2010 DEER CONFERENCE

Catalyst Design for Urea-less Passive Ammonia SCR Lean-Burn SIDI Aftertreatment System

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Global Research & Development

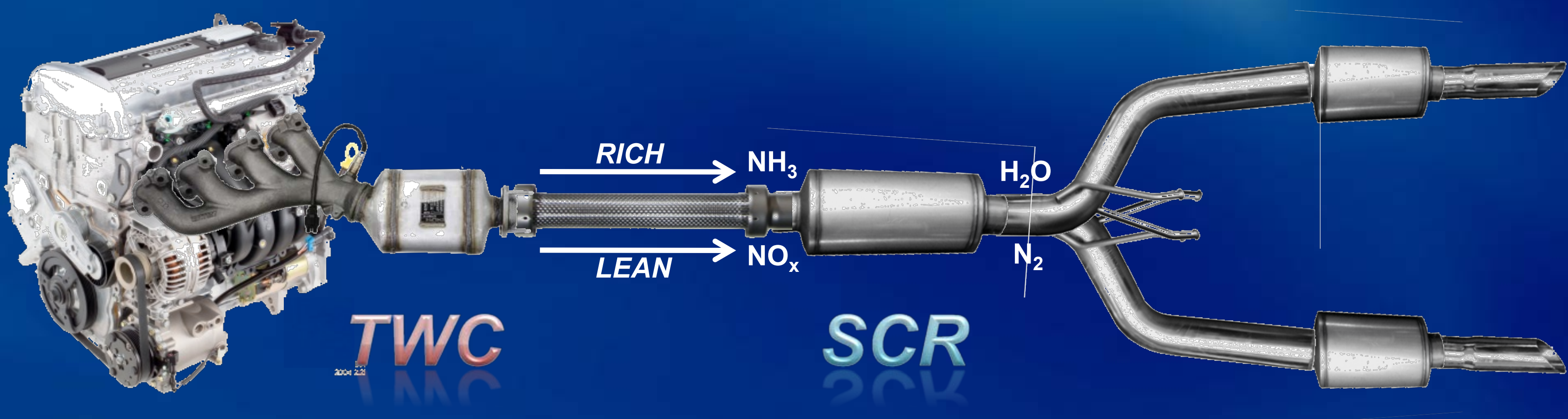
September 28, 2010

Effective May 3, 2010 DOE Funded Project
Award Number DE-EE-0003379

Fuel Efficiency vs. Emission Control

PASS - How Does It Work?

Urea-Free SCR System



DURING RICH:

$$NO_X + H_2/CO \Leftrightarrow NH_3 + CO_2$$

Use H_2 and CO to generate NH_3 over TWC and store NH_3 in multiple SCRs

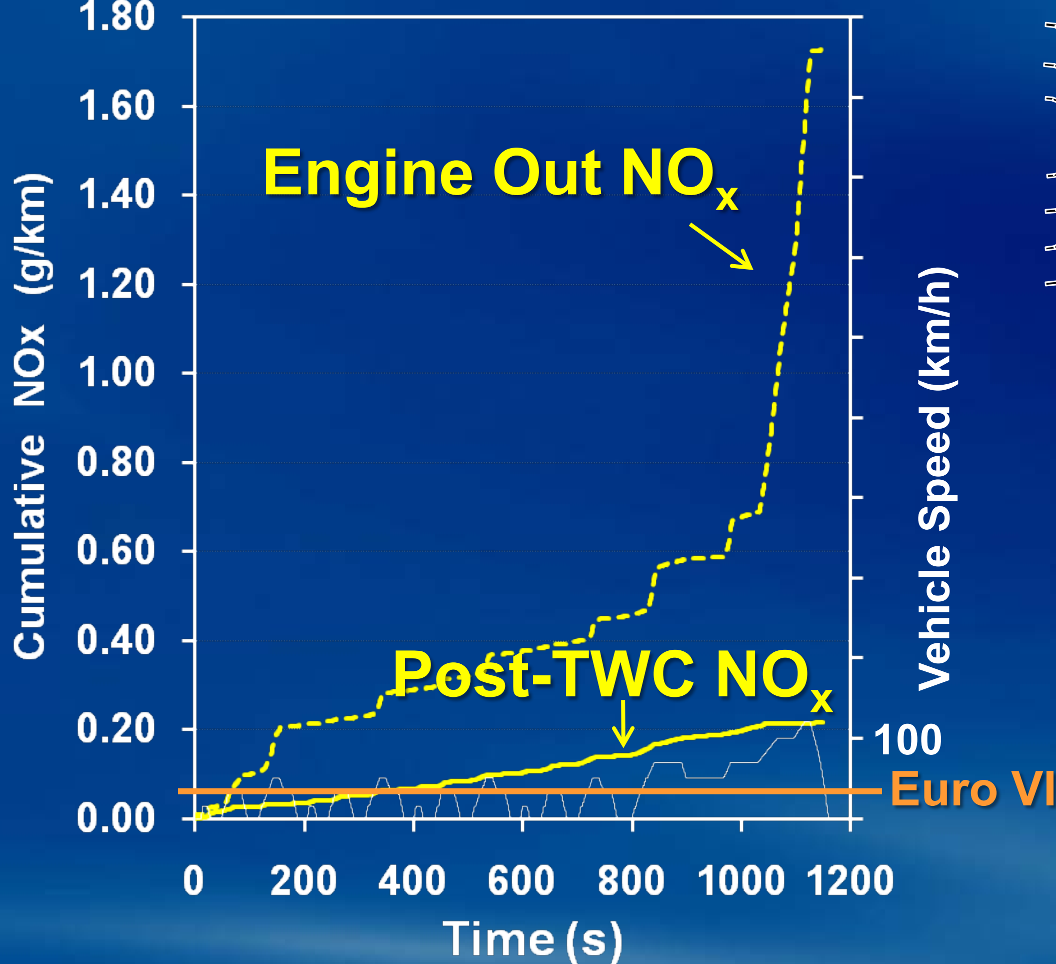
DURING LEAN:

