Simplification of Diesel Emission Control System Packaging Using SCR Coated on DPF

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Clean air is our business

Overview

- ☆ **Engine and Catalyst System**
- ☆ **Two Development Phases:**
  - Phase 1 – Does it work?
  - Phase 2 – Major characteristics and determinant factors
- ☆ **Conclusions and Next Steps**

Engine & Catalyst System

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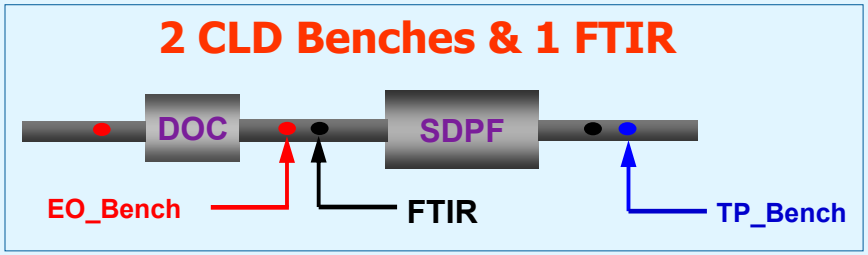
☆Steady State Tests

- 6.6L Duramax; '04 emissions
- NH3 or Urea injection

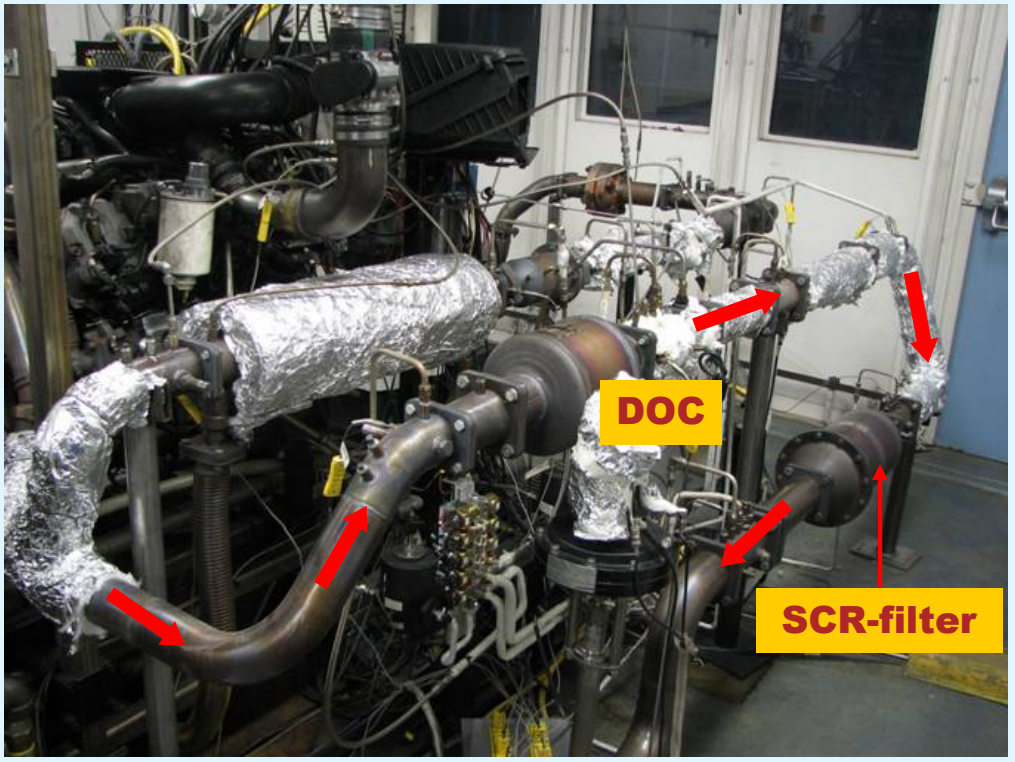


☆Catalyst System

- 10.5" x 12" (17L)
- SCR Washcoat
- Optimized washcoat

☆Aging

- Oven (hydrothermal)
- 50H @ 750 deg C



SCR Filter Loading and Coating Process Optimized to Minimize Back-Pressure

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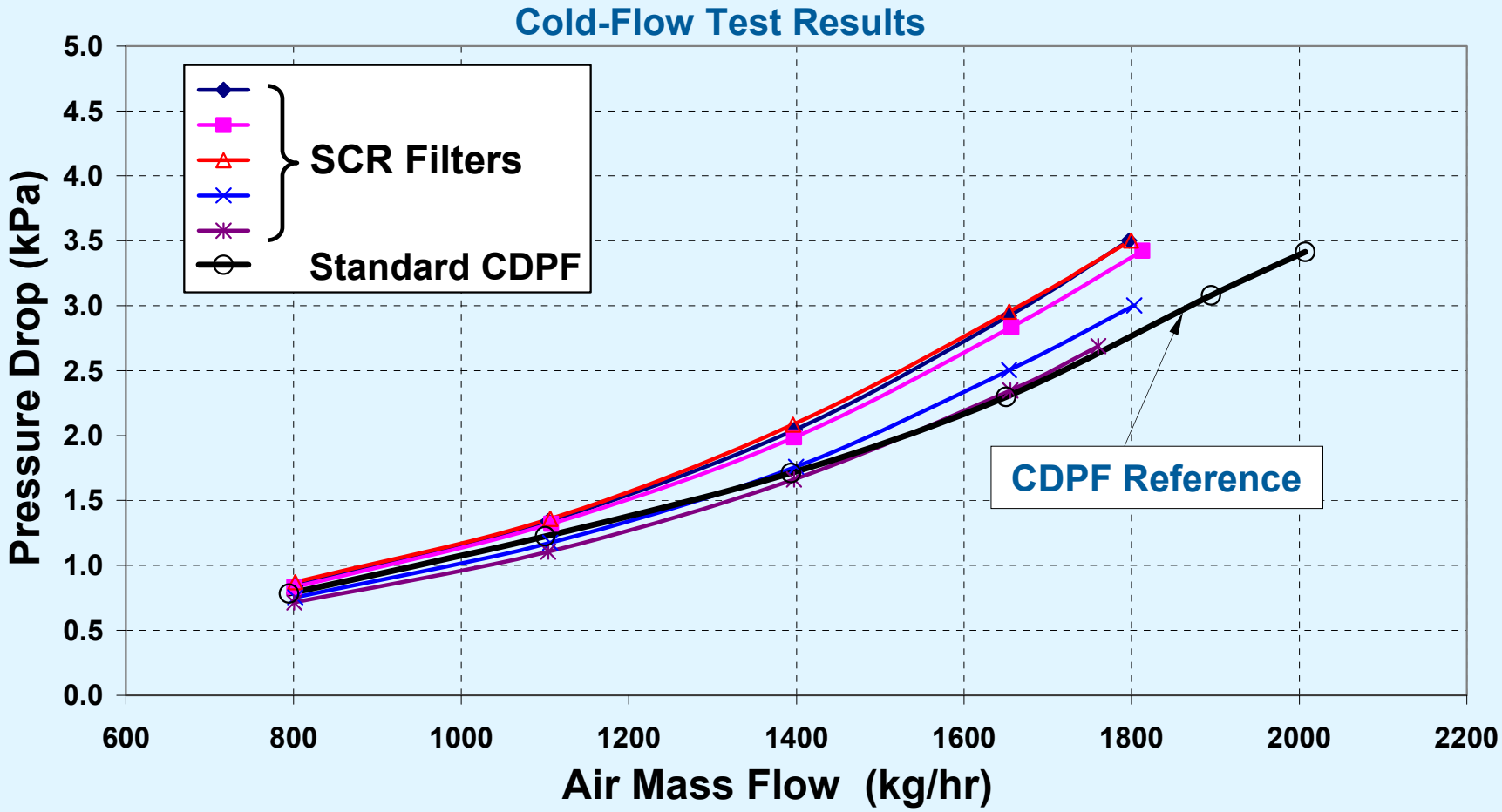

