Ford/DOE SCR Program Update

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DOE Ultra-Clean Fuels Program

Outline of Ford's program to achieve Tier 2 emission standards for 2007 using low sulfur diesel fuel as an enabler for a high efficiency aftertreatment system.

Primary Contractor

Ford Research and Advanced Engineering

Subcontractors

ExxonMobil Research and Engineering

FEV

Catalyst Suppliers

ENGELHARD

JM Johnson Matthey

umicore

Phase I - Initial build/test phase (July01-July02)
Establish baseline emission control system
Deliver engine dynamometer NOx and PM test results
Deliver prototype vehicle NOx and PM test results
Deliver urea delivery (infrastructure) prototype

Phase II - System/component optimization phase (July02-July04)
Define final system hardware components
Deliver NOx and PM performance data from fresh system

Phase III - Durability phase (July04-Dec05)
Definition of durability test procedure
Final NOx and PM emission levels
Final report for the completed program

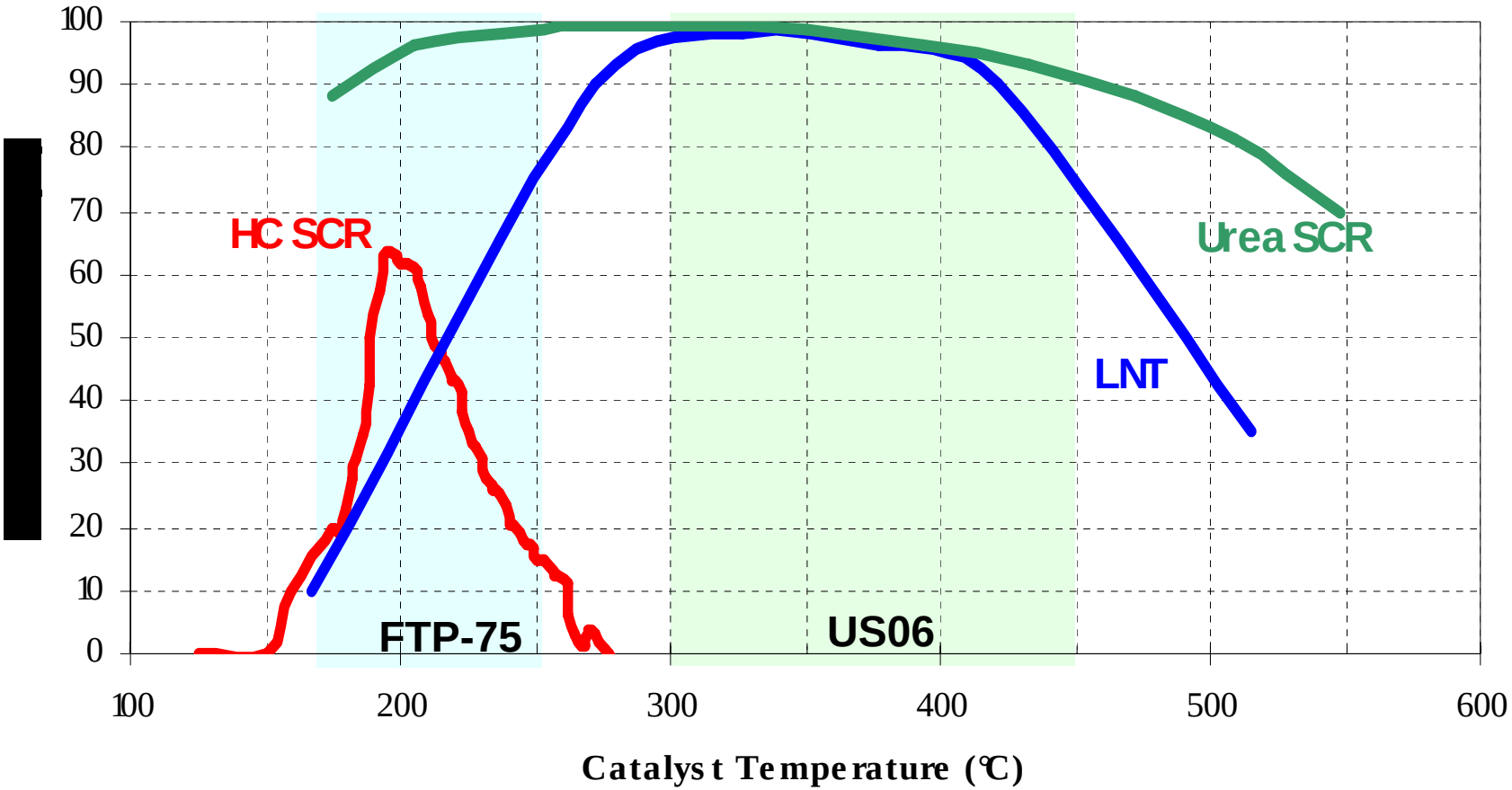
Introduction

- Tier 2 Bin 5 standards represent 90-95% NOx and PM reduction from today's Tier 1 standards for diesels.

Standard	NOx (g/mi)	PM (g/mi)
Tier 1 (100k mi)	1.25	0.10
Tier 2 Bin 5 (120k mi)	0.07	0.01

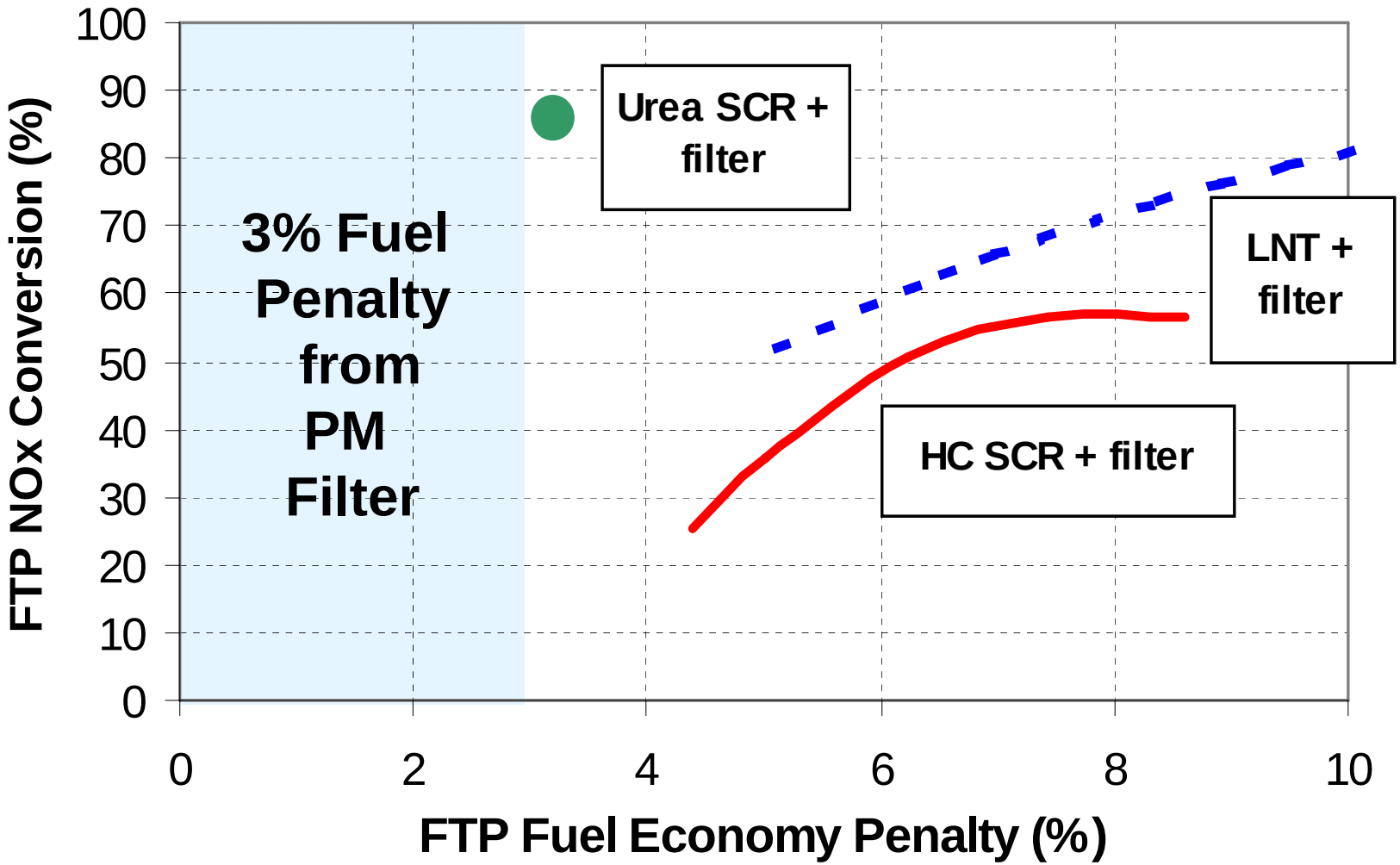
- NOx and PM control remain a challenge for diesels.
- Choices for PM include catalyzed filter.
- Choices for NOx include Lean NOx Trap and Urea SCR.