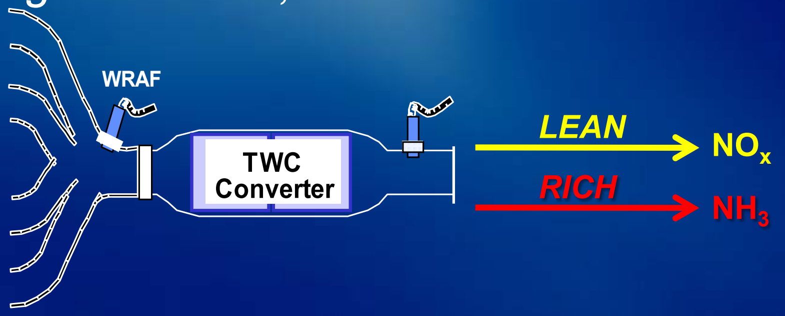
$$NO_X + NH_3 \Leftrightarrow N_2 + H_2O$$

Use the stored NH_3 for lean NO_x conversion

NEDC Results from Stratified Charge Application – *Extended Lean Operation*

Dynamometer data based on: European Passenger Car – I4, Manual Transmission





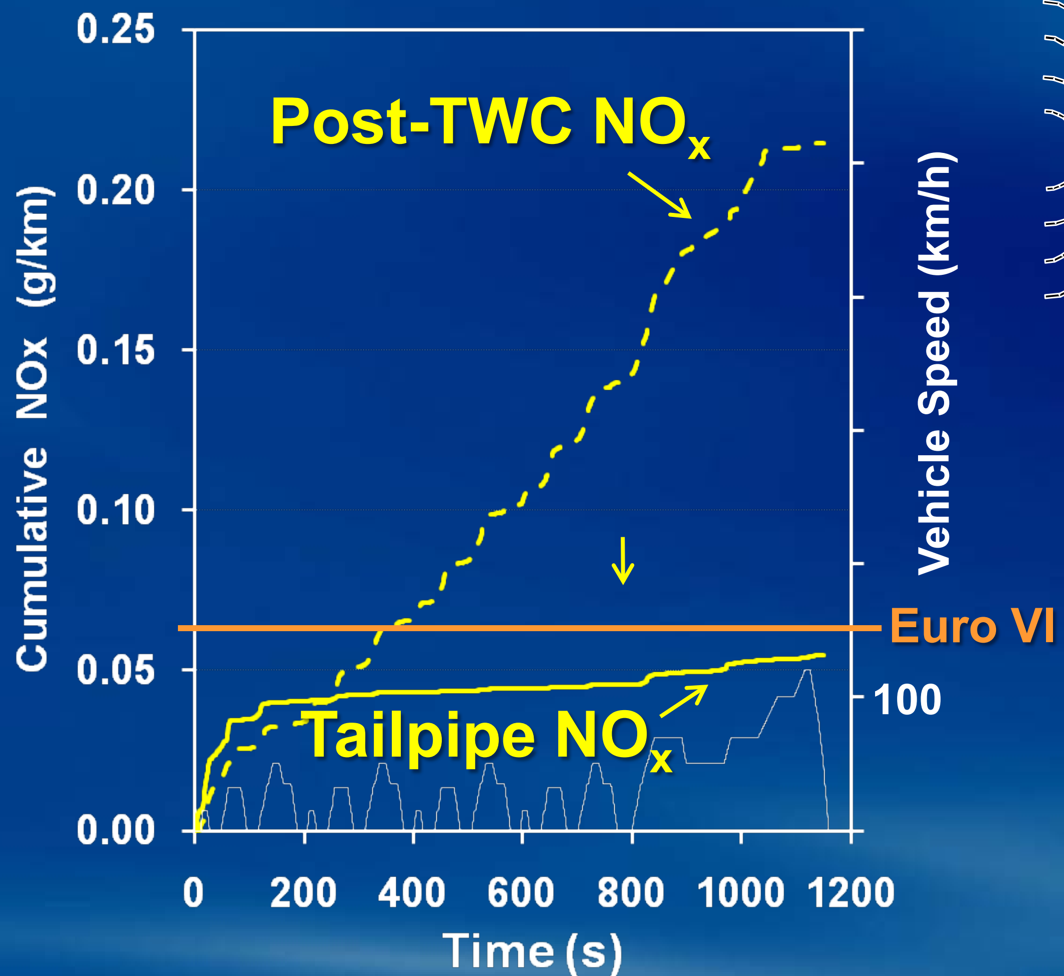
TWC

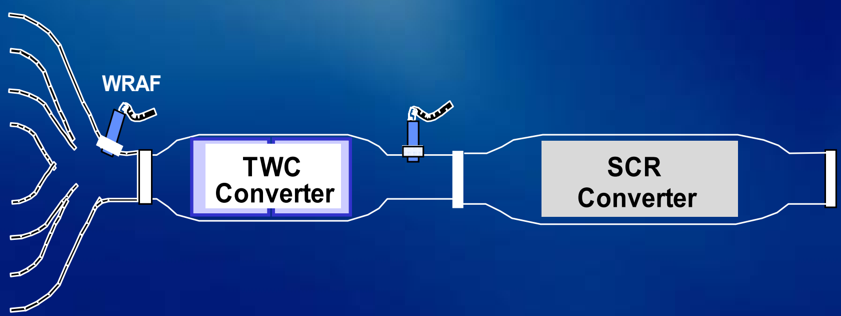
- Front Brick: 0.8 L
  200 g/ft^3, 0/200/0
- Rear Brick: 1.2 L
  70 g/ft^3, 0/60/10

