Development of a Desulfurization Strategy for a NO_x Adsorber Catalyst

(Phase II Project under Diesel Emissions Control - Sulfur Effects Program)

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Outline

- **Introduction**
  - **Objectives**
  - **Background**
- **Test Engine, Set-up and Fuels**
- **Test Results**
  - **Improved NO_x Regeneration Strategy**
  - **Desulfurization Process Development and Demonstration**
- **Summary and Conclusions**

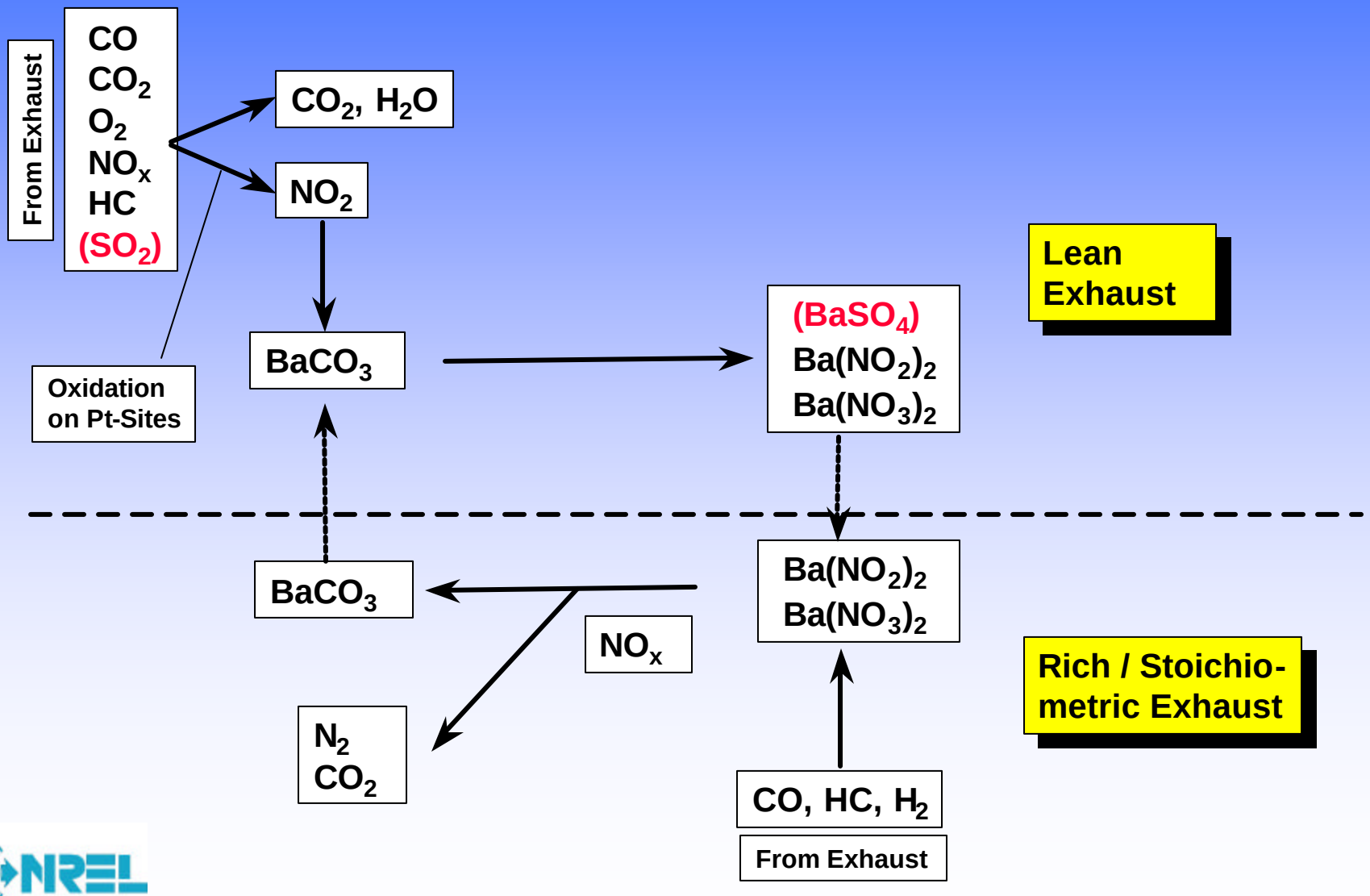
Introduction

Objectives:

