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Johnson Matthey Catalysts

Development of SCR on Diesel Particulate Filter System for Heavy Duty Applications

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EMISSION CONTROL TECHNOLOGIES

Outlines

- Introduction
- Objectives
- Experimental
- Results
  - NOx Conversion
  - Backpressure
  - Passive Regeneration
- Summary

Introduction

- Most 2010 heavy duty systems include:
  - DOC + CSF + SCRs + ASC
  - NO_x reduction with emission control has been introduced

- With proposed future regulations for GHG control and more emphasis on improved fuel economy, future engines will be designed with higher engine out NO_x

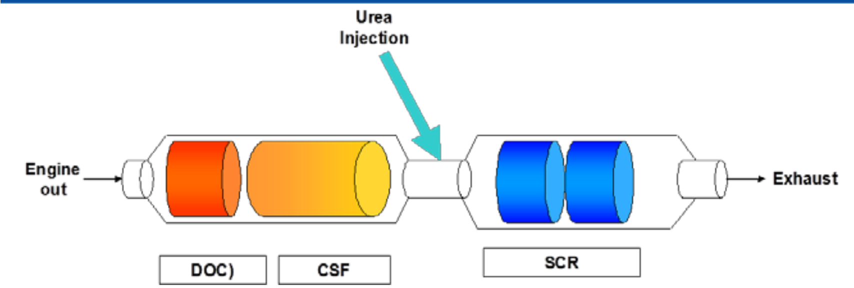
- Therefore, these future engines will require emission control systems with much higher NO_x conversion capability

- Additional NO_x control across the DPF is being considered as one means of improving overall system NO_x reduction capability

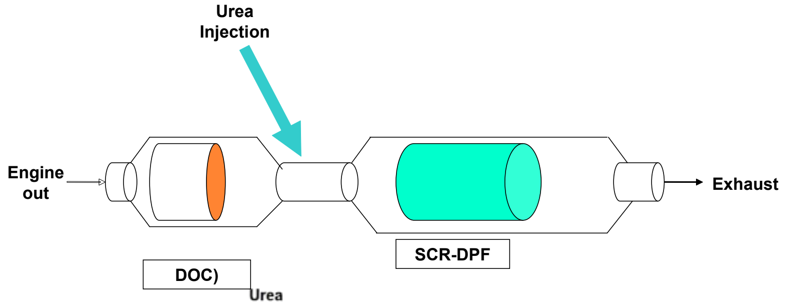
Objectives

- Evaluate SCR coated DPFs in US 2010 configuration to understand NO_x conversion capabilities of such systems
  - Test under Steady state
  - Test under Transient cycles
- Determine how SCR-DPF system can support higher NO_x reduction for higher engine out NO_x
- Evaluate how filter regeneration is affected by introducing SCR coating on the DPF

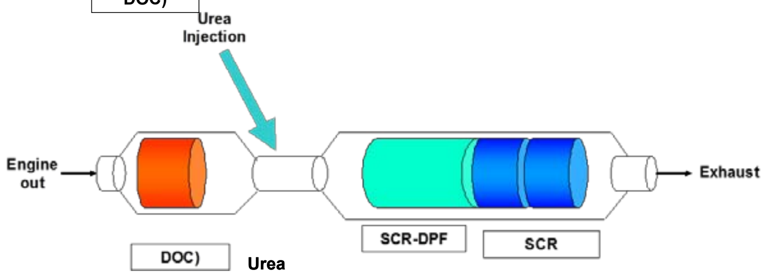
Experimental - Systems for Testing



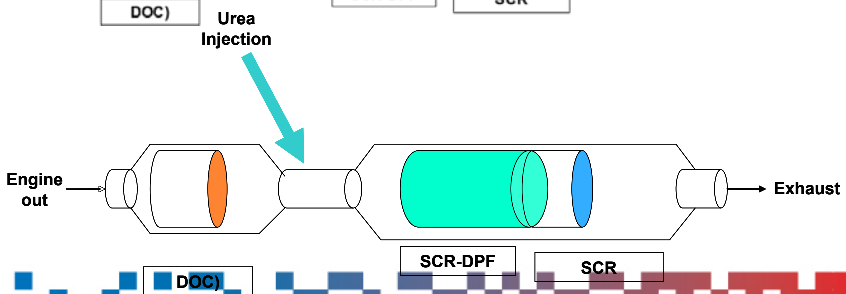
CSF System



SCR-DPF System



SCR-DPF + 2 SCR System



SCR-DPF + SCR System

Experimental Procedure

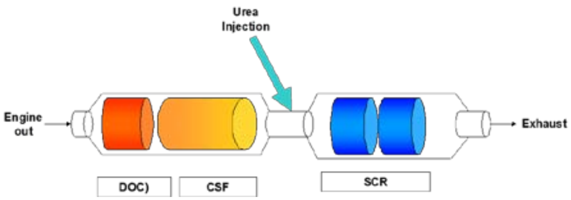
- ***Engine:*** ***6 Cylinder US 07 engine***
  - EGR off, NO_x= 4-5 g
- ***Units:***

  DOC: Degreened, aged at 700ºC for 100hrs with 10% water

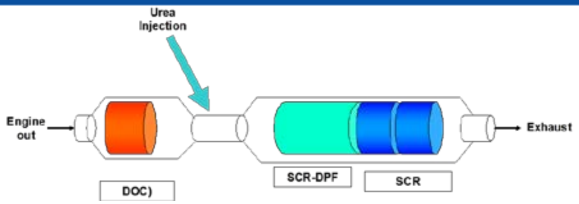
  SCR-DPF/SCR: Aged at 650ºC for 100hrs with 10% water
- ***Steady State:***
  - Temp from 200°C to 440°C, ANR=1.2
- ***FTP Runs***
  - Cold FTP
  - Hot FTP
  - ANR ~ 1.3