☆ Washcoat optimization helps minimize ΔP from SCR filter

☆ Increase in ΔP becomes more pronounced above 1400 kg/hr of flow

Phase 1 Results:
Oven-Aged (48H @ 650 deg C) SCR Filter
Up to 95% NOx Conversion Achieved

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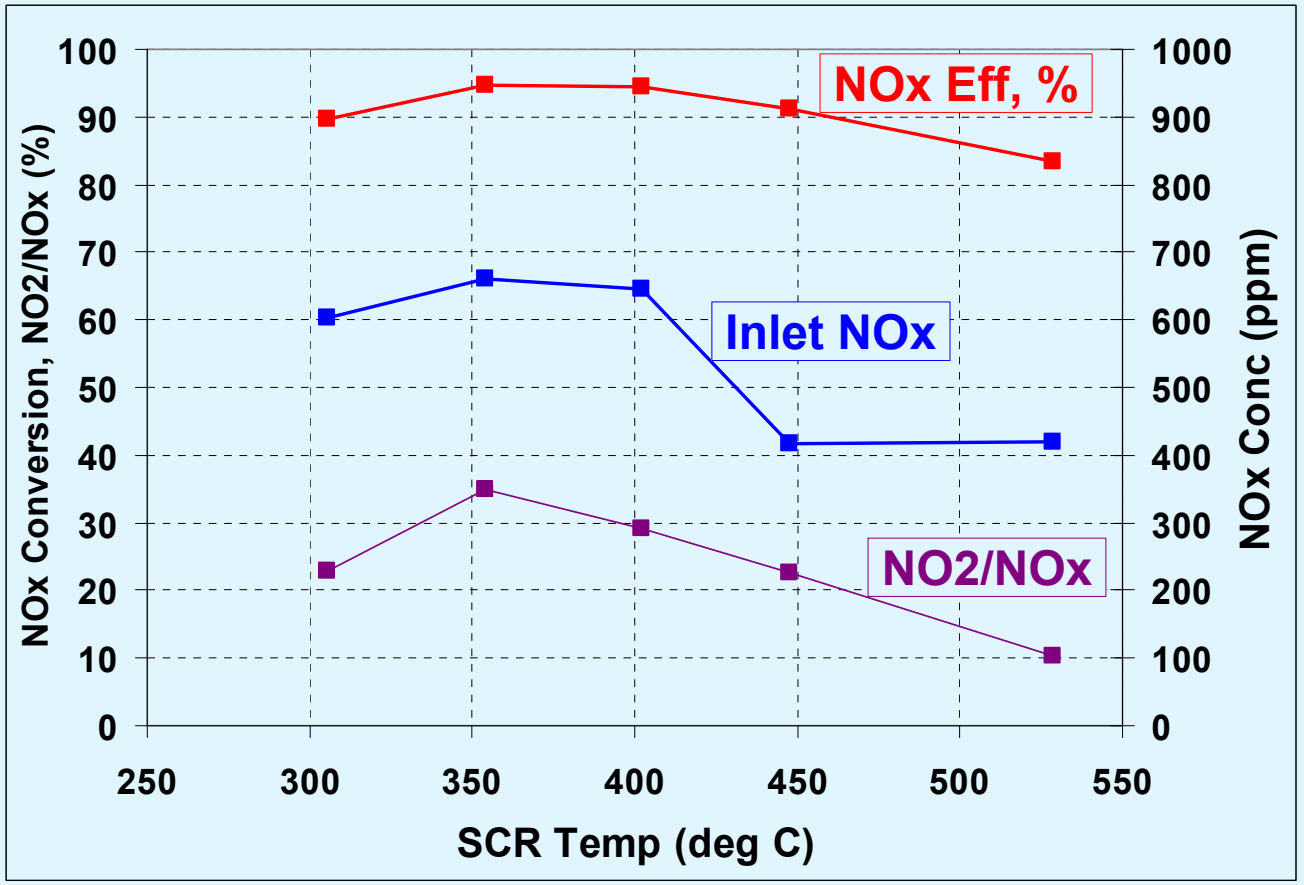
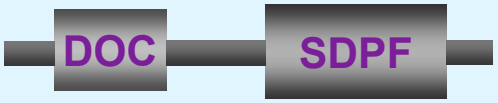
Test conducted with NH3 injection
(NH3 quantity increased until no change in tailpipe NOx)