➔ Poor NO_x conversion over TWC during NEDC

➔ TWC produced NH_3 with rich operation

NEDC Results from Stratified Charge Application – *Extended Lean Operation*





TWC

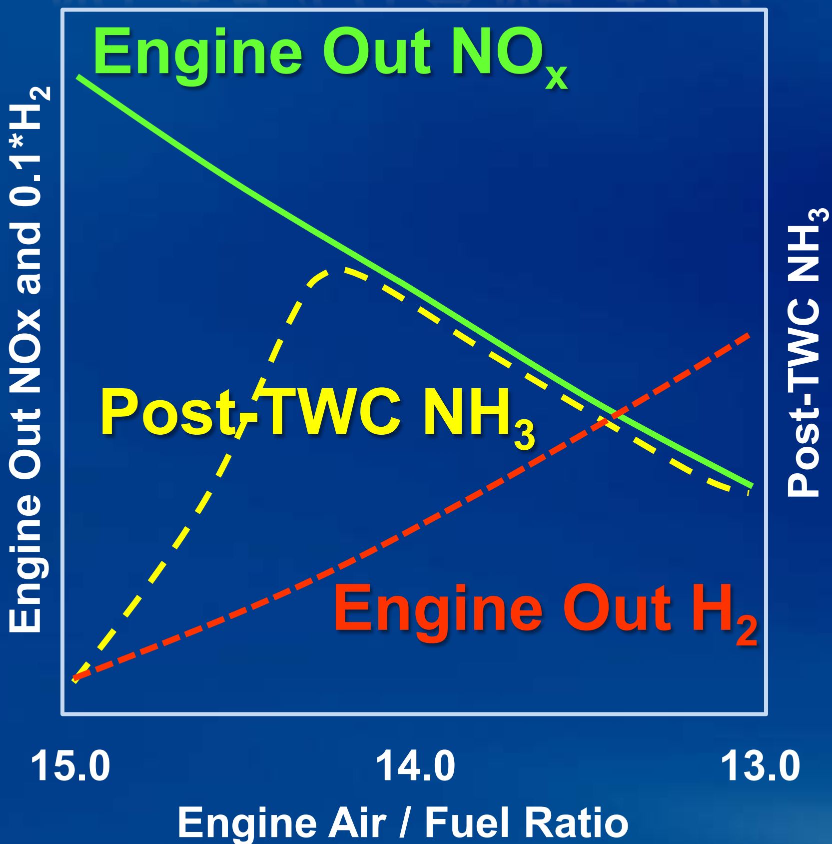
- Front Brick: 0.8 L
  200 g/ft^3, 0/200/0
- Rear Brick: 1.2 L
  70 g/ft^3, 0/60/10

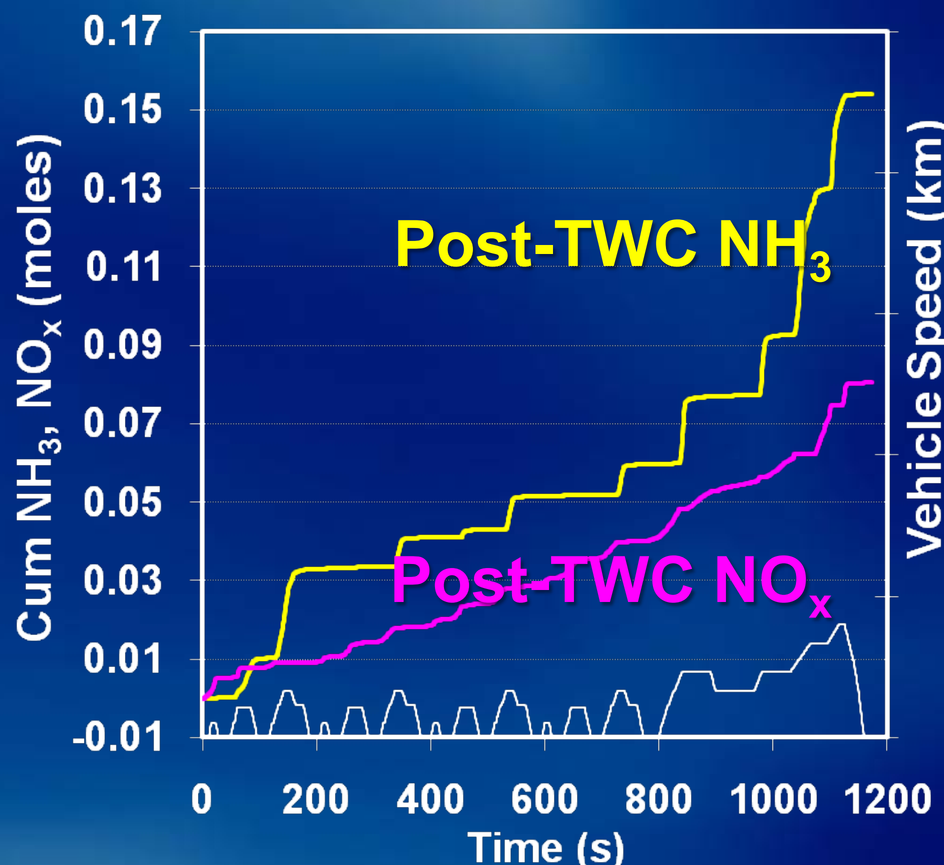
SCR

- 2.0 L
  Cu-based

NH_3 Formation over TWC

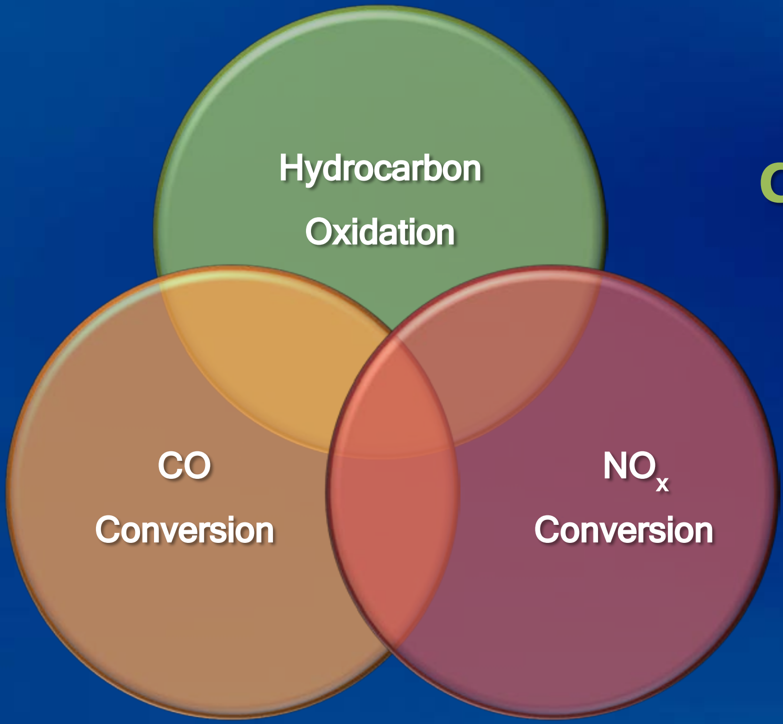
$NO_x + H_2/CO \Leftrightarrow NH_3 + CO_2$





➔ NH_3/NO_x ratio is always greater than 1 over SCR for maximum conversion efficiency

