Diesel Advanced After Treatment For Non-Road Applications

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Executive Summary

- Post advanced legislation implementation for On-Road similar complexities are now part for Non-Road applications
- Hence a lot of learnings can be transferred horizontally from OnRoad applications and at the same time need to understand the Non Road criticalities
- Most of the advanced after treatments can be transferred to non road applications however application tuning for these after treatment systems are imperative
- The most critical application is being Trem V Tractor with most of the applications follow DPF route which have much complexities for different tractor applications
- Hence extremely high level of coordination and collaboration is required between OEM and Catalyst supplier

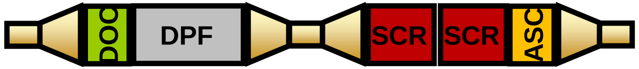
Bharat Stage NRMM V
System Scenarios

Engine power(kW)	Techncial Routes	DPF Reg.	Comment
19<P<56	Non CR, EGR, DOC+cDPF	CRT+Standstill	with HC doser
		Active Reg.	with HC doser
	CR, EGR, DOC+cDPF	Active Reg.	**Mainstream**
56<P<560	CR, w/ or w/o EGR+SCRT	CRT+Standstill	
		Active Reg.	
P>560	CR, w/o EGR, (DOC)+SCR	No filter needed	**Mainstream**

TREM V

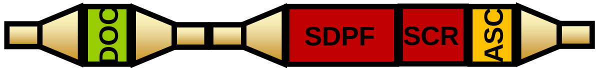
Mainstream

Up to 56kw



Mainstream

From 56kw to 560kw



Stage V Europe

System Approaches

Power category [kW]	Stage (2014)	CO [g/kWh]	NOx [g/kWh]	HC [g/kWh]	PM [g/kWh]	PN [#/kWh]
0 - 8	-	8	7.5 (NOx + HC)		0.4 0.6	-
8 - 19	-	6.6	7.5 (NOx + HC)		0.4	-
19 - 37	IIIA	5.0	4.7 (NOx + HC)		0.015	1x10[12]
37 - 56	IIIB	5.0	4.7 (NOx + HC)		0.015	1x10[12]
56 - 130	IV	5.0	0.4	0.19	0.015	1x10[12]
130 - 560	IV	3.5	0.4	0.19	0.015	1x10[12]
> 560		3.5	3.5	0.19	0.045	-

No EATS (0 - 19 kW)

DOC + DPF or DDPF (19 - 56 kW)

SCRT / DOC-SDPF-SCR / DDPF-SCR (56 - 560 kW)

No EATS / V-SCR / DOC(-POC/DPF) (> 560 kW)

Stage V Europe

System trends (medium power range)

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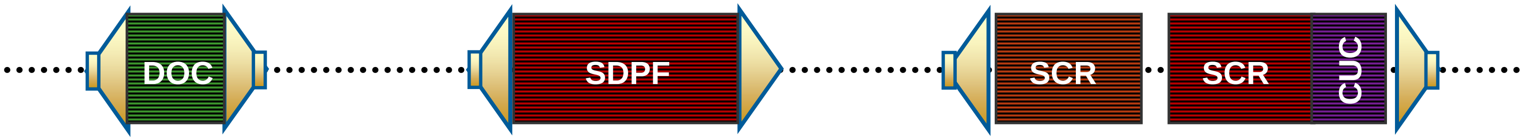
OEM	Prime Stage V solution* 56–560 kW
A	DOC – CDPF – Dos. – SCR
B	DOC – Dos. – SDPF – SCR
C	DOC – Dos. – SDPF(VWT) – SCR
D	DOC – CDPF – Dos. – SCR
E	DOC – Dos. – DPF – SCR
F	DOC – CDPF – Dos. – SCR
G	DOC – Dos. – SDPF – SCR
H	DOC – CDPF – Dos. – SCR

*) based on public available information, solutions may vary dependent on application and power range

