Passive NH_3 SCR for Lean SIDI: Experiment Results

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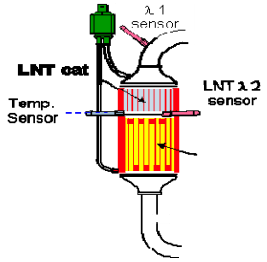
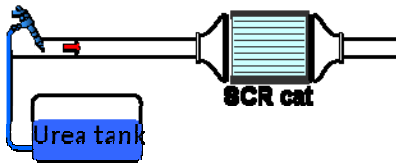
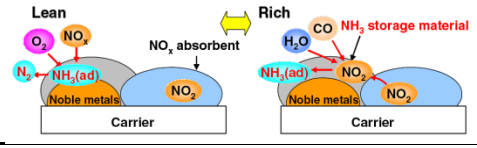
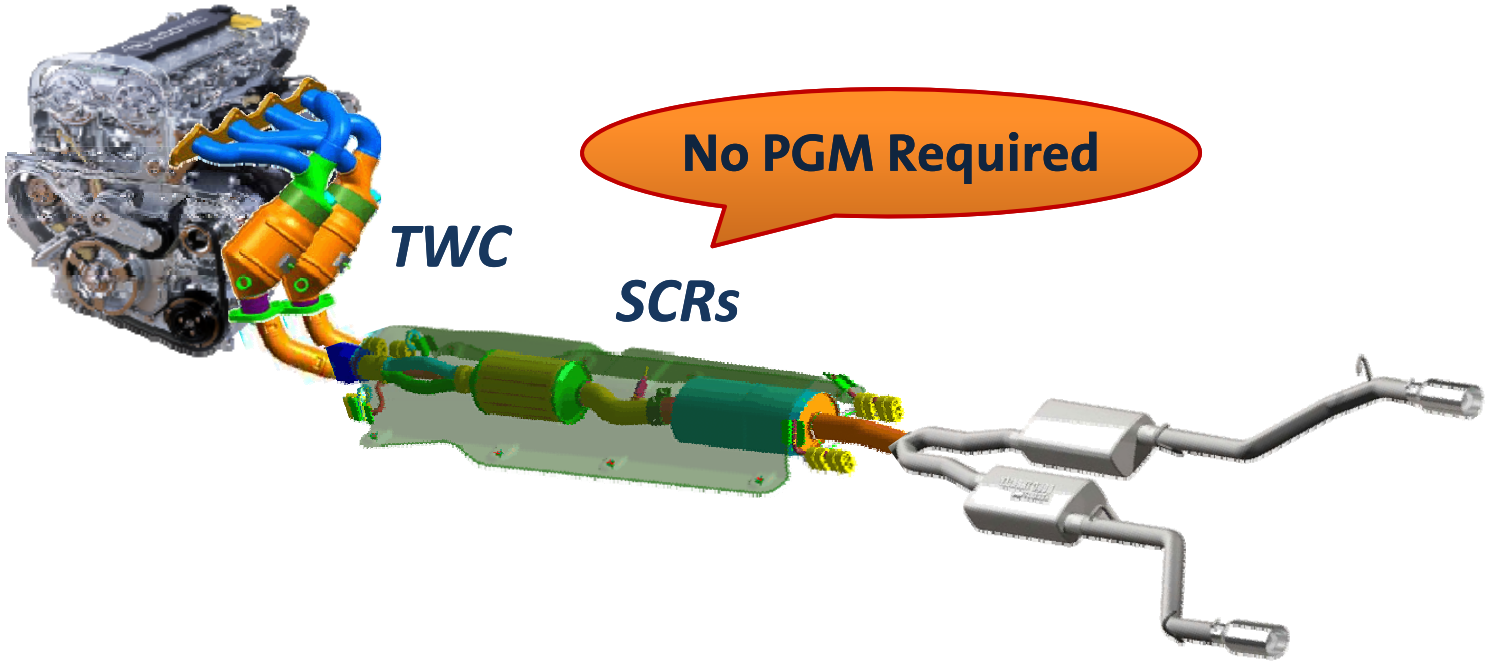
Outline

- Background
- Experimental
- NH_3 Formation
- NEDC Results
- Steady State Results
- Summary

Lean NOx Aftertreatment

Aftertreatment Technology	Challenges
Lean NO_X Trap 	• High PGM Cost • Sulfur Poisoning • Desulfation
Active Urea SCR 	• Secondary urea tank with injection system; high urea consumption • Urea Infrastructure • Urea solution freezing
LNT + Passive NH_3 SCR 	• High PGM Loading • Difficult to control

Passive NH3 SCR Concept



- Use rich pulses to generate NH_3 on the TWCs and store it in multiple SCRs

  Rich: $\mathbf{NO_x + H_2 / CO \Leftrightarrow NH_3 + CO_2}$

- Use the stored NH_3 for lean NO_x conversion

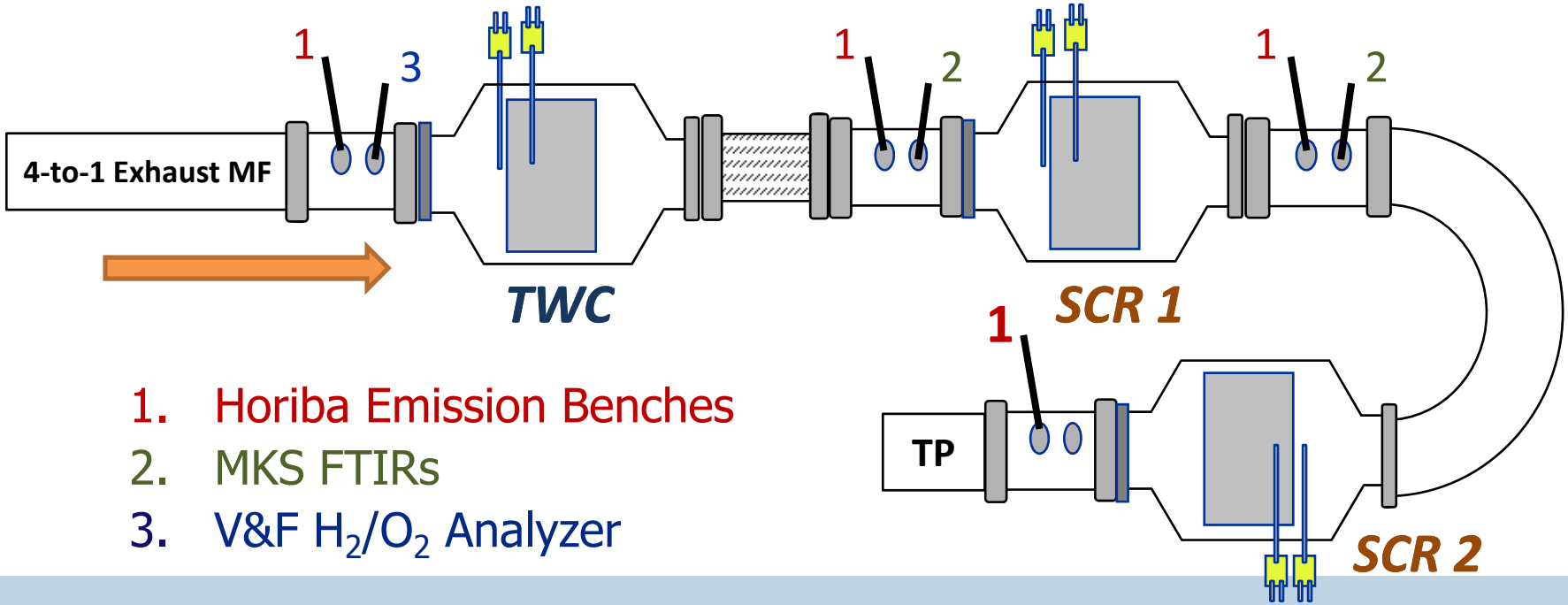
  Lean: $\mathbf{NO_x + NH_3 \Leftrightarrow N_2 + H_2O}$