The Multiple Roles for TWC



Engine Operation

Lean ***Stoic.*** ***Rich***

$C_xH_y + O_2 \Leftrightarrow CO_2 + H_2O$

$C_xH_y + H_2O \Leftrightarrow CO_2 + H_2$

$CO + O_2 \Leftrightarrow CO_2$

$CO + H_2O \Leftrightarrow CO_2 + H_2$

$NO_x + H_2 \Leftrightarrow NH_3 + H_2O$

$NO_x + CO \Leftrightarrow CO_2 + N_2$

Pt Pd Rh ? OSC

➔ TWC design is critical for ***PASS***

Experimental Design

- Engine: 2.2L, stratified-charge developed by GM R&D
- Controller: d-SPACE with Micro-autobox
- Transient Dynamometer Equipped with Horiba Emission Benches, MKS FTIRs, and V&F H_2/O_2 Analyzer

I:

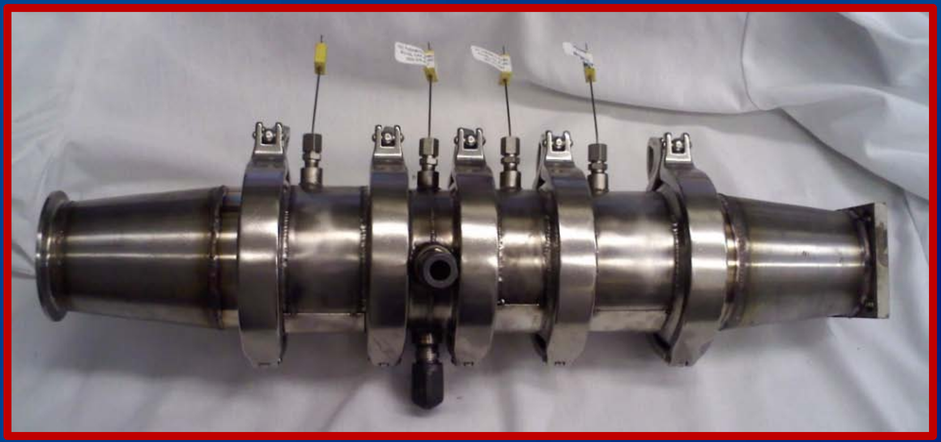
→ Investigate the effect of Rh and OSC for NH_3 formation

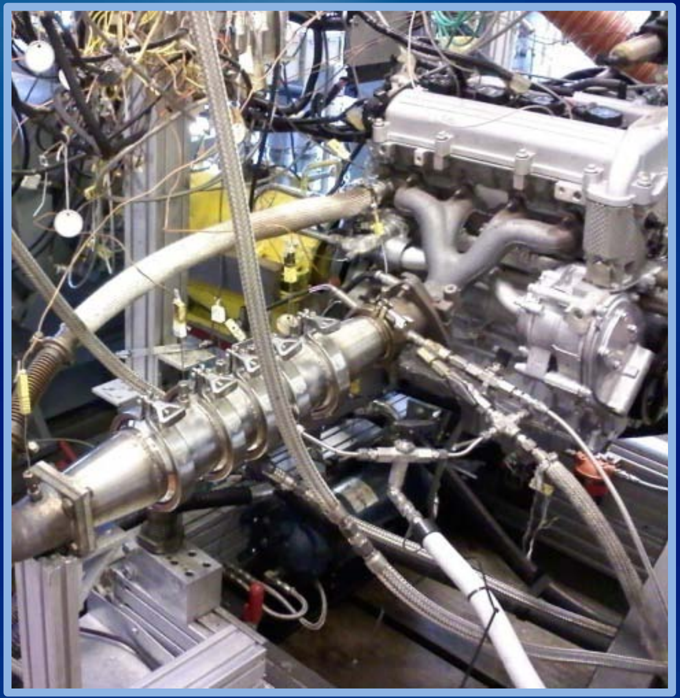
- **Pd Brick: no OSC**
  200 g/ft^3, 0/200/0
- **Pd/Rh Brick: Std. OSC**
  70 g/ft^3, 0/60/10
- **Aged in RAT H cycle for 50 hrs**

II:

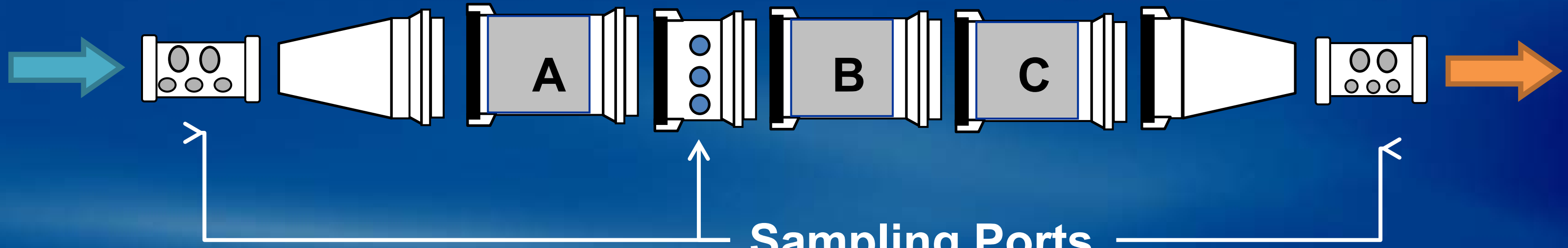
→ Investigate the effect of Pd, Rh, and OSC for NO_x reduction & CO/HC Oxidation

