Two in One:
SCR on Filter

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Potential Systems for Diesel Exhaust Control

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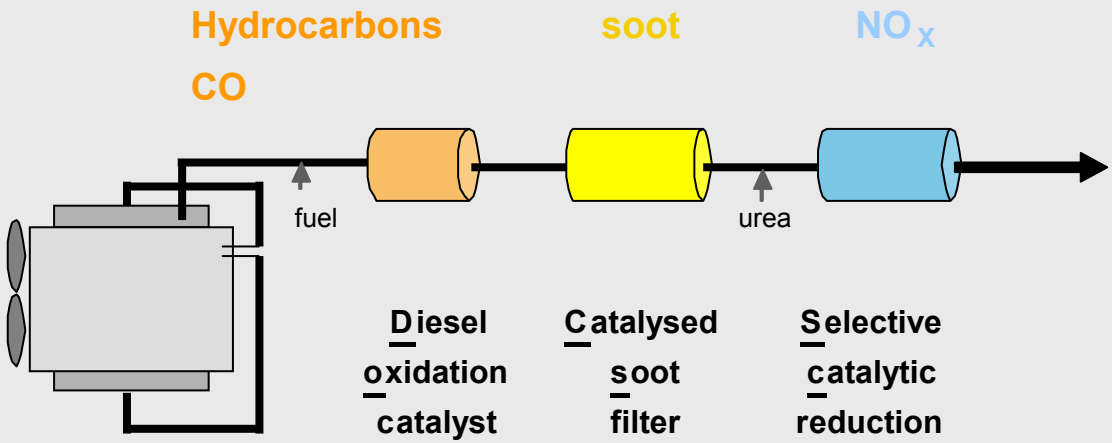
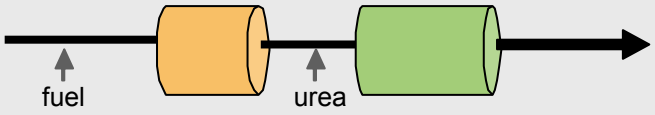
TODAY



TOMORROW



SCR on Filter

Requirements for a Combined SCR on Filter System

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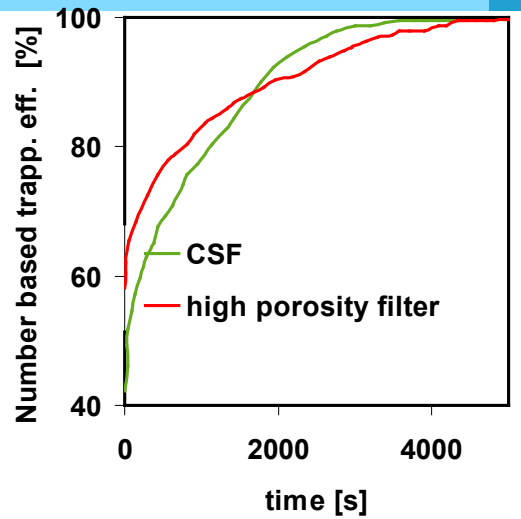
soot filter — high filtration efficiency, low backpressure