DOC

- 7.5" x 7" (5.1L); Pt-only
- Oven-Aged 16H @ 700°C, 10% H2O

SDPF

- 10.5" x 12" (17L)
- Oven-aged 48H @ 650°C, 10% H2O
- SV = 23 to 52 kh^{-1}

Setup for SDPF Soot Burnout

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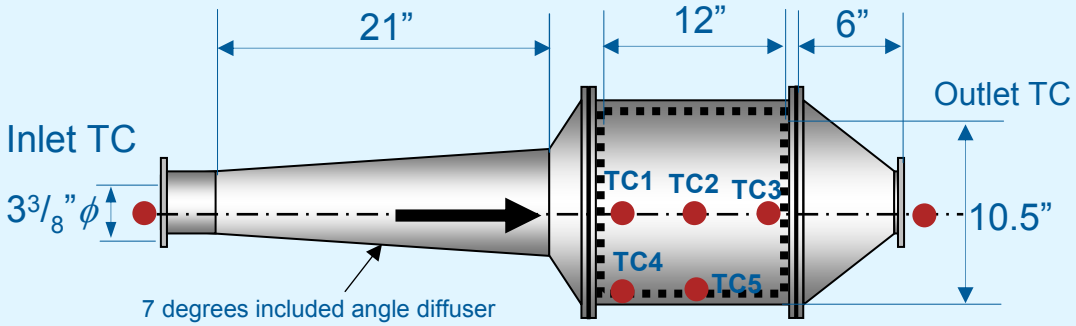
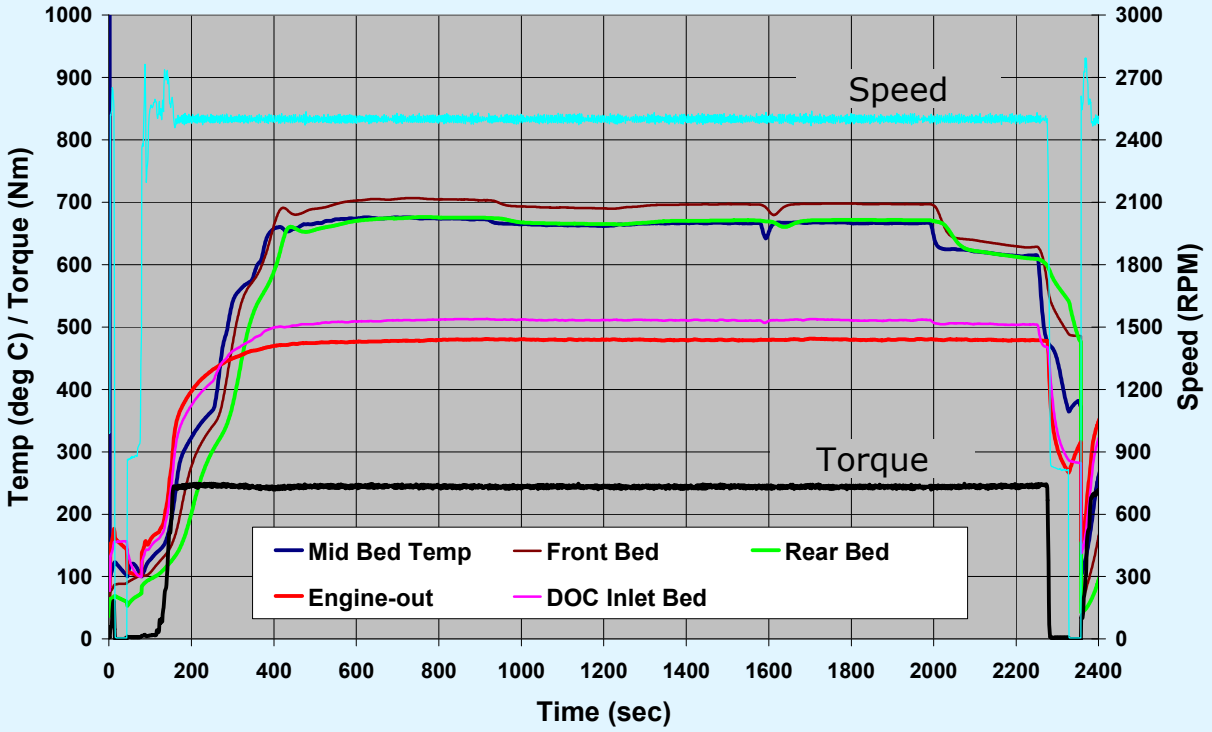
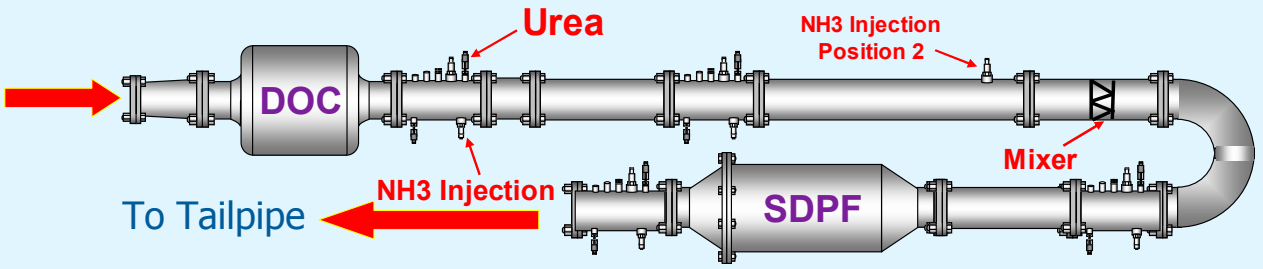
SDPF Test Procedure

- Active regeneration following each test
- HC dosing targeting 700°C SDPF bed T
- Burnout duration is approx. 20 minutes
- Exhaust Mass: 455 kg/hr; Space Velocity: 20.7 khr^{-1}





NH3 vs Urea test results confirmed that urea decomposition is not a limiting factor



