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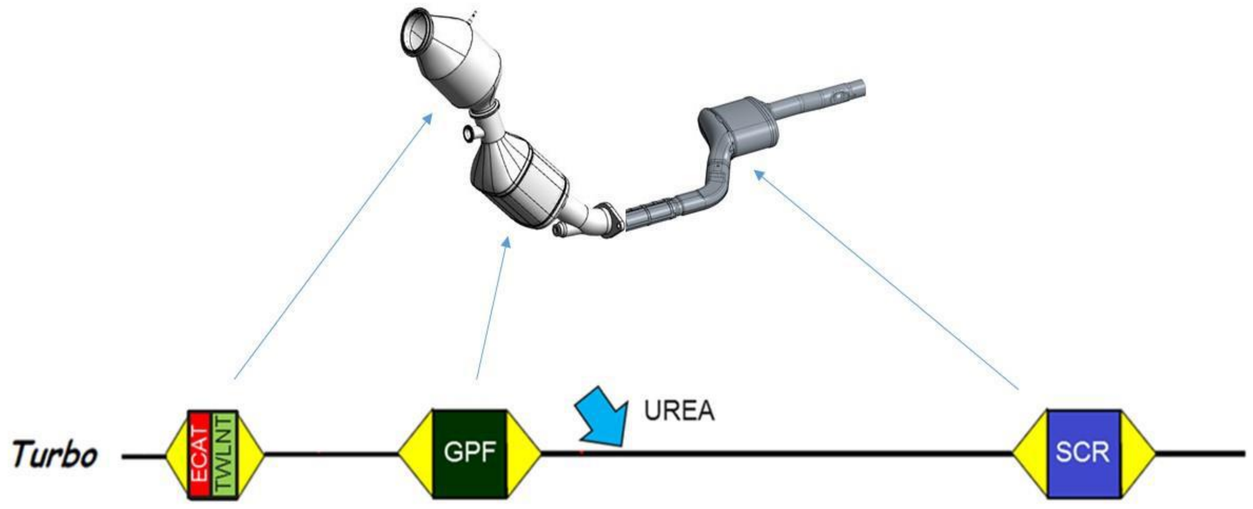
# PaREGEn + PEMs 4Nano

# Lean-NOx Emissions Aftertreatment System with Low Particle Number down-to-10nm

## System Overview

Aftertreatment system must provide excellent emissions control under lean (λ>1) conditions, whilst being thermally durable to withstand high temperatures under peak-load λ=1 conditions. Final system design comprised.

1) **Three-Way Lean NOx Trap (TWLNT) -** three-way (CO, HC, NOx) and Lean NOx trap technologies combined for stoichiometric performance and lean NOx conversion. Coated on electrically-heated catalyst (EHC) substrate for good cold-start performance.
2) **Gasoline Particulate Filter (GPF) -** High filtration efficiency (FiE) for particles down to 10nm in size. Three-way coating technology with additional $NO_2$-make function.
3) **Selective Catalytic Reduction (SCR) catalyst -** lean NOx conversion with ammonia (urea) dosing. May also store/convert $NH_3$ formed over upstream catalysts.

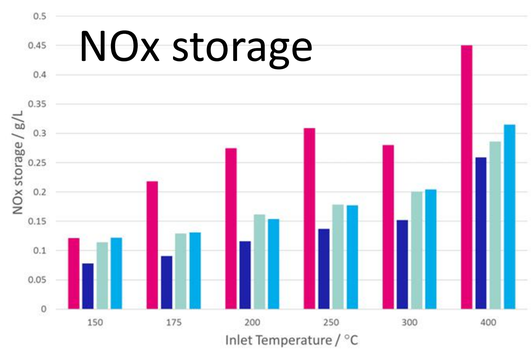


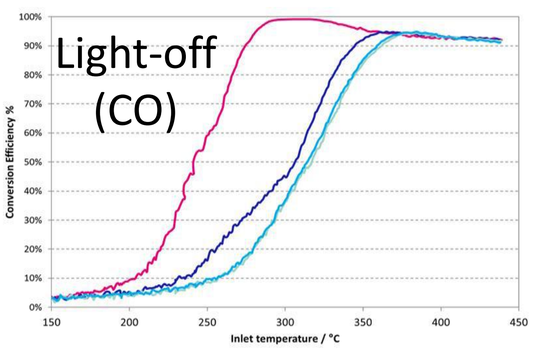

## TWLNT development

As the starter catalyst in the system, technology must maintain excellent TWC performance and lean NOx storage following exposure to temperatures potentially >1000°C. Following high-temperature ageing, **TWLNT1** showed the highest NOx storage and TWC performance.

