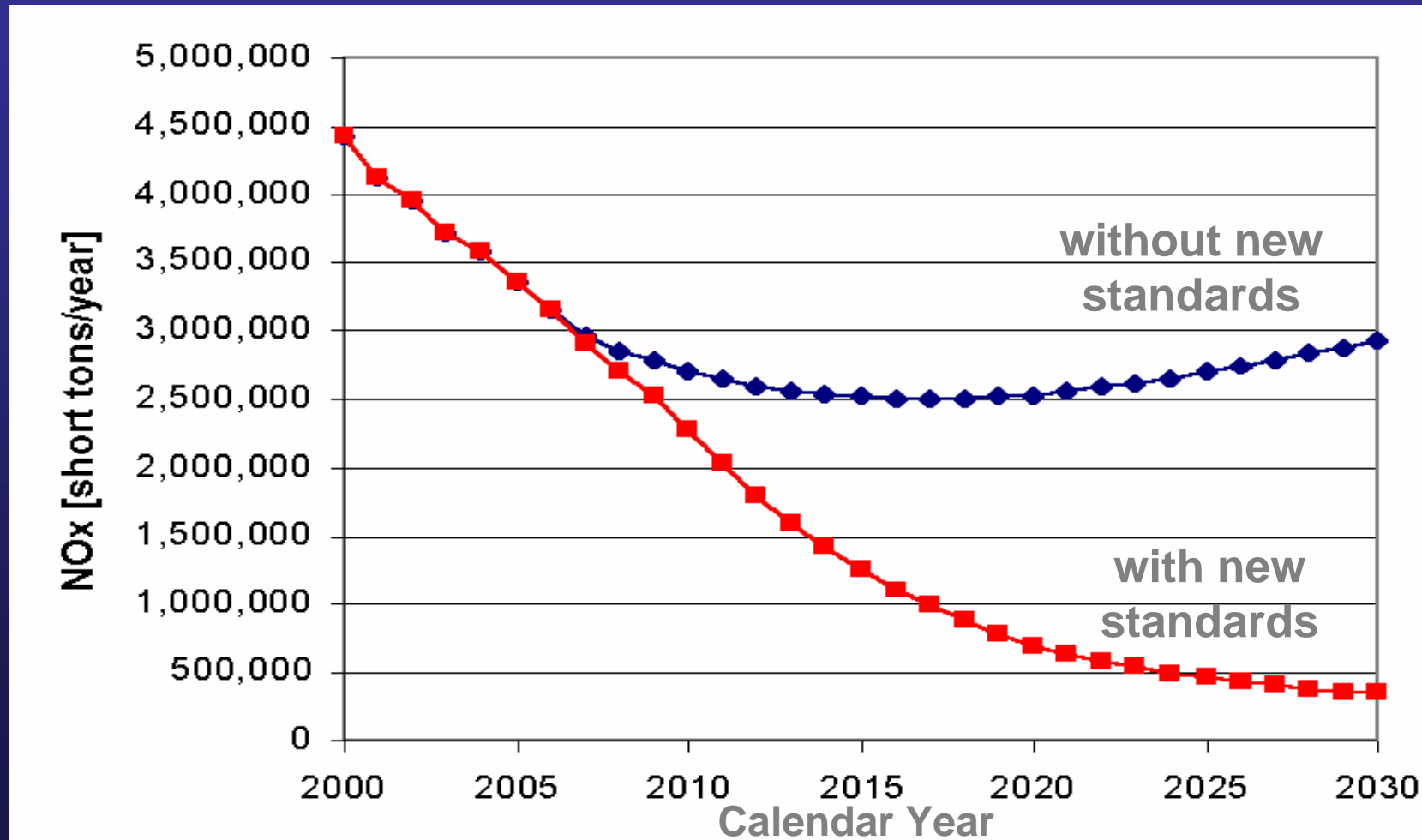
# Far-Reaching Impacts Beyond U.S. Trucking Industry

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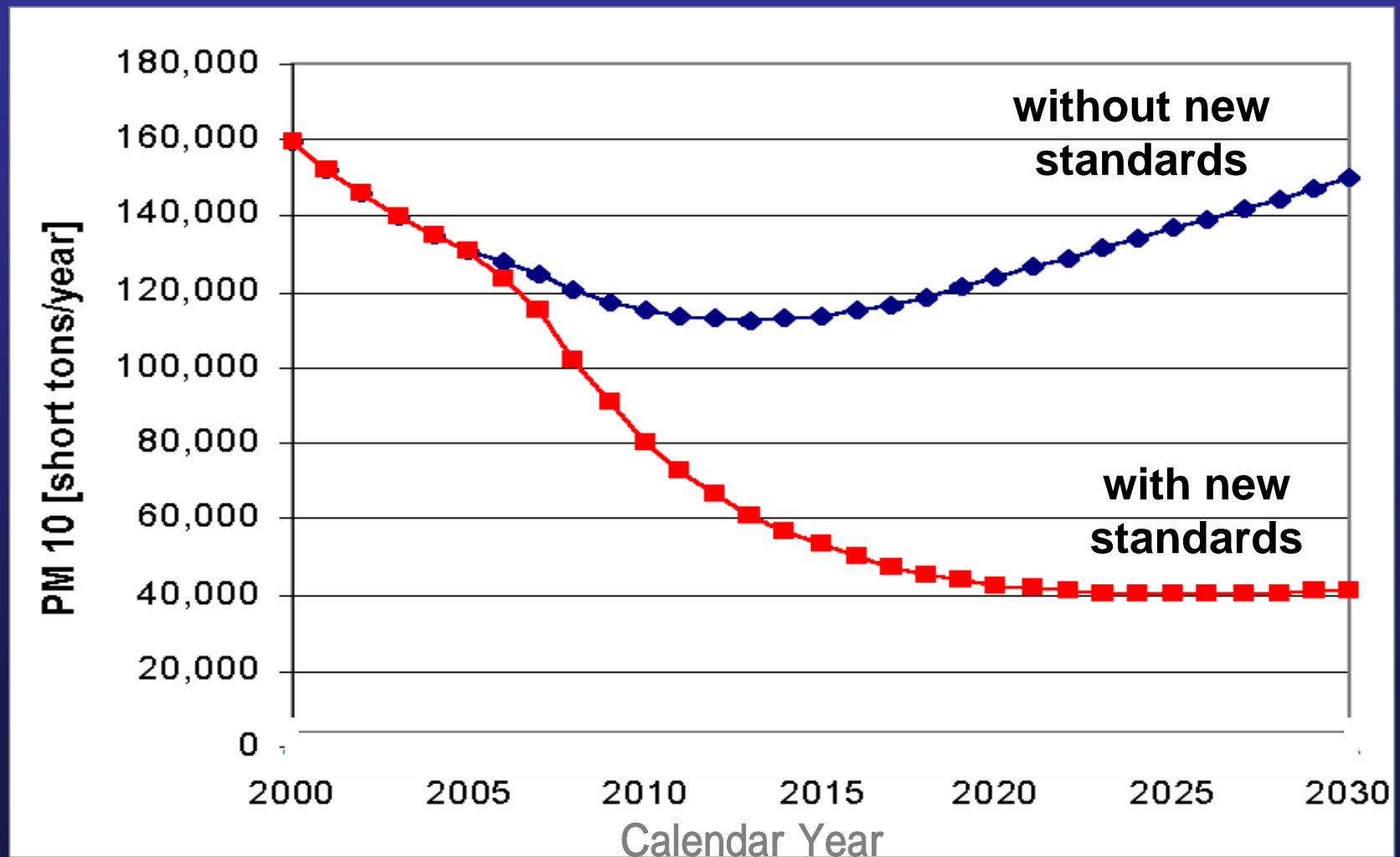
- Growing prospects for U.S. **light-duty** diesel
  - including drive toward fuel-efficient diesel and diesel-electric hybrid cars, trucks and SUVs
- Proposed Nonroad Tier 4 program
  - relying heavily on transfer of advanced technology from highway



