Aftertreatment Catalyst Durability: Information Gaps and Future Needs

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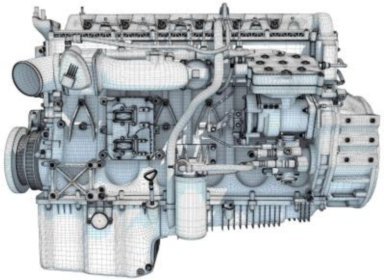
September 13, 2021

Define Durability

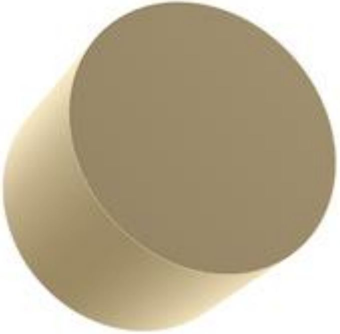
Exhaust Emissions
i.e. ≤20 mg NOx /bhp-hr
≥435k miles

Ensure clean operation throughout Useful Life (UL)



Exhaust Emission
i.e. ≤20 mg NOx /bhp-hr
8000+ hrs

Demonstrate Durability to meet emission targets



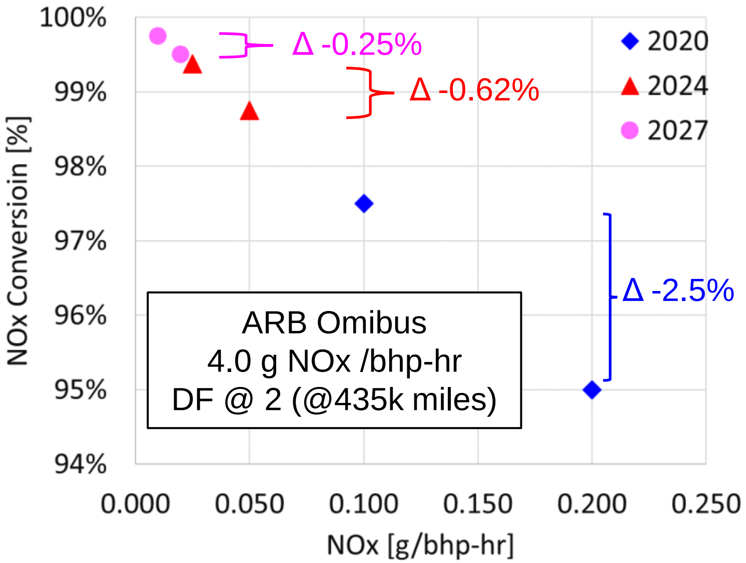
Conversion
i.e. >99% NOx Conversion
8000+ hrs.