Goal of the Work

- Proof of Concept
  - Ability to make NH_3
  - Ability to store NH_3 and convert NO_x
- Catalyst Durability
  - High temperature redox aging
- Aftertreatment System Architecture
  - Thermal management
- Engine Control Strategy

Experimental

- Engine
  - 2.2L, stratified-charge developed by GM R&D
  - Controller: d-SPACE with Micro-autobox
- Transient Dynamometer
- Emission Measurements



1. Horiba Emission Benches
2. MKS FTIRs
3. V&F H_2/O_2 Analyzer

Experimental

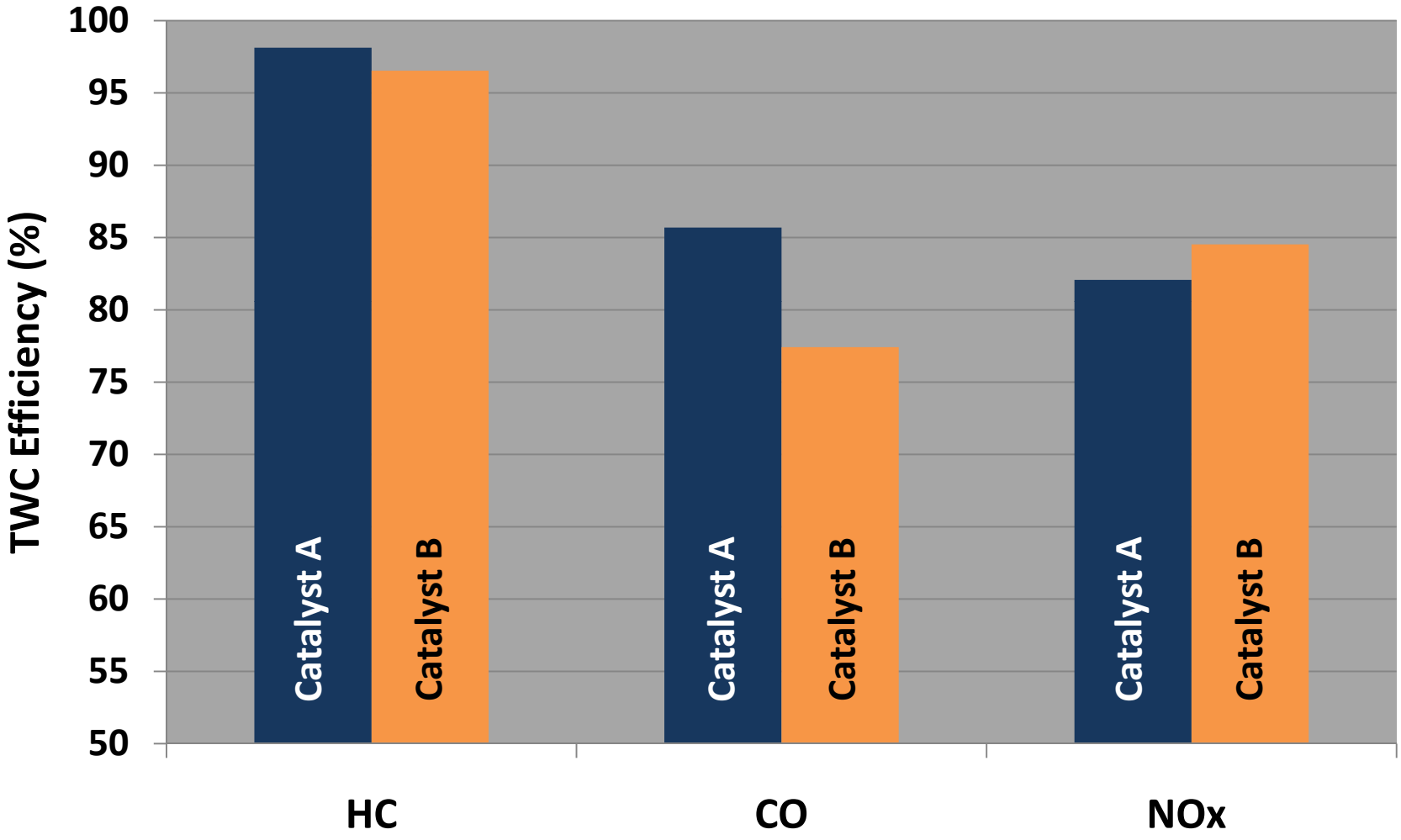
- Test Conditions
  - Simulated NEDC Cycle
  - Steady State
    - Load: 2000 rpm – 2 bar, 3000 rpm – 3 bar
    - Lean-Rich Cycle: 60 sec Lean / 30 sec Rich
- Catalysts & Aging Conditions