NOx Conversion

SCR-DPF Provides Significant NOx Conversion Advantages
Equivalent system volume



CSF System



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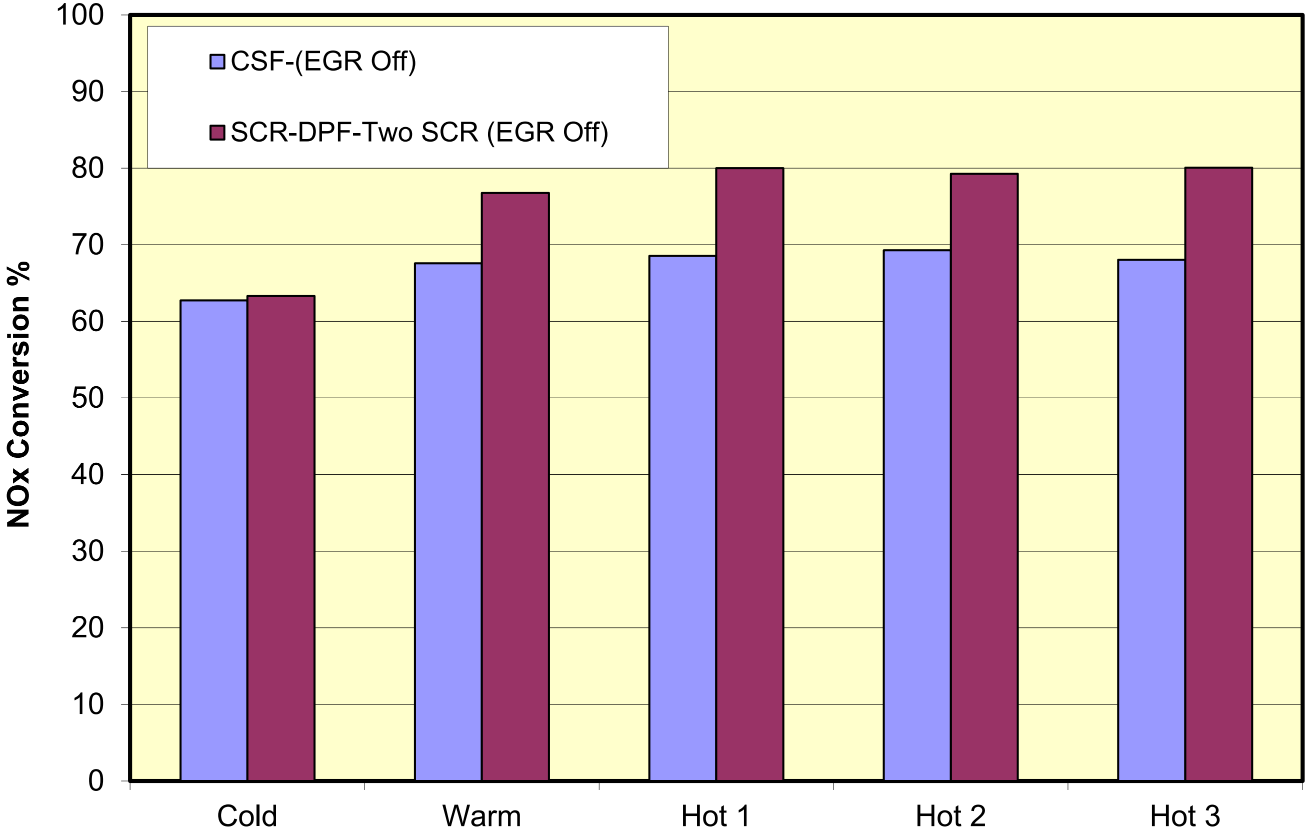
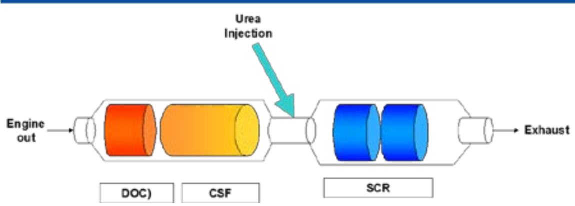
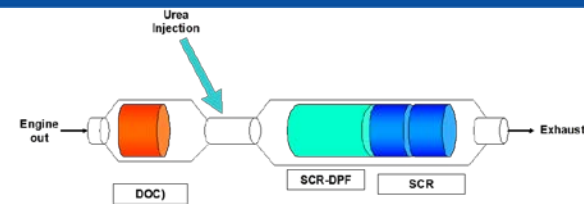