Comparison of NOx Reduction Technologies



FTP Fuel Economy Penalty Comparison

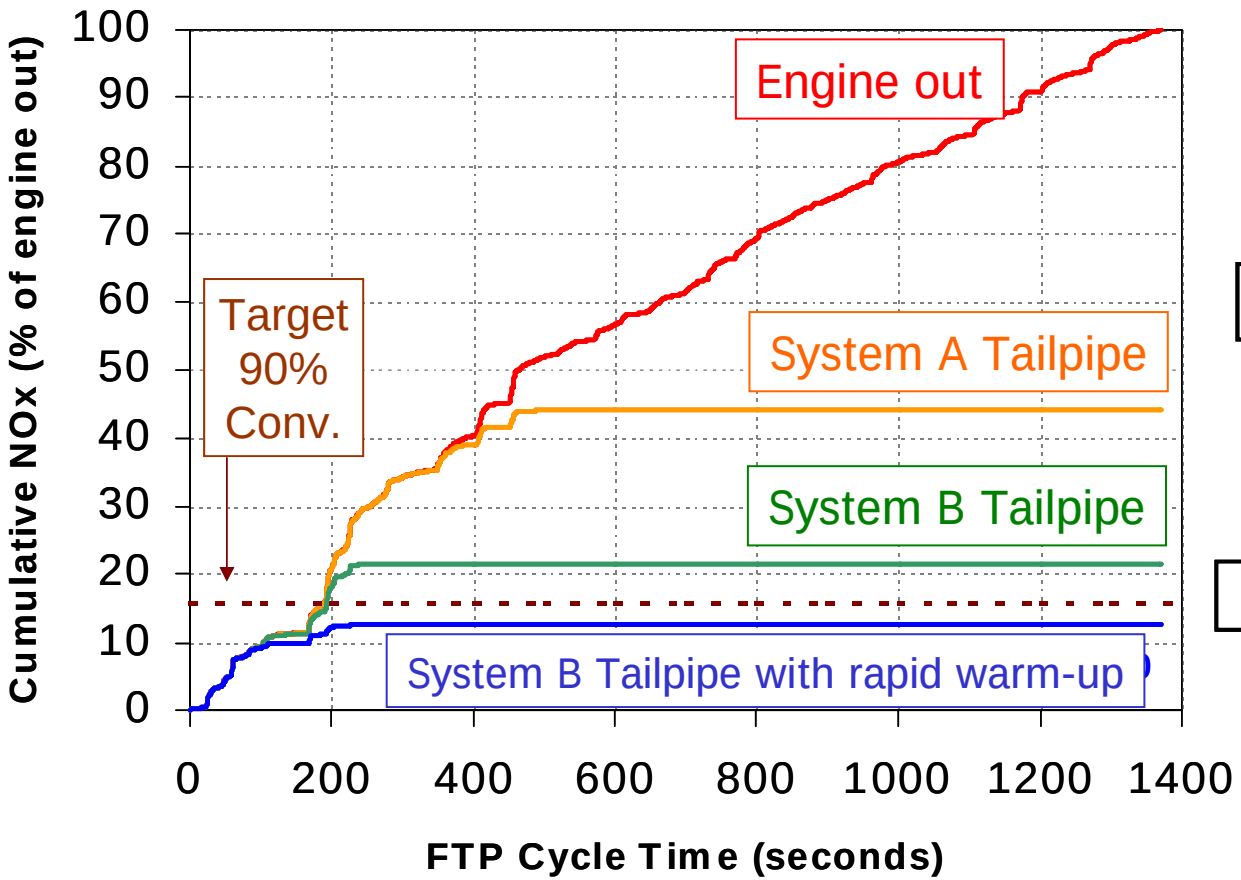
(estimated using 2.5L York Transit feedgas)

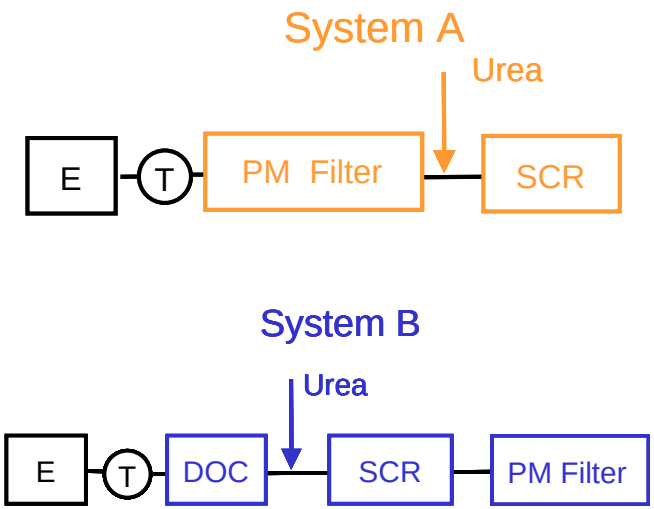


Use of Modeling for Improved SCR Function

- Predict system performance
  - Predict NOx conversion levels
  - Predict fuel economy impact
  - Provide direction for system design
- Evaluate system performance
  - Diagnose problems with system hardware/strategy
  - Provide direction for future system testing