Set #	TWC	SCR 1	SCR 2
1	Catalyst A	Cu-SCR	Cu-SCR
2	Catalyst B		

  - Aging Protocols
    - RAT H for TWC
    - RAT 750 for SCR1 & SCR2

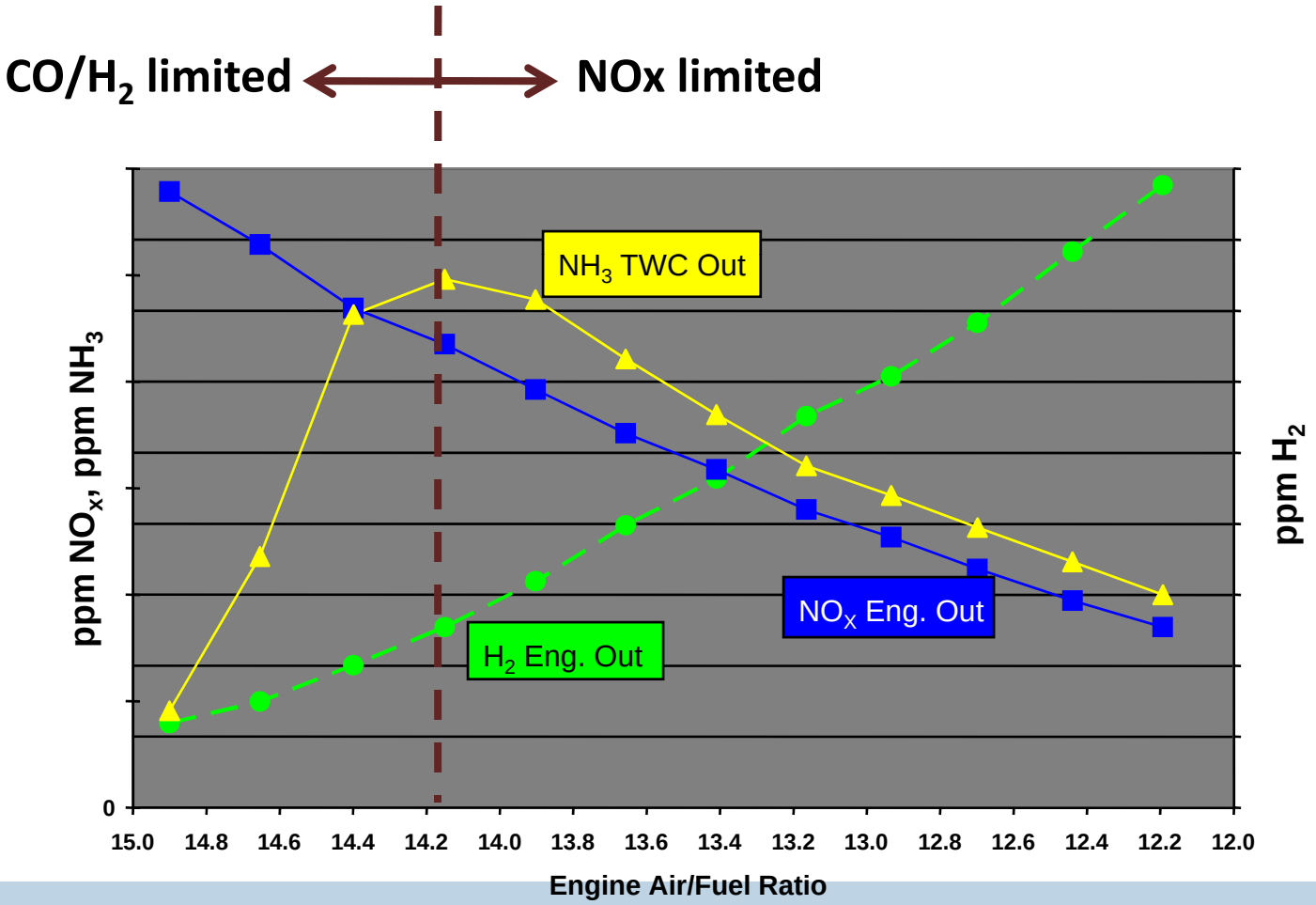
NEDC Cycle