# Nationwide Heavy-Duty NOx Emissions



# Nationwide Heavy-Duty PM Emissions



# Benefits

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- Health benefits

*The program will prevent annually*

- Over 8,300 premature deaths
- Over 750,000 respiratory illnesses
- 1.5 million lost work days
- 2.6 million tons of NO<sub>x</sub>, 110,000 tons of PM, and 17,000 tons of toxic pollutants

- Monetized benefits: \$70.3 billion/year

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# *Key Elements of the Program*



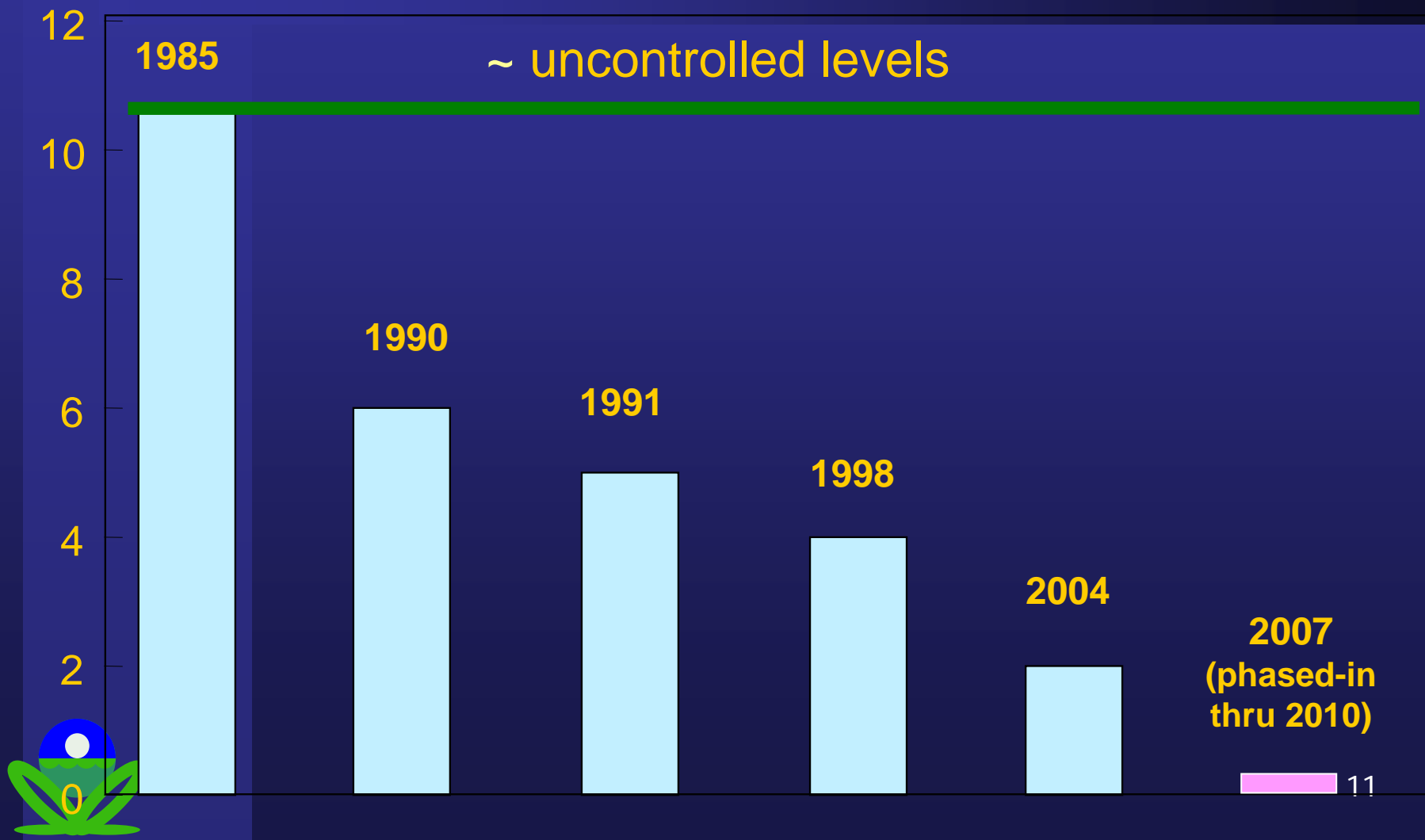
# Reminder: What the Rule Does

- Clean (near zero sulfur) fuel by 2006
  - enables use of advanced emissions technology
  - maintenance savings for new and old trucks
- Particulate matter (PM) reductions of 90% or better through use of catalyzed PM filters by 2007
  - Large reductions in toxic hydrocarbons as well
- Oxides of nitrogen (NO<sub>x</sub>) reductions phase in: averaging 50% by 2007, 90% or better by 2010