Test Protocol for NH3 versus Urea Comparison

- **Back-to-back NH3 and Urea injection**
  - Minimizes variation due to soot loading
- **Set Alpha = 1 for the NH3 Injection Test**
- **Catalyst purged with NOx before initiating urea**
  - Avoids impact of pre-filling with NH3
- **Urea setting adjusted to match tailpipe NOx from NH3 test**

Back-to-back NH3 versus Urea tests show same level of NOx performance

SCR Temperature = 250 °C

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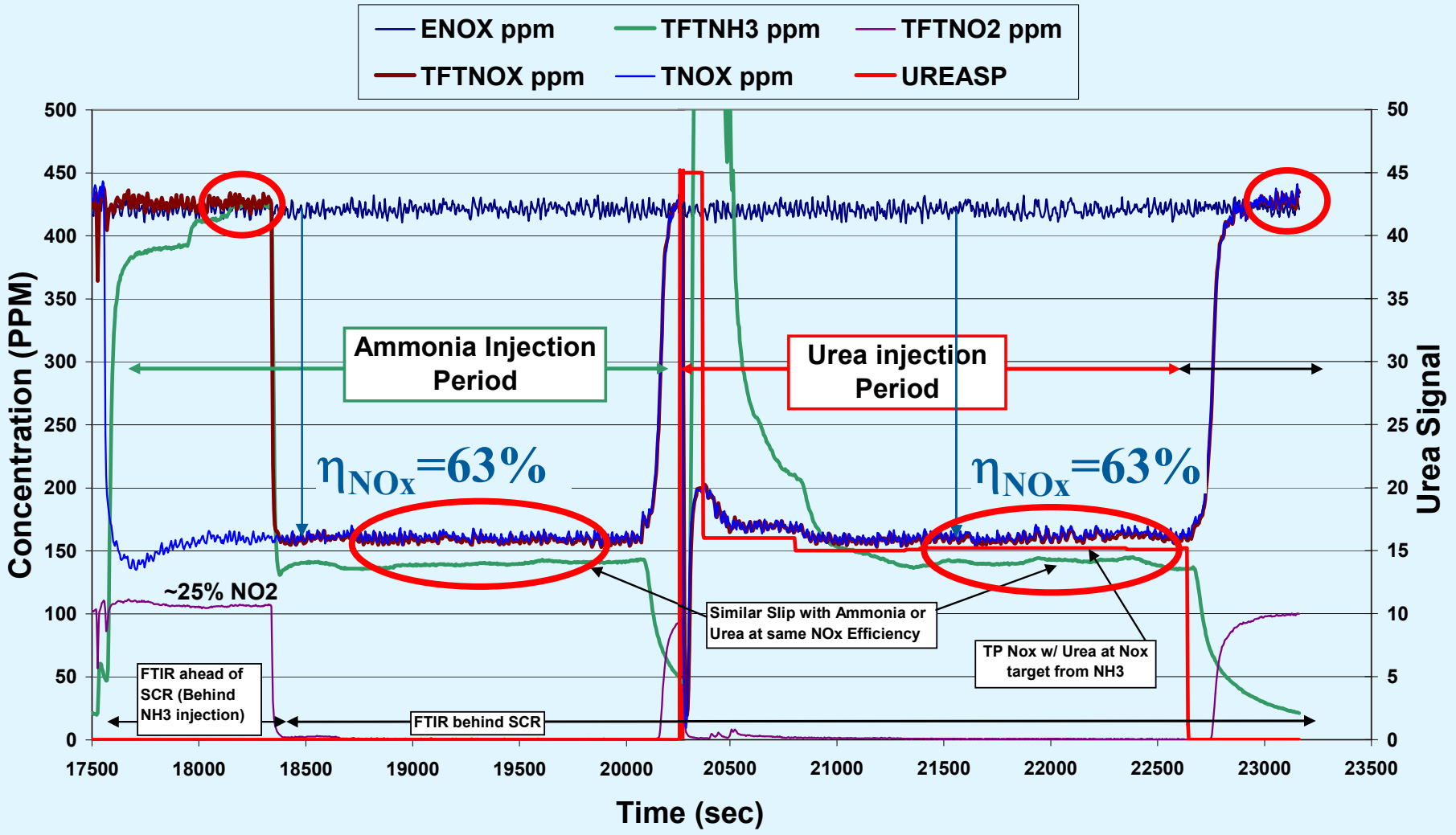

Identical NOx Conversion supports matching of NH3 slip NH3 injection test to set identical alpha ratio for the urea injection test