Modular Converters for TWC Design

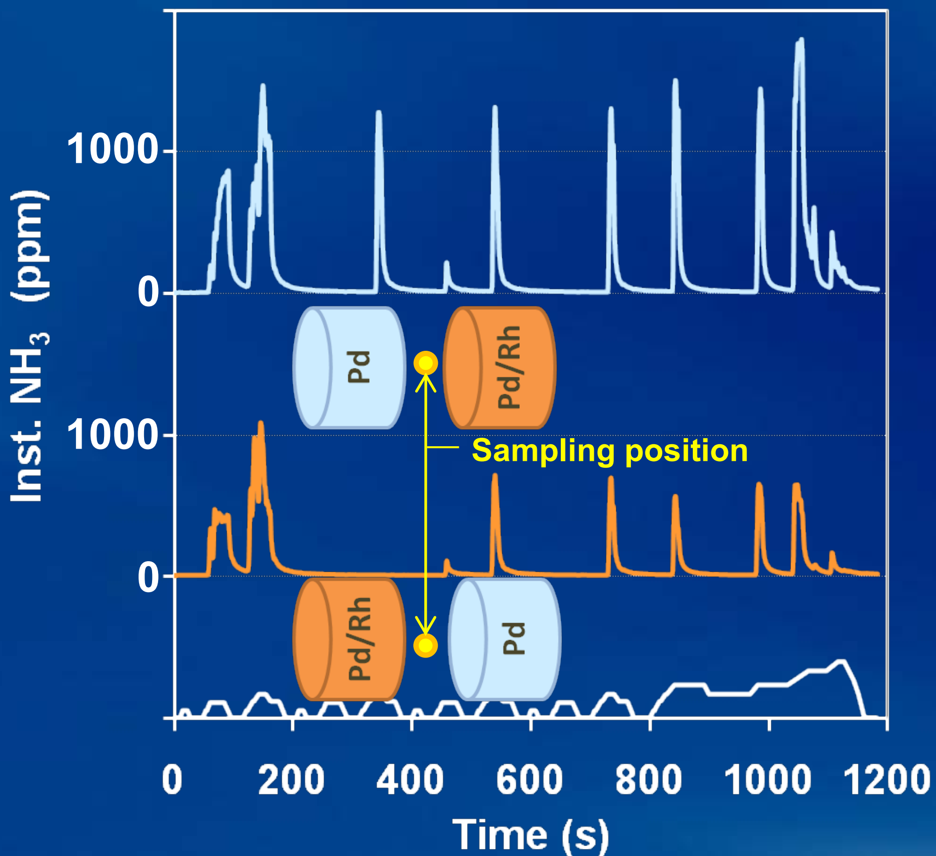


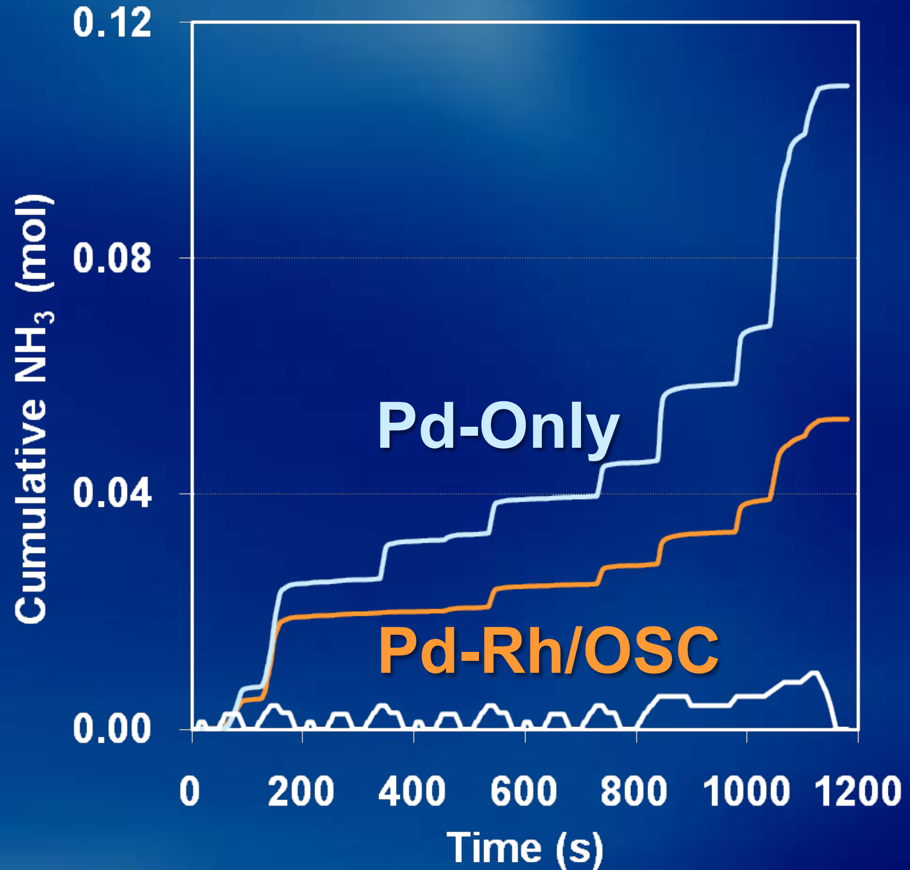


→ Modular testing allows to characterize the individual components in TWC



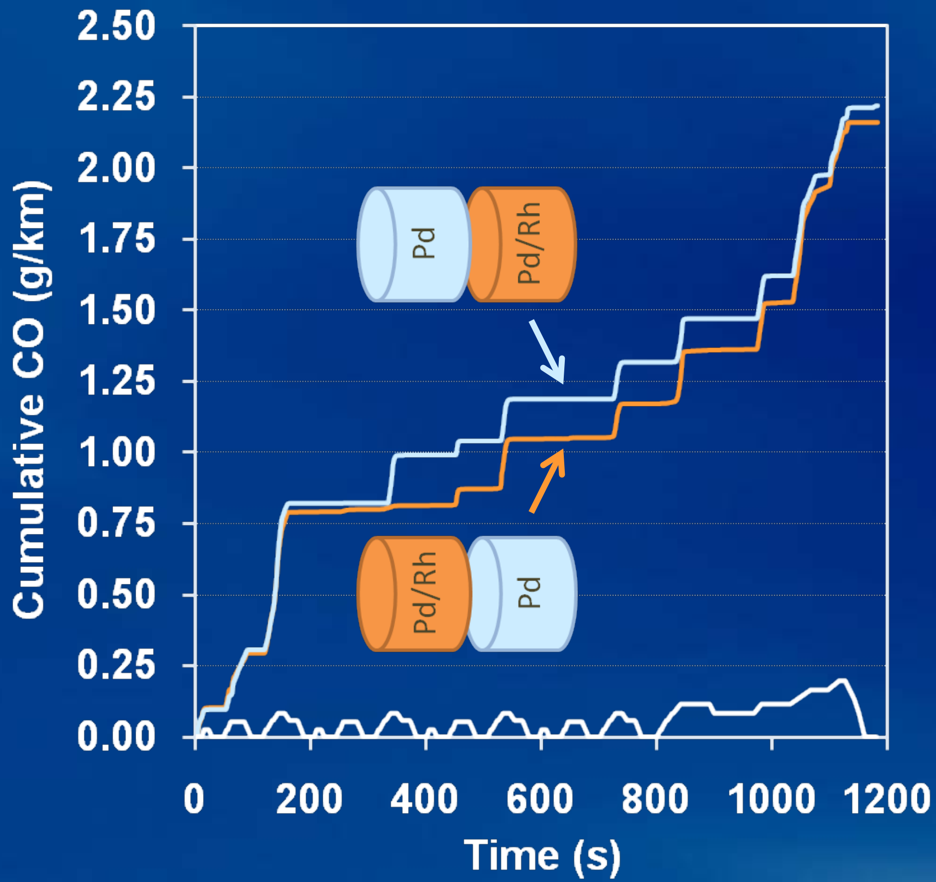