Conversion Efficiencies over TWC during NEDC



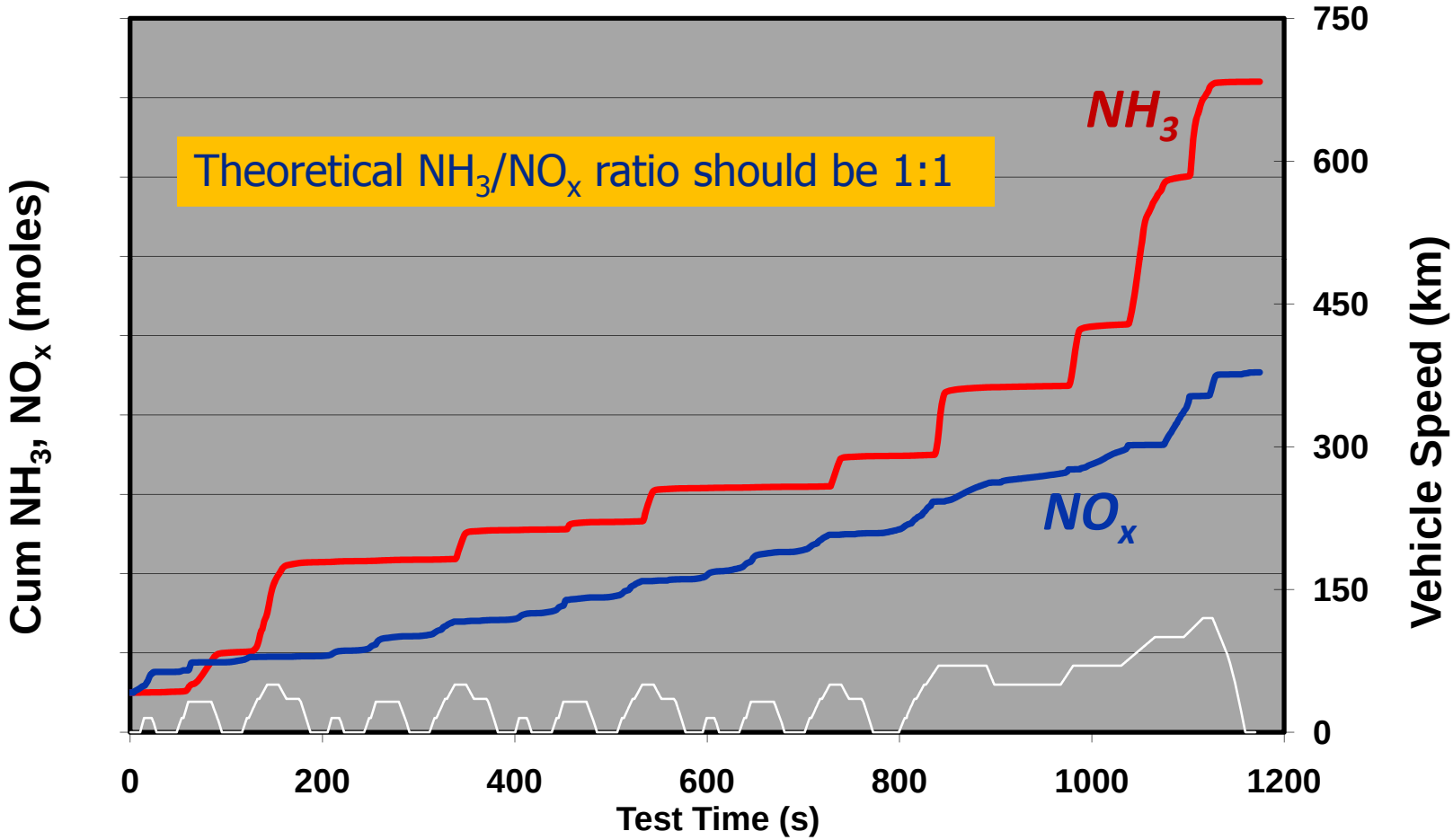
NH_3 Formation over TWC

- $NO + 1.5H_2 + CO \Leftrightarrow NH_3 + CO_2$

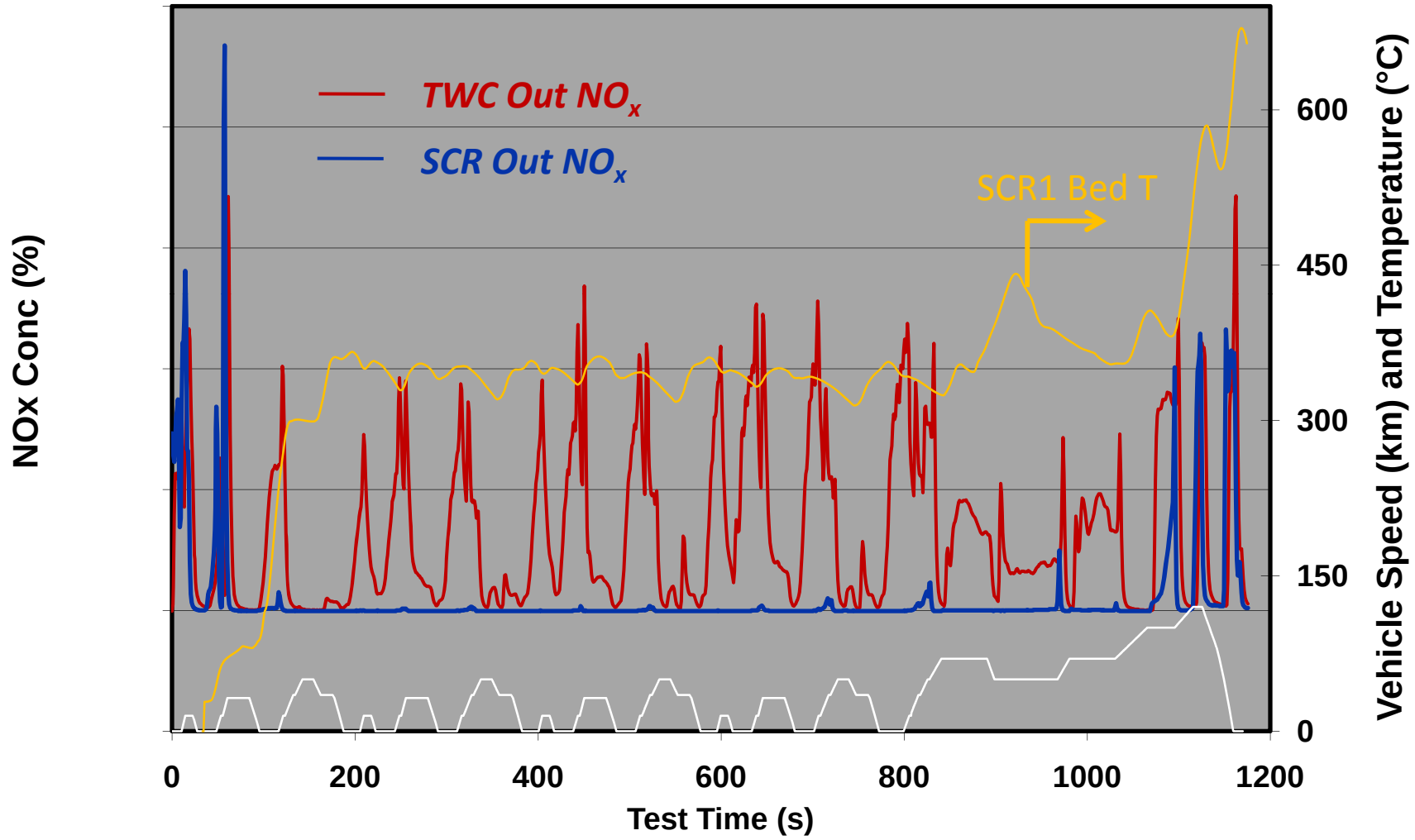