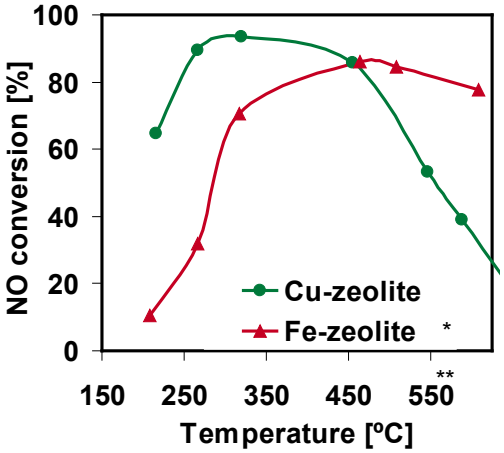
→ **high porosity filter**



NO_x abatement — high NOx efficiency

highly thermally stable to withstand soot burnoff

→ **highly active and hydrothermally stable catalyst**



* Aging: 850°C 5 hours
** Aging 750°C 5 hours

SCR Catalyst Loading into High Porosity Filters

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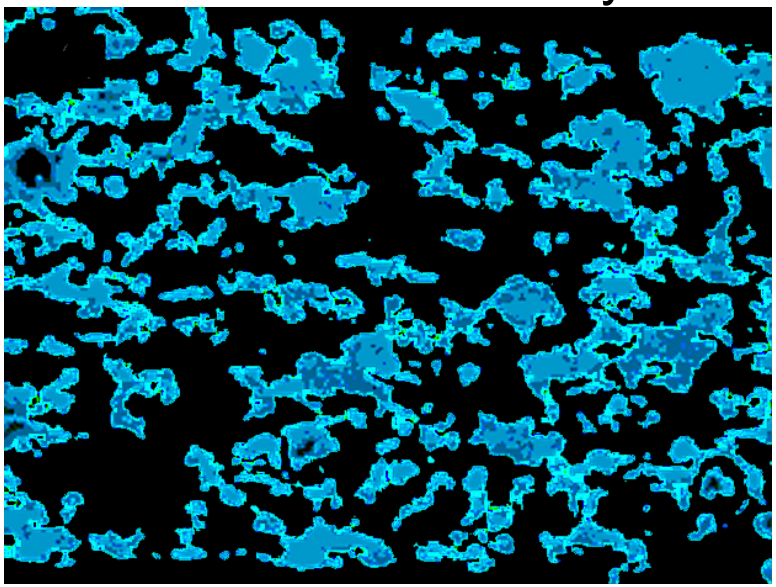
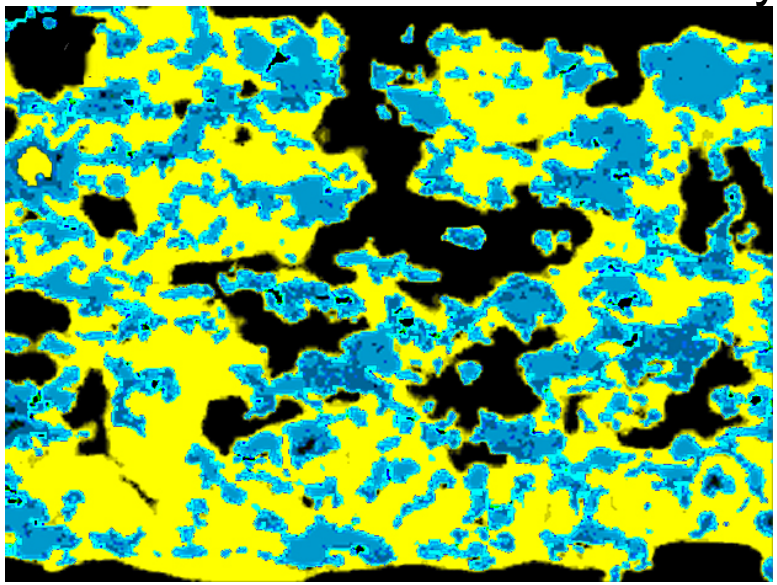
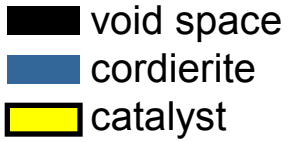
SEM of cordierite wall only