SCR-DPF Provides NOx Conversion Advantages at Low temperature

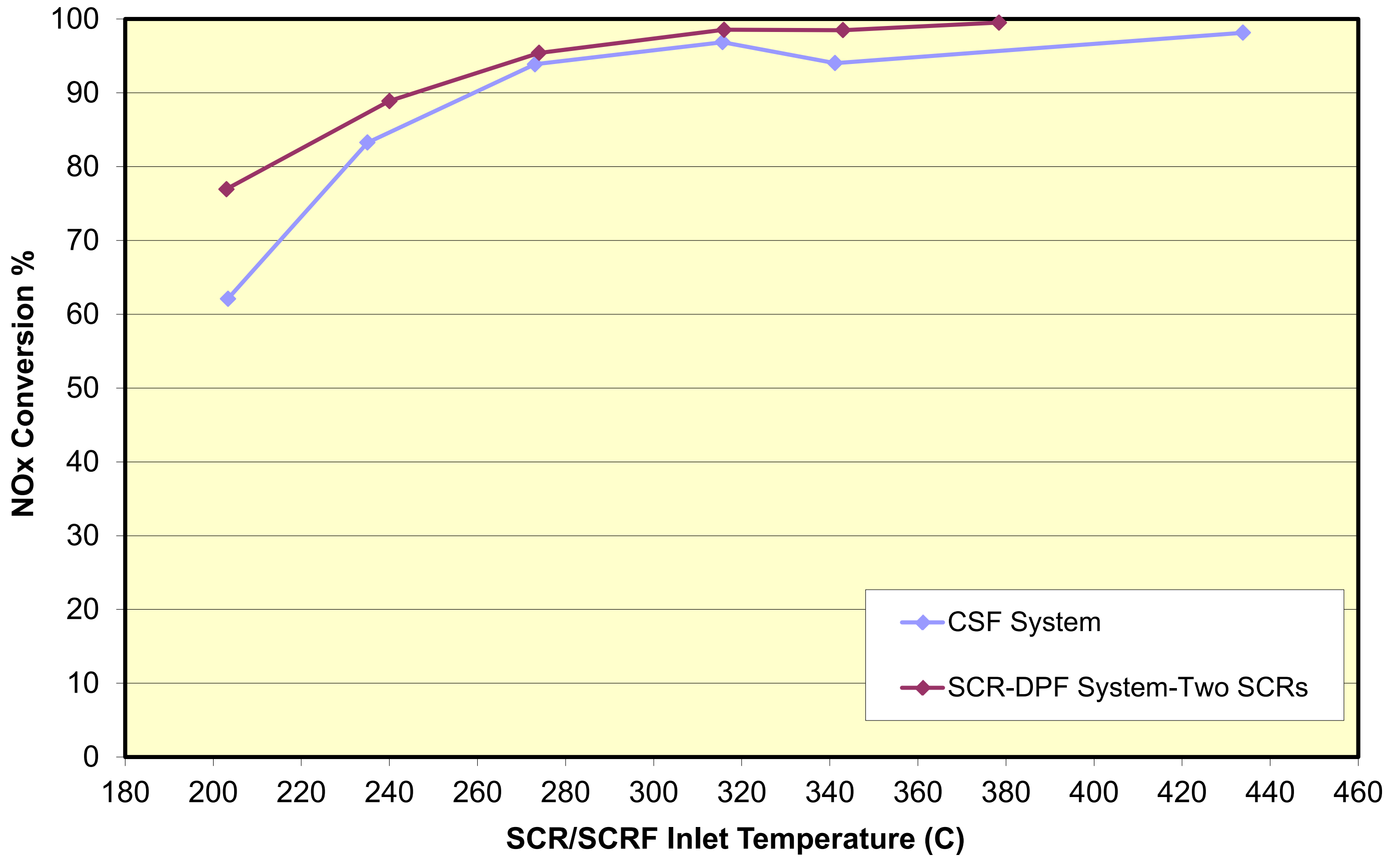
Equivalent system volume, ANR=1.2



CSF System

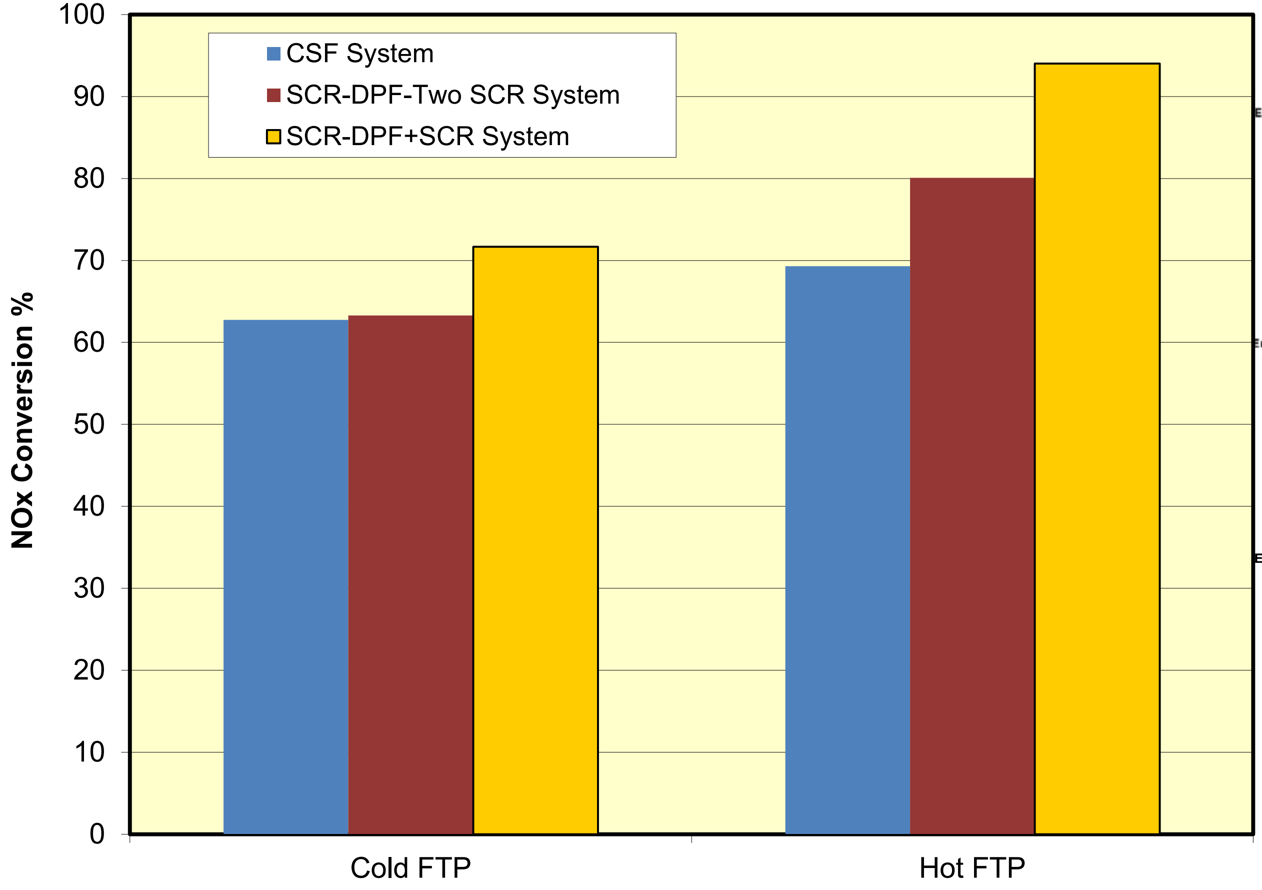


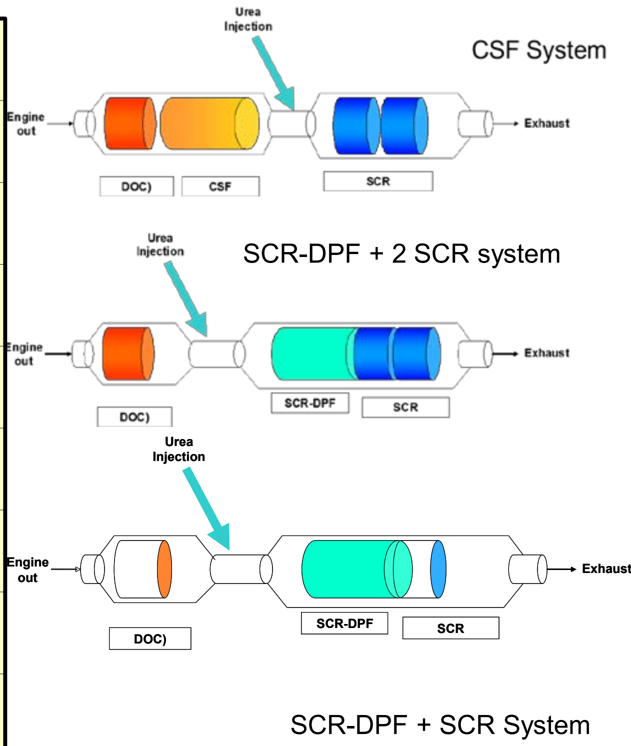
SCR-DPF + 2 SCR system