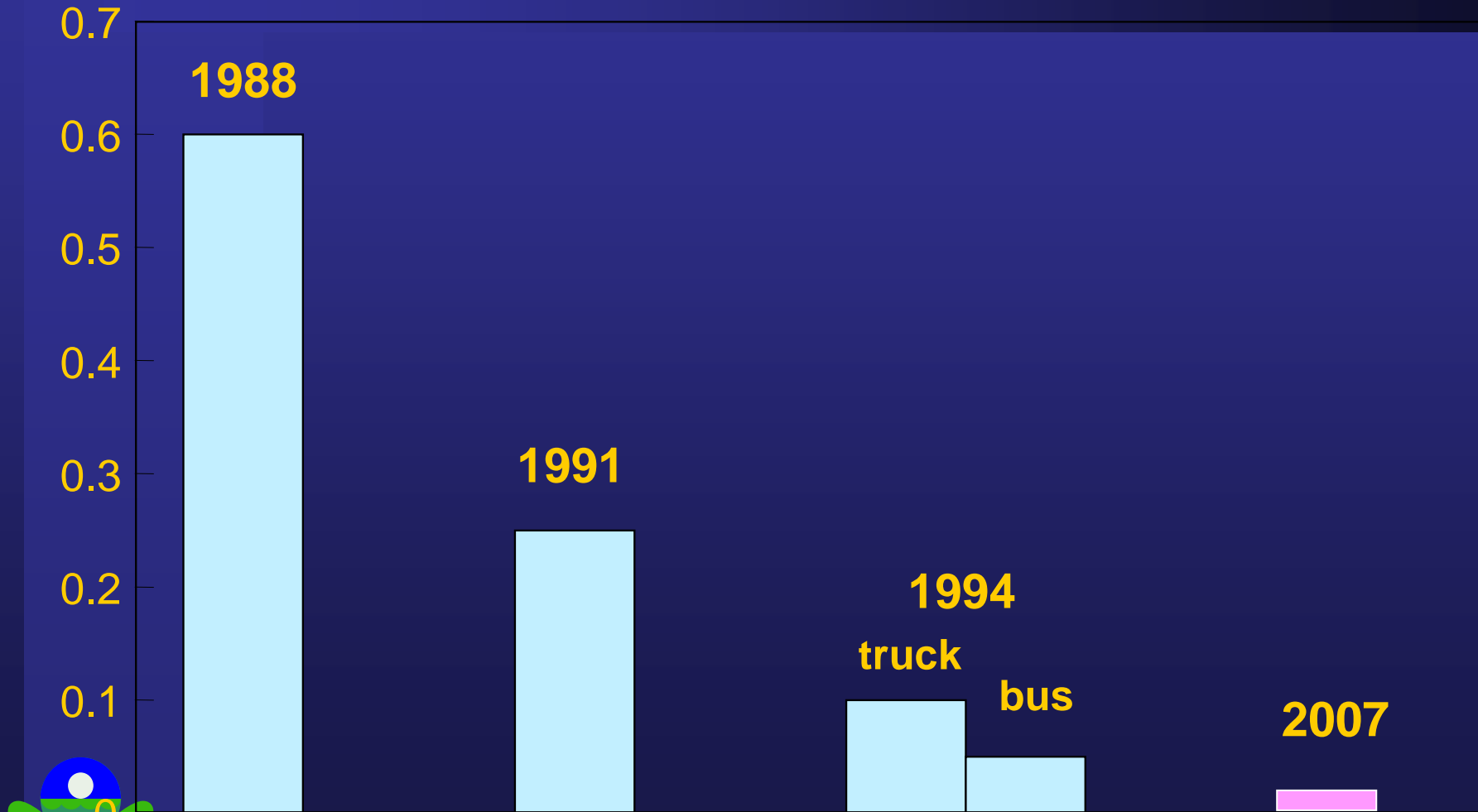
# Highway Diesel NOx Standards

grams per hp-hour

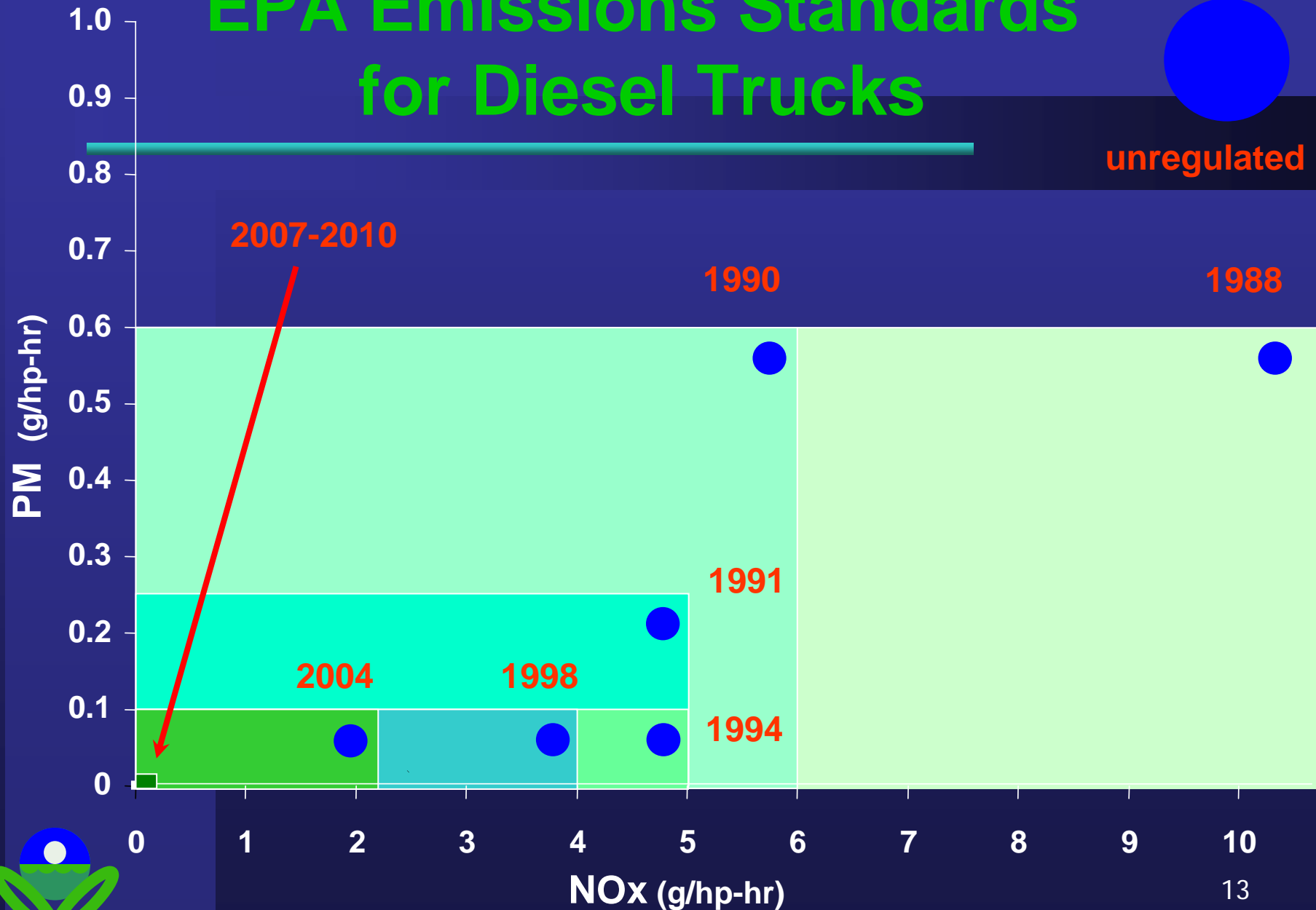


# Highway Diesel PM Standards

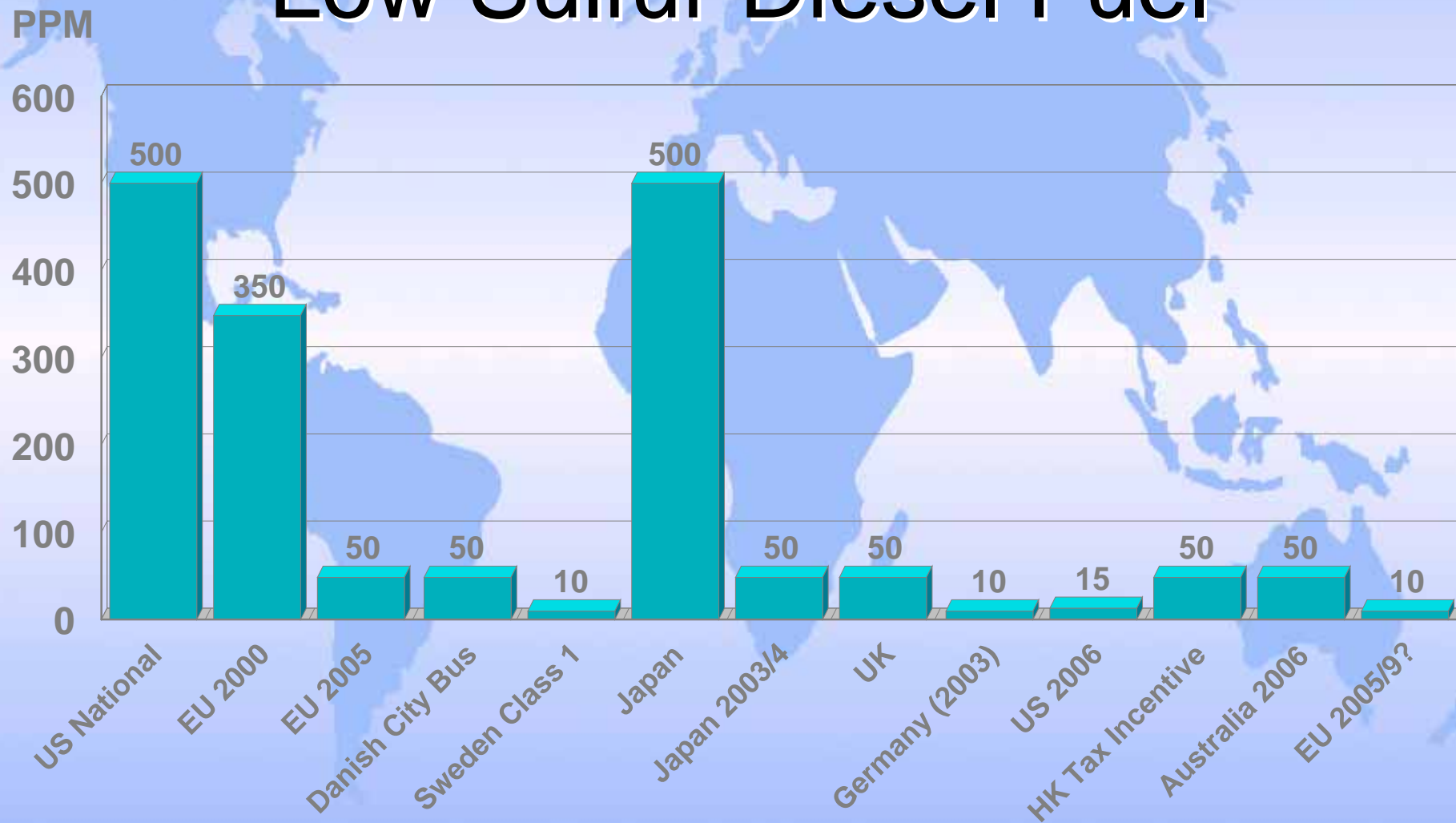
grams per hp-hour



# EPA Emissions Standards for Diesel Trucks

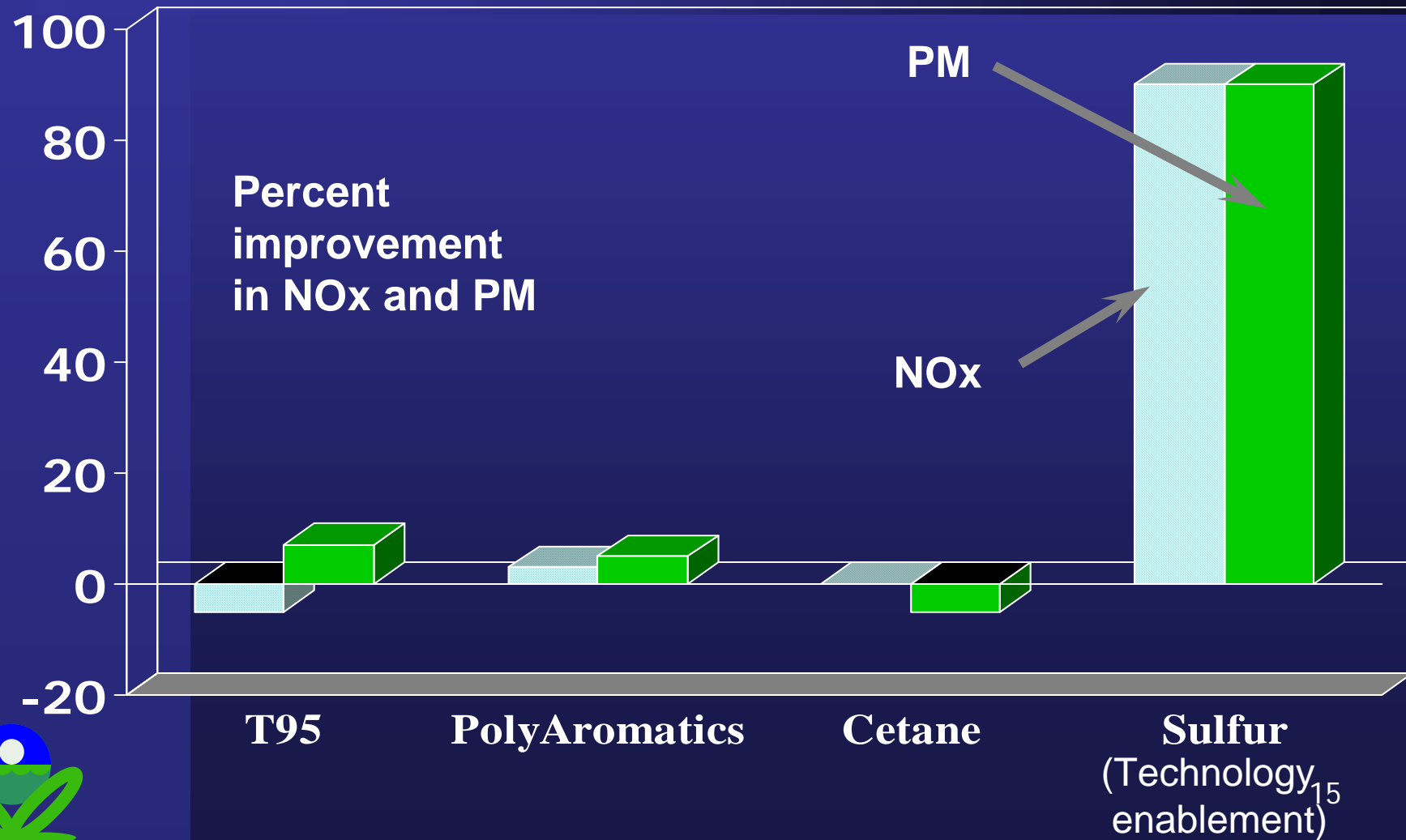


