2007 Program Update
Timeline for Vehicle and Engine Integration

Facilitating Field Testing

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Timeline for Vehicle and Engine Integration Facilitating Field Testing

Topics

- 2007 Program Objectives
- 2007 Aftertreatment Technology Options and Challenges
  - » Particulate Reduction Systems
  - » NOx Reduction System
- 2007 Timeline
- 2007 Field Testing Plans
- Summary

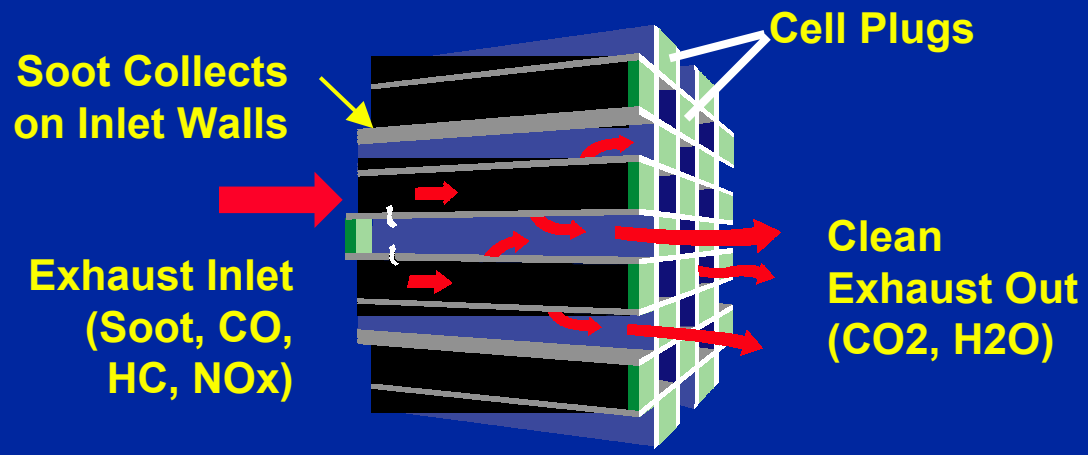
2007 Program Objectives

- **2007 Program Objectives**
  - **Develop and Demonstrate Systems Achieving 2007 Emissions**
  - **Maximize Reliability & Fuel Economy**
  - **Minimize Product Cost & Development Cost (for OEM & Engine Manufacturer)**
  - **Develop Solutions for Heavy Duty and Midrange**
  - **Allow Customers to demonstrate performance and reliability**