Cumulative TWC Out NH_3 and NO_x

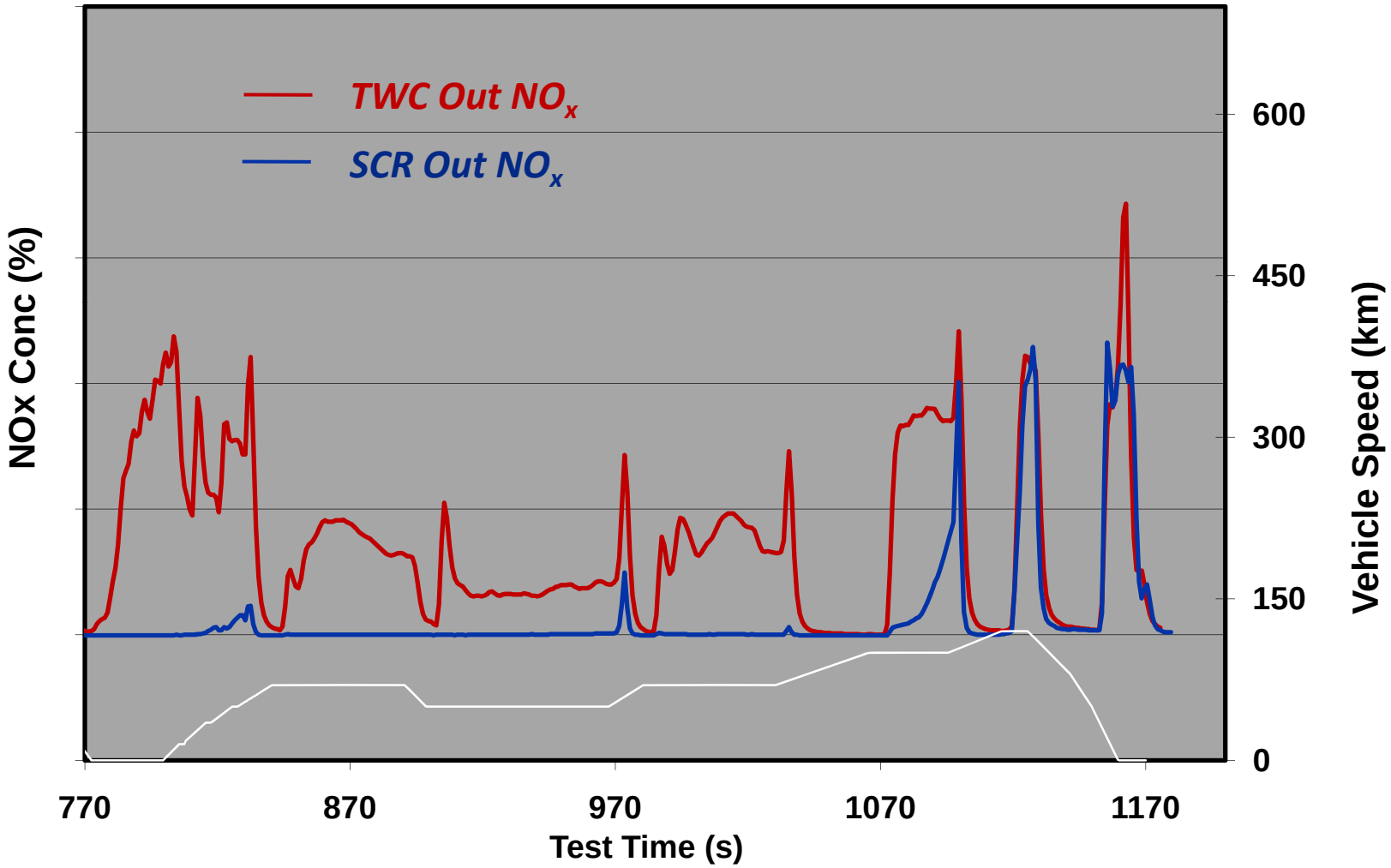
$NOx + NH_3 \Leftrightarrow N2 + H_2O$



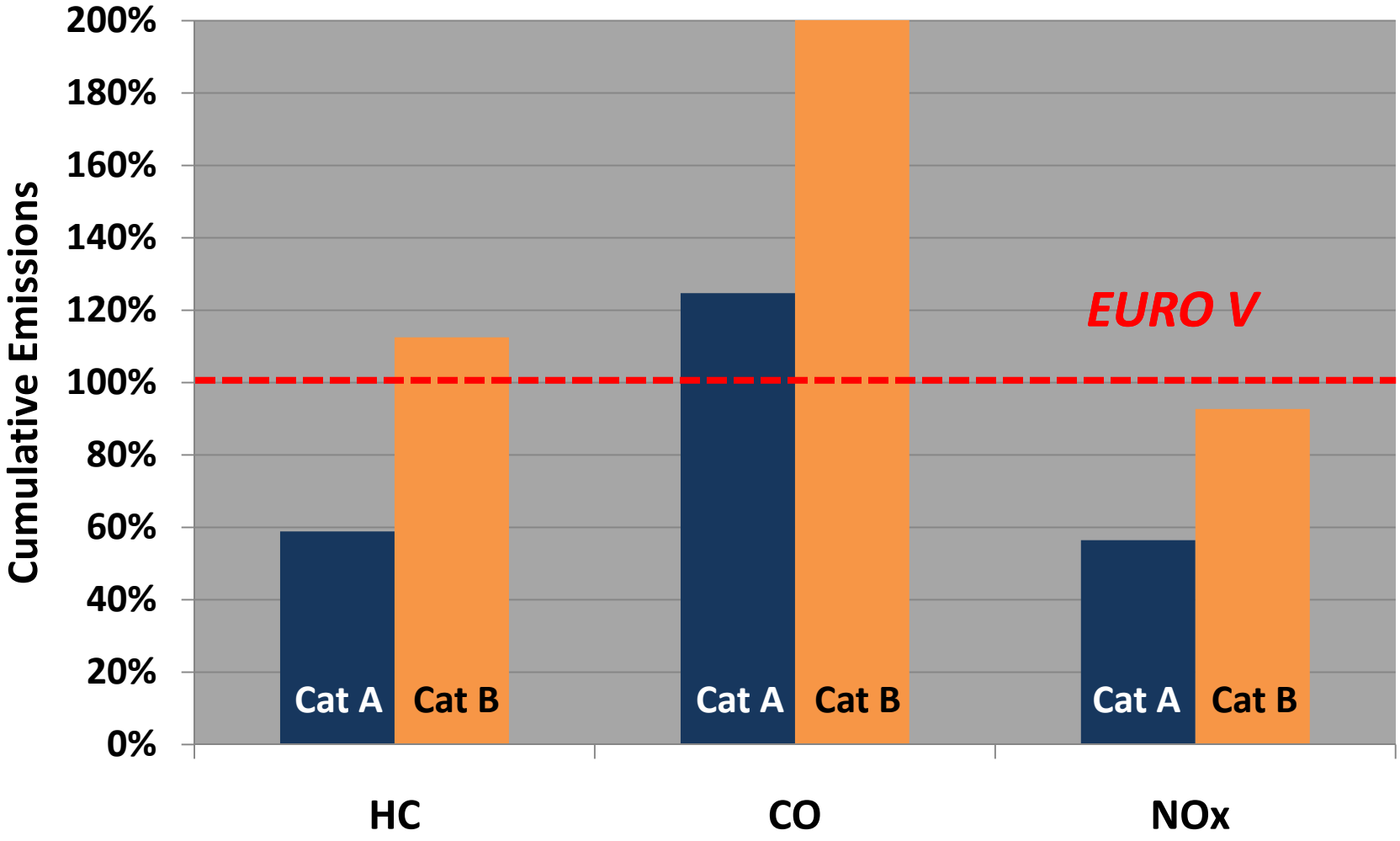
NO_x Conversion Efficiencies over SCR