# Worldwide Progress Toward Low Sulfur Diesel Fuel



# Why Sulfur?

## Some Data On Fuel Effects

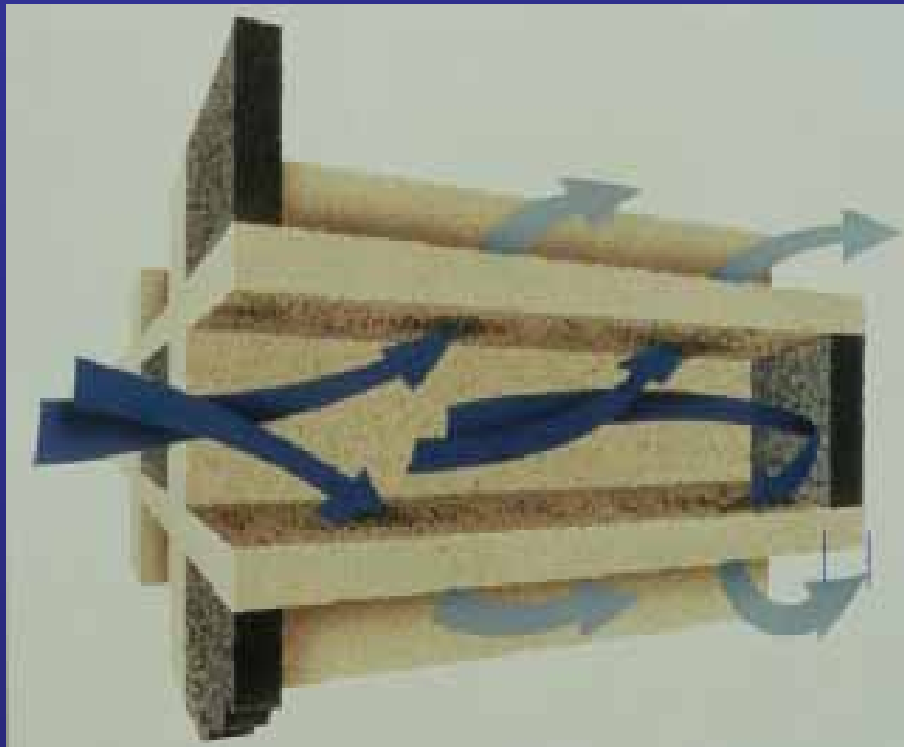


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# *Engine Technology*



# *Catalyzed Diesel Particulate Filter*



Mechanical Filtration of PM  
(~ like an air filter in your house)

Holds soot in the excess O<sub>2</sub>  
exhaust until it can be oxidized  
(~ provides residence time for soot to burn)

Soot burn rate  $\geq$  soot accumulation  
rate or filter will “plug”