NH_3 Formation over Pd-only vs. Pd-Rh

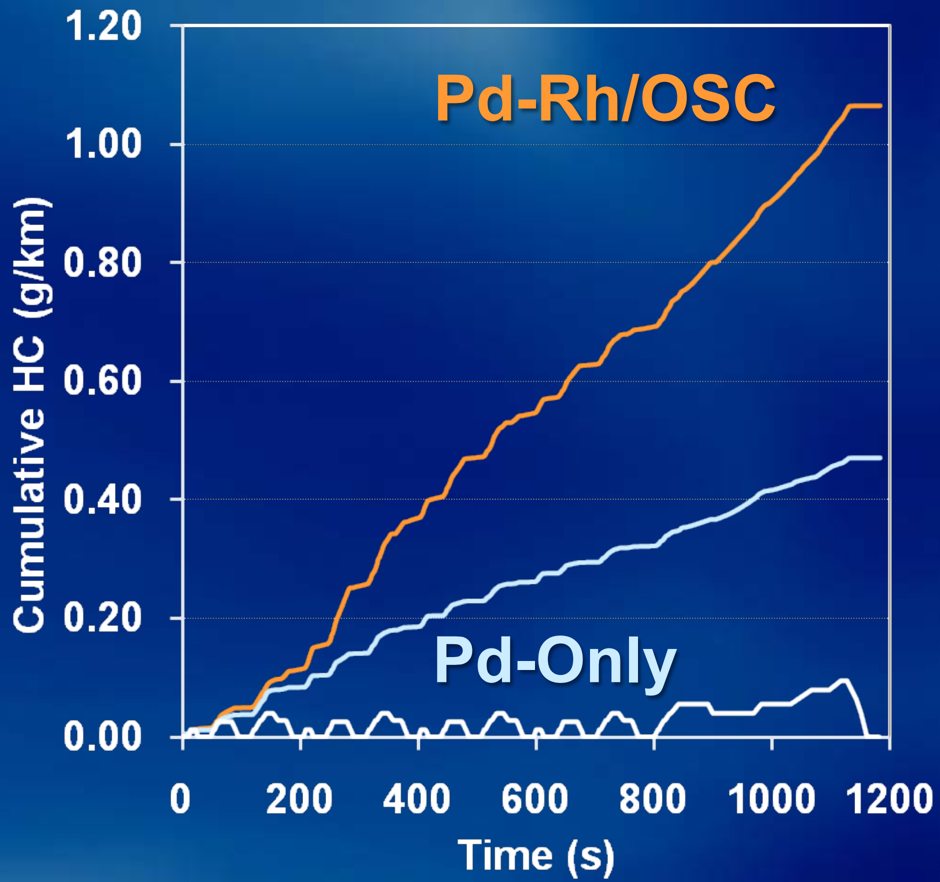




➔ Pd/Rh catalyst with OSC makes much less NH_3 compared to Pd only catalyst

CO and HC Efficiency

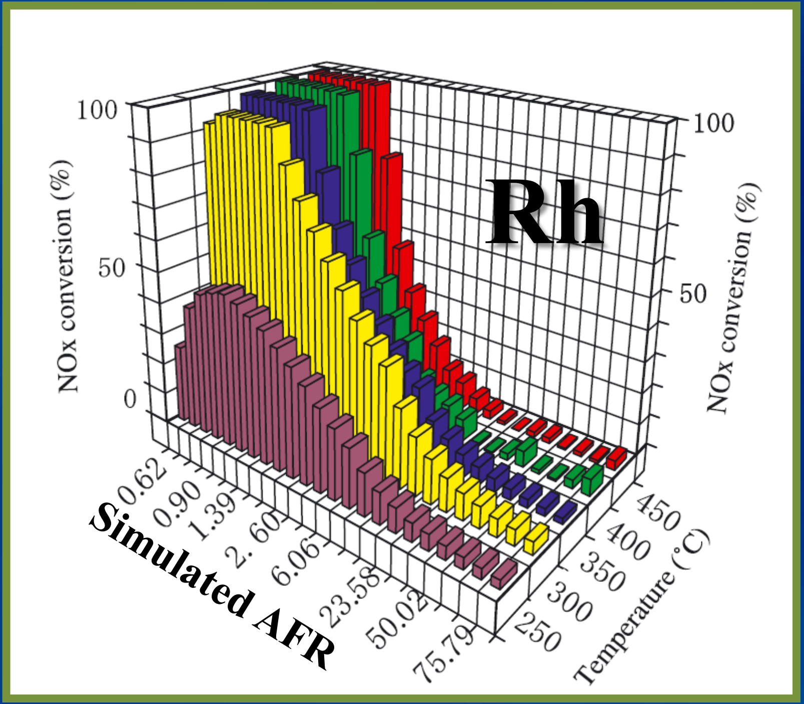




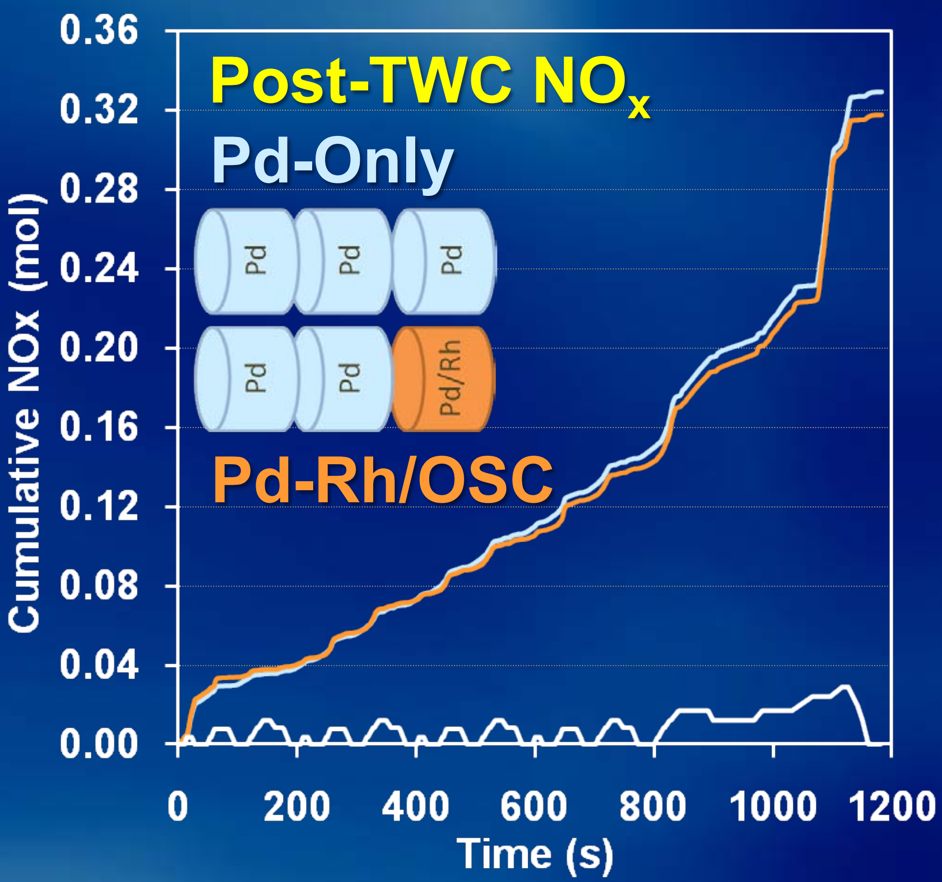