Maintain catalytic activity throughout UL

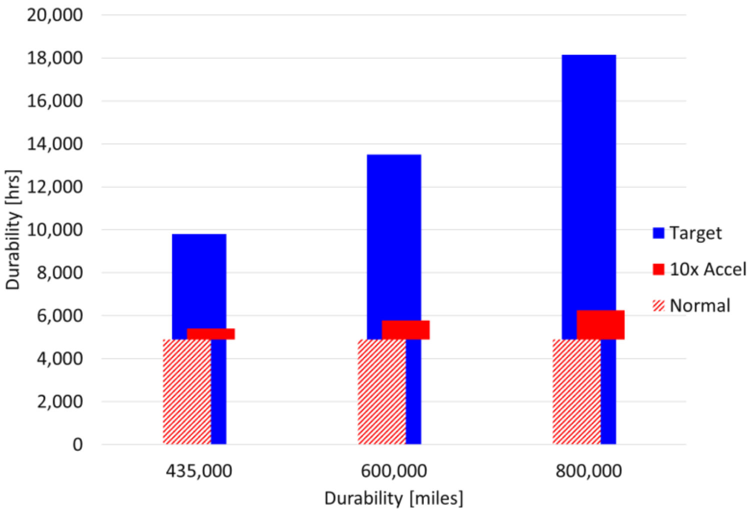
Durability is Measured by Performance

Maintain high efficiency for longer durations

Emission / Conversion



Durability : Distance or Time

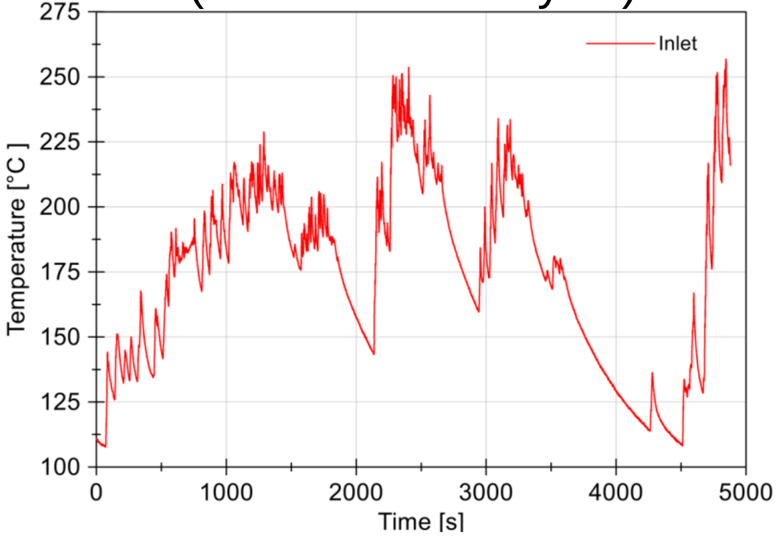


Challenge to achieve high conversion efficiency with little to no performance deterioration under increasing distance / time demands for useful life (UL)

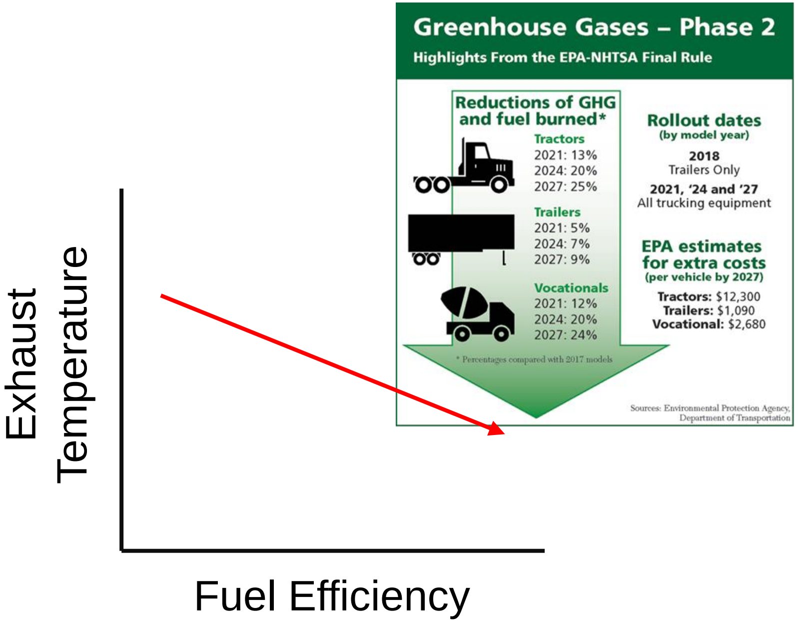
Durability is Measured by Performance

Achieve high efficiency at increasingly challenging conditions

Operating Cycles
(i.e. Low Load Cycle)



Operating Temp



Requirements vs. Application

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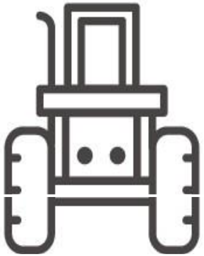

	Off Road	On Road
Application Variety *(Engine size, Duty cycle, DPF management, etc.)*	++	+
Regulated NOx Levels	+	++ (ARB)
ATS Complexity (i.e. LO SCR)	+	++
Environmental Harshness	++	+
OBD	+	++

ATS Directions for Low NOx

Catalysts and Configurations

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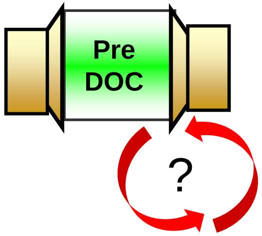
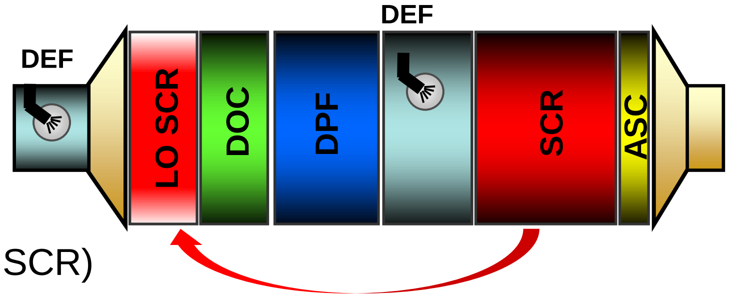
Automotive Catalysts