Particulate Reduction Technologies

Wall Flow Filter Technology

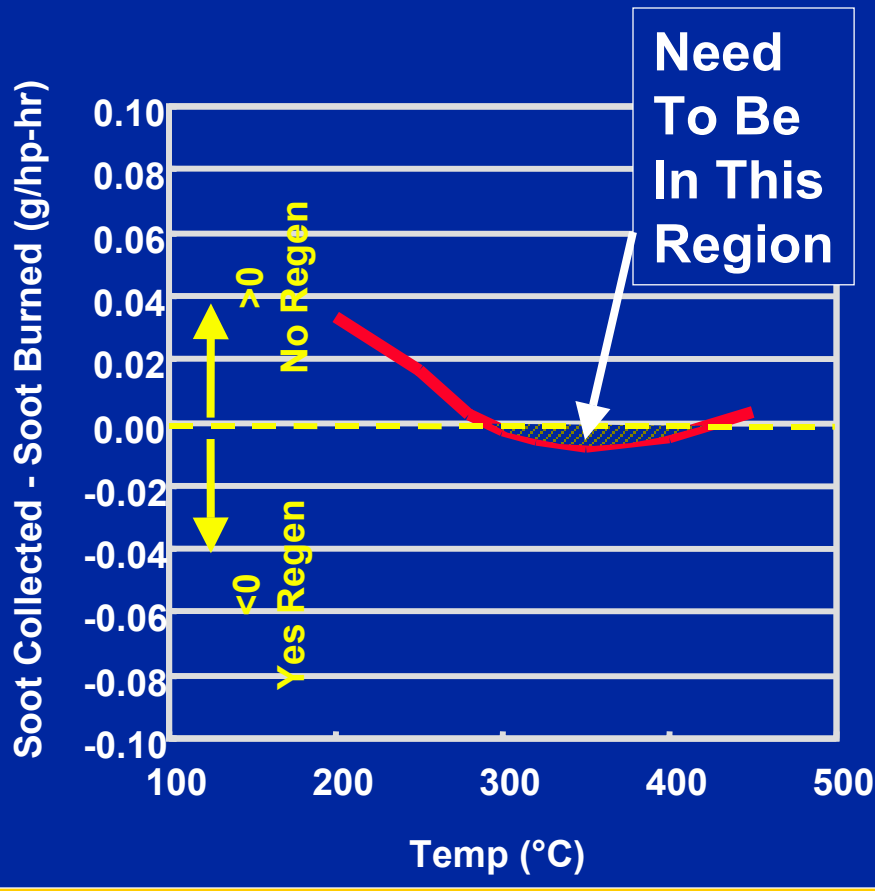
Filter Substrate



- Diesel Particulate Filter (DPF)
- Collects Soot