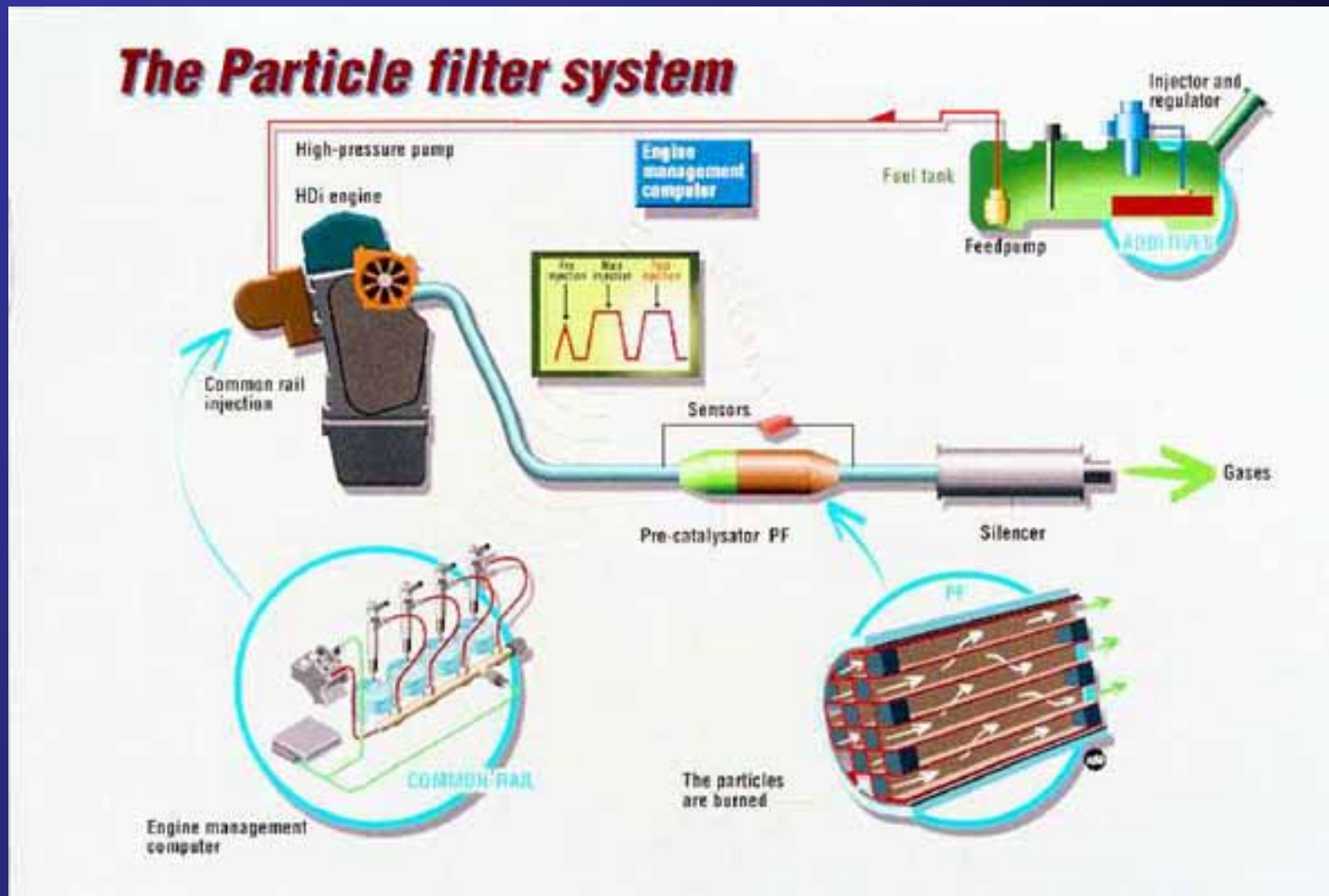
Catalyst promotes faster burn

Catalysts are sulfur sensitive

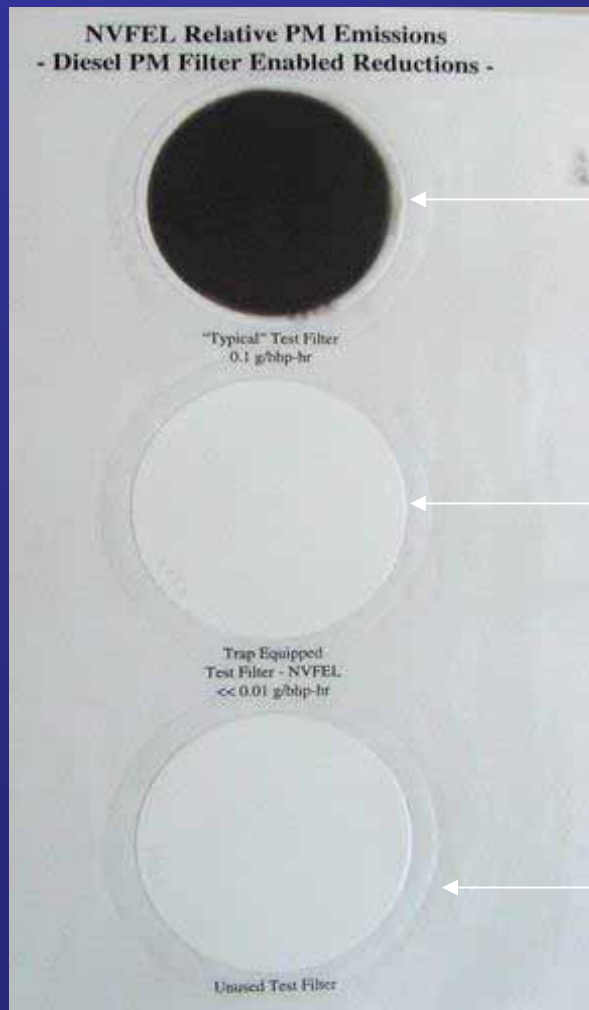
- oxidize sulfur to sulfate PM
- are poisoned by sulfur



# PSA Peugeot Diesel Particulate Filter System



# *A vivid reminder of what this is all about*



■ Typical test filter – current standards

■ Test filter – 2007 standards

■ Unused test filter

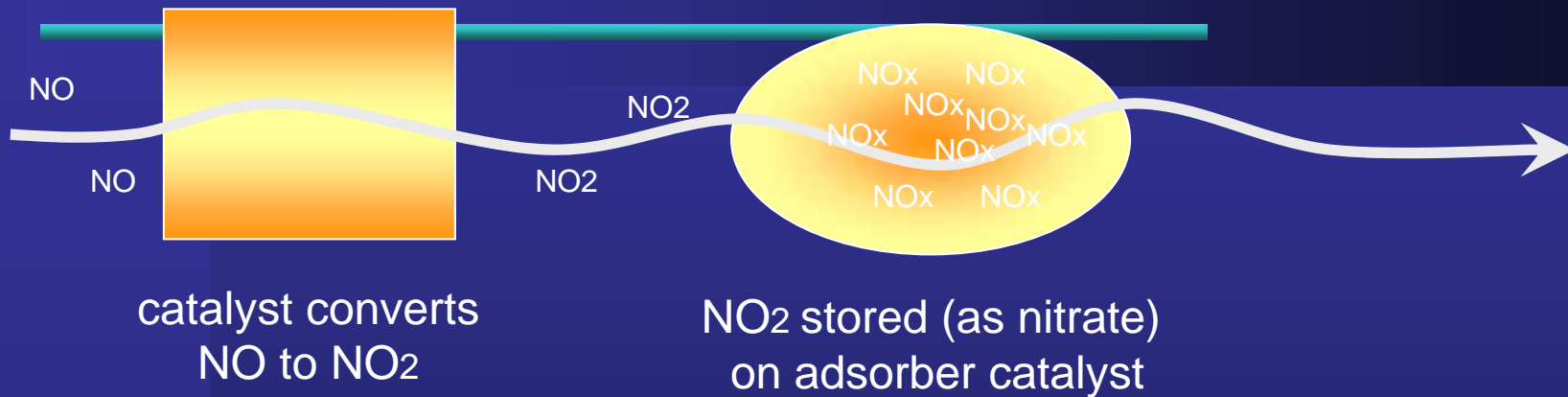


# *Diesel Particulate Filter Summary*

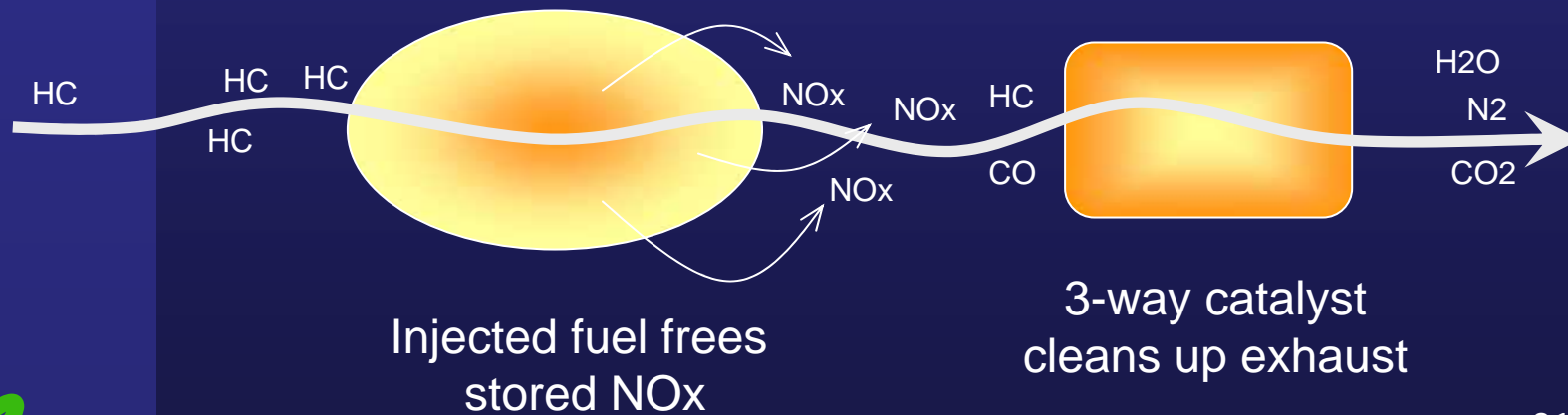
- Diesel particulate filters are highly effective
- Challenge has always been regeneration
- Light-duty diesels are showing the way
  - Tough duty cycle (low load = low temperature)
  - Tight constraints on packaging/cost
- PSA/Peugeot system introduced in 2000
  - By end of 2003, over a 500,000 units sold
  - Other manufacturers following because of customer demand