SEM of cordierite wall with catalyst

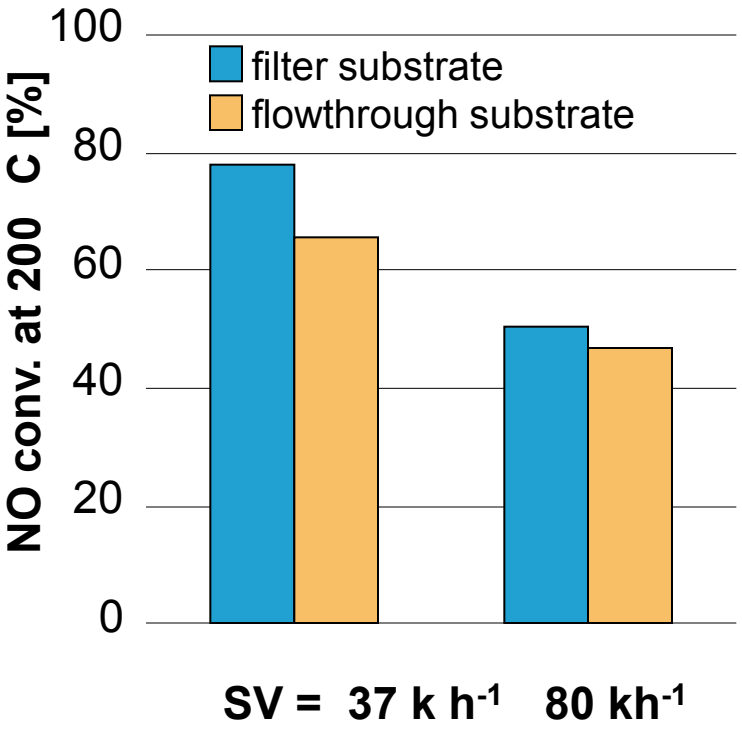




Pore microstructure influences:

- backpressure of filter
- mechanical strength of filter
- catalyst distribution and NO_x conversion

Comparison of NO Conversion of SCR on Filter Substrate and Flowthrough Substrate



- Higher NO conversion observed for filters at comparable washcoat loading.
- Better catalyst utilization of filters compared to flowthrough substrates due to larger geometrical surface.

Aged at 850 C for 5 Hours

Optimization of Catalyst Loading on Different Cordierite Filters with Different Porosity