Lightoff SCR ATS



Challenges:

- NOx Conversion at <<200 °C
  - NH3 availability at temps << 200 °C
- Near 100% NOx conversion vs. useful life

Trends

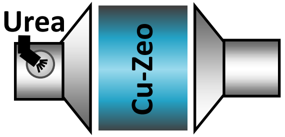
- Add SCR upstream to high temperature location (LO SCR)
- Dual DEF dosing at both locations as conditions dictate

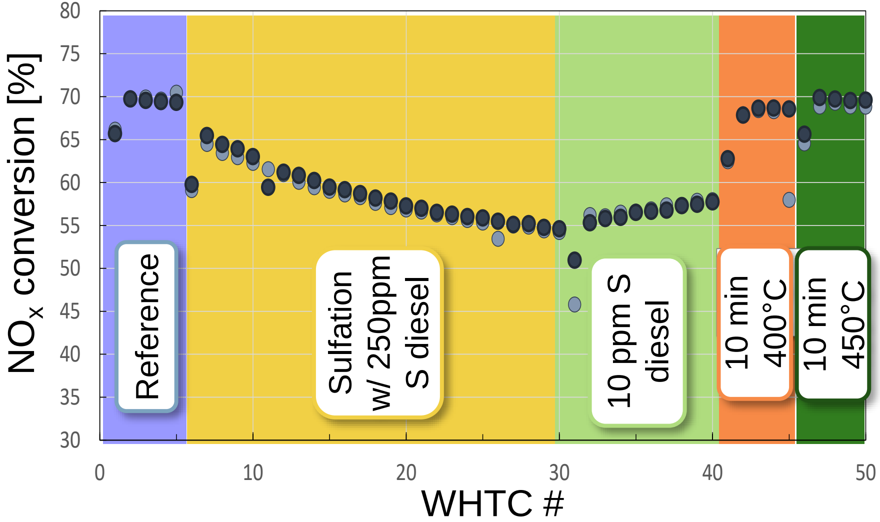
Catalysts Needs:

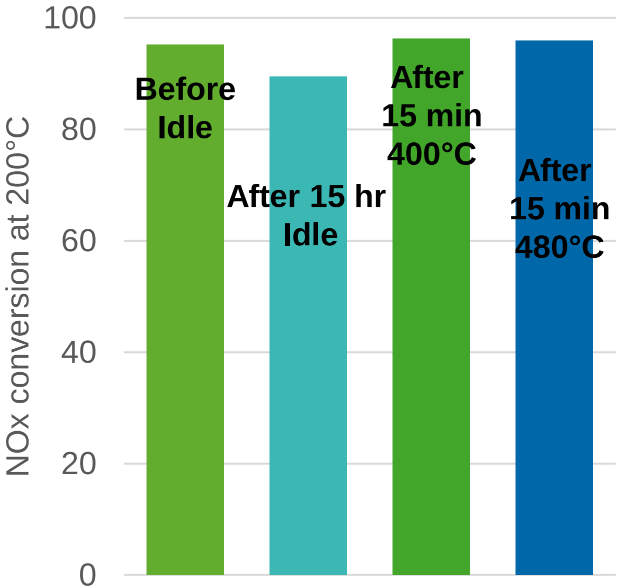
- SCR:
  - Improved Low temperature NOx performance
  - Dynamic conversion (decrease reliance on stored NH3)
  - Fuel tolerant (impact at idle, HC ignition, etc.)
- 1st Position:
  - Poison tolerant (Sulfur, Phosphorus)
  - Avoid face fouling/plugging

Cu SCR as LO SCR

Sulfur and HC Impact







Sulfur level must be managed on Cu SCR

15 hr idle has only mild impact to performance

ANR = 0.75

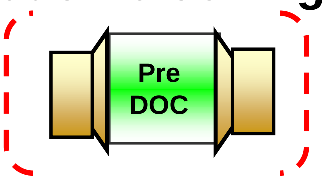
Sulfation over 25 WHTCs cycles @250 ppm S