Prediction of FTP Performance

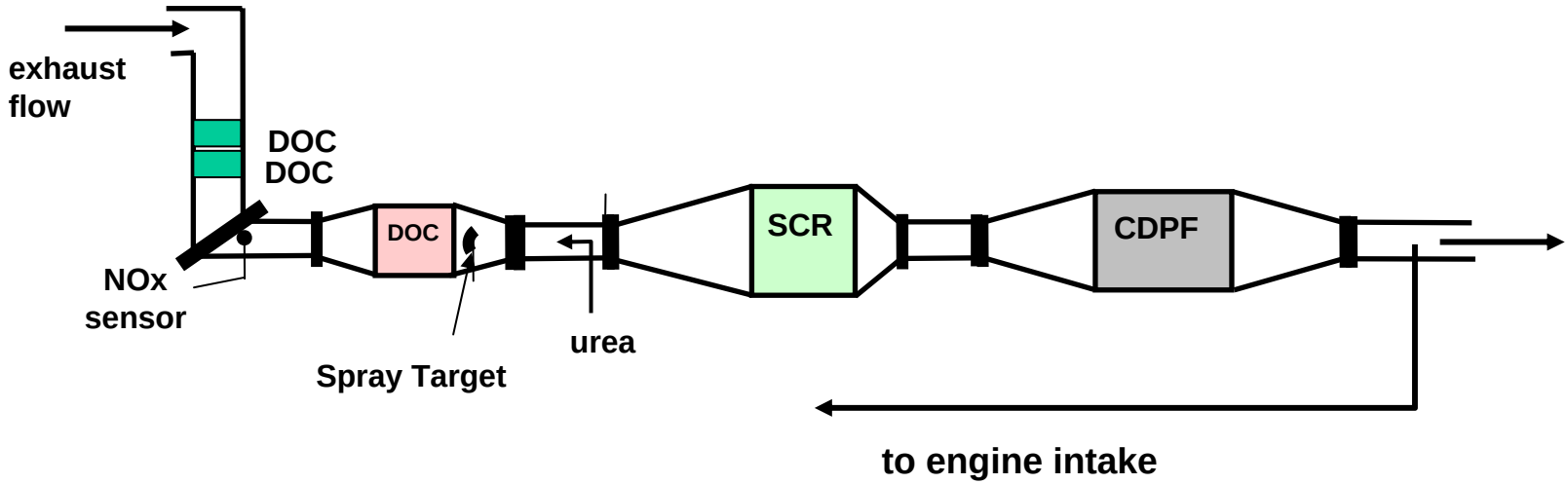




Rapid warm-up = extra 50°C ramped in over first 30s of test.

LDT Exhaust System (NOx)

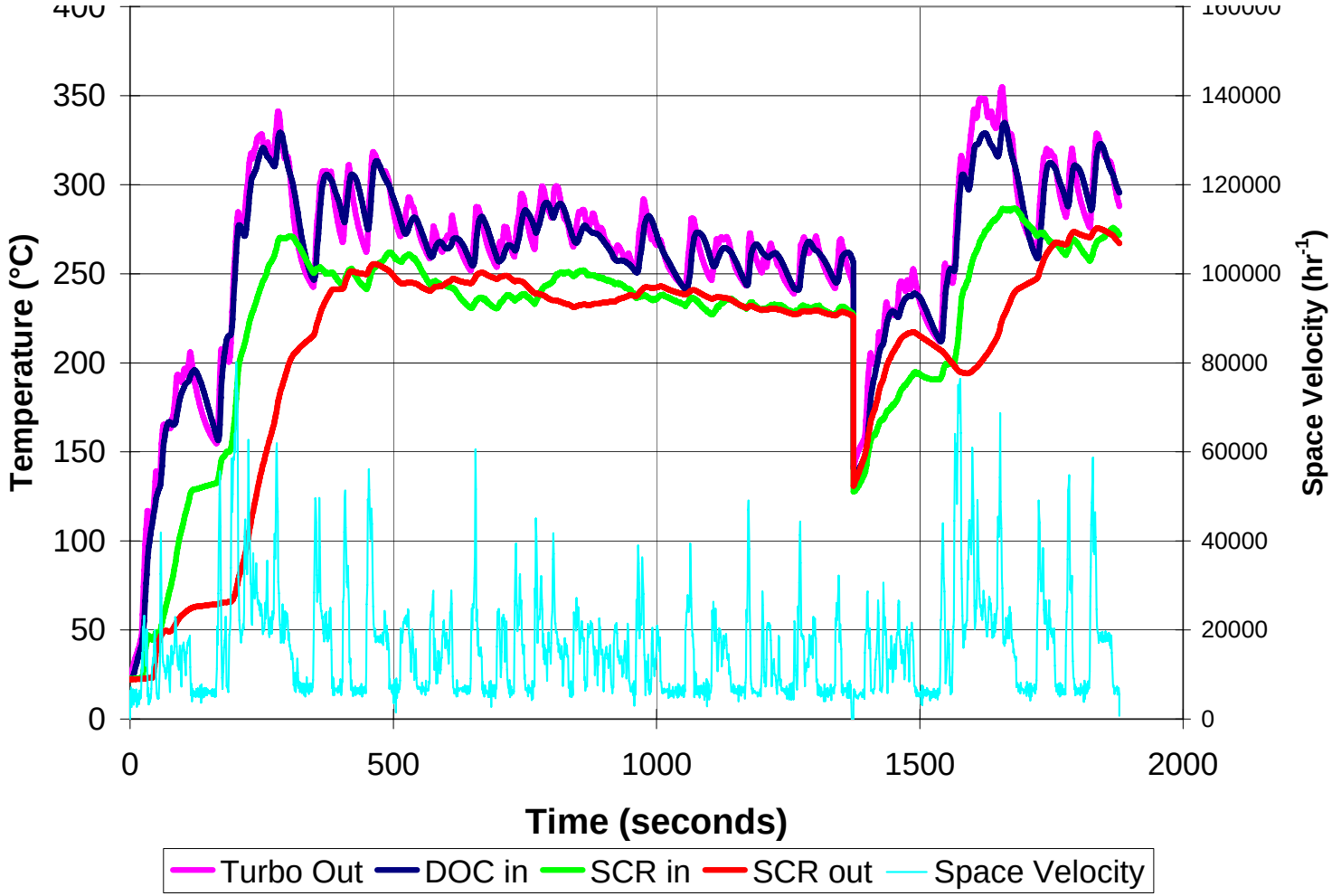
>90% FTP NOx conversion, 0.05 g/mi TP NOx