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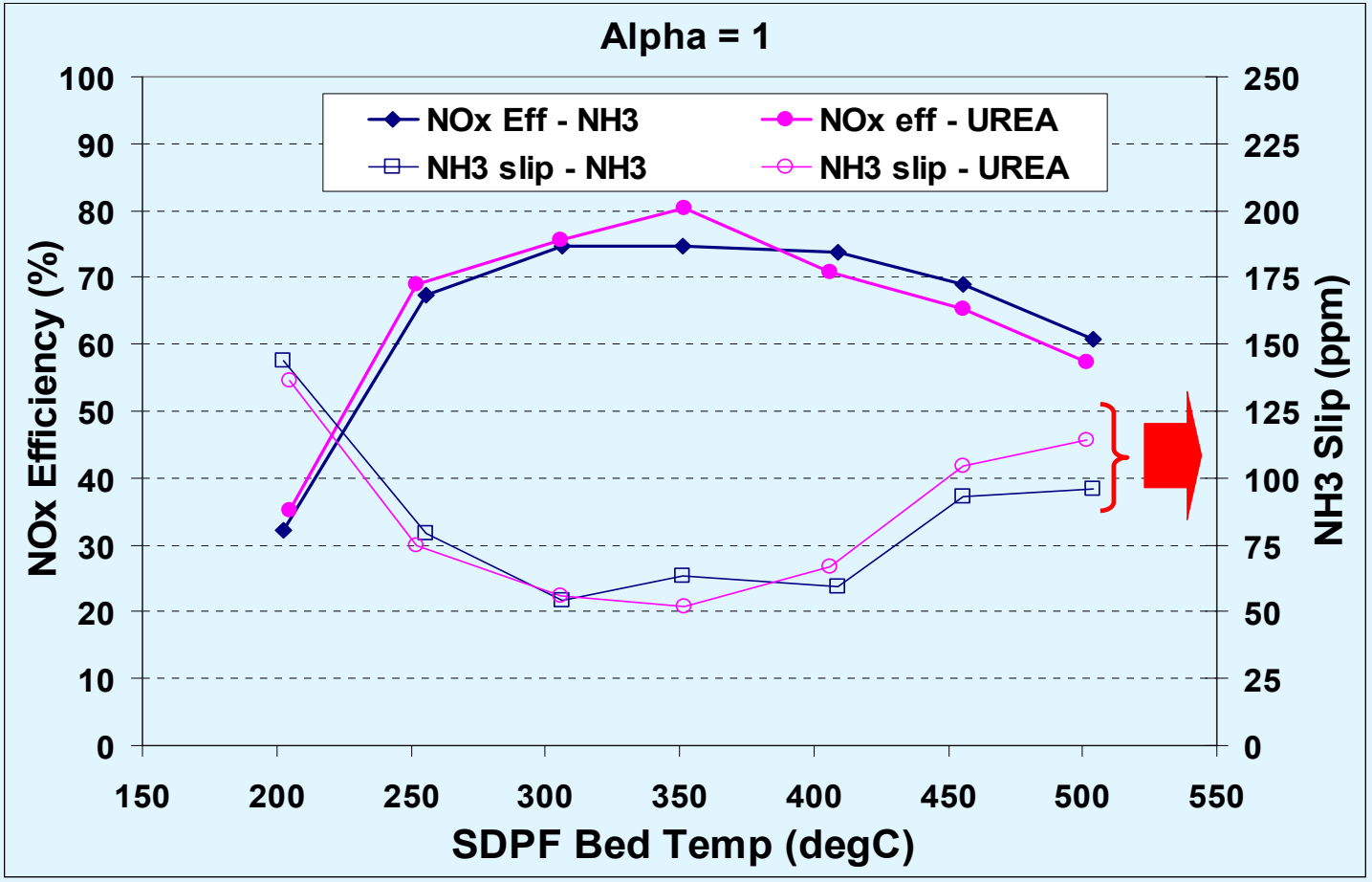
Aged: 50H @ 750 deg C hydrothermal



☞ *Hydrolysis and mixing not limiting factors*

Phase 2 Test & Evaluation:

Performance Xtics & Determinant Factors

- SCR Filter Washcoat Optimization
- Effect of Soot Loading
- Comparison to Equivalent Flow-Through SCR
- Performance Over FTP and SET Cycles

Most important impact of washcoat optimization is on flow restriction, not performance

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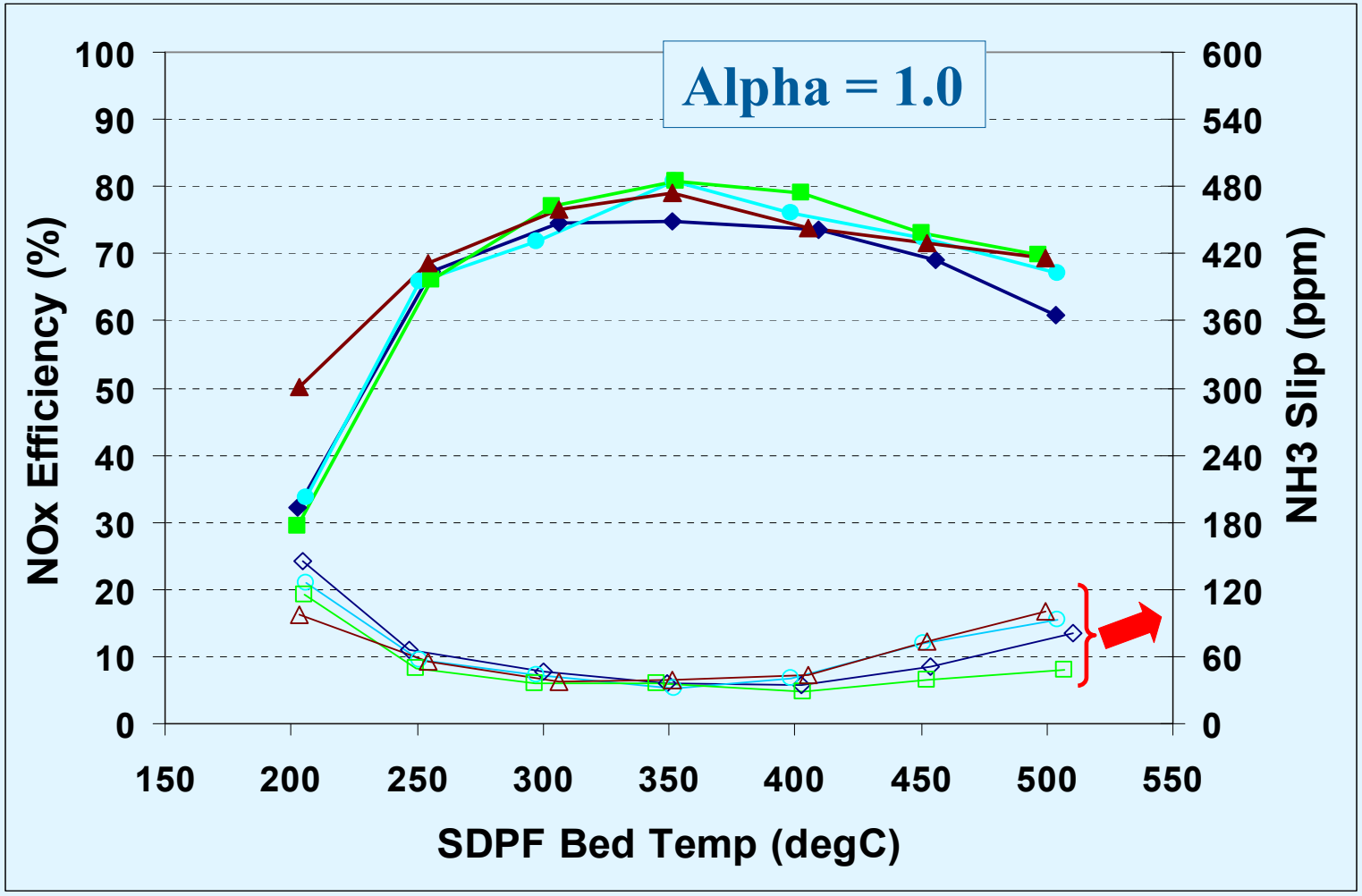
Aged: 50H @ 750 deg C hydrothermal