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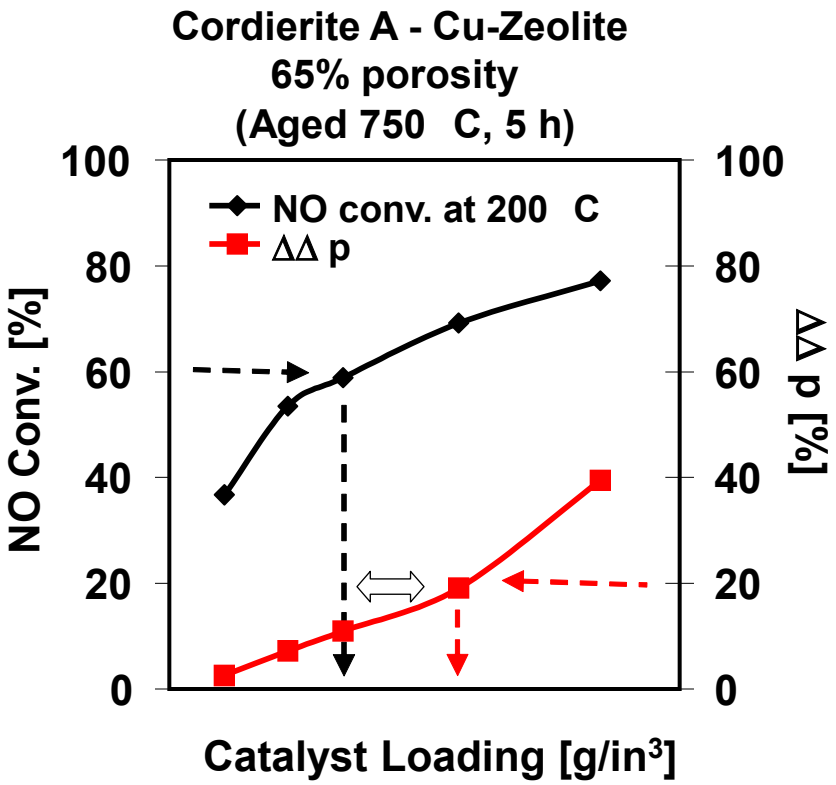
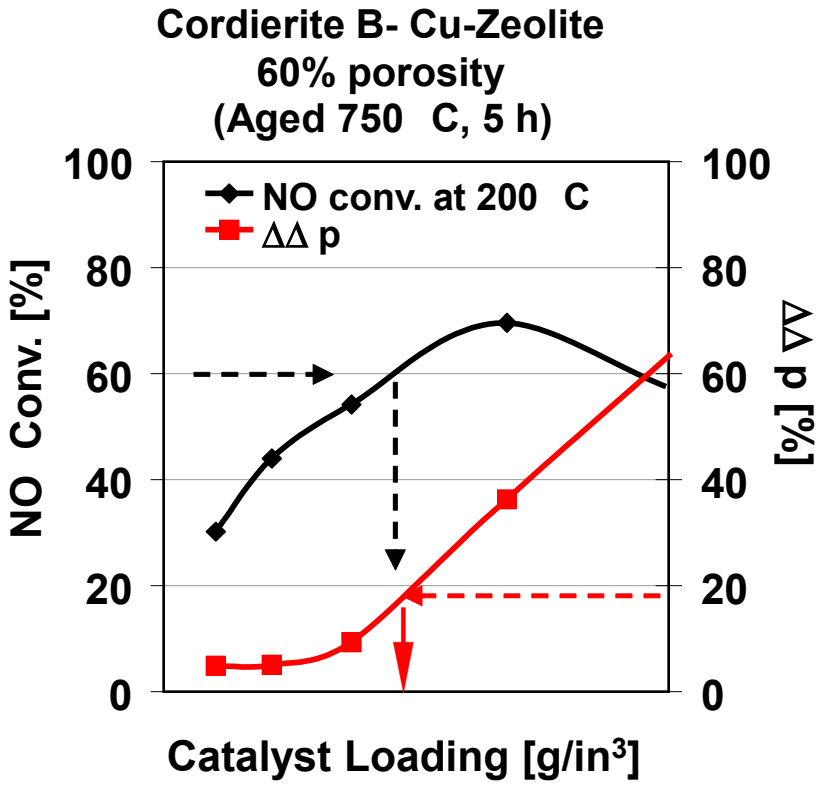
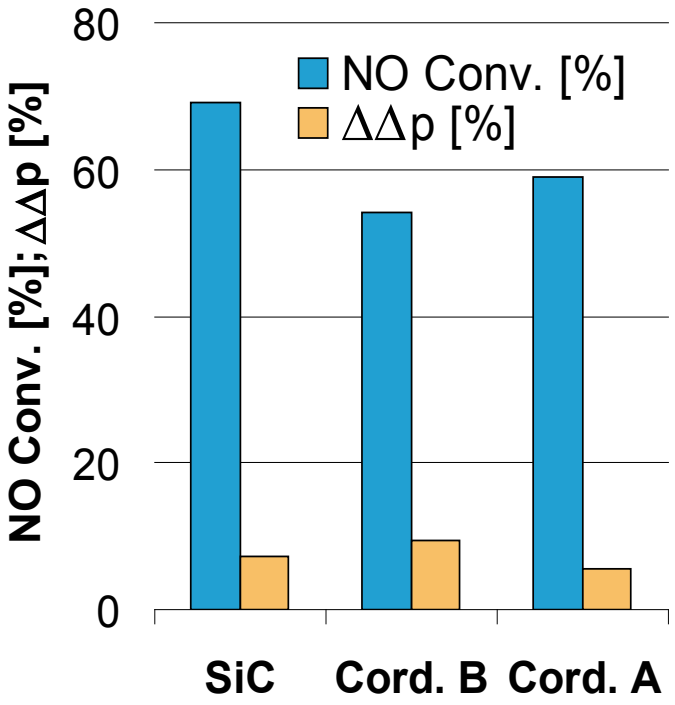




- Combination of conversion and backpressure defines operation window
- Operation window is determined by filter porosity and pore size distribution

Comparison of Cordierite and Silicon Carbide Filters at Constant Catalyst Loading



Cordierite:	A	65 % porosity
	B	60 % porosity
Silicon Carbide:		59 % porosity

Results are show for samples at a constant catalyst volume and loading.

Silicon carbide microstructure allows greater conversion at equivalent catalyst volume or better catalyst utilization.