SCR-DPF Optimization

Optimization include; high NO2, improved SCR-DPF coating, improved SCR formulation





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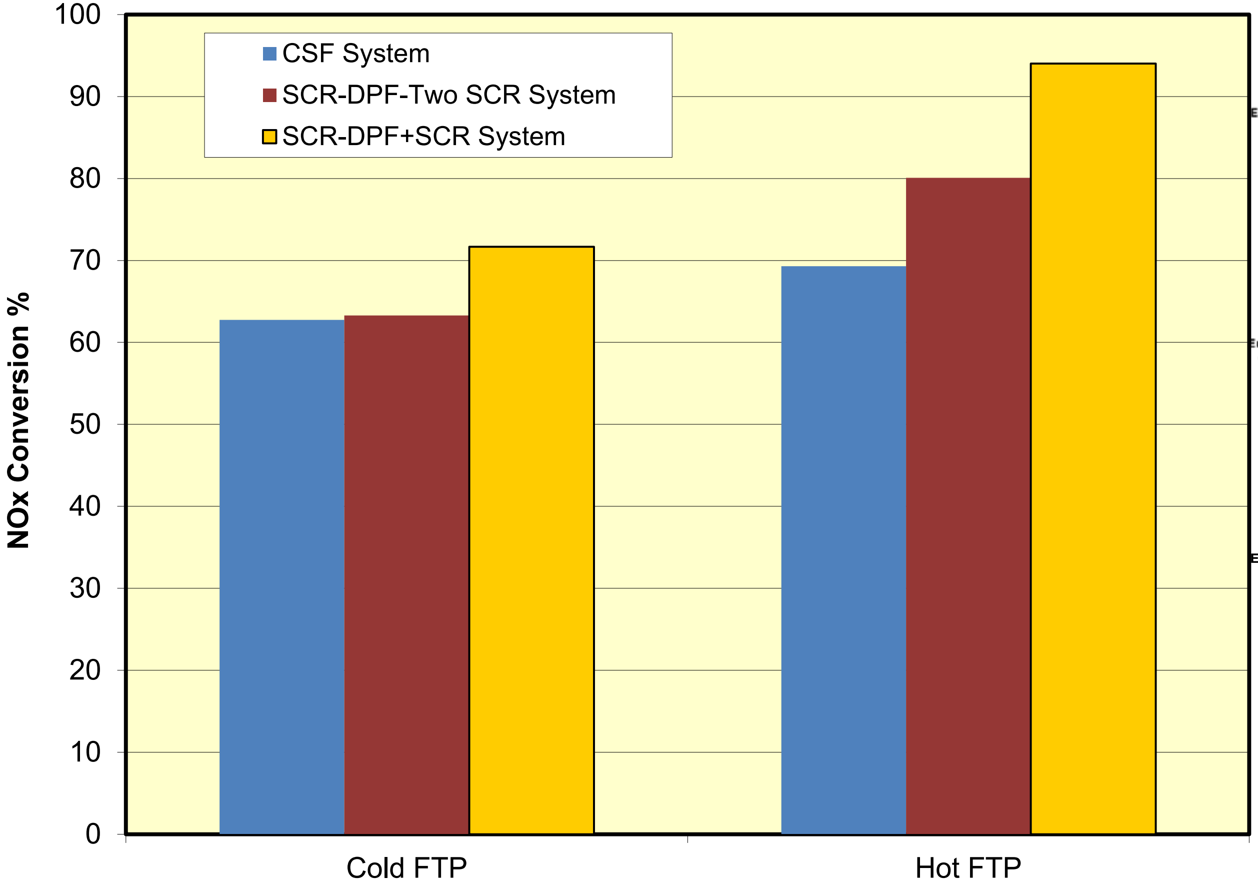
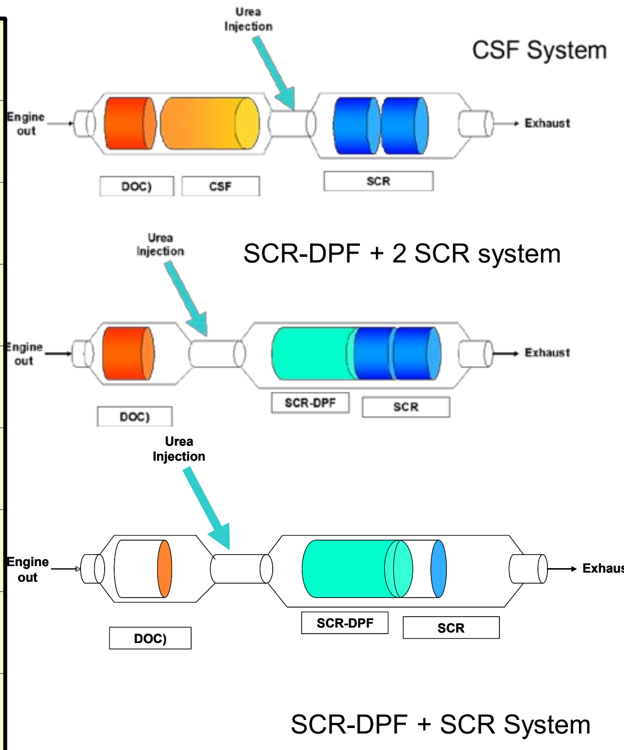