NH_3 Storage and NO_x Efficiencies

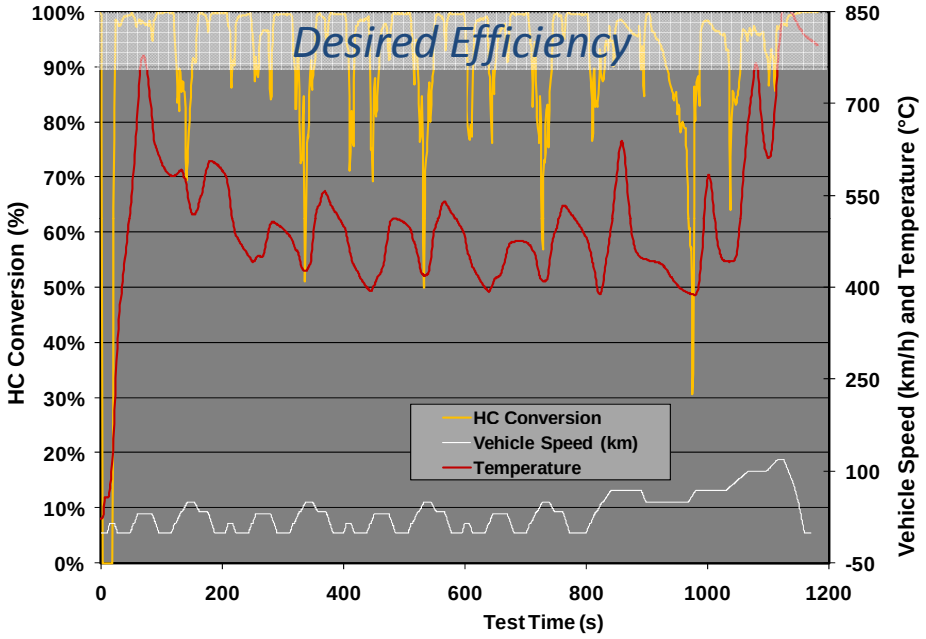


Cumulative Tail Pipe Emission

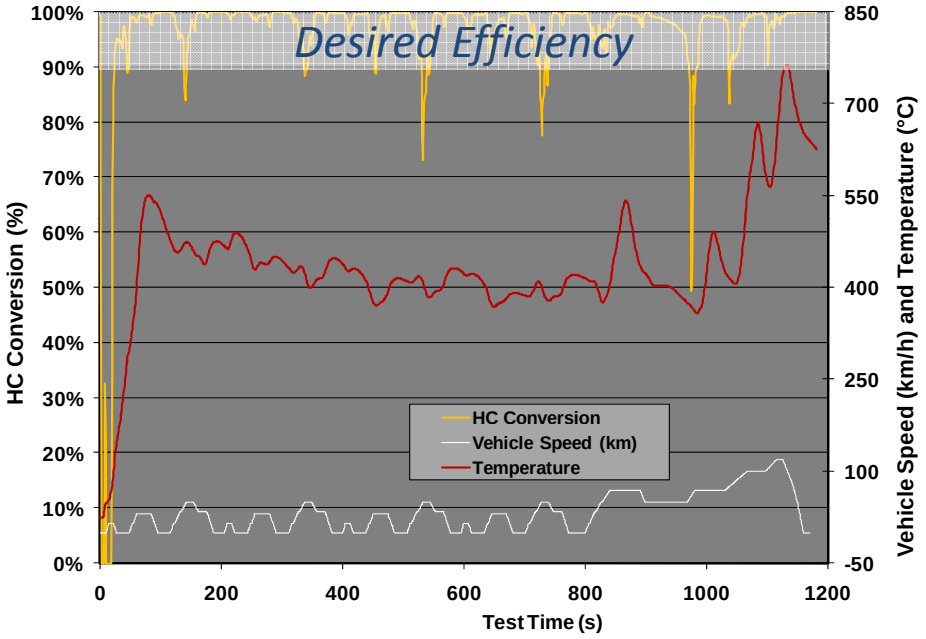


Challenge – HC Efficiency with Low PGM

TWC Out HC Emission