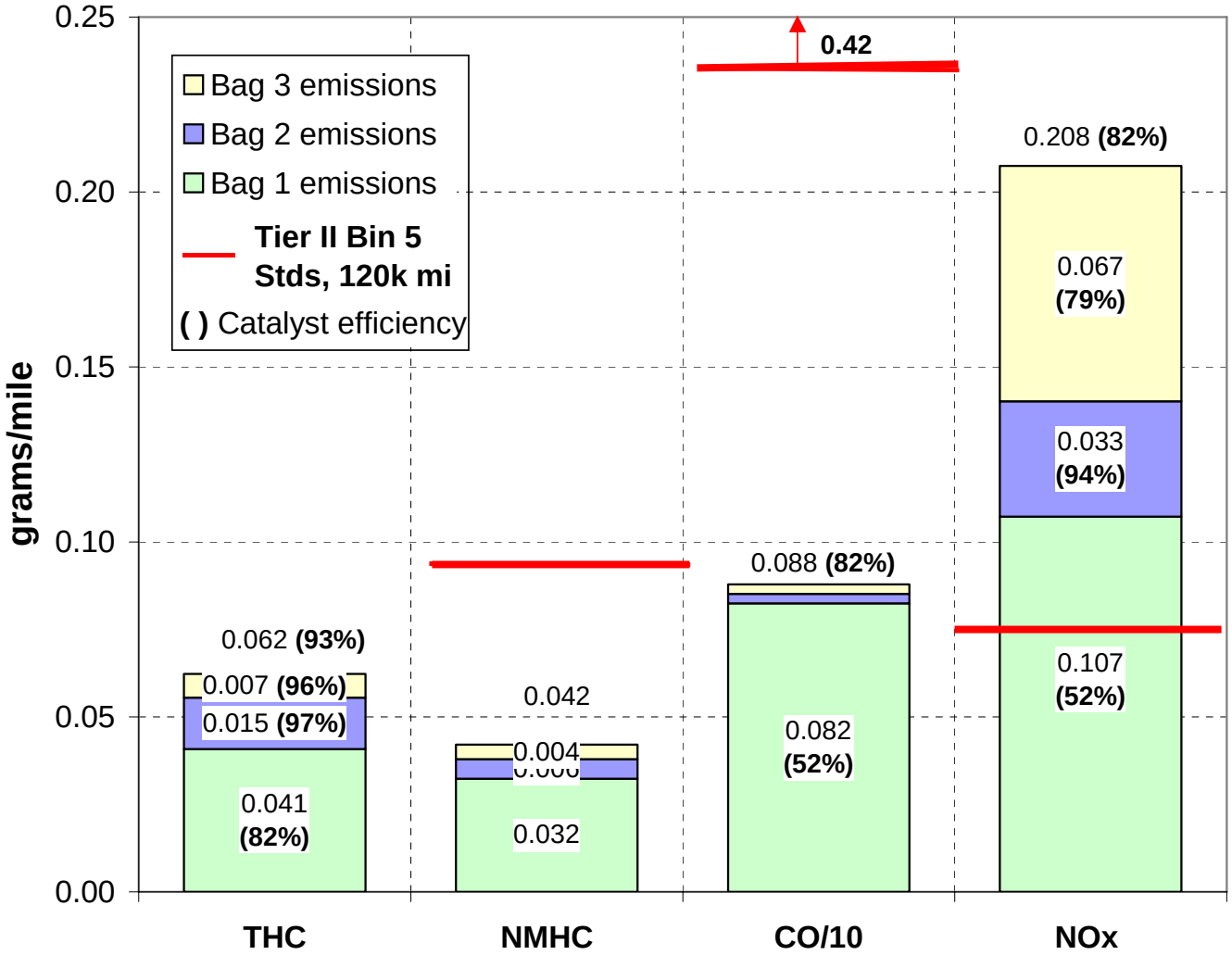
- Engine-out NOx lowered by 40% with increased EGR
- Low tailpipe NOx achieved with rapid warm-up strategy
  - lower thermal mass upstream of catalyst system
  - engine calibration changes during cold start (post injection & inc. idle speed)

LDT Temperatures and Space Velocity on FTP

(without rapid warm-up strategy)

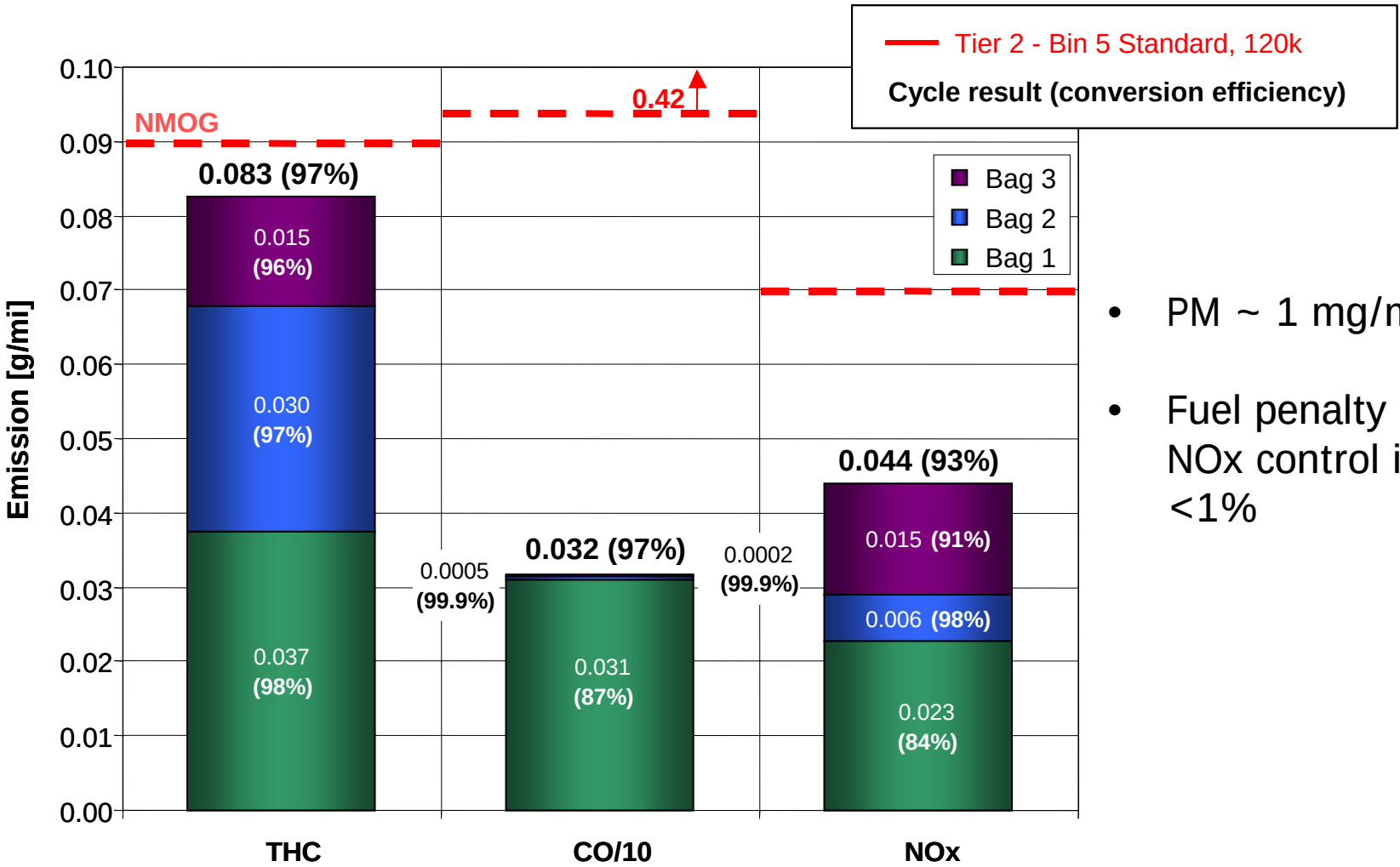


Weighted FTP-75 Emissions
(Without Rapid Warm-up Strategies, September 2003)