- **Improve NO_x regeneration calibration developed in DECSE Phase I project to understand full potential of NO_x adsorber catalyst over a range of operating temperatures.**
- **Develop and demonstrate a desulfurization process to restore NO_x conversion efficiency lost to sulfur contamination.**
- **Investigate effect of desulfurization process on long-term performance of the NO_x adsorber catalyst.**

Introduction

Background - Chemistry of NO_x Adsorber Catalysts



Test Engine, Set-up and Fuels

Test Engine Specification

- 1.9 L HSDI Diesel Engine
- 81kW @ 4200 rpm
- Turbocharged
- Intercooled
- EGR
- Intake Air Throttling
- Common Rail Fuel Injection System
- Fully Accessible ECU

Test Engine, Set-up and Fuels

Calibration Requirements

Calibration

Engine

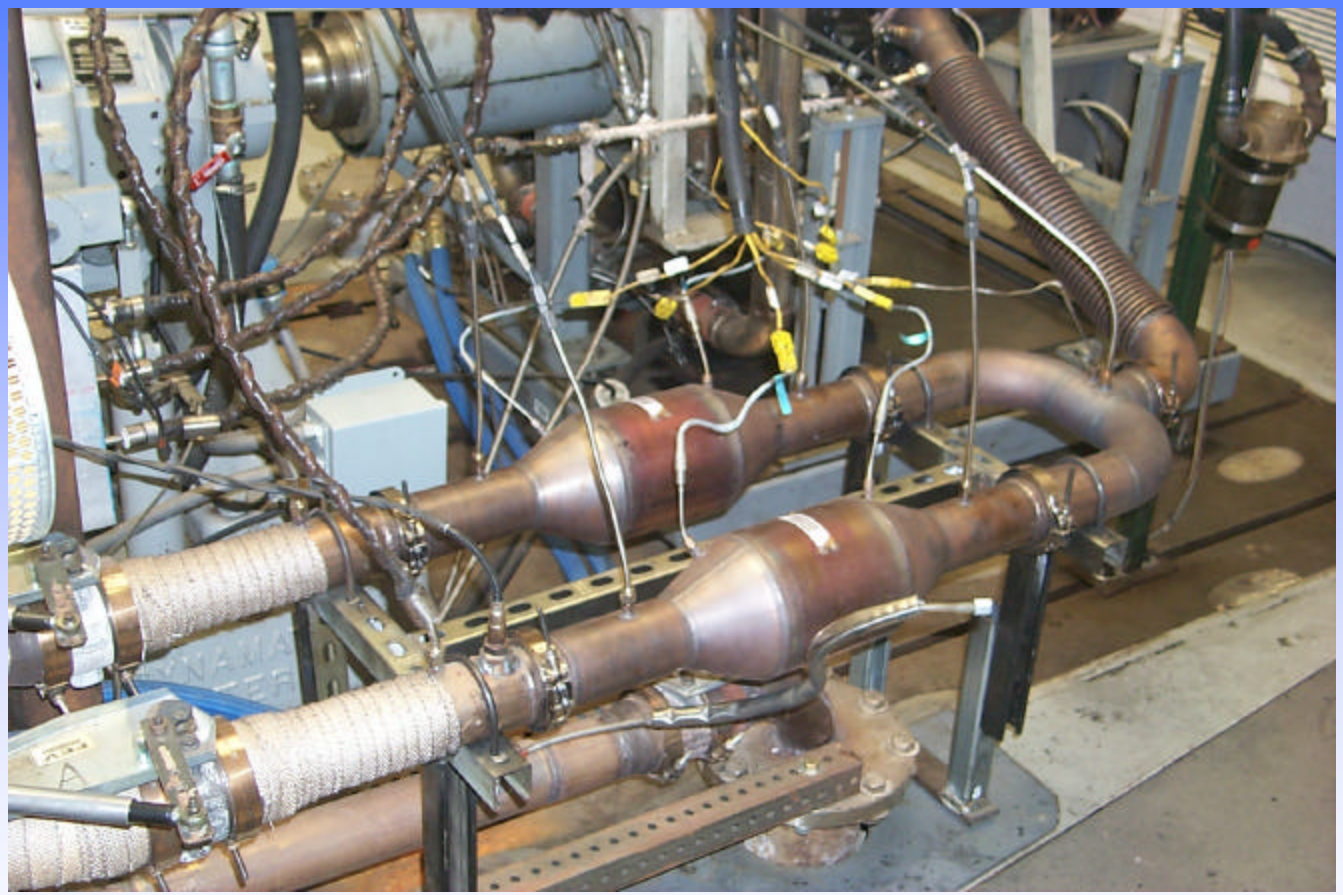
- BOI and Quantities for Pilot, Main and Post Injection
- Injection Pressure
- EGR Rates
- Throttling
- VTG