- Oxidizes / Burns Soot
- Wall Flow Ceramic Filter
- Optional Diesel Oxidation Catalyst

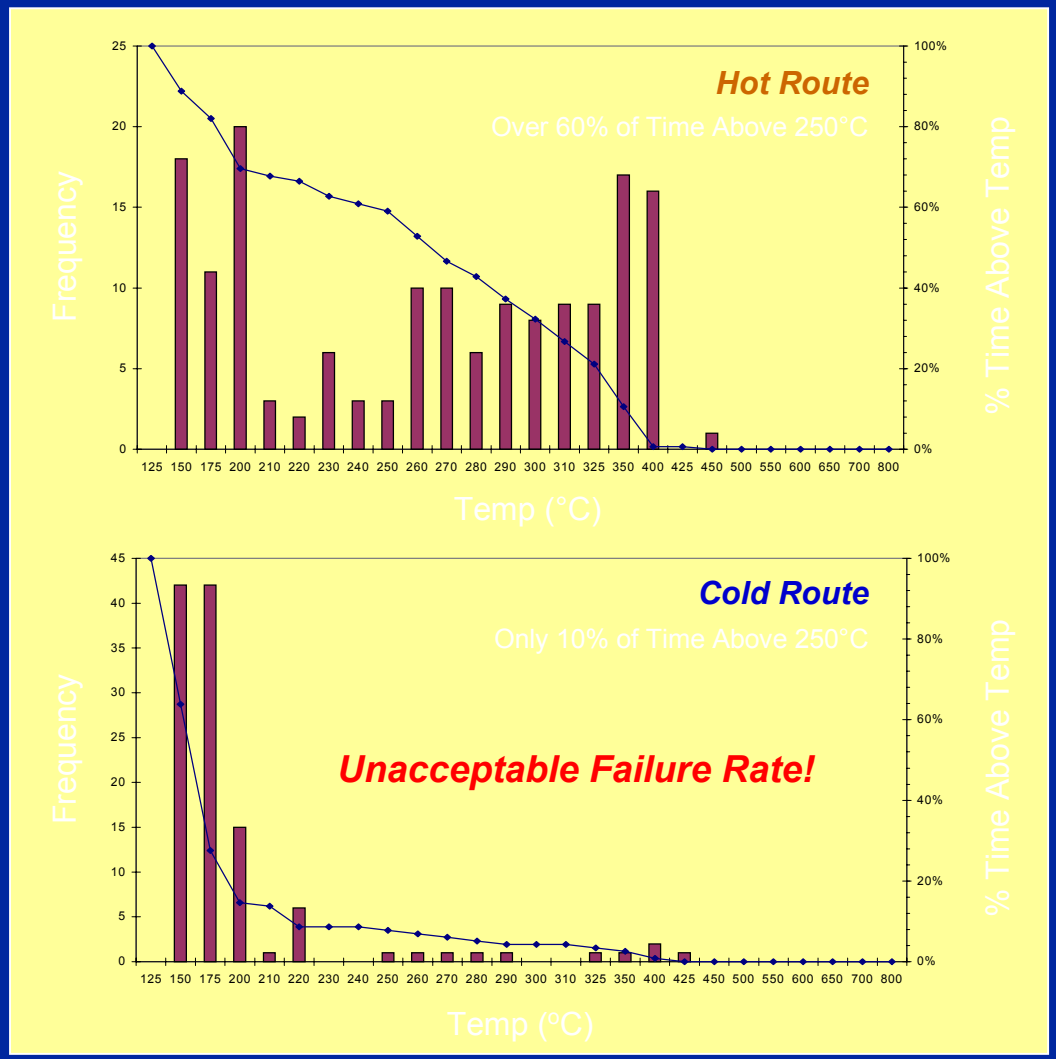
Temperature Is Key to Filter Regeneration