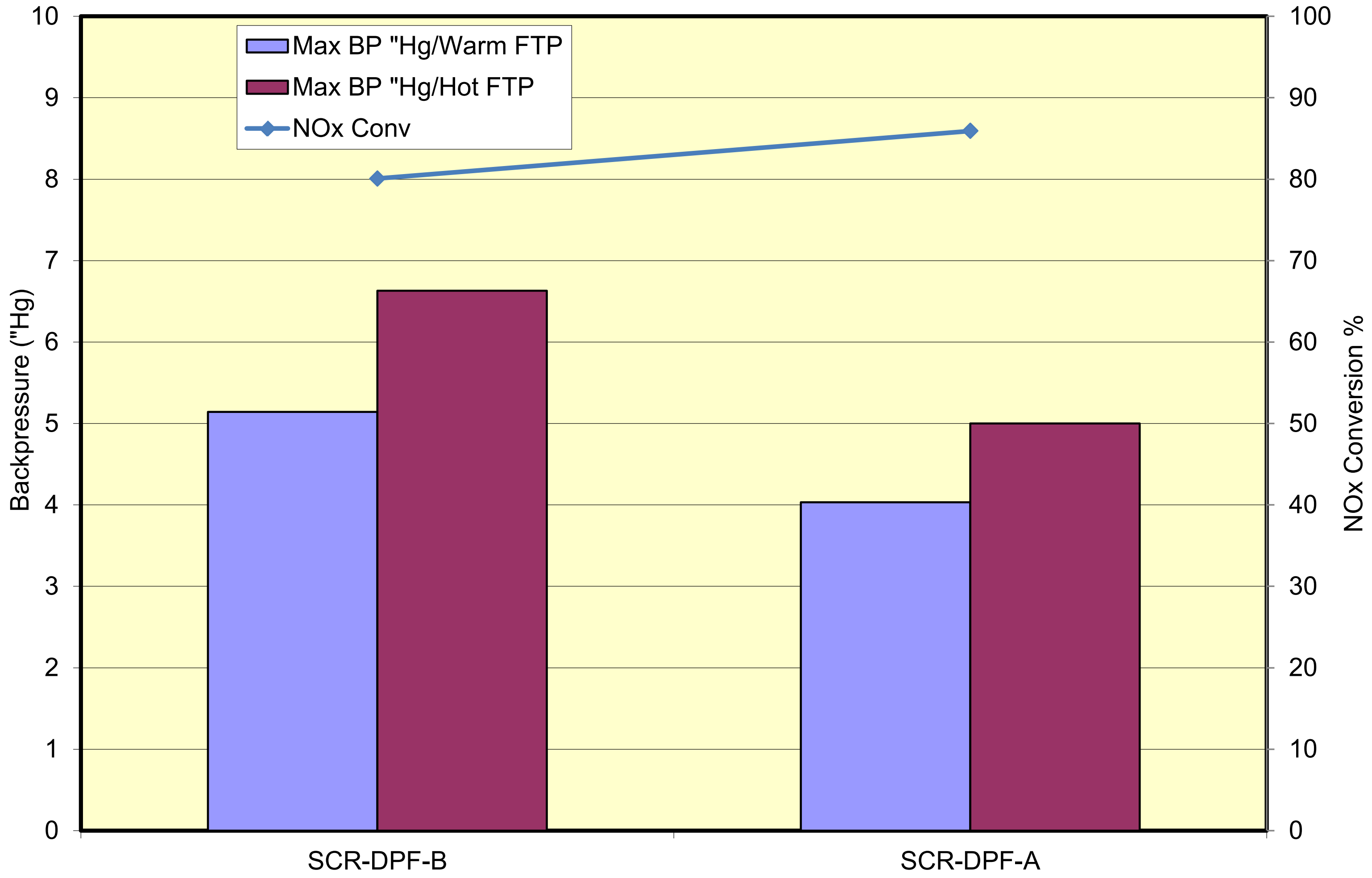


Optimized SCR-DPF system can provide high NOx conversion even with single SCR substrate