Cycle

- Initiation of Regeneration Mode
- Lean Mode Duration
- Rich Mode Duration

Test Engine, Set-up and Fuels

Test Cell Set-Up

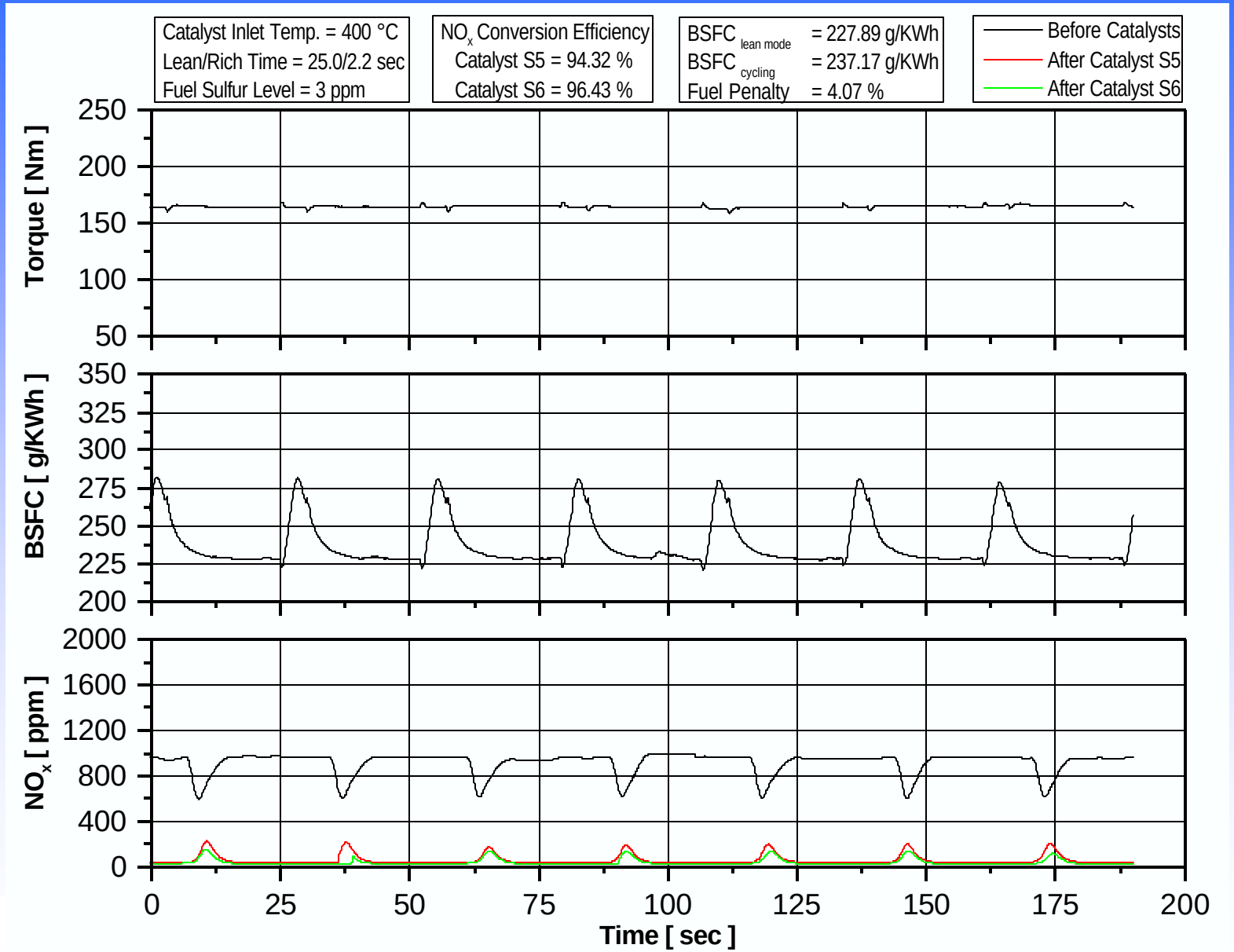


Test Fuels

- Bulk of testing conducted with ultra-low 3-ppm sulfur diesel fuel
- Catalysts from DECSE Phase I had been aged with 3-, 16- and 30-ppm sulfur fuel
- Diesel fuels with 78-, 150- and 380-ppm sulfur levels used for portions of testing