Weighted FTP-75 Emissions

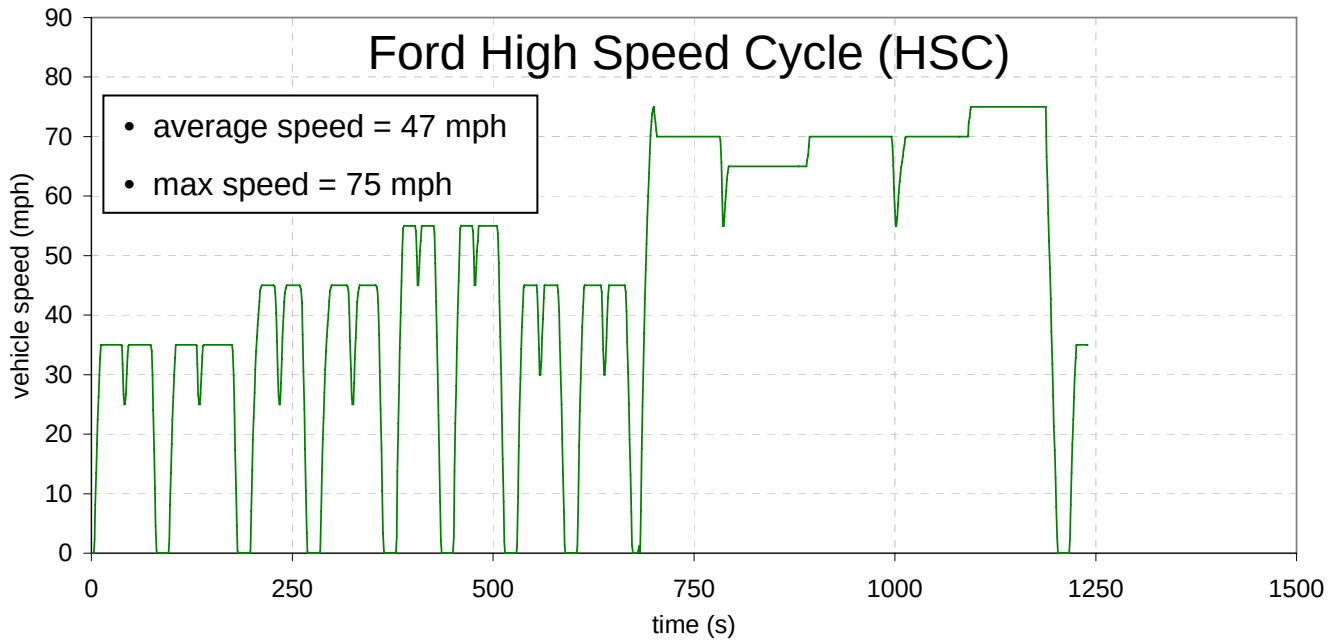
(with rapid warm-up and fresh catalysts on engine dyno)



- PM ~ 1 mg/mi
- Fuel penalty for NOx control is <1%

Current Status

- System has been aged for 50k mi on engine dyno.
- Vehicle testing is underway to determine emissions.