Catalyst loading process needs to be developed for each filter type

Conclusions from Laboratory Reactor Studies

- SCR on Filter demands high porosity substrates for acceptably low backpressure.
- Backpressure targets and NO conversion targets define catalyst loadings specifically for each filter type.
- Catalyst loading processes must be optimized for each filter type and application.
- Next Steps:
  - Proof in engine testing.
  - Investigation of interaction with soot.

SCR on Filter Performance in NEDC Testing: Test Conditions and Program

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System: DOC and SCR on Filter system with Urea injection tested on 2 l engine

- DOC 1.2 l 120 g/ft³ for HC and CO conversion
- SCR on Filter: Cu-Zeolite on SiC substrate Ø 5.66“x 6“ (2.5 l)

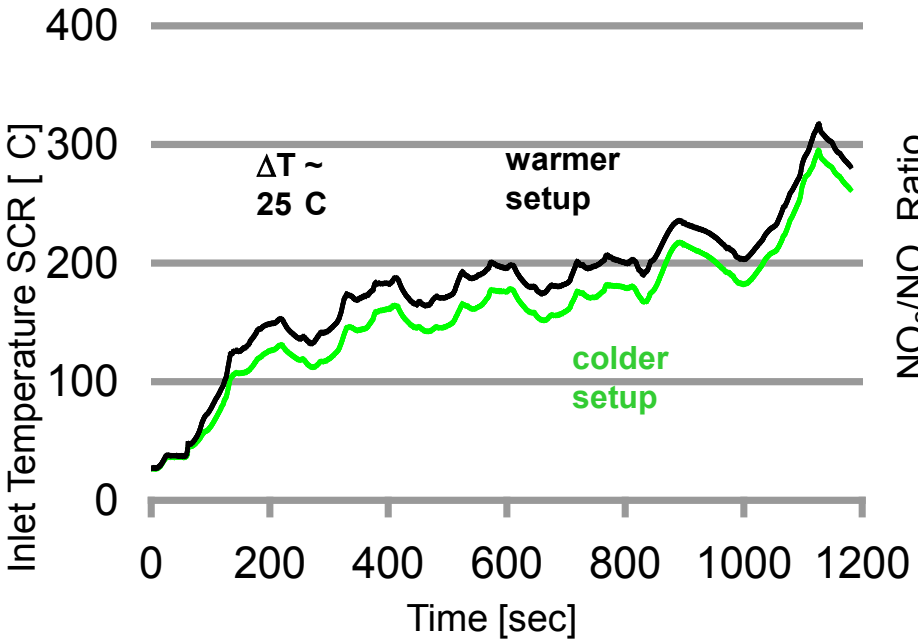
NEDC test program:

- SCR on Filter Characterization:
  - fresh and after hydrothermal oven aging 5 h at 750 C.
  - 3 different NO_2/NO_x ratios at inlet SCR
  - testing of soot free and with 8 g/L soot loading on SCR on Filter
- For comparison with flowthrough catalyst, 2 different temperature profiles