Ageing: 1100°C, 4h, 10% $H_2O$, 10% $O_2$

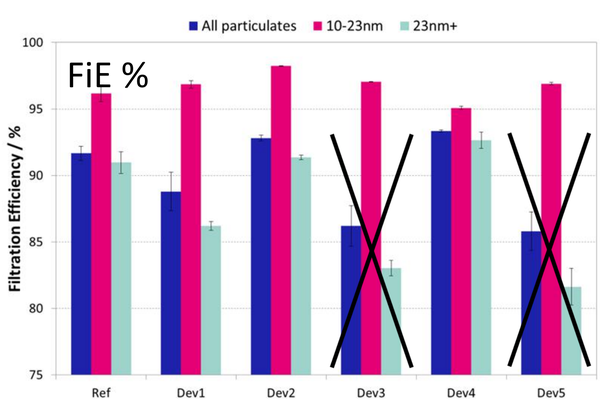
**TWLNT#1**
**TWLNT#2**
**TWLNT#3**
**TWLNT#4**

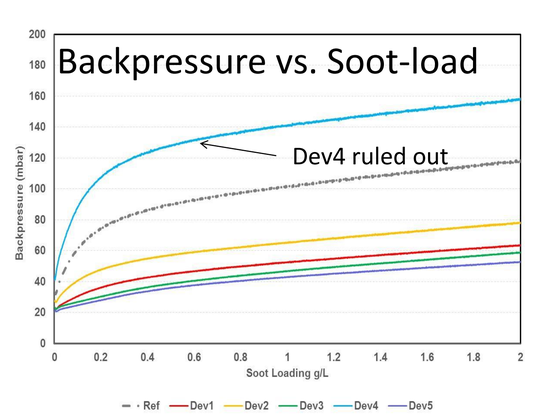


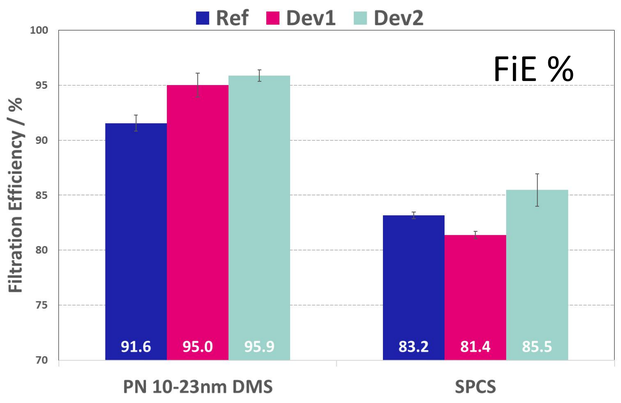

## GPF technology with high FiE down to 10nm

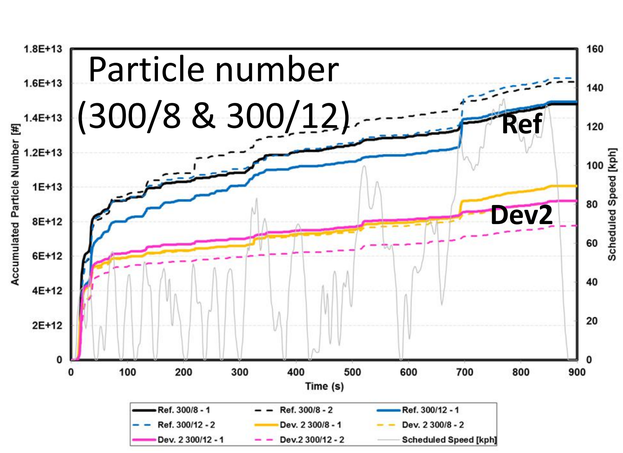
Following preliminary screening, **Dev 1** and **Dev2** were taken forward for chassis-dynamometer evaluation, based on filtration performance and backpressure.