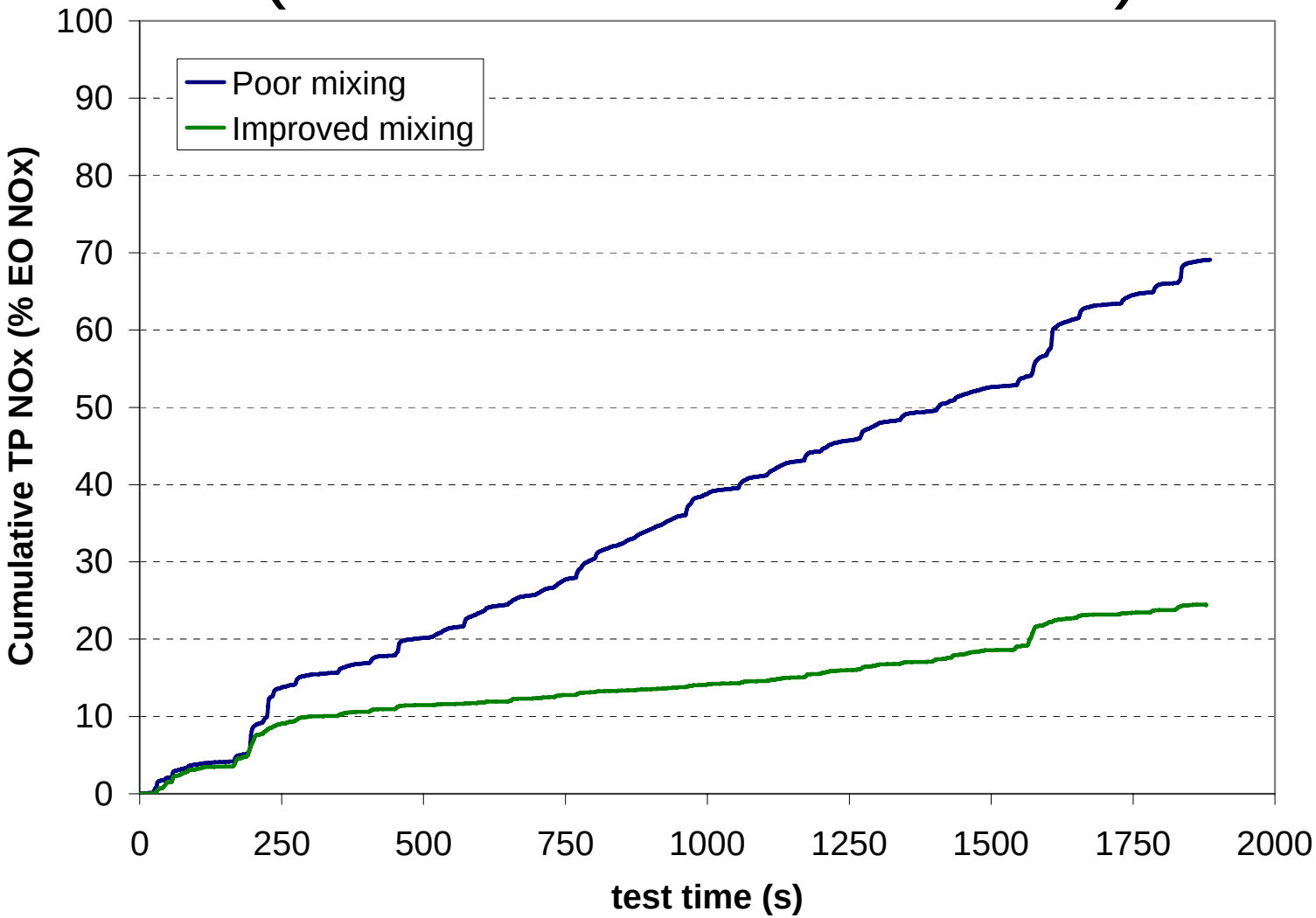


Important Parameters for Urea SCR

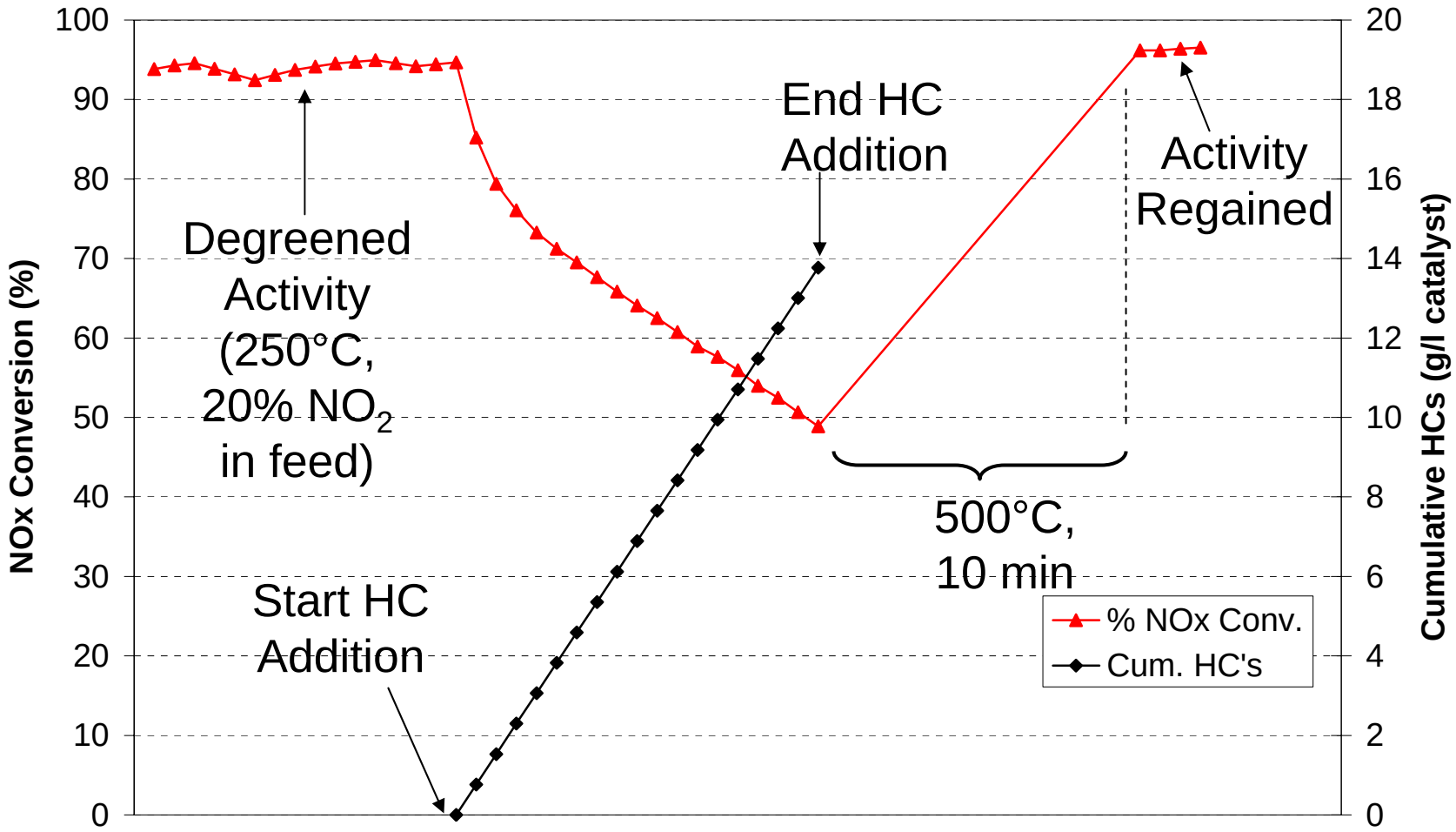
- mixing of reductant in exhaust gas
- rapid warm-up vs HC slip to SCR catalyst
- thermal durability of SCR catalyst
- NO_2/NOx ratio entering SCR catalyst
- effect of sulfur on SCR catalyst

- Others: NH_3/NOx ratio, SV

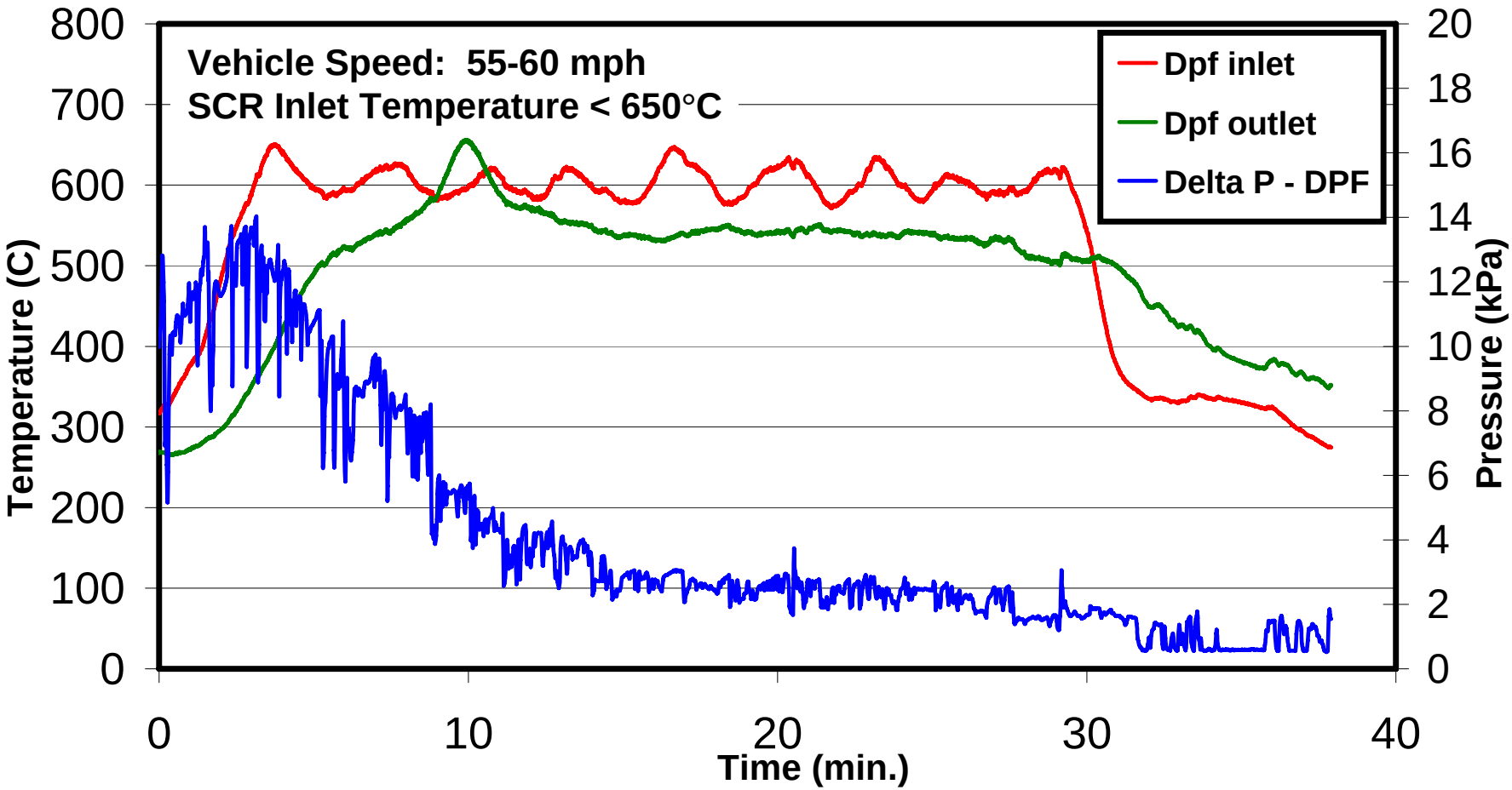
Importance of Urea Mixing (Transient Vehicle Results)