Test at 250 °C; Soot level = 2.5g/l

Higher soot load caused more reduction in NOx conversion

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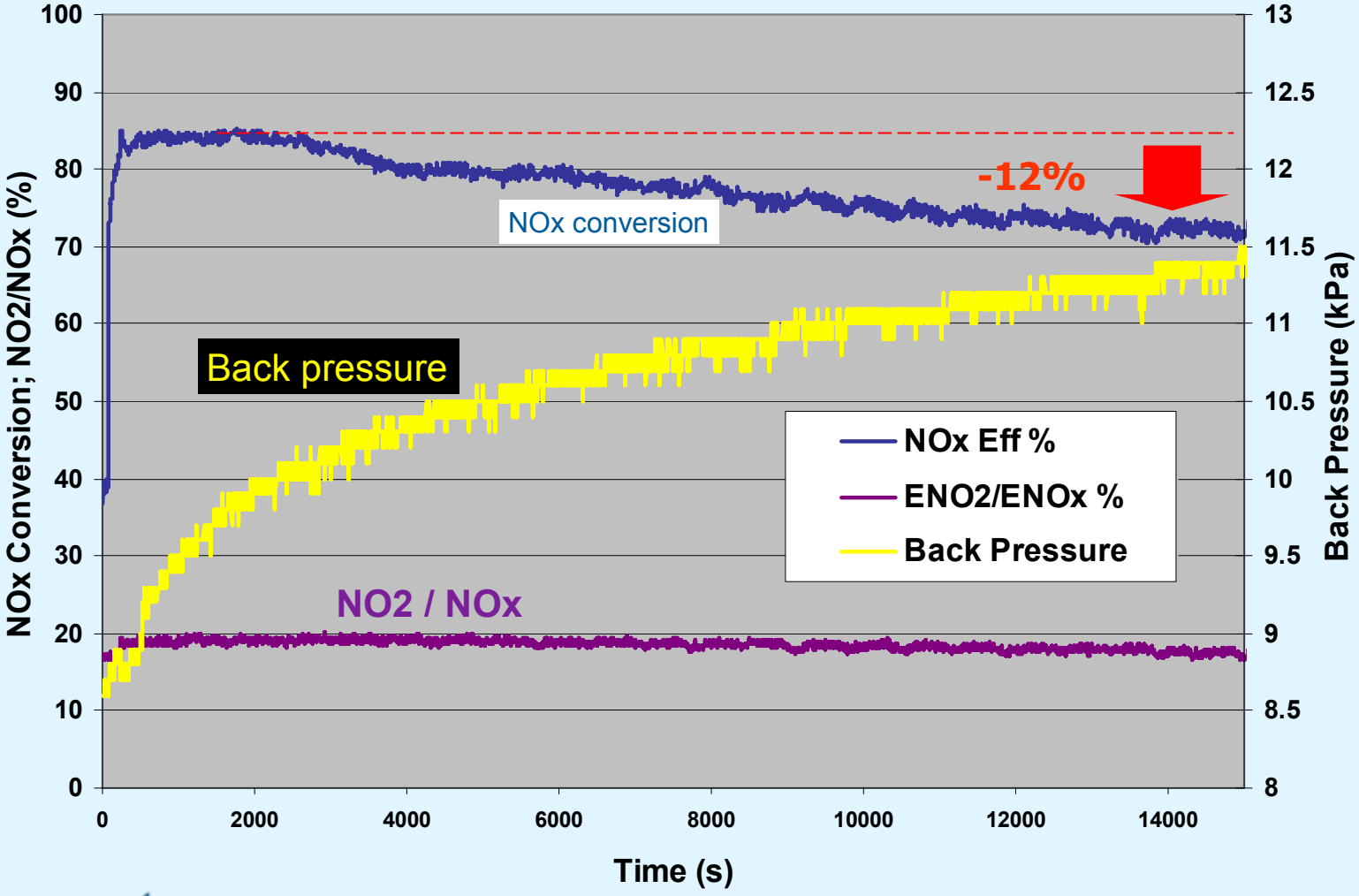
4-Hour Steady State Test at SV = 21 khr^{-1}; Alpha = 1



Comparison to Flow-Through
Basis: Equivalency of total WC Mass

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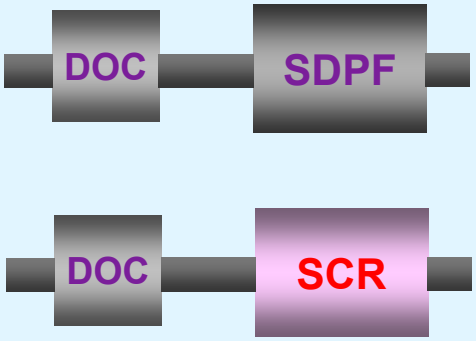
- SCR Filter
  - 10.5” x 12” (17L)
- Flow-Through
  - Sized as appropriate to get equivalency
- Oven-Aging:
  - 50H @ 750 deg C hydrothermal



Test Summary

- Both parts burnout at 700 °C to ensure
  - No soot is present in SCR filter before test
  - Flow-through has same thermal history
- Same DOC & Test Conditions (Inlet NOx; NO2/NOx; Space Velocity)