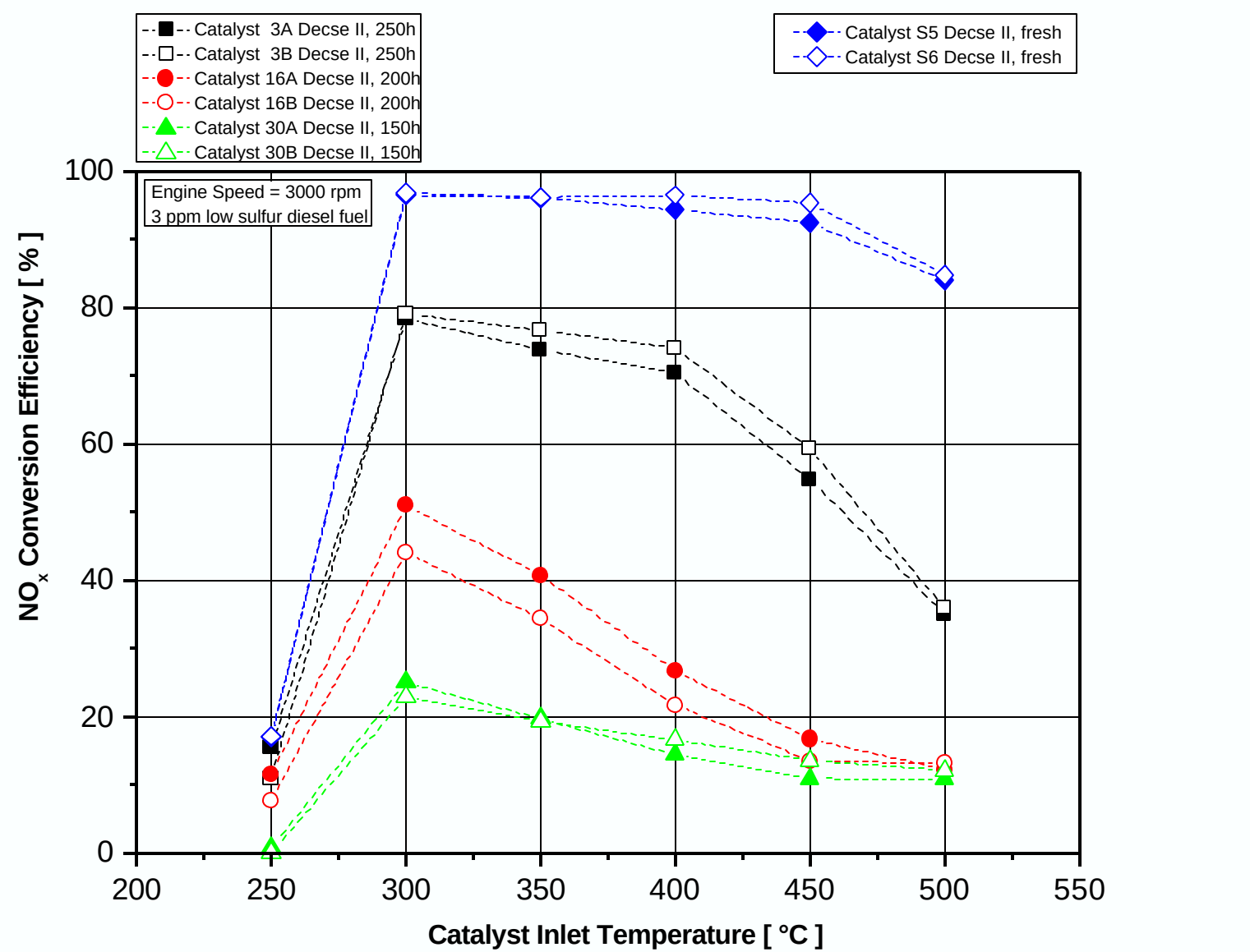
Test Results: NO_x Regeneration Strategy

Catalyst Regeneration



Test Results: NO_x Regeneration Strategy

NO_x Conversion Efficiency Results



Test Results: Desulfurization Process

Desulfurization Process Targets

Necessary Sulfur Release Boundary Conditions:

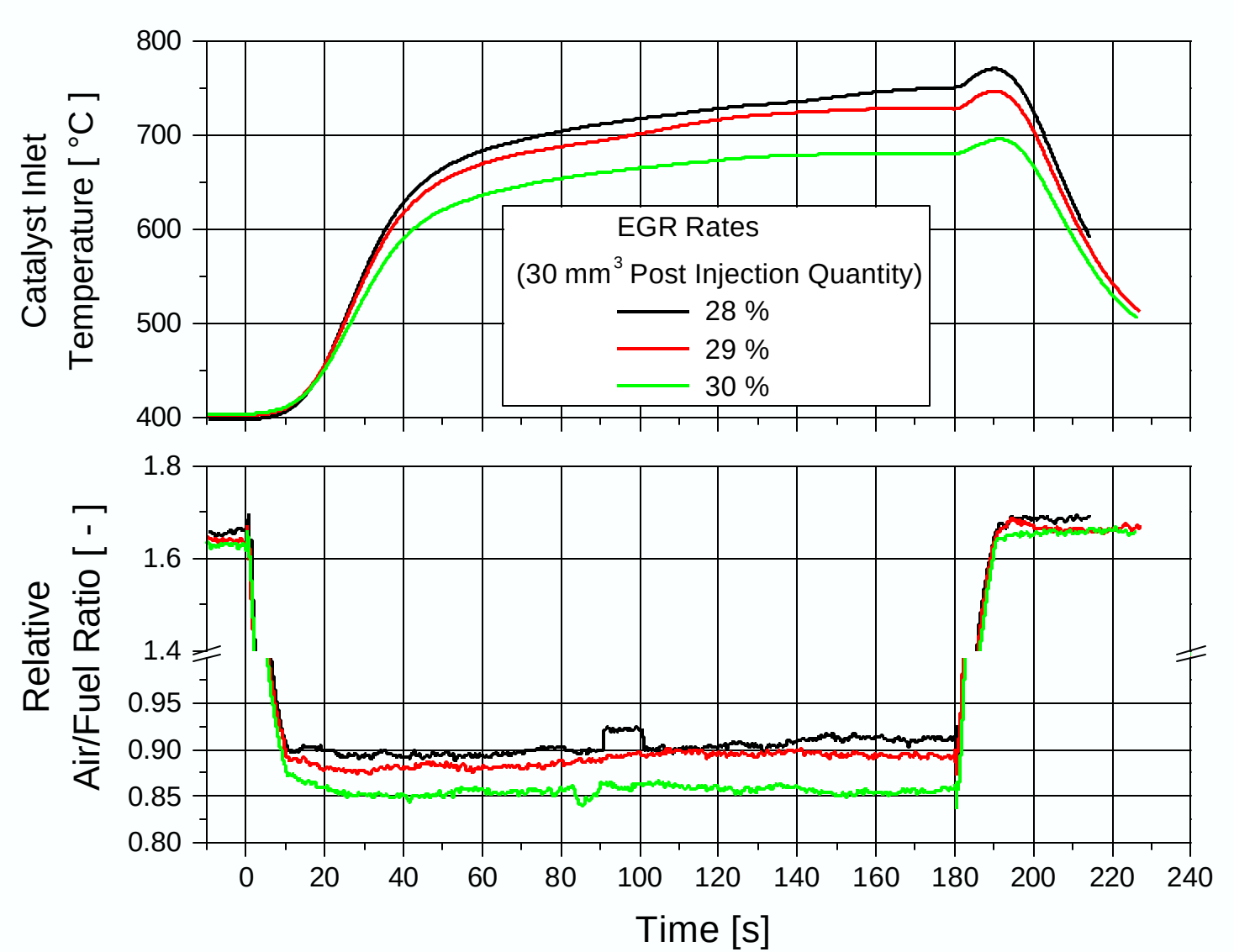
• NO_x Adsorber Catalyst Inlet Temperature	700°C*
• Relative Air/Fuel Ratio	~ 0.9**
• Desulfurization Event Period	~ 3-10 min.
• Fuel Economy Penalty Target	N/A

* Achieved using a warm-up catalyst upstream of the NO_x adsorber and post-injection