Impact of HC on SCR performance

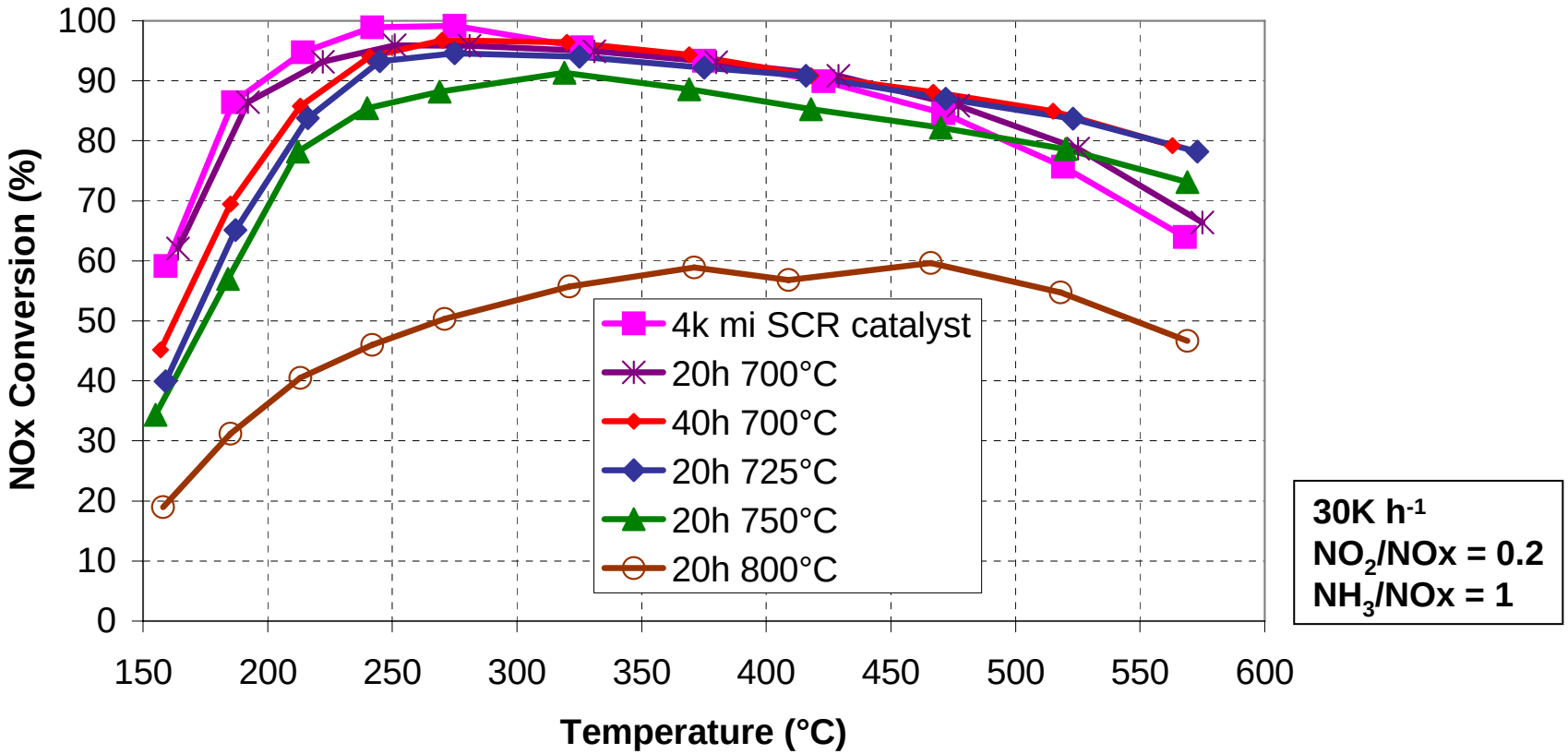


SCR Catalyst Durability: LDT CDPF Regeneration



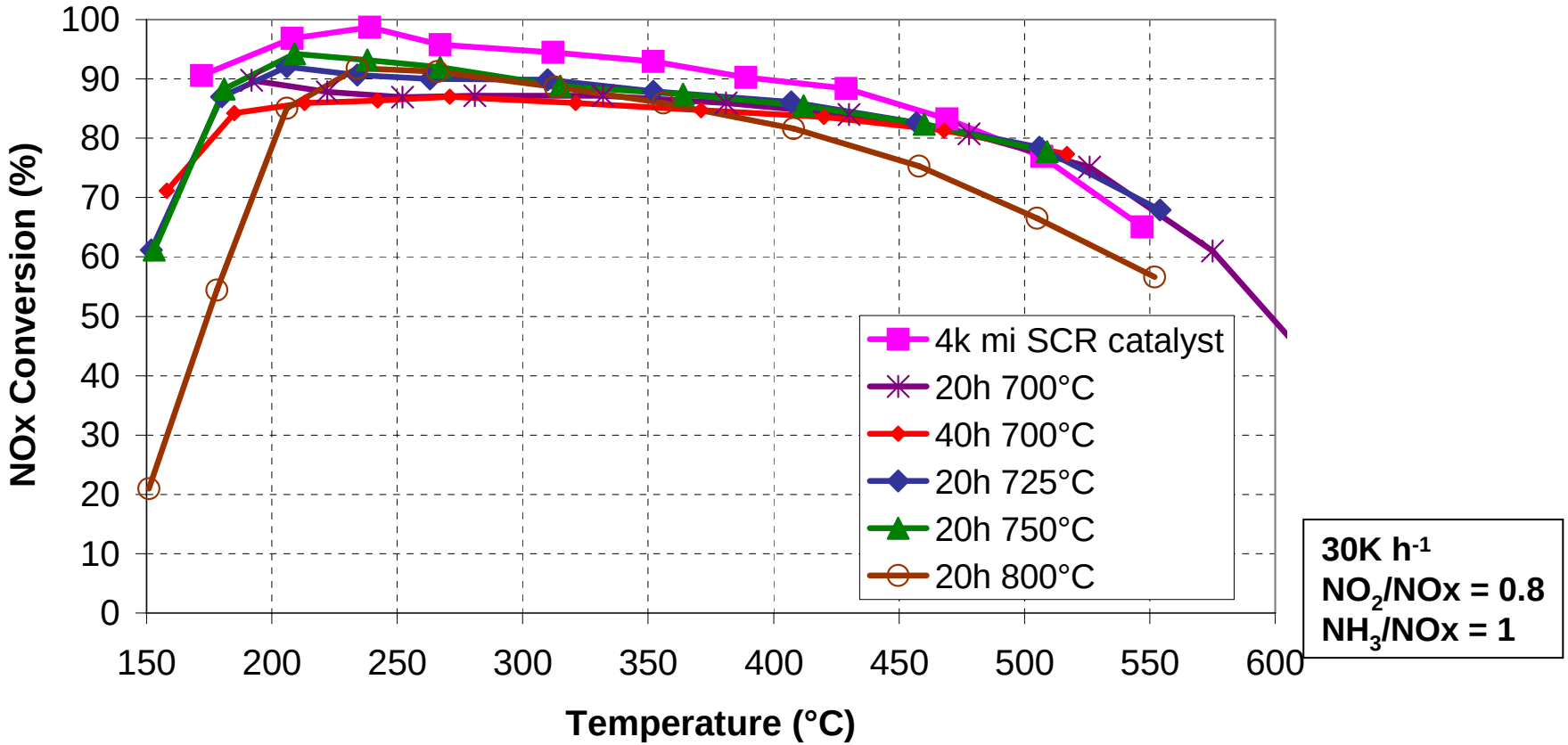
- SCR activity was identical before and after regeneration