Comparison to Flow-Through SCR:
Test Conducted with Urea Injection

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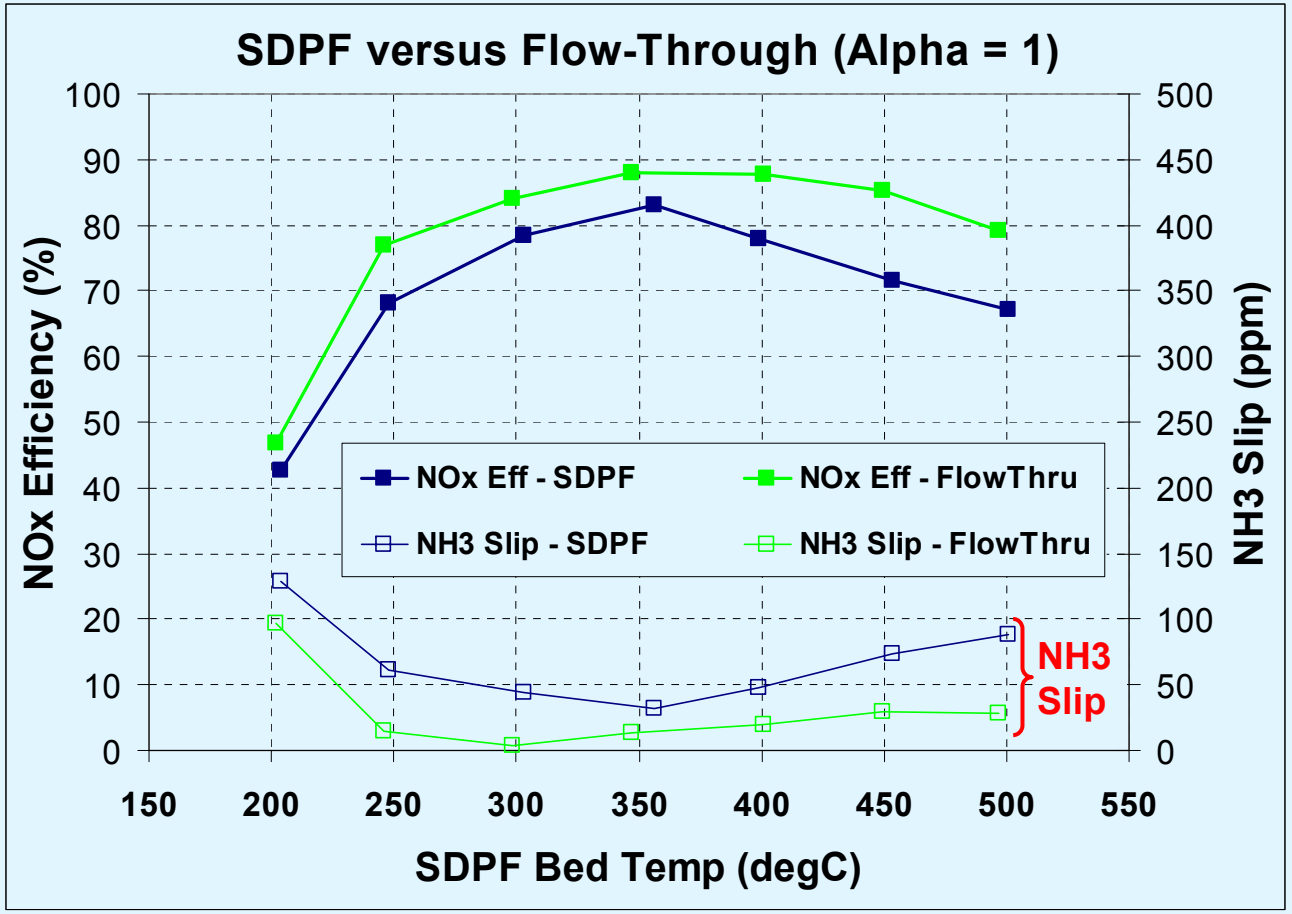
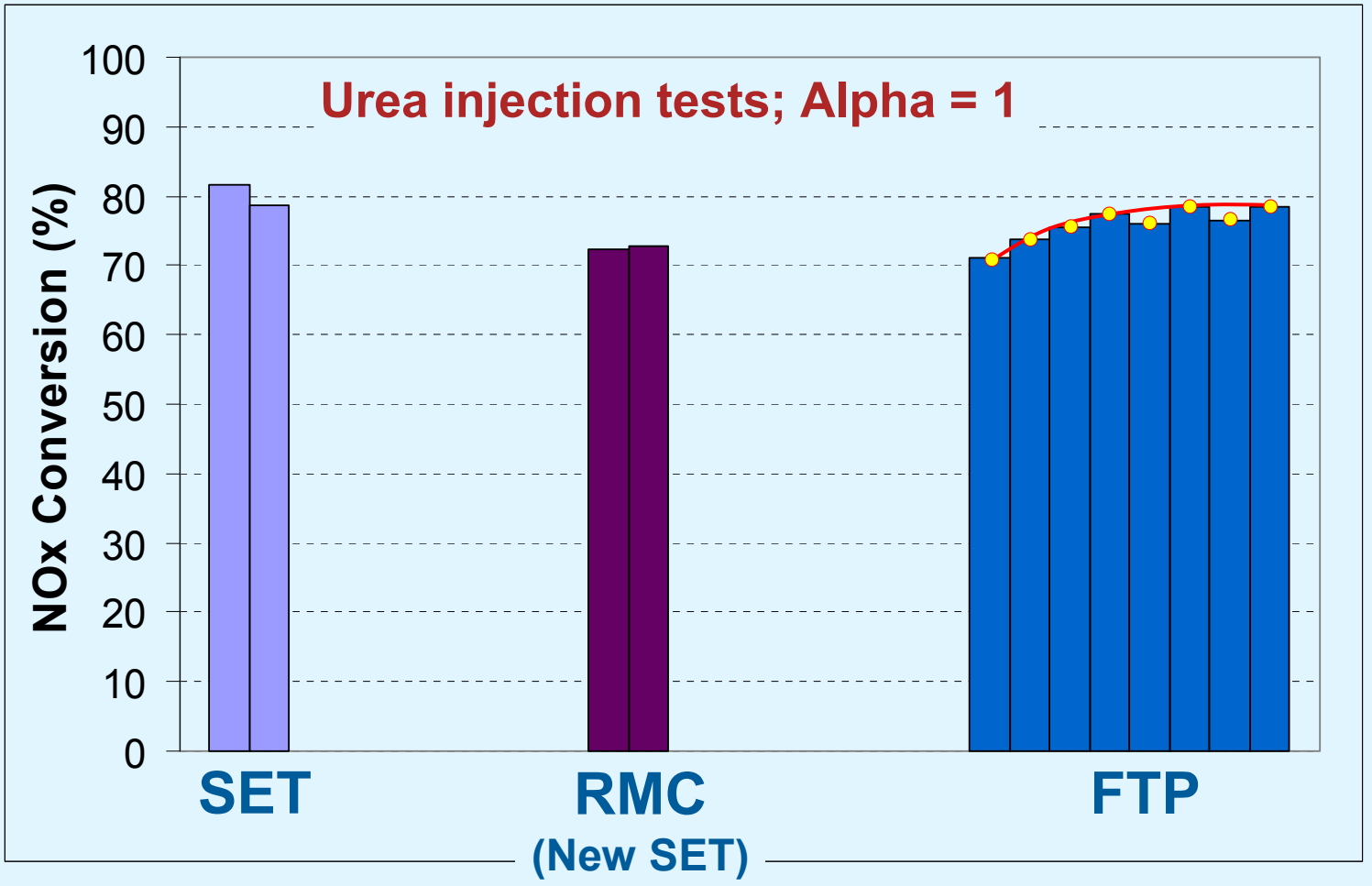
Oven-Aging: 50H @ 750 deg C hydrothermal