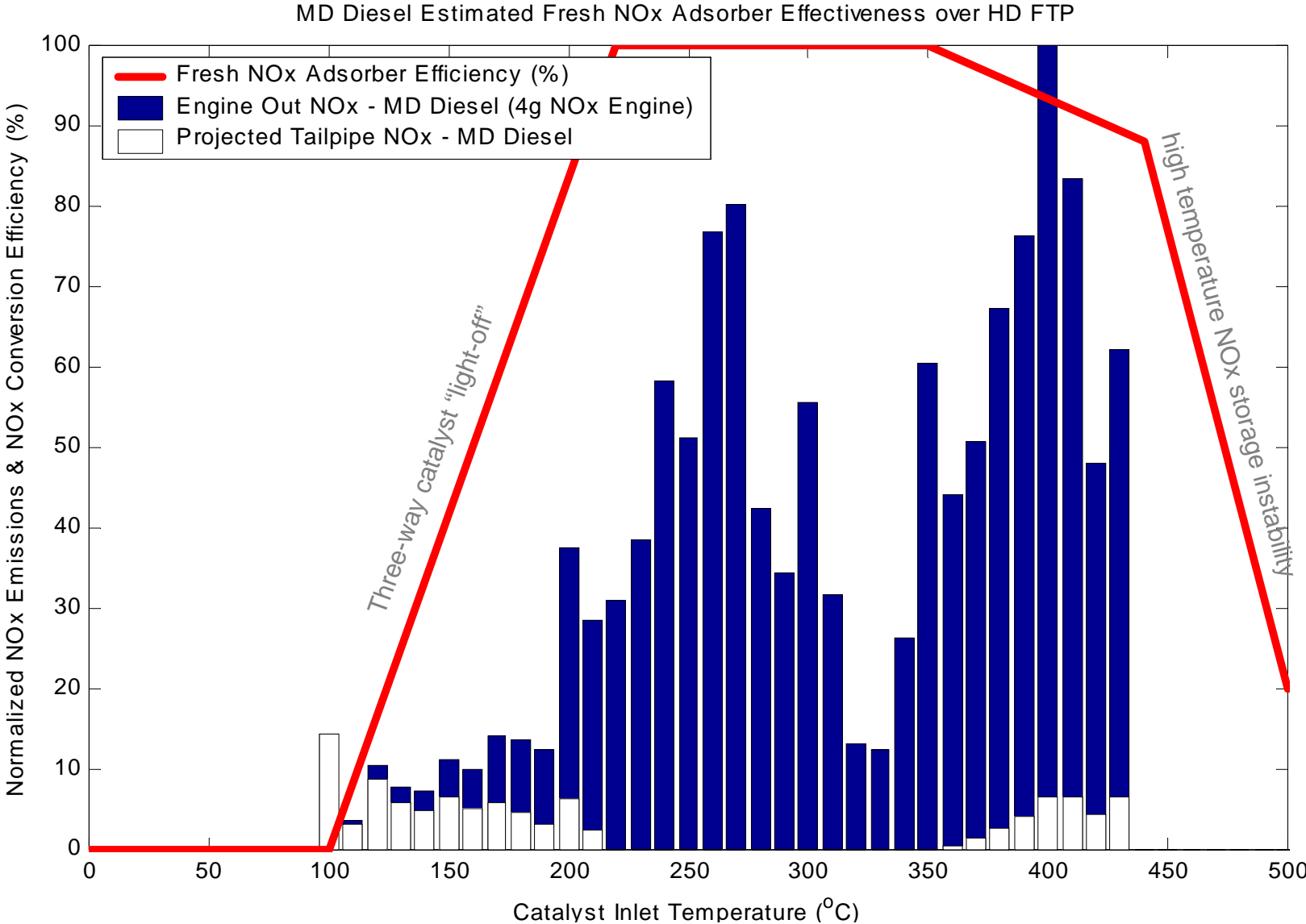
# NOx Adsorber Catalyst



## *Rich (HC injection) Phase:*



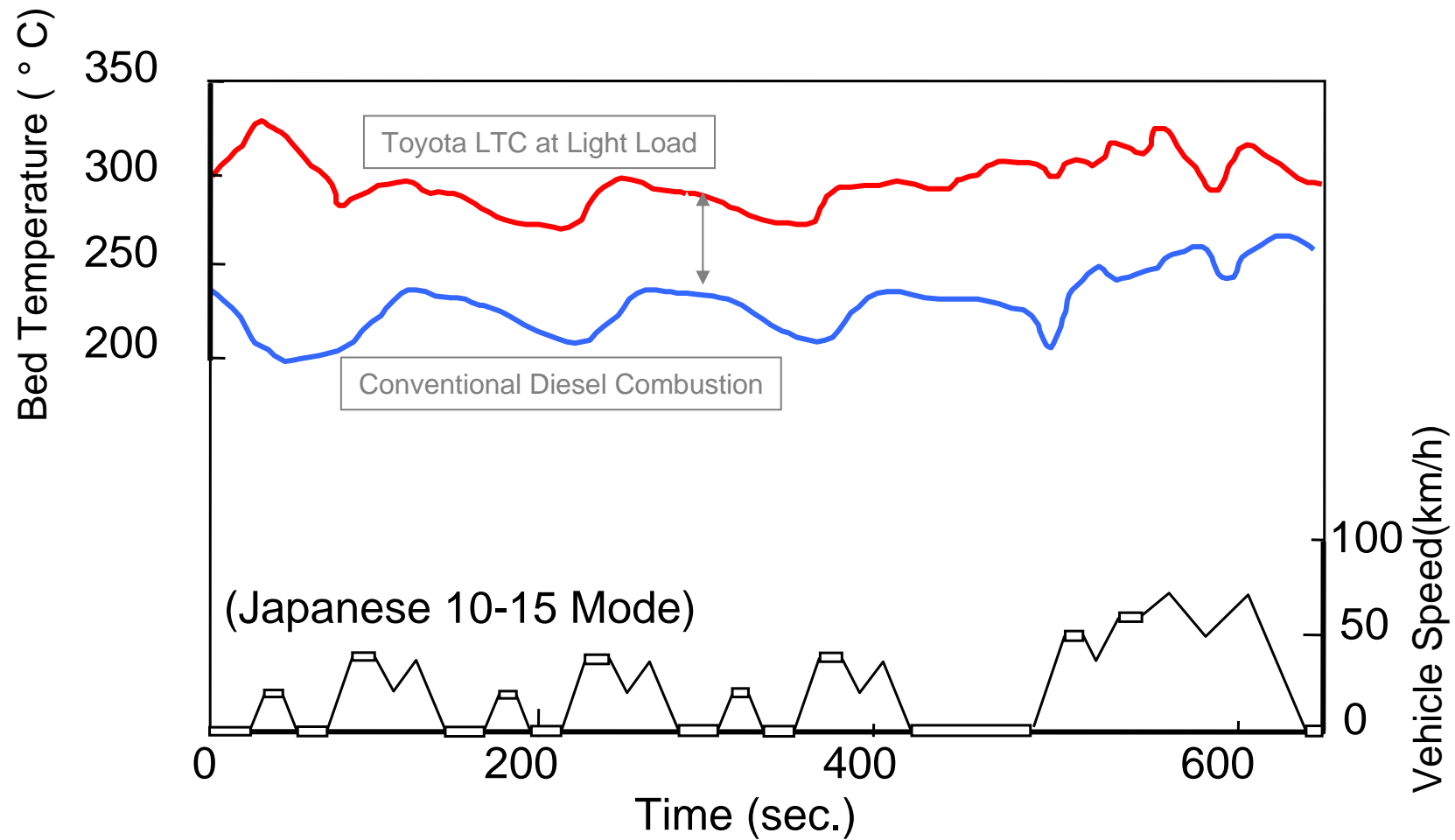
# NOx Adsorber Technical Challenges



# Major LD Diesel Manufacturer

Changes in diesel combustion to improve catalyst function

[Temperature Window]



# *Improvements in Diesel Combustion [System Integration]*

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- New air-handling systems (turbomachinery, EGR) along with improvement fuel systems being implemented for 2004 will provide a good starting point for 2007
  - Allow for better A/F control for regeneration
  - Potential to lower engine out emissions
- New combustion approaches (Toyota LTC, Nissan MK)
  - Allow for very low engine out emissions under certain circumstances (e.g., at light load)
  - Create conditions conducive to NO<sub>x</sub> regeneration and desulfation



# *NOx Adsorbers*

## *Remaining Technical Challenges*

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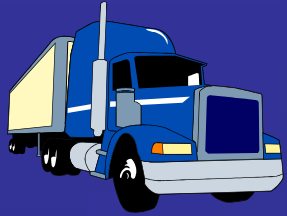
- Temperature range for high NOx conversion
  - Broader range for effective NOx control
  - New combustion approaches can match exhaust conditions to catalyst technology
- Resistance to thermal damage from desulfation
  - Improved catalyst formulations
  - Better catalyst substrates
- Improvements in sulfur management
  - Strategies to minimize effective of sulfur/desulfation
  - Demonstrated improvements in system performance at extended life
- System integration
  - Better system control, lower fuel consumption
  - Increased engine operating range for regeneration



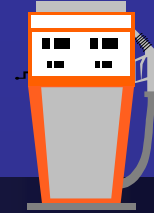
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*HD2007 Progress -  
What's Happening Now?*





# *Progress Toward 2007*



- Clean Diesel Independent Review Panel
- Technology progress reviews
- Engine technology test program
- Refiners/Importers pre-compliance reports
- Implementation workshops and pre-certification meetings



# *Progress Toward 2007: Clean Diesel Independent Review Panel*

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## Independent review conducted in 2002

- Open, public process following FACA requirements
- Panels Findings:

## Panels Findings

### Engine Emission Control Technology

- Very encouraging rate of progress to date.
- No insurmountable issues at this time.
- Key technical challenge remaining is NO<sub>x</sub> adsorber durability.

### 15ppm Desulfurization Technology

- No technological impediments to going forward.
- In general, refiners are where they are expected to be.
- Some are proceeding ahead of schedule, others are evaluating compliance options
- New technologies have been introduced which could lower costs to<sub>28</sub> produce 15 ppm S fuel.



# *Progress Toward 2007: EPA Technology Progress Reviews: Engines*

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- 2002 EPA Progress Review report - progress made on all fronts:
  - PM filter in production in U.S. on HD applications
  - NOx aftertreatment improvements in all key areas (durability, wider temperature range, desulfation)
  - Technical issues remain, but industry is focused on resolving remaining issues
- 2003 Status