SCR Catalyst Durability: High Temperature



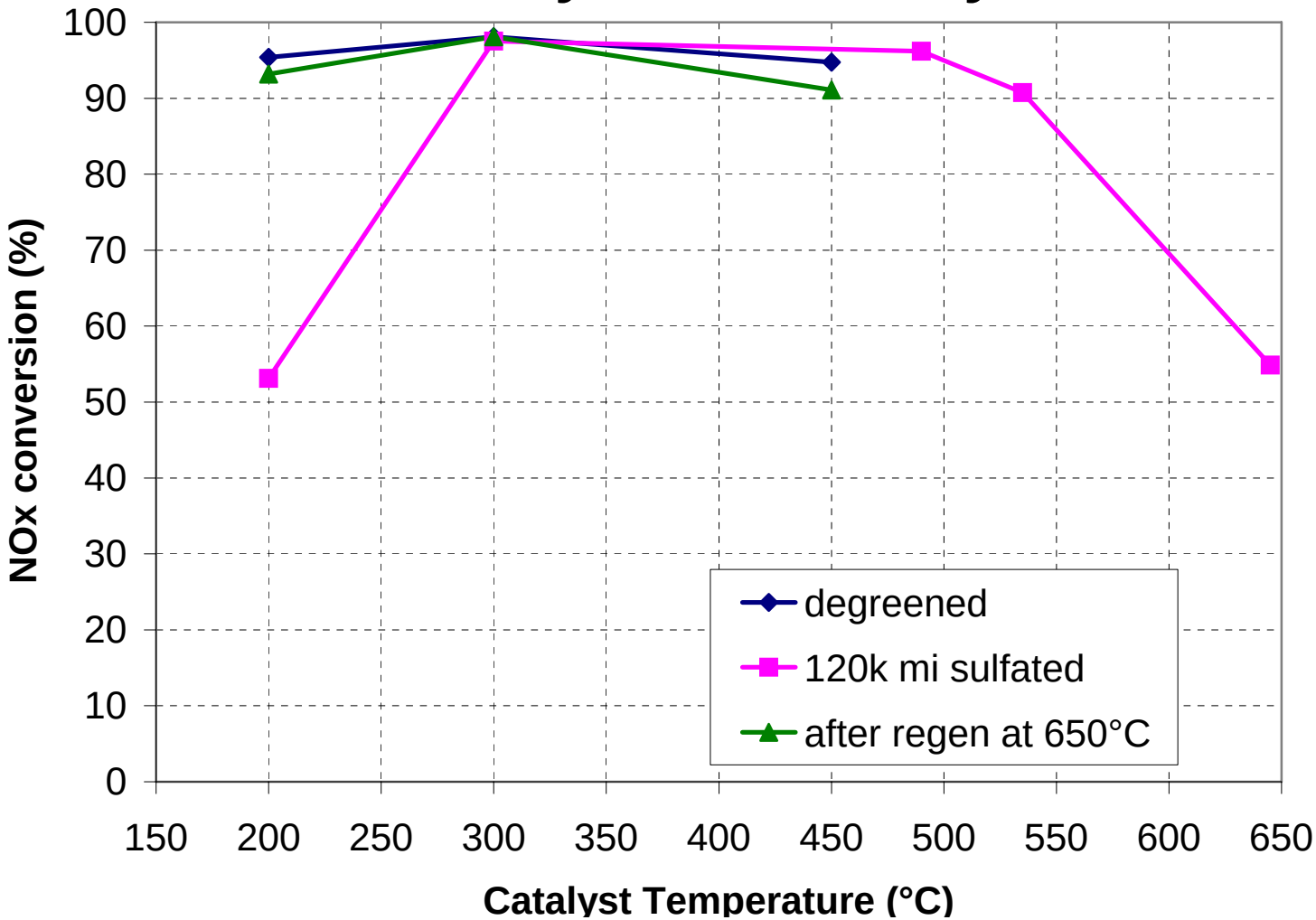
- With 20% NO_2/NOx feed, the catalyst is durable to 750°C

SCR Catalyst Durability: High Temperature



- With 80% NO_2/NOx feed, the catalyst is durable to 800°C

SCR Catalyst Durability: Sulfur

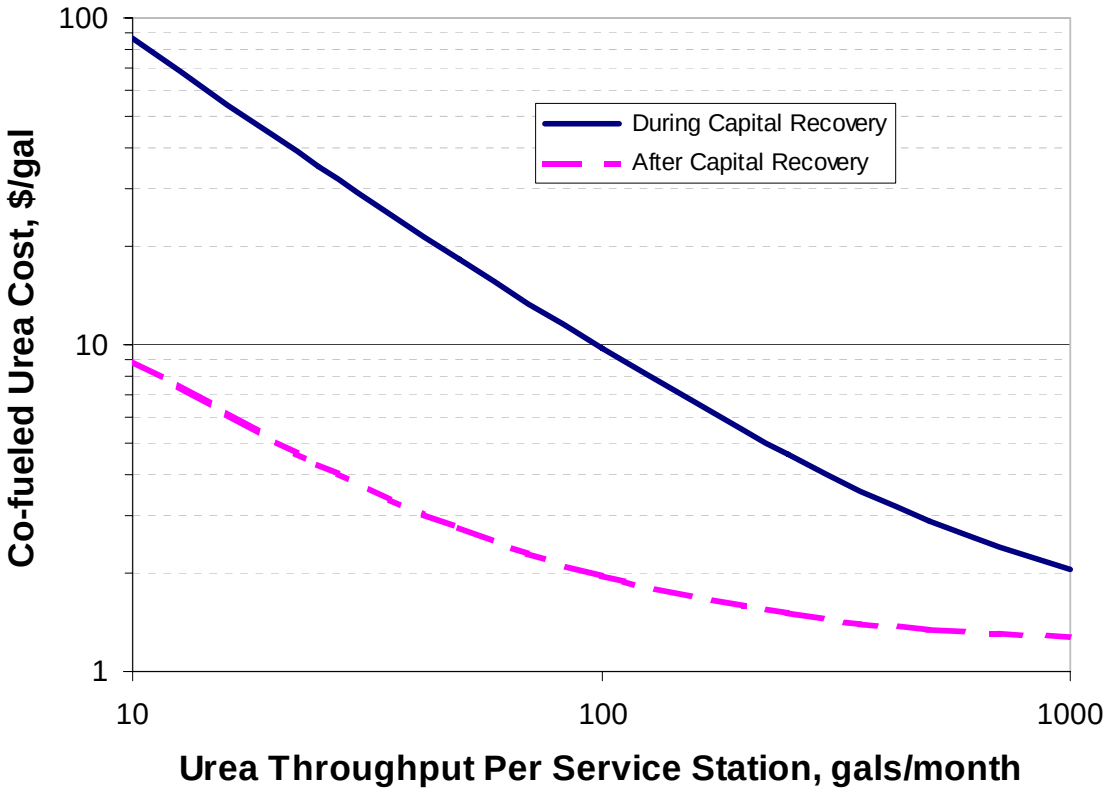


- Sulfur poisoning is reversible after 650°C, lean

Status of Co-fueling Technology

- Co-fueling hardware completed
  - Co-axial nozzle with fill-neck insert provided by a major nozzle manufacturer
  - Urea pumping system with flow meter
  - Urea tank integral with dispenser
  - Urea heating system
  - 32.5 wt% urea in water assumed

Economics of Co-fueling



- Cost of co-fueling infrastructure is high at beginning when vehicle volume using urea is low.

Acknowledgements

Ford

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