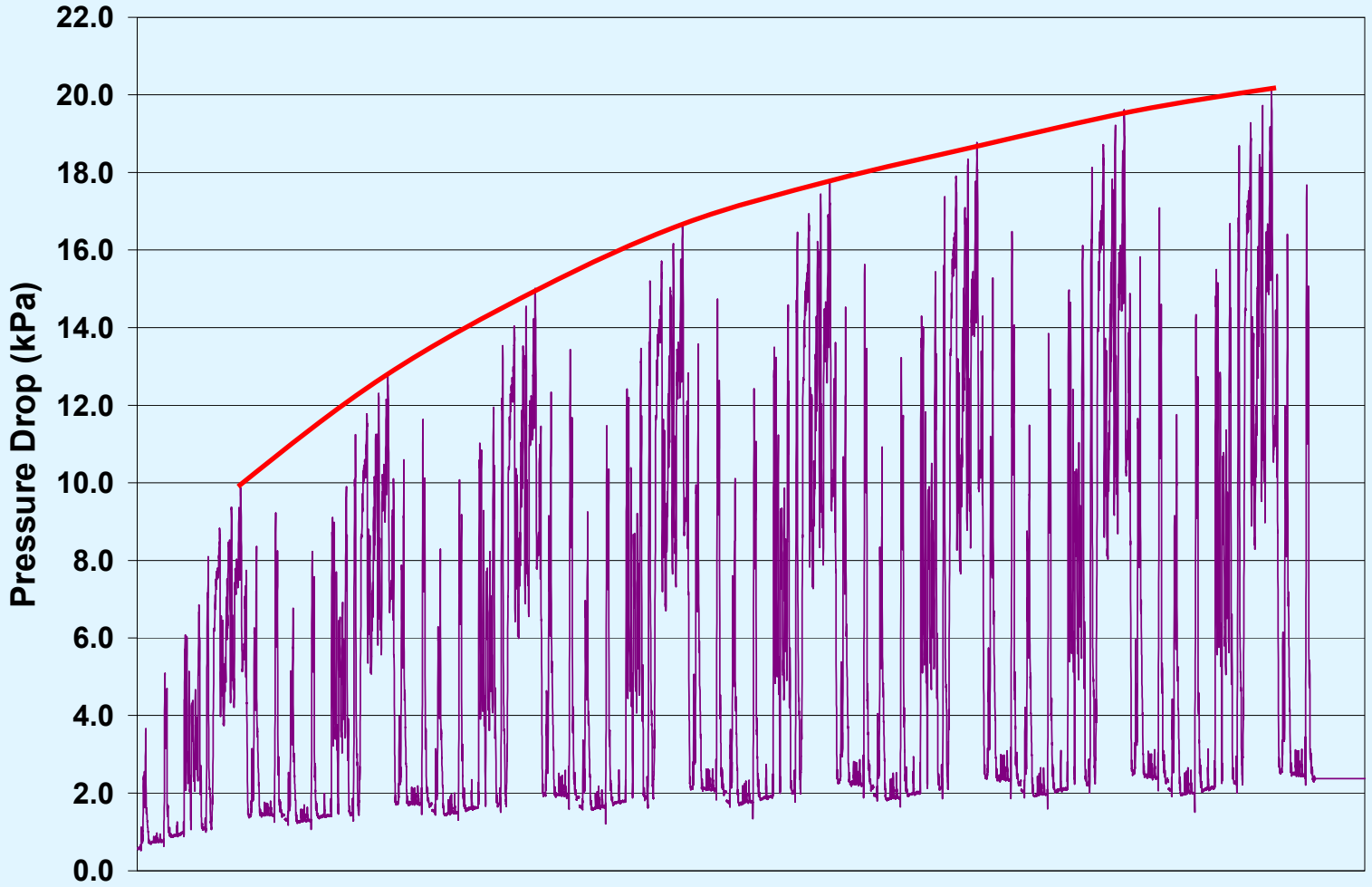
- Flow-through shows NOx conversion advantage over SDPF
- Incorporation of flow-through and SDPF may offer system configuration benefits



NOx Performance Over Standardized Heavy-Duty Diesel Cycles



Pressure Drop Across SDPF During Consecutive FTP'S



Conclusions and Next Steps

- ☆ Results demonstrate possibility of high NOx performance with SCR Filter
- ☆ Using washcoat optimization, flow restriction was minimized without significant impact on NOx performance
- ☆ Under low temperature, some reduction in NOx conversion occurs with soot loading
- ☆ DF characteristics is currently under study
- ☆ Umicore's advanced technology expected to further improve capability of the SCR filters

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