  - EPA has continued progress updated meetings with engine and aftertreatment companies
  - We have met with all of the major HD diesel companies
  - EPA 2nd Progress Review report in early 2004



# *Progress Toward 2007: EPA Technology Progress Reviews: Engines*

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- 2002 → 2003
  - Technology focus has shifted from R&D programs to product development
- Engine companies have reached or are approaching technology down-select
  - Most companies have multiple technology paths capable of achieving 2007 standards
    - NOx control options being considered include engine-out, NOx adsorber, urea-SCR
  - Senior engineers preparing for formal company gate reviews to choose final 2007 package
    - Most companies will make decision in 4th quarter 2003 or 1st quarter 2004



# *Progress Toward 2007: EPA Engine Technology Test Program*

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- EPA began NOx adsorber test programs in 1999 - with key support from MECA companies
- Results thus far include;
  - Demonstrated 2010 standards, SAE papers 2001-01-1351, 2001-01-3619
  - New NOx adsorber desulfation techniques, SAE paper 2002-01-2871
  - Thermal aging investigations, SAE paper 2003-01-0042
  - Novel vehicle packaging investigation, SAE paper 2003-01-2305
- Future work looking at long term durability



# *Fuel Precompliance Report*

## *Industry is On Target*

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- Results are consistent with the expectations in the final rule and EPA's 2002 Highway Diesel Progress Review
  - However, results are preliminary
  - Plans could still change, prompting different results next year
- Most companies are in the planning stage now and expect to make final decisions by 1Q 2004



## *Progress Toward 2007: 15 ppmS Diesel Fuel will be Available*

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- 15 ppm fuel will be widely available —
  - On a volume basis, over 95% of highway diesel fuel produced in 2006 is projected to meet the 15 ppm sulfur standard
  - On a facility basis, over 90% of refineries/importers have stated that they plan to produce some 15 ppm diesel fuel
- A large credit volume is expected
  - Accommodates off-spec material
  - Provides a supply “safety valve”
  - Allows for an additional volume of 500 ppm highway diesel fuel without violating the 80/20 TCO requirement



## *Progress Toward 2007: Implementation Workshops and pre-Certification Meetings*

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- Implementation workshops
  - A forum for stakeholders to discuss and address implementation issues questions
  - Clean Diesel Fuel Workshop held in Nov. 2002
  - Clean Diesel Engine Workshop held in Aug. 2003
- EPA pre-certification engine meetings
  - A normal part of new program implementation
  - Allows companies to discuss specific questions and product plans with EPA on a one-on-one basis
  - We encourage all companies to come and speak with us early regarding any certification concerns



## *For More Information...*

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- 2007 Heavy-duty Engine and Vehicle home page:

<http://www.epa.gov/otaq/diesel.htm>

- Contact:

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