Catalyst 2 with Low PGM

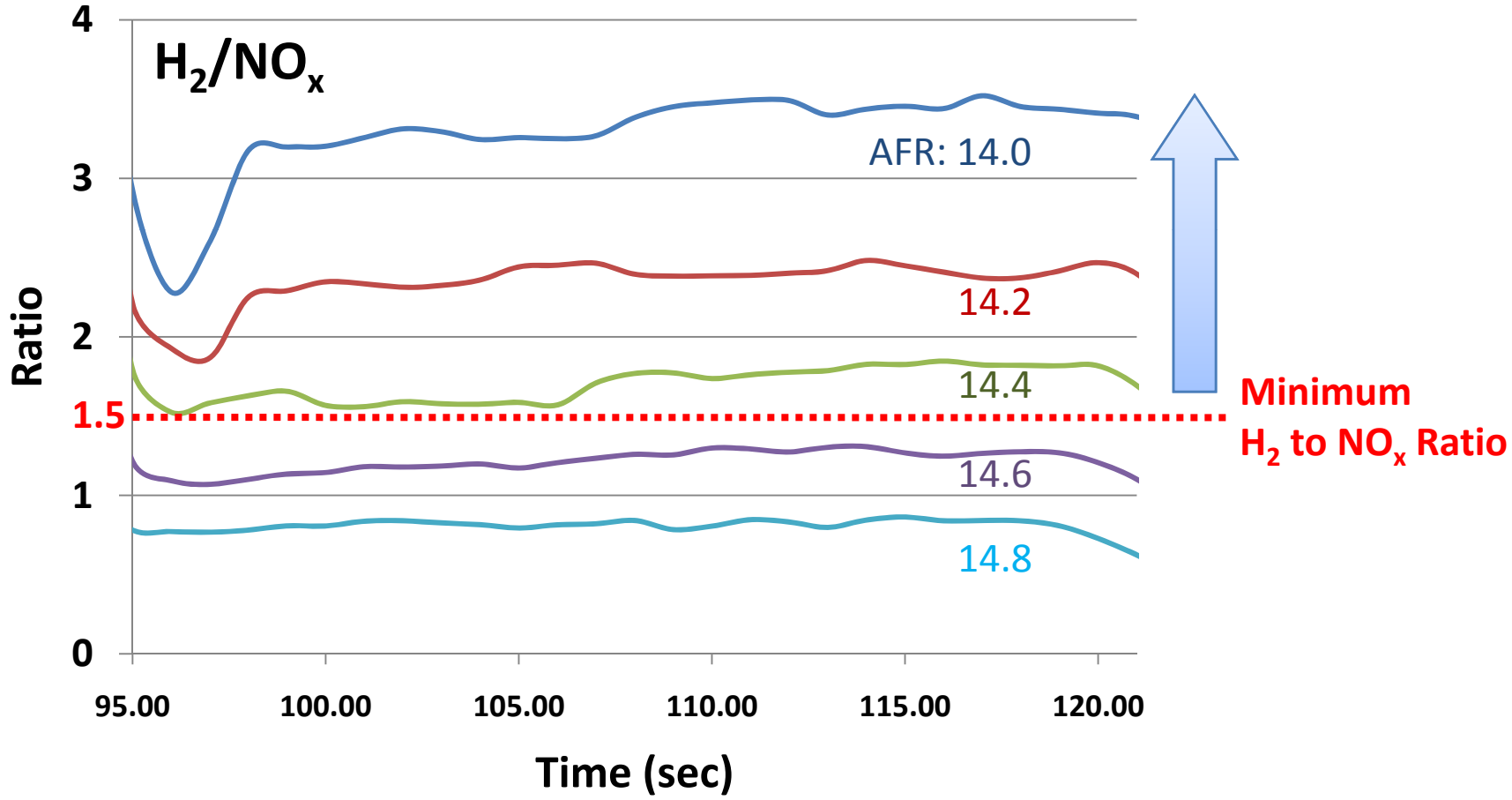


Catalyst 2 with High PGM

Steady State

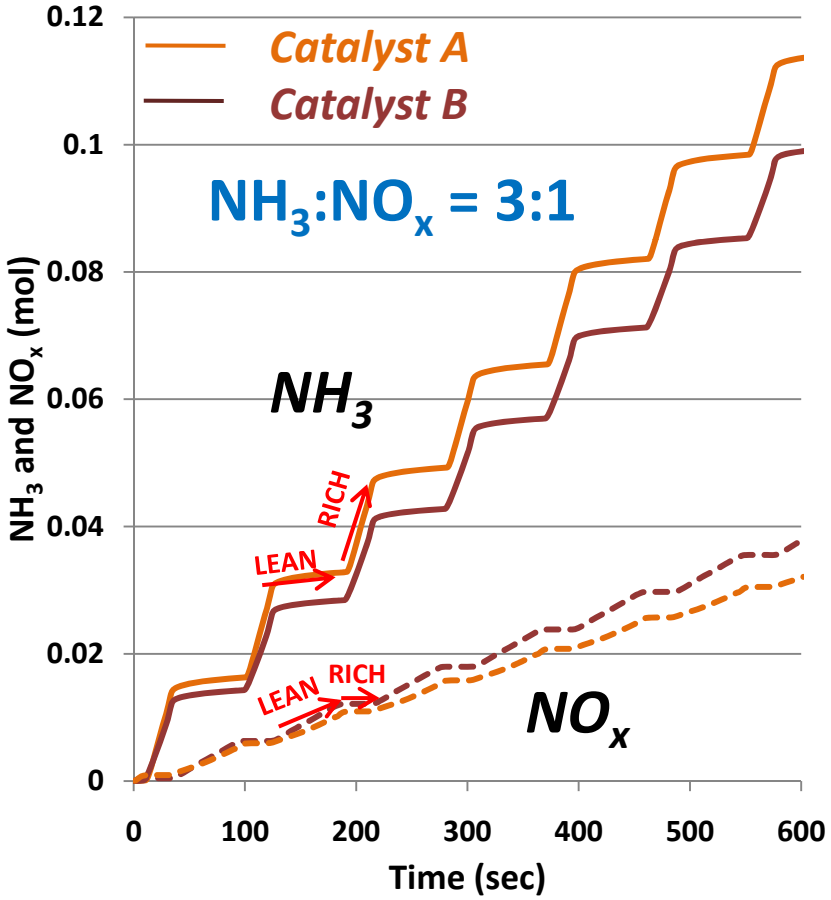
Making NH_3 from Engine Out NO_x and H_2