- Optimum is 350°C (660°F)
  - – Below 300°C (570°F) too Slow
    - »Low Temperature
  - – Above 400°C (750°F) also Slow
    - »NO - NO_2 Equilibrium Limits Soot Burning



Best Value Solution will be if Engine Can be Tailored for Thermal Management

Temperatures Vary With Application and Duty Cycle



System integration ensures successful filter regeneration.

Filters must be successful in all possible application scenarios

Note: 250 degrees is minimum temperature supplier recommends for this type of particulate filter

Diesel Particulate Filters
Other Issues

- Minimize Backpressure Effects
- Servicing To Remove Ash From Filter
- Active Generation Transparent To The Operator
- Size Of System Impacts Chassis
- Cost High Due To Precious Metal Content

NOx Reduction Technologies and Options

NOx Reduction Options

Engine NOx Technology

- Advanced Diesel Combustion

Aftertreatment NOx Technology Options

- DeNOx Catalyst
- NOx Adsorber
- Urea SCR

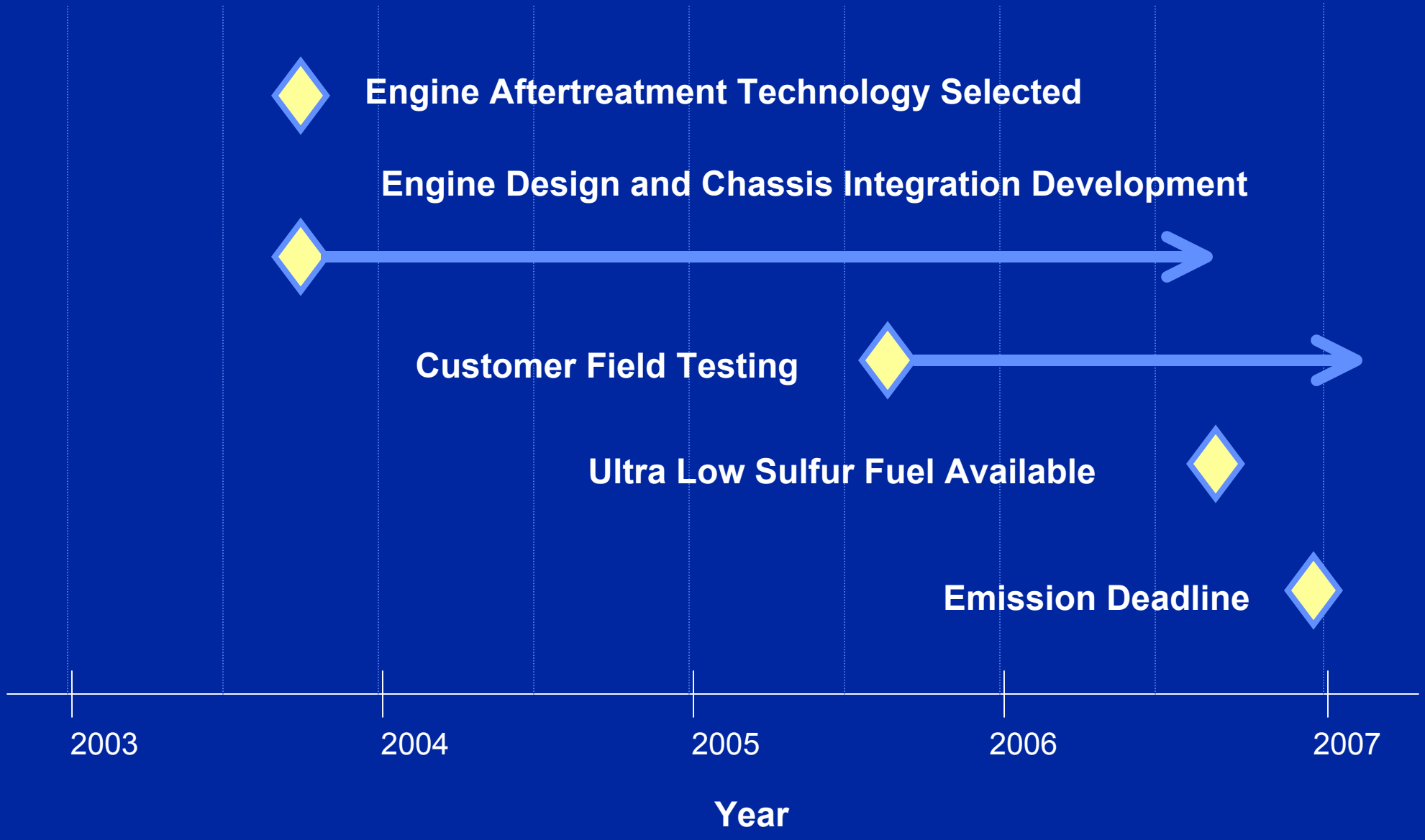
- Engine-Out NOx Measures Can Reduce Size / Cost of Aftertreatment
- Aftertreatment Options Need to Be Evaluated for Maturity and Cost
- Combination of Engine-Out and Aftertreatment May Provide Best Value Path

Advanced DeNOx Catalyst

- Aftertreatment Technology to Reduce NOx Emissions
  - Capable of Substantial NOx Reduction
- Current Development Work:
  - Integration of DeNOx With Engine Measures for NOx Reduction
  - System & Component Design
  - System Performance & Packaging
  - Catalyst Development
  - Catalyst Performance Evaluation

2007 Emissions Development Timeline

2007 Timeline & Critical Dates



Field Demonstrations of Aftertreatment Technologies

2007 Field Demonstrations Program Objectives

Real World Conditions
"Stretch the Envelope"
Evaluate varying Aftertreatment Technologies