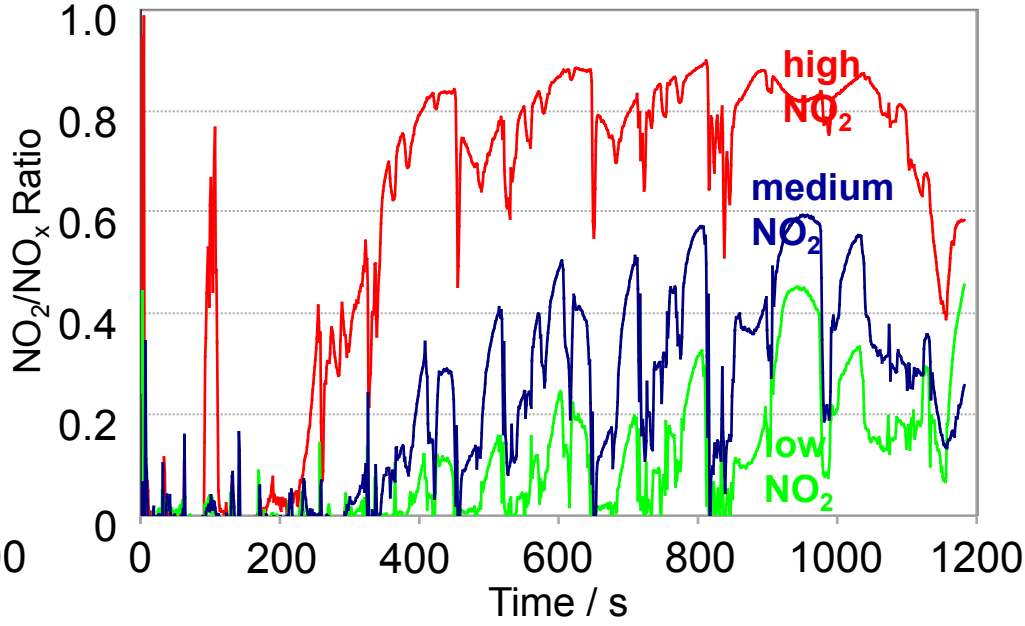
  Closed coupled (SCR on Filter) vs.

  Underfloor position (SCR on Flowthrough substrate)

NEDC Test Program Parameters: SCR Inlet Temperature Variation and NO_2/NO_x Inlet SCR Variation

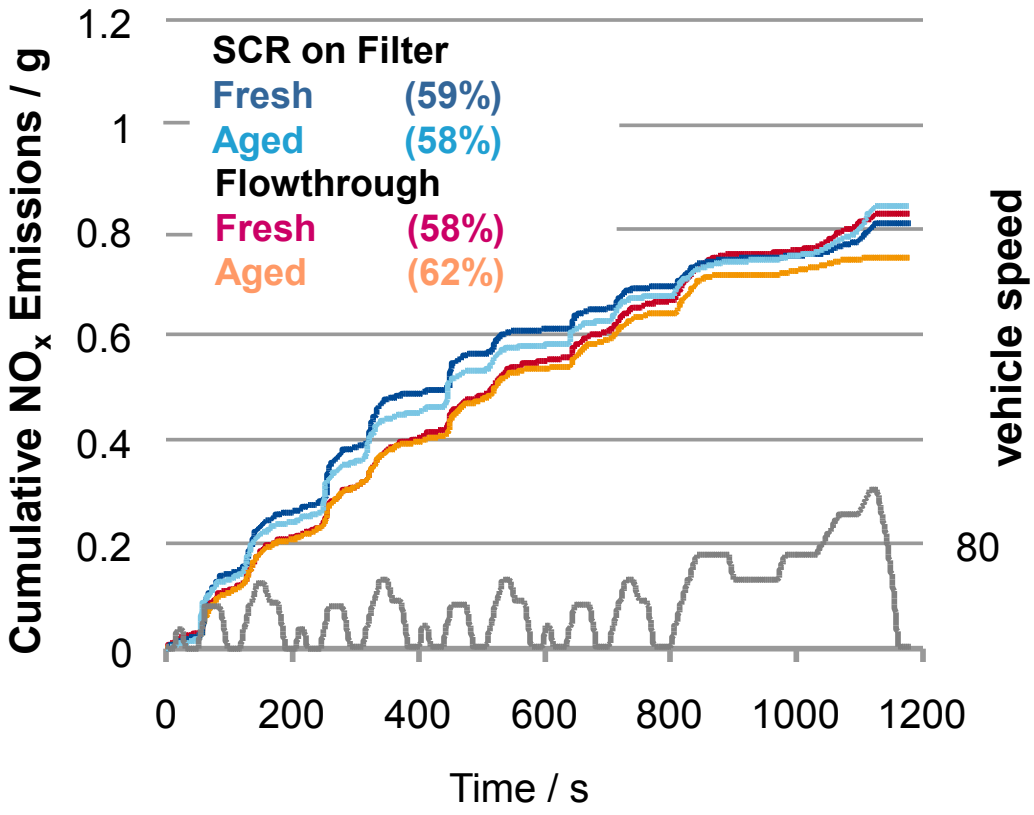


Approximately 25 C difference in closed coupled vs. underfloor position of the SCR component