- $NO_x + 1.5H_2 + CO \Leftrightarrow NH_3 + CO_2$

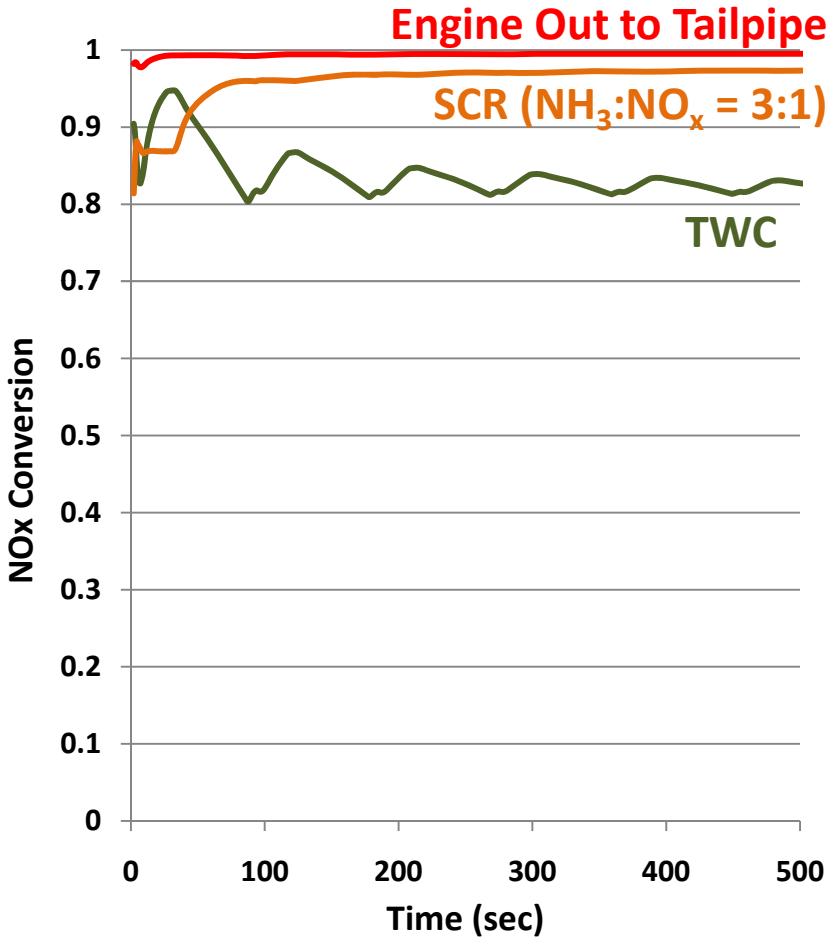


Cumulative TWC Out NH_3 / NO_x and SCR

2000 rpm / 2 bar

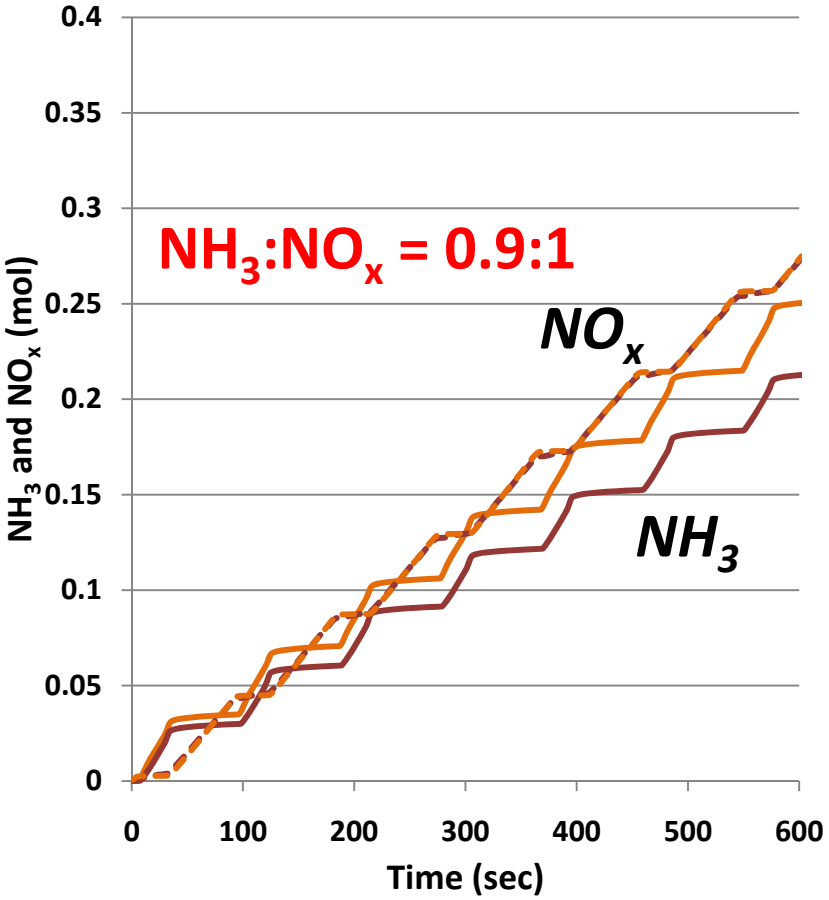


2000 rpm / 2 bar

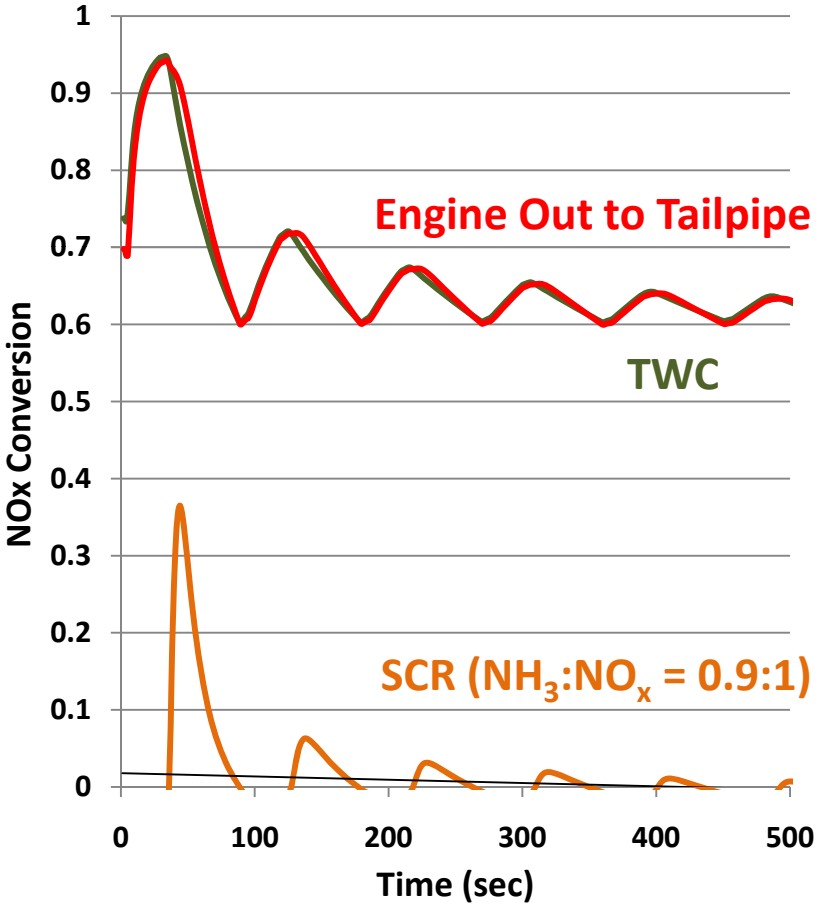


Cumulative TWC Out NH_3/NO_x and SCR

3000 rpm / 3 bar



3000 rpm / 3 bar



Summary

- Passive NH_3 SCR has been demonstrated as an efficient and lower cost alternative lean NO_x aftertreatment technology for stratified gasoline engines.
- Very high NO_x conversion efficiencies were achieved during NEDC transient cycles.
- HC emission reduction is challenging due to the low exhaust temperatures
- Further improvements in SCR catalyst technologies are required for high speed (≥100 km/h) lean operations.

Passive NH_3 SCR: key enabler for lean gasoline engines