→ HC conversion efficiency over Pd only catalyst was much higher than that over Pd/Rh with OSC

NO_x Reduction Efficiency over TWC

NO_x reduction in Lean Exhaust

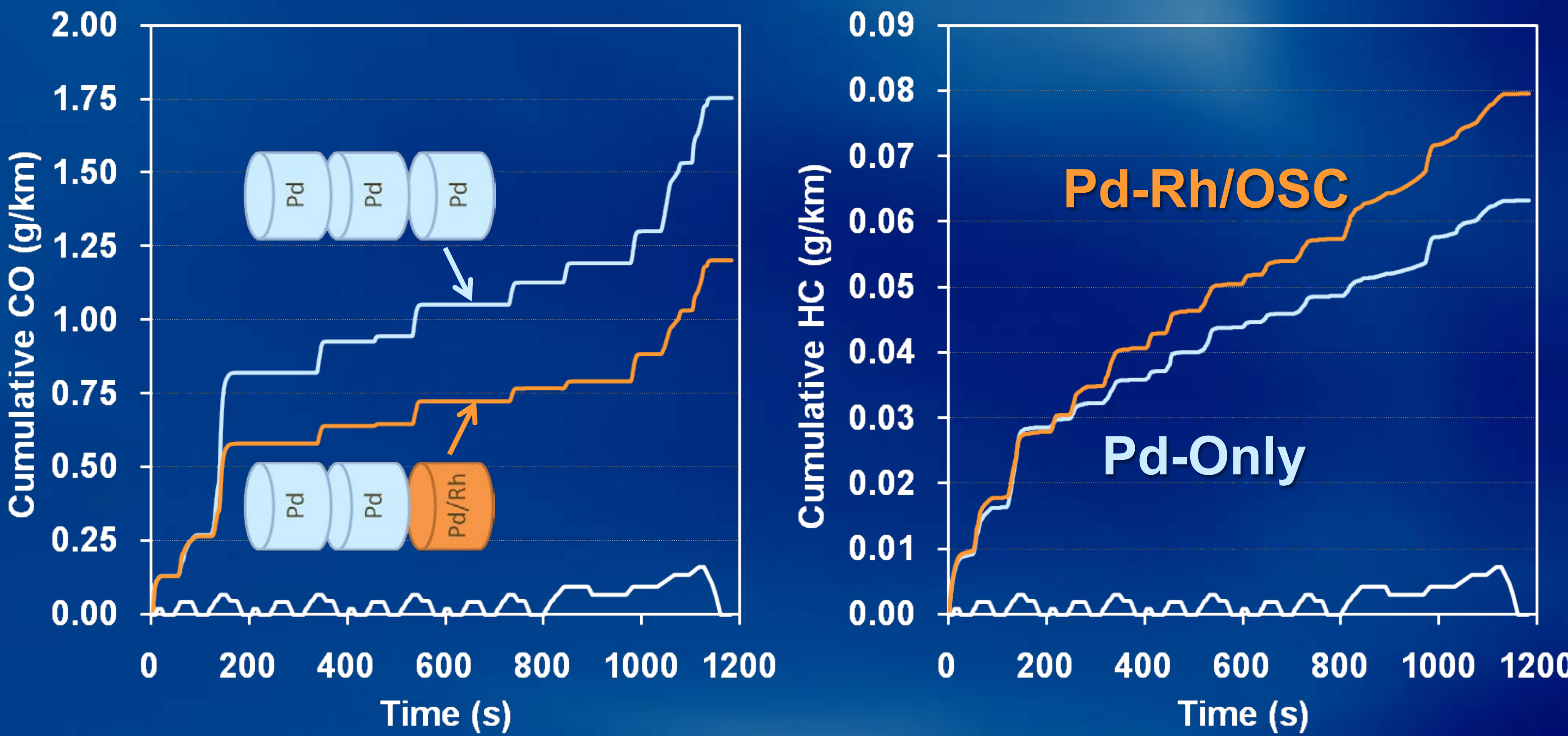


(Shinjoh et al., 2004)