Backpressure

SCR-DPF Backpressure Improvement

Optimized coating helped to reduce backpressure while maintaining NOx conversion



Passive Regeneration

Test Protocol

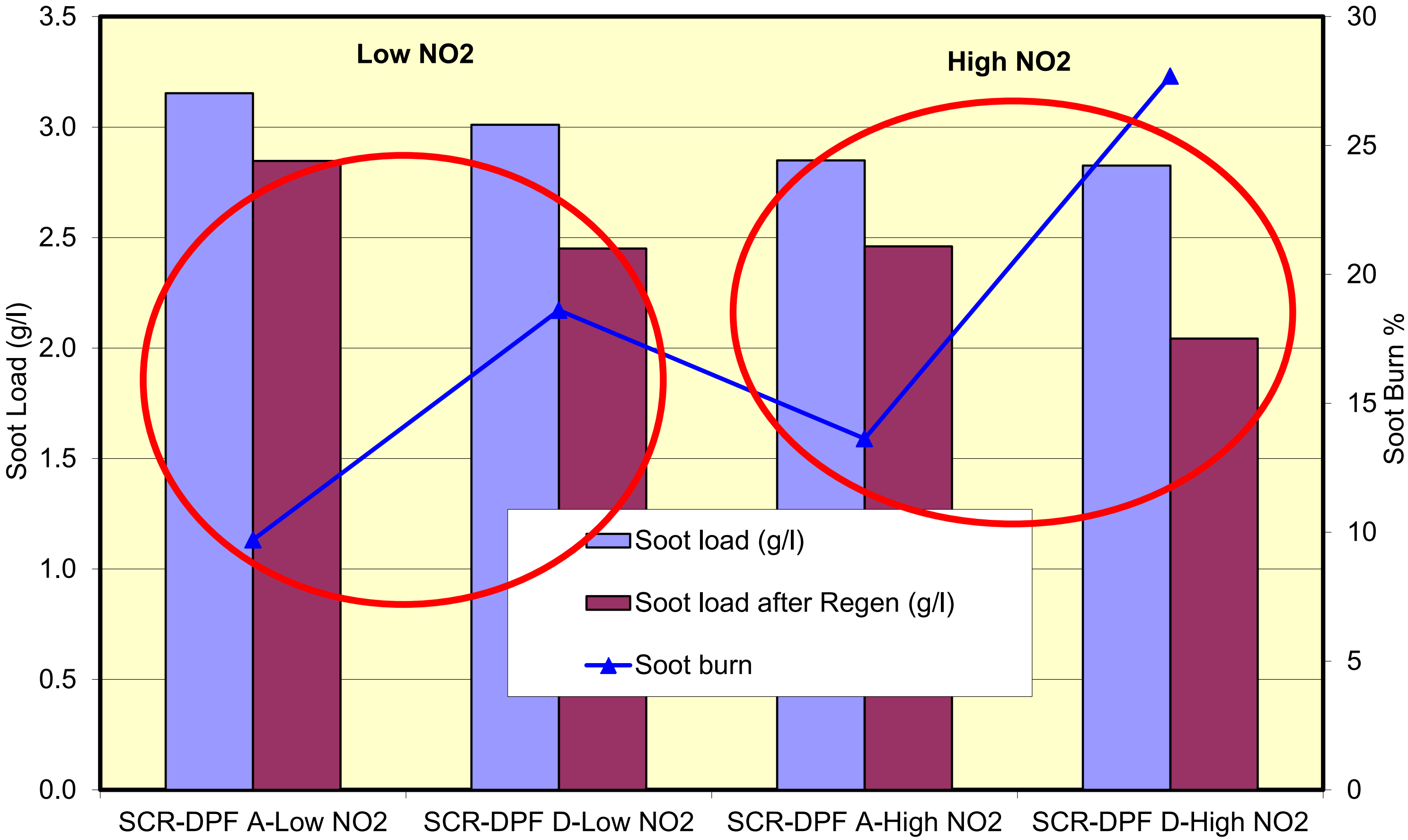
- SCR-DPF loaded up to 3g/l of soot
- Speed A and DOC inlet temperature 400°C was chosen to evaluate passive regeneration. Filters were regenerated for 30 min.
- Passive Regeneration during FTP cycle with urea injection (30hrs).
- Following regeneration, filters were weighed while still hot at around 180°C
- SCR-DPF was regenerated with EGR off
- SCR-DPF passive regeneration capability was studied with urea injection (ANR=1.0)

Test Condition During Steady State

Engine Out NO_x (g/hp-hr)	5.5-5.8
NO_2/NO_x (%) DOC Out (Aged DOC)	400ºC=33-35%
NO_2/NO_x (%) DOC Out (Degreened DOC)	400ºC=45%
DOC SV (1/hr)	105,000
DPF SV (1/hr)	35,000

Combination of SCR-DPF Design and NO_2/NOx Optimization Allows for Good Passive Regeneration with SCR-DPF