2007 Field Demonstrations
"Stretch the Envelope"

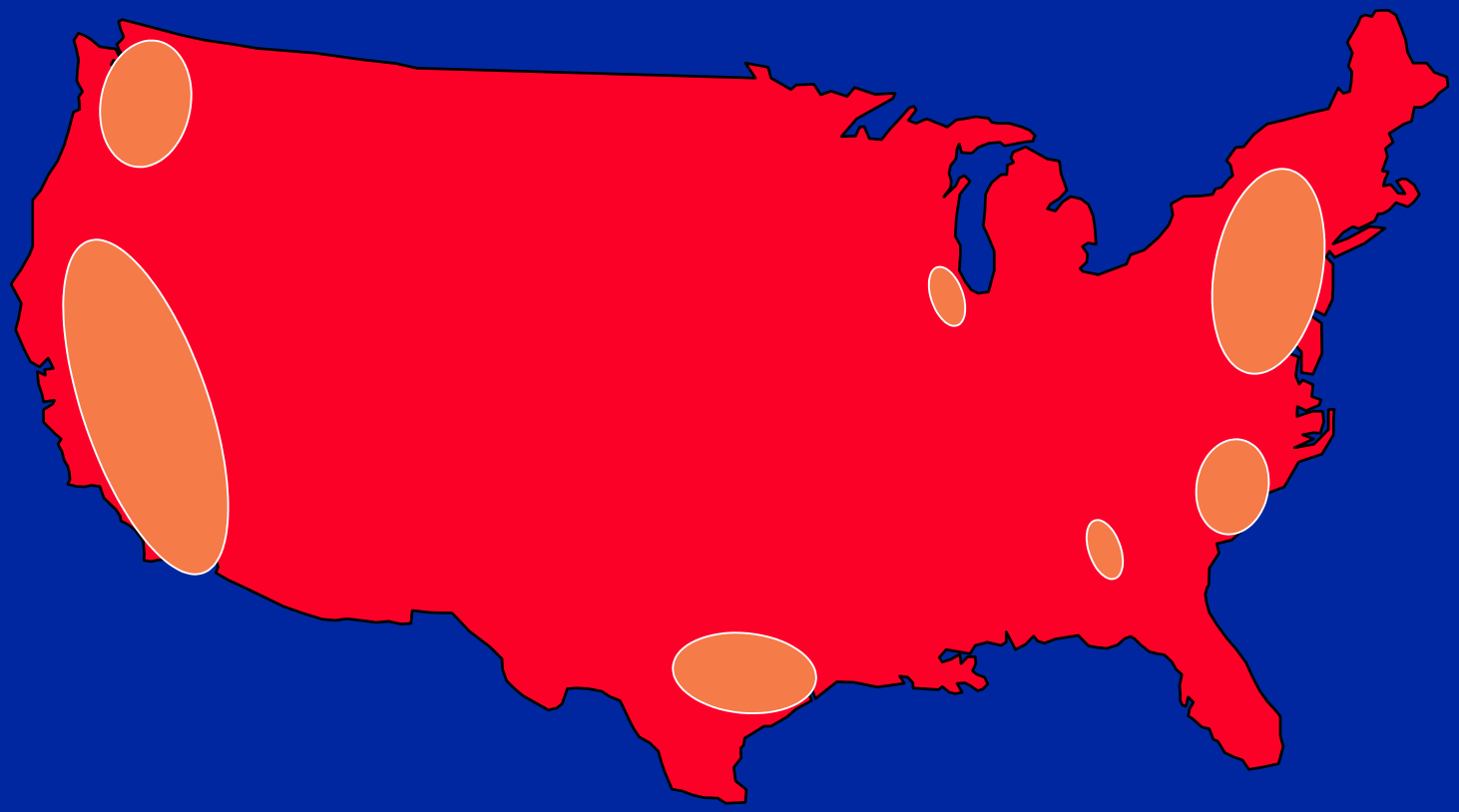
Applications/Temperatures/Thermal Cycling
Duty Cycles/Service Intervals
Operating Fluids (Fuels/Oils)

Aftertreatment Field Demonstrations Examples

Internal Development and Demonstration Vehicles
Retrofit Opportunities – School Bus/Transit Bus Fleet Programs
Government Funded – Federal/State
Off Road Applications

Primary Retrofit Markets

Particulate Control Devices



Aftertreatment Field Demonstrations Testing Limitations

Ultra Low Sulfur Fuel Availability
Cost of Aftertreatment Installations
Current Technology Not Demonstrating 2007 Emission Levels
Not Demonstrating All Applications/Conditions

2007 Program
Aftertreatment Field Demonstration
Summary

Technologies Required for 2007
Engine Manufacturers Timeline
Test Activities

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