** Achieved using post-injection, throttling and EGR

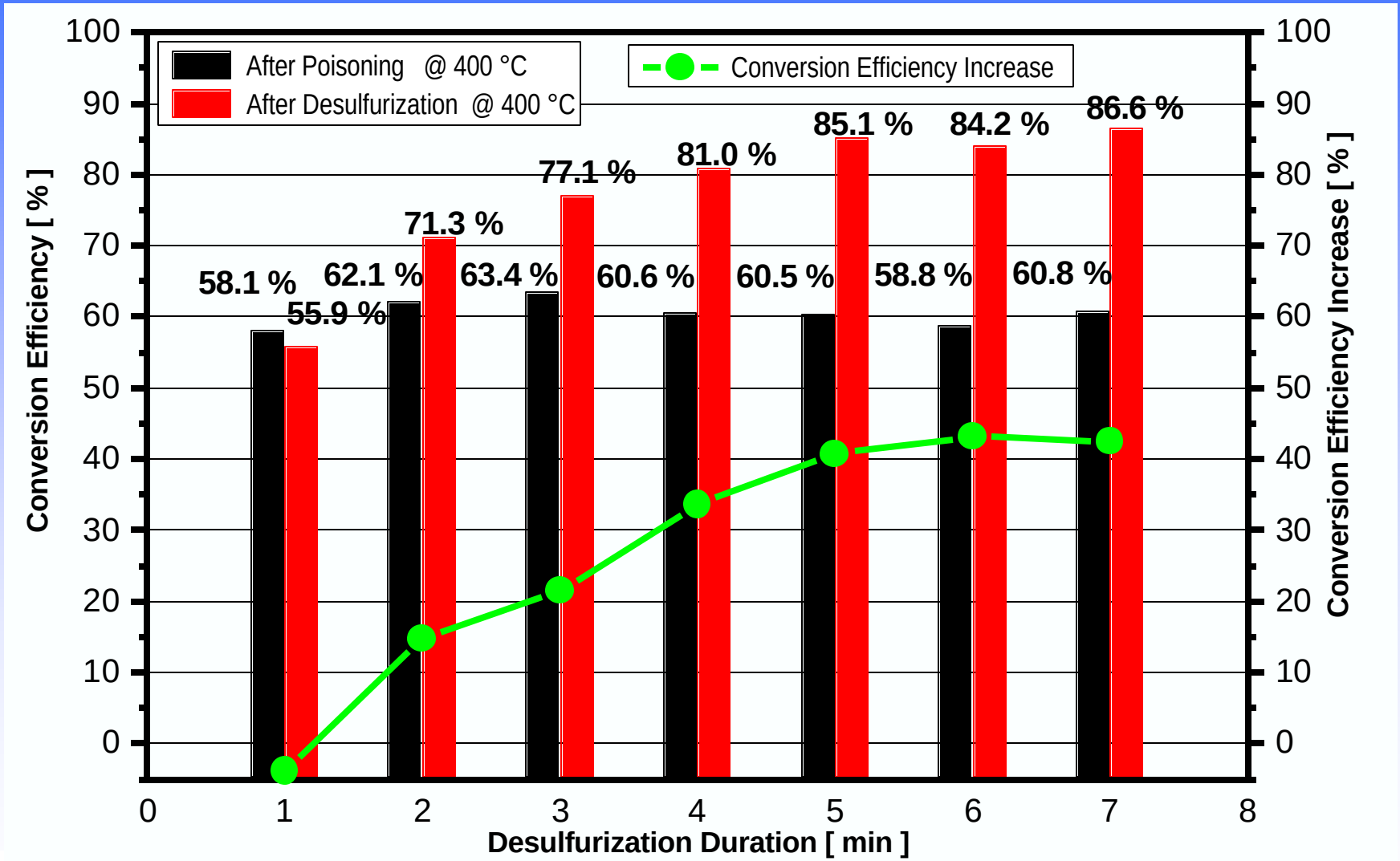
Test Results: Desulfurization Process

Demonstration of Desulfurization Conditions



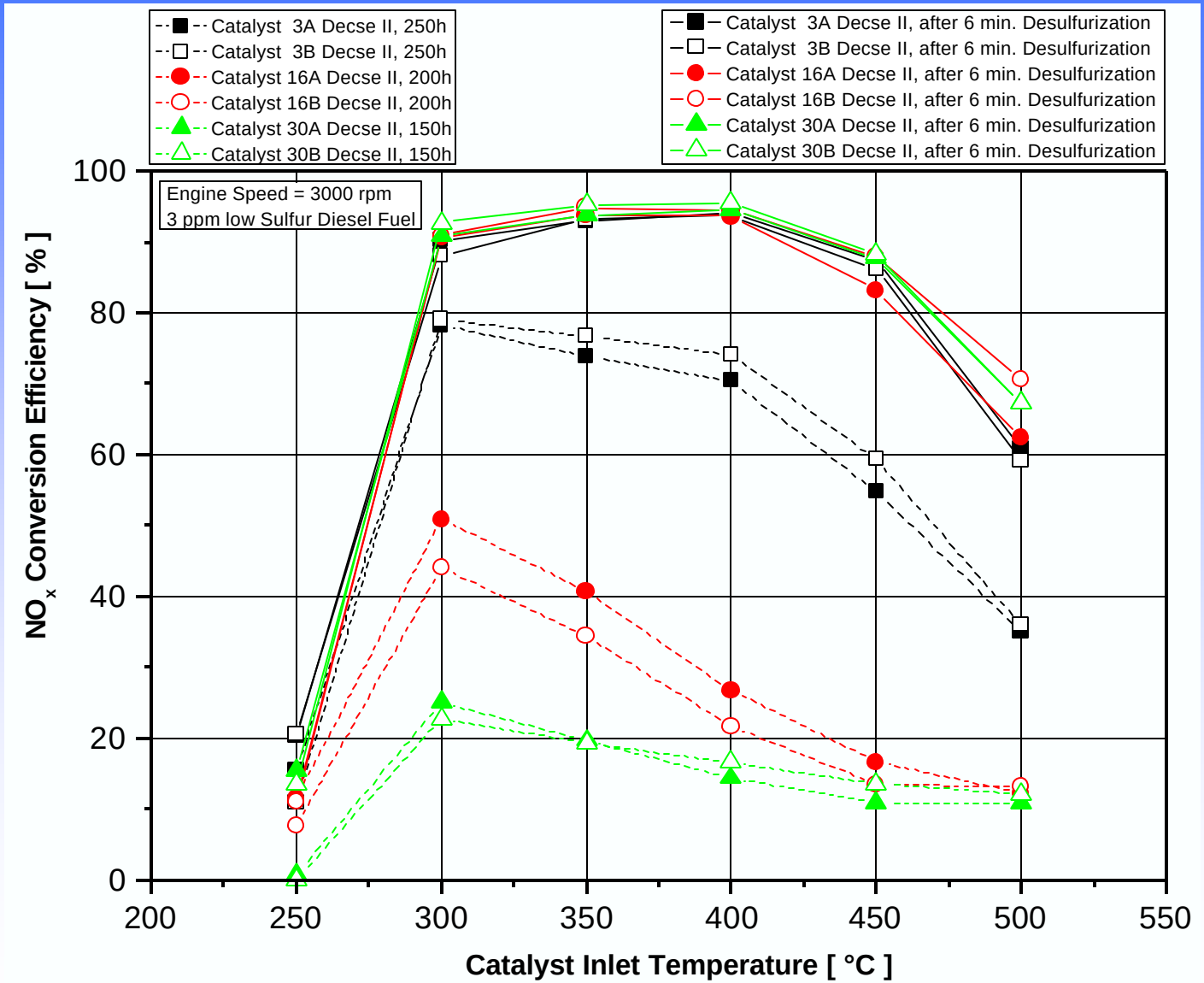
Test Results: Desulfurization Process

Influence of Desulfurization Time



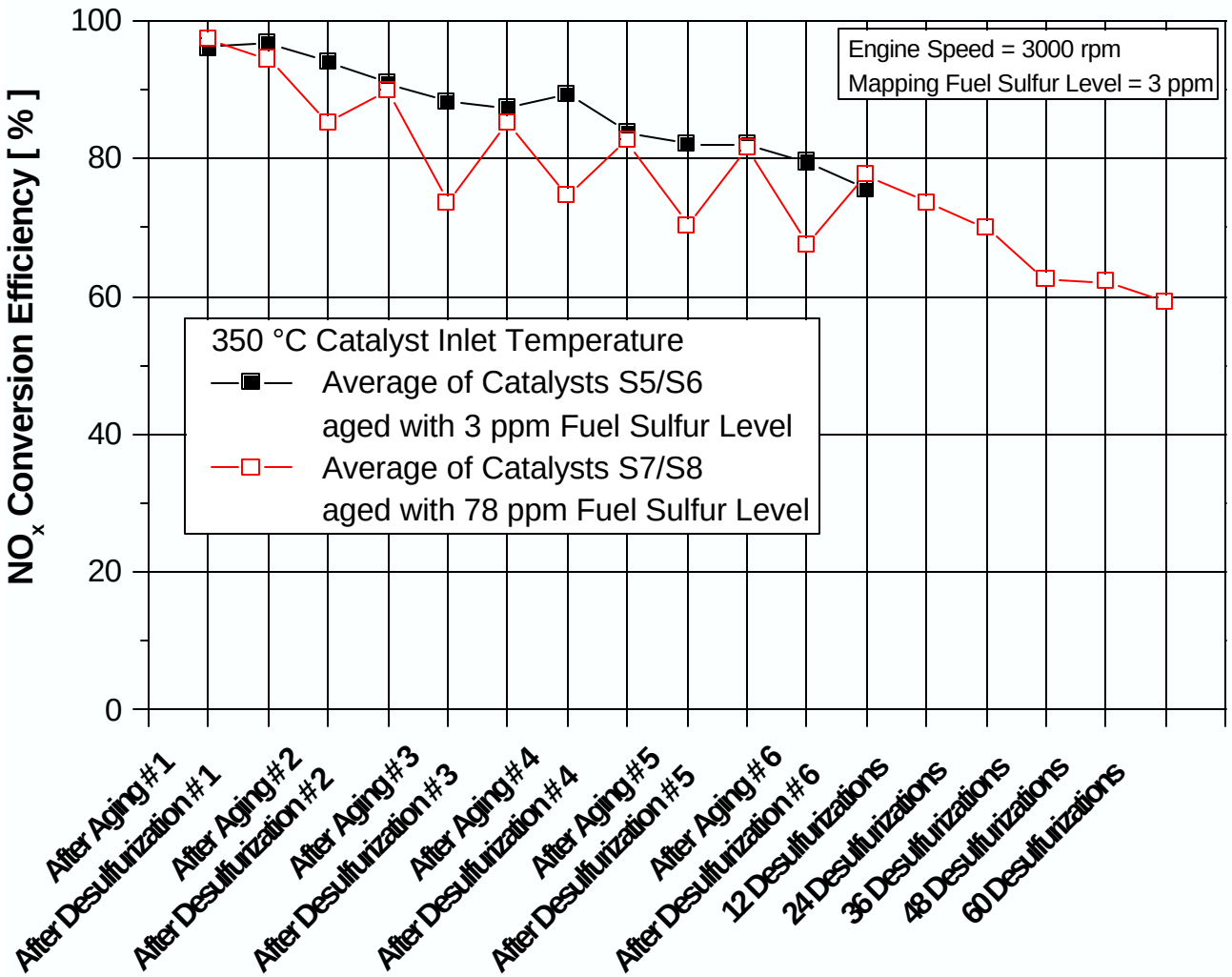
Test Results: Desulfurization Process

Recovery of NO_x Conversion Following Desulfurization



Test Results: Desulfurization Process

Influence of Aging with Higher Sulfur Levels



- Series of single desulfurization events with 10 hour aging between (3-ppm or 78-ppm sulfur fuel for aging), performance mapped following each aging and each desulfurization
- Series of multiple desulfurization events followed by performance maps

Summary and Conclusions

- **Improved lean/rich engine calibration achieved resulted in NO_x conversion efficiencies exceeding 90% over catalyst inlet operating temperatures from 300°C to 450°C.**

- **Desulfurization procedure showed recovery to greater than 85% NO_x conversion efficiency in catalysts exposed to 3-, 16-, and 30-ppm sulfur fuel for up to 250 hours over 300°C to 450°C range after single desulfurization event.**

- **Desulfurization procedure developed has the potential to meet in-service engine operating conditions and provide acceptable driveability conditions.**

Summary and Conclusions

- **Although aging with 78-ppm sulfur fuel reduced NO_x conversion efficiency more than aging with 3-ppm sulfur fuel as a result of sulfur contamination, the desulfurization events restored the conversion efficiency to nearly the same level of performance. However, exposing the catalyst repeatedly to the desulfurization procedure developed in this program caused a continued decline in the catalyst's desulfurized performance. Additional work will be necessary to identify the cause of this performance decline.**

- **Rate of sulfur contamination increased with repeated desulfurization cycles when using 78-ppm sulfur fuel. This was not observed with 3-ppm sulfur fuel.**

Project Support

This was a Phase II project under the Diesel Emissions Control - Sulfur Effects (DECSE) Program

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