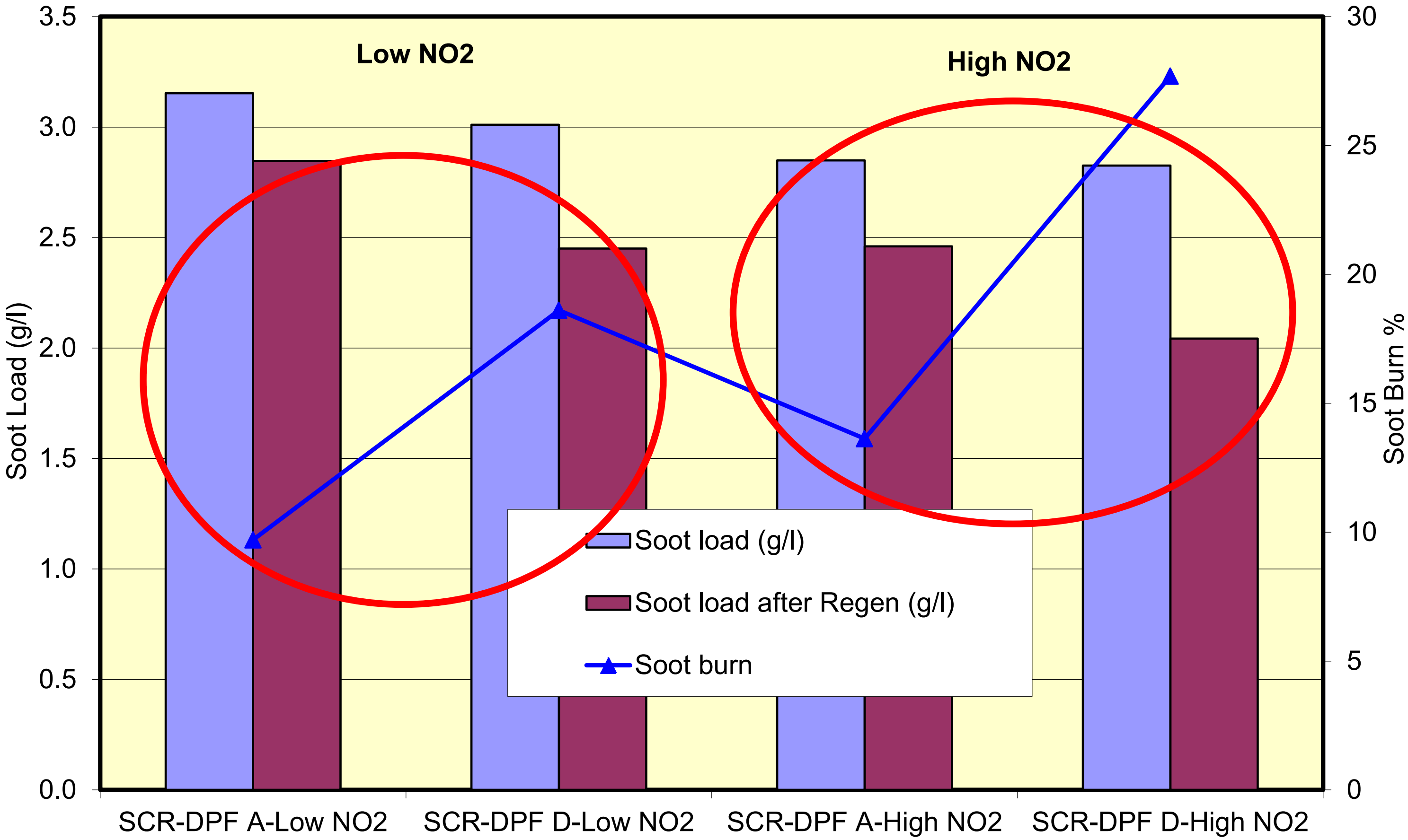
SCR-DPF (EGR Off)-30min Regeneration-Urea dosing ANR=1.0



Combination of SCR-DPF Design and NO_2/NOx Optimization Allows for Good Passive Regeneration with SCR-DPF