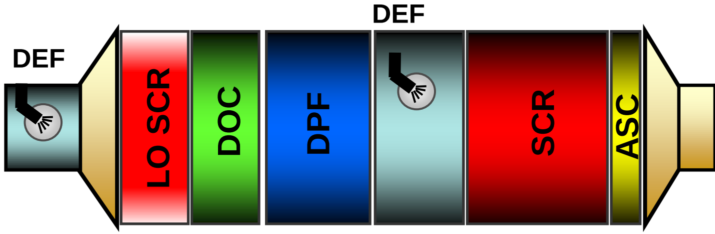
- ~4 g S / L (LO SCR)

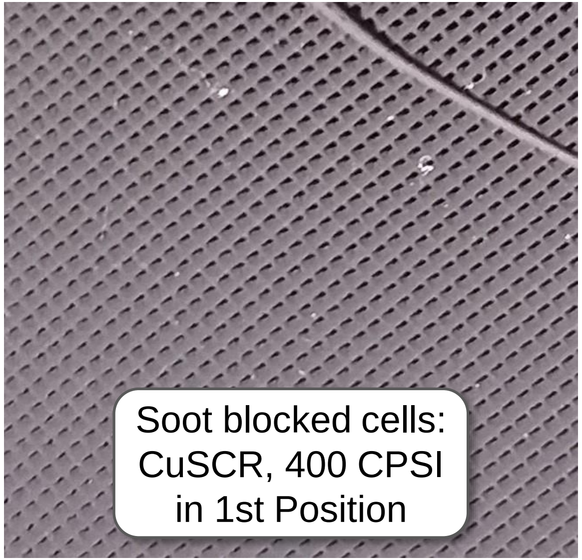
$T_{SCR,in}$ = 339°C (max) / 239°C (avg)

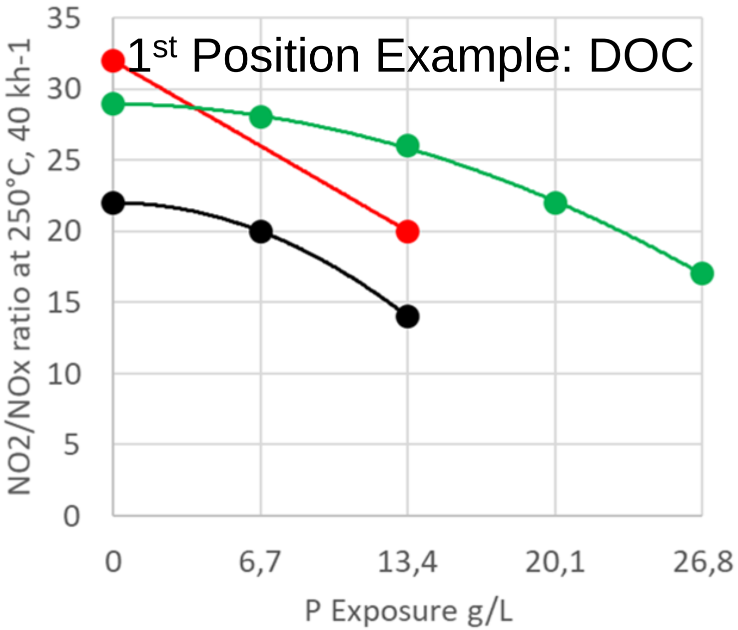
1st Position

Face Fouling and Phosphorous Poisoning









Information Gap

How to effectively age catalyst beyond 10x acceleration and accurately mimic thermal and chemical impact to the catalytic function seen in field?

Diversity in applications, and resulting operational conditions, are likely to show variety in the level of thermal vs. chemical deactivation of experianced

Chemical Poisoning ⟷ Thermal Deactivation

Causal determination of field returned samples (missing the true “history”)

- Link between catalyst state and driving profile
- Will remote monitoring help close this gap?

Lack of aging experience wrt. LO SCR especially with CuSCR and/or high performing systems (>99% Conversion Efficiency)

Lack of appropriate/working aging models for catalysts, etc.

Can supplemental heating help achieve and maintain high conversion?

Can supplemental heating measure achieve durability requirements?

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materials for a better life