NO_2/NO_x ratio achieved by changing PGM content of the exhaust system

SCR and SCR on Filter for Fresh and Aged Catalysts: Low NO_2/NO_x Ratio, without Soot at Comparable Sizing

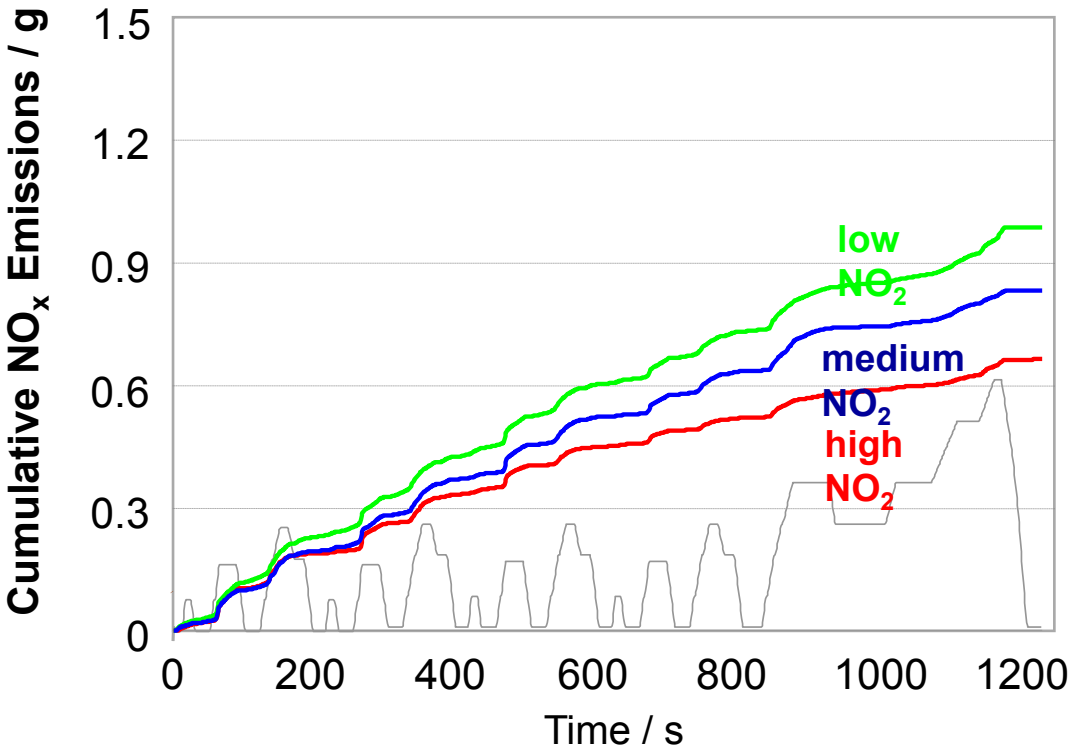


- No deactivation upon 750 C aging.
- Comparable NO_x conversion of DOC + SCR on Filter relative to DOC + CSF + SCR system. SCR on Filter is at the warmer position.

Aging: SCR on Filter: 5 h at 750 C
SCR 40 h at 750 C

Cumulative raw NO_x emission: 2g

Results NEDC Test Program: Impact of Soot on NO_x Conversion at as a Function of NO_2/NO_x Ratio



- Accumulated soot has a small positive impact on the NO_x conversion of SCR on Filter at high NO_2/NO_x ratios.

Cumulative cycle raw NO_x emission: 2g

Summary SCR on Filter

- SCR on Filter performance comparable to flowthrough at equivalent volume and loading
  - Good catalyst utilization on filters.
  - Catalyst loading and thus NO_x conversion of filters is limited due to backpressure limitations.
  - Filter type, porosity determines catalyst utilization.

- NEDC testing with Cu zeolite on Filters
  - High $DeNO_x$ activity fresh and after aging.
  - Small impact of soot on NO_x conversion.