Stage V Europe- System Testing

Stage V: >56kW

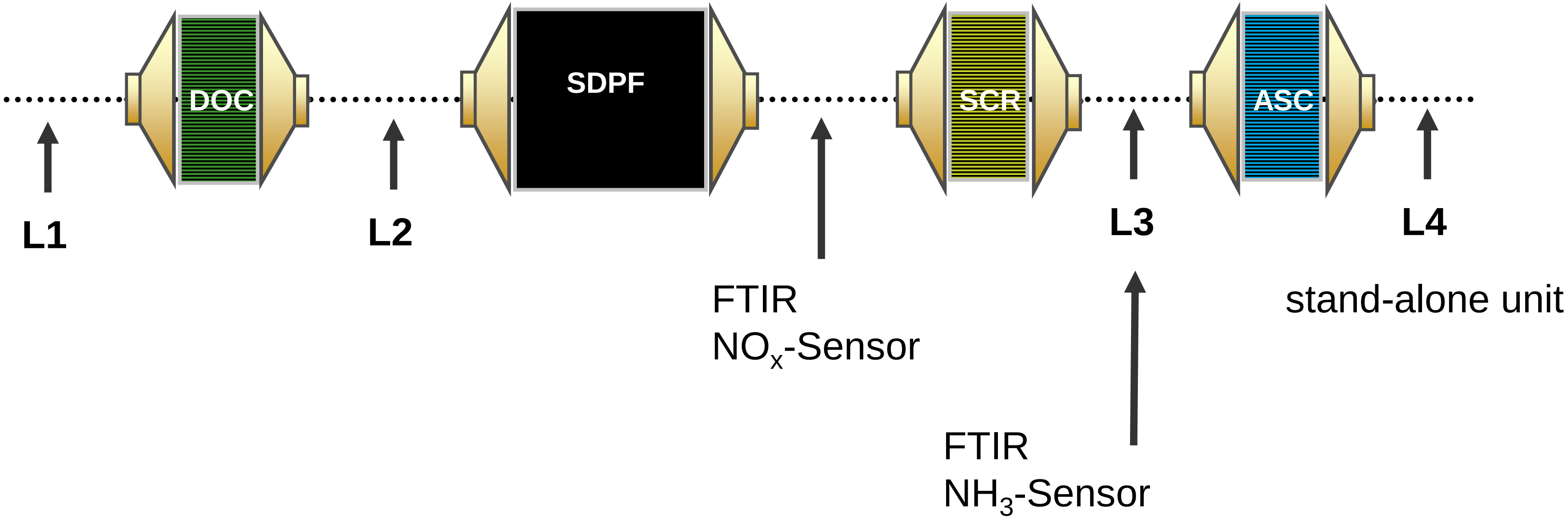


	DOC'A' (Pt/Pd = Lo)	DOC'B' (Pt/Pd = Hi)
Development Focus:	**balanced Heat-up and NO2-Make**	**mainly Passive Technology**

Features:

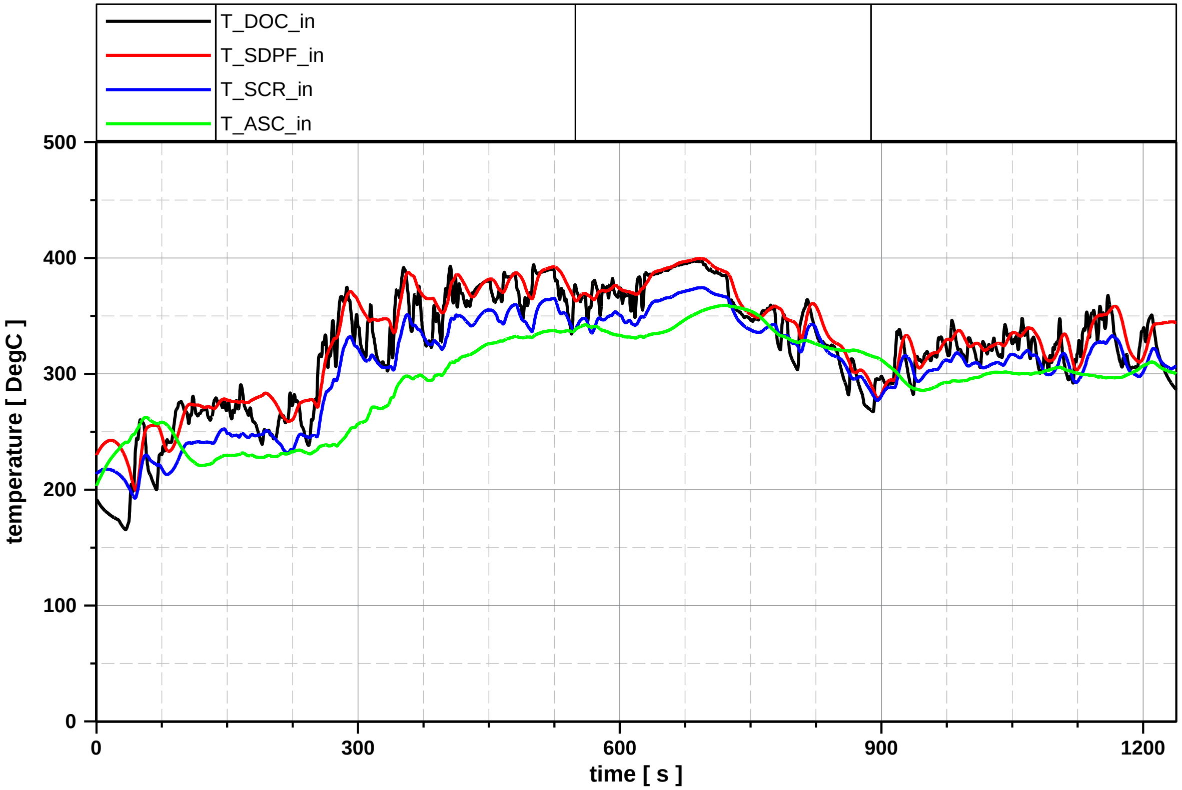
Active Regen.	**+ yes**	**(+) moderate Heat-ups only**
NO2-Make	**+ yes**	**++ yes**
DOC Modular Approach	**+ yes** **Performance Tuning by adjusting the Zoning and Layering Design**	**- no**

Catalyst Set-Up



Results

Temperatures during a NRTC cycle



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NO_2 ratio after the different DOCs

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