SCR-DPF (EGR Off)-30min Regeneration-Urea dosing ANR=1.0

Promising Passive Regeneration was achieved

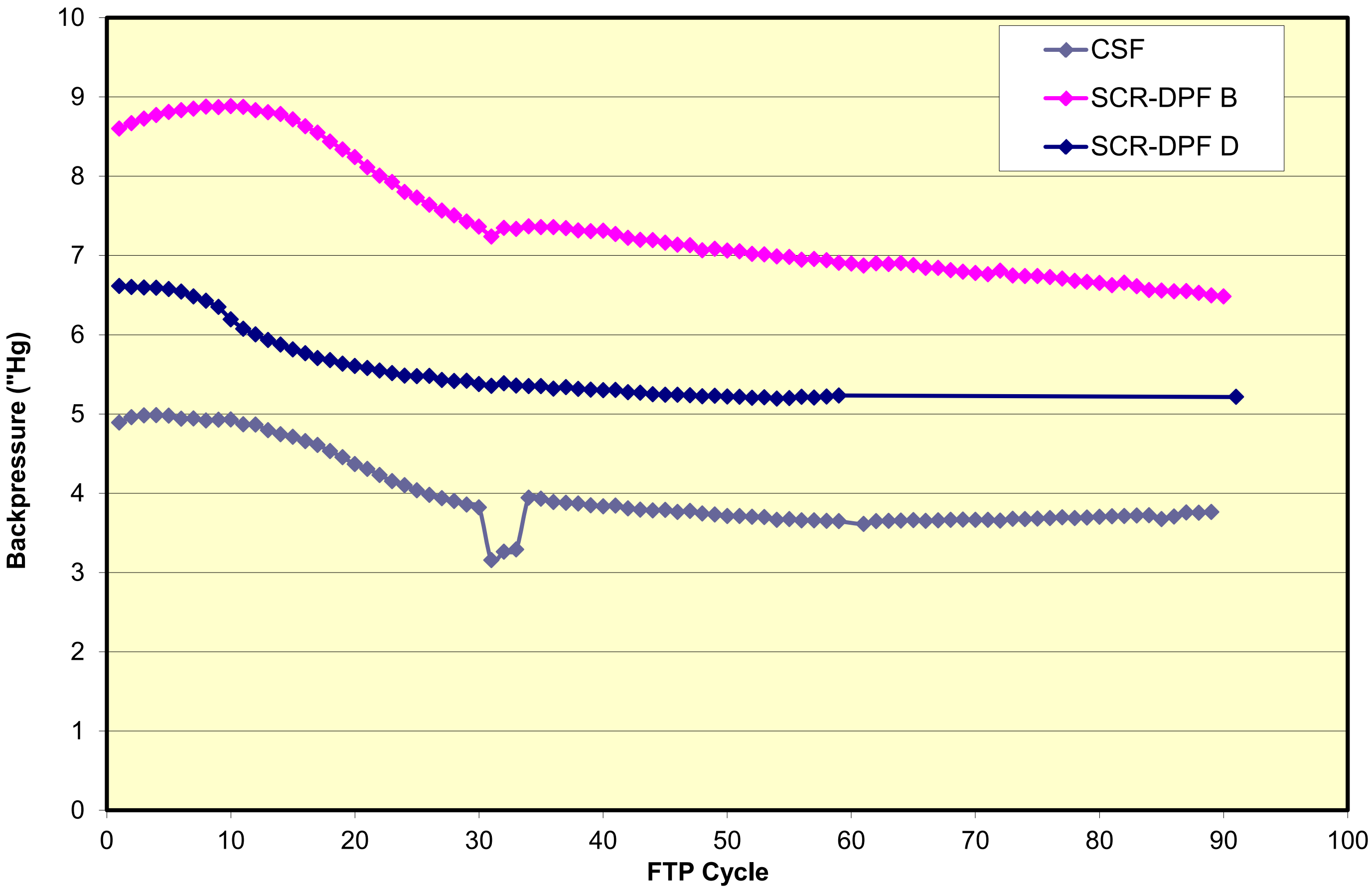


Test Protocol

- SCR-DPF loaded up to 3g/l of soot
- Speed A and DOC inlet temperature 400°C was chosen to evaluate passive regeneration. Filters were regenerated for 30 min.
- Passive Regeneration during continuous FTP cycles with urea injection (30hrs).
- Following regeneration, filters were weighed while still hot at around 180°C
- SCR-DPF was regenerated with EGR off
- SCR-DPF passive regeneration capability was studied with urea injection (ANR=1.3)

SCR-DPF Design Allows for Good Passive Regen under Transient Test Condition

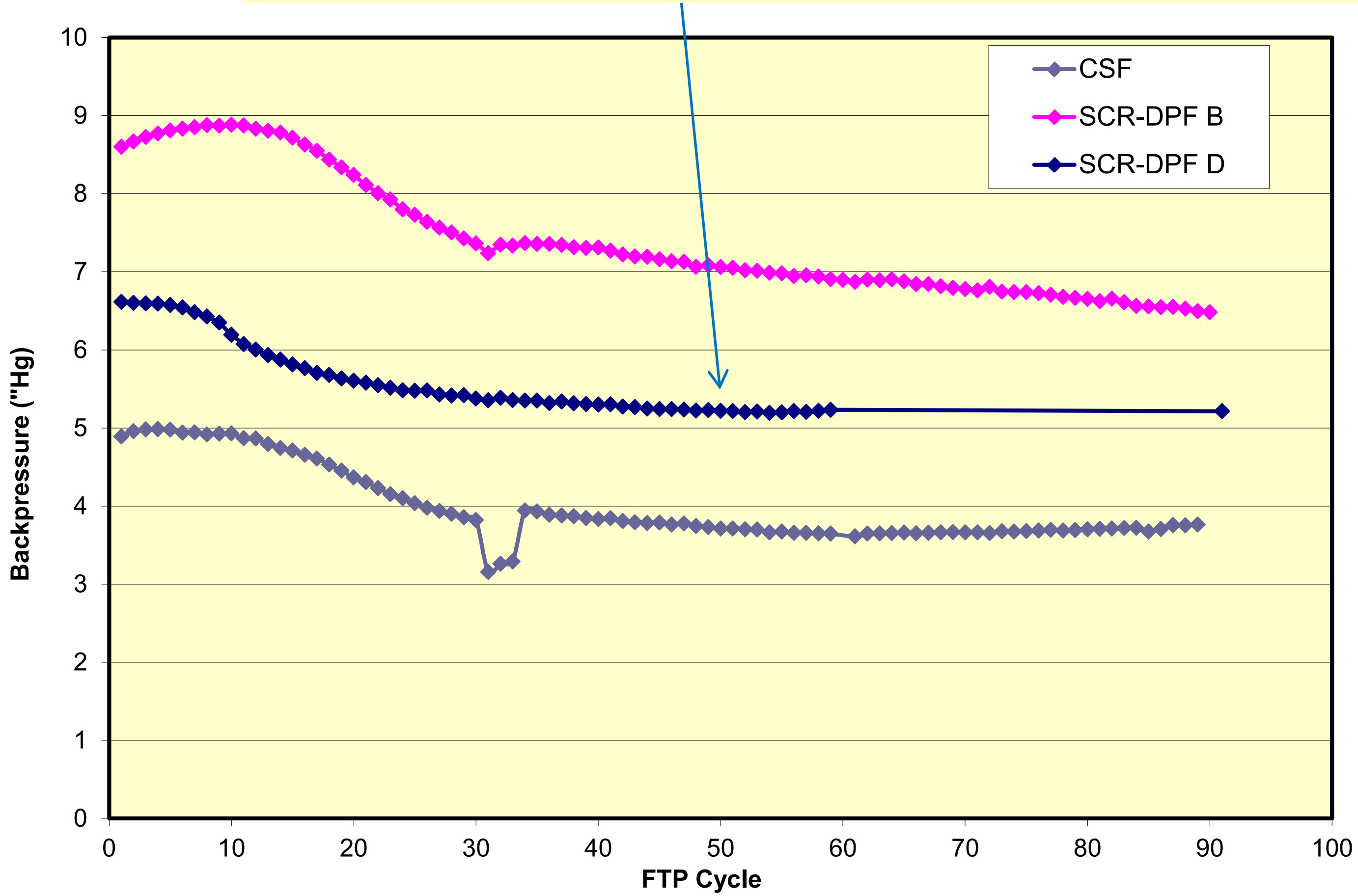
30 hrs of FTP cycle, with urea injection, ANR~1.3, no urea injection during Soot loading, NO2/NOx ~40%



SCR-DPF Design Allows for Good Passive Regen under Transient Test Condition

30 hrs of FTP cycle, with urea injection, ANR~1.3, no urea injection during Soot loading, NO2/NOx ~40%

Optimized SCR-DPF has similar passive regeneration as CSF



Summary

- SCR coated DPF systems are being designed to provide improved NO_x reduction in future emission control systems
- Transient results indicate that optimized SCR-DPF system provides high NO_x conversion using same or smaller package volume as compared to 2010 system
- SCR-DPF shows promising passive regeneration with higher engine out NO_x during steady state
- Passive regeneration was achieved during transient cycle under the conditions chosen for this study
- These results suggest that SCR coated DPF can significantly help in meeting emissions with future higher NO_x engines and thus assist in meeting higher fuel economy targets