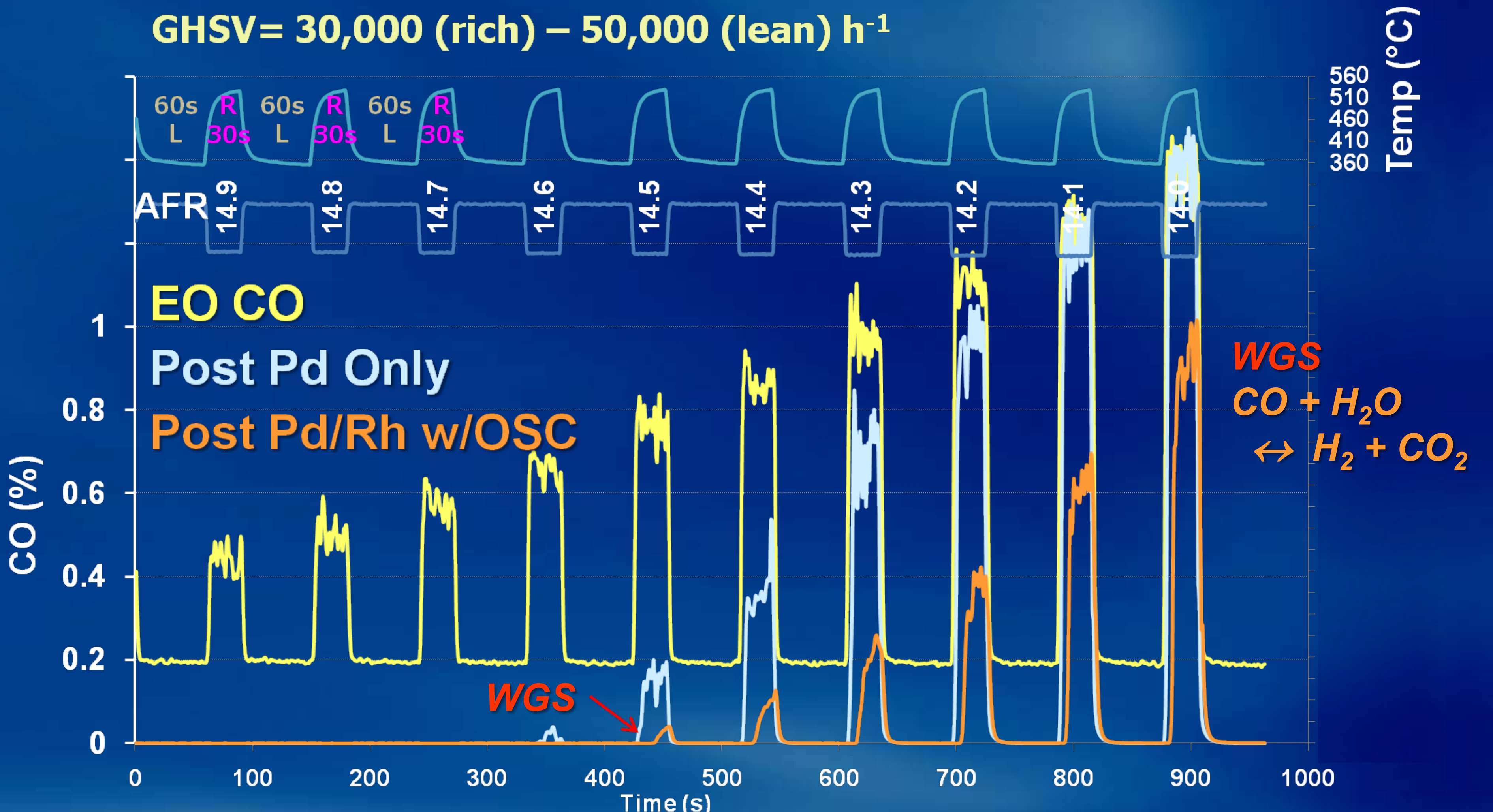
➔ Not much benefit of using Rh in terms of NOx efficiency under lean environment

OSC Effect on CO and HC Efficiency



➔ HC conversion efficiency was great over Pd-only catalyst, however CO efficiency is strongly linked with Rh and OSC

CO Conversion during Rich Operation

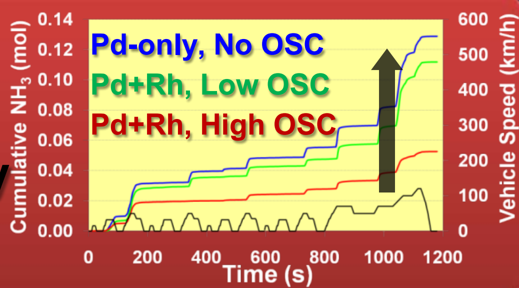


→ CO is removed by water gas shift reaction over Rh/OSC

GM RD CENTER

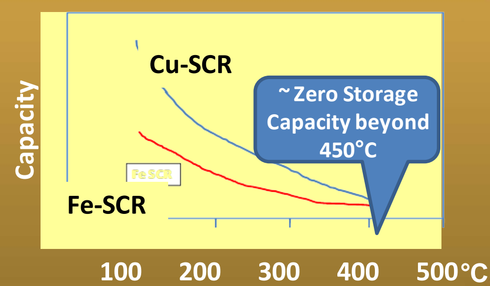
Challenges

TWC Technology



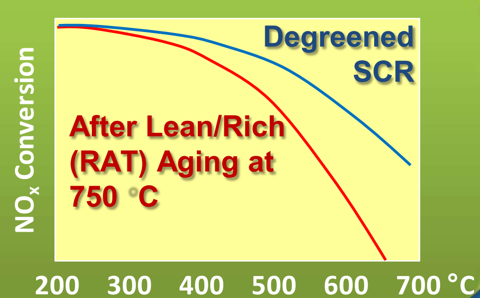
- ***High NH_3 Efficiency***
- ***PGM & OSC Optimization***

SCR Technology



- ***NH_3 storage beyond 450 C***
- ***High Temp. NO_x Efficiency***

Thermal Durability



- ***Stable TWC under Lean Env.***
- ***Stable SCR under Reducing Env.***

PASS

Oxygen Tolerant Universal Aftertreatment

Summary

- PASS concept: a universal, oxygen tolerant aftertreatmemt system for SI engines
  - Minimize PGM while improving fuel economy potential
- TWC technology that maximizes NH_3 production and CO/HC conversion under slightly rich conditions is the most important element in PASS
  - Modular TWC experiments guided us how EO emission interacts with Pd, Rh, and OSC components in TWC
  - Most NH_3 was produced from the Pd only catalyst
  - WGS reaction may be the most effective way to reduce CO during rich operations

THANK YOU !

Breaking
the **paradigm...**

NOW
green
and **fun**
to **drive**

can go TOGETHER

Leading a Transformation in the Industry