Particle number evaluated on vehicle using Horiba SPCS (≥23nm) and Cambustion DMS500 (10-23nm). **Dev2** demonstrated best FiE % over all particle-size ranges – verified on 300/8 and 300/12 substrates.

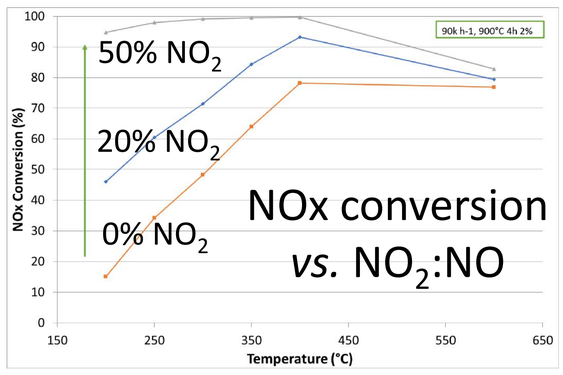


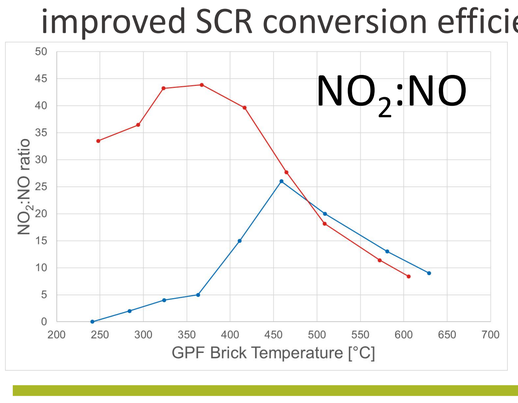

Results shown are over WLTC on MY17 Jaguar XE 2.0

## Optimisation of SCR performance

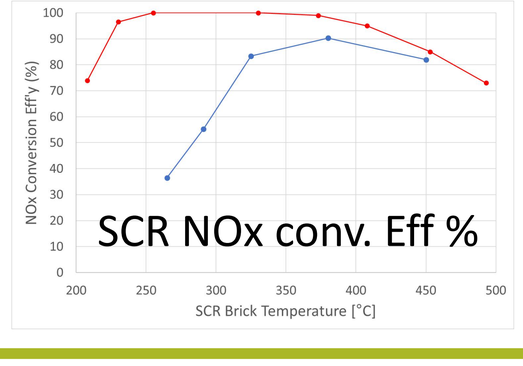
- An iron-based SCR catalyst was chosen because of its tolerance of rich/stoichiometric conditions and high exhaust temperatures.
- NOx conversion efficiency at low temperatures strongly dependent on $NO_2$:NO ratio.

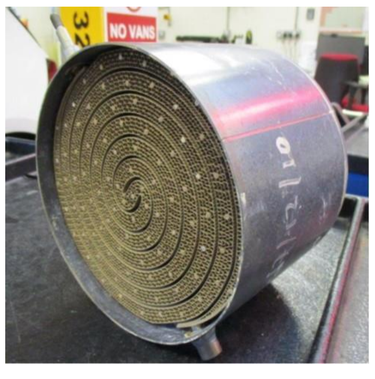



- Initial trials indicated that low $NO_2$ concentrations at GPF outlet were limiting peak NOx conversion over SCR.
- Further optimisation of the **Dev2** technology led to higher $NO_2$-make and improved SCR conversion efficiencies.




**Dev2**
**Dev2-opt**




TWLNT coated on 48V electrically-heated catalyst substrate for rapid response from cold-start conditions.

## Conclusions

- Aftertreatment system developed for lean-burn gasoline demonstration vehicle.
- Selected catalyst technologies designed to be thermally robust under high loads/temperatures.
- Optimised GPF technology for high FiE down to 10nm and enhanced lean $NO_2$-make, enabling improved SCR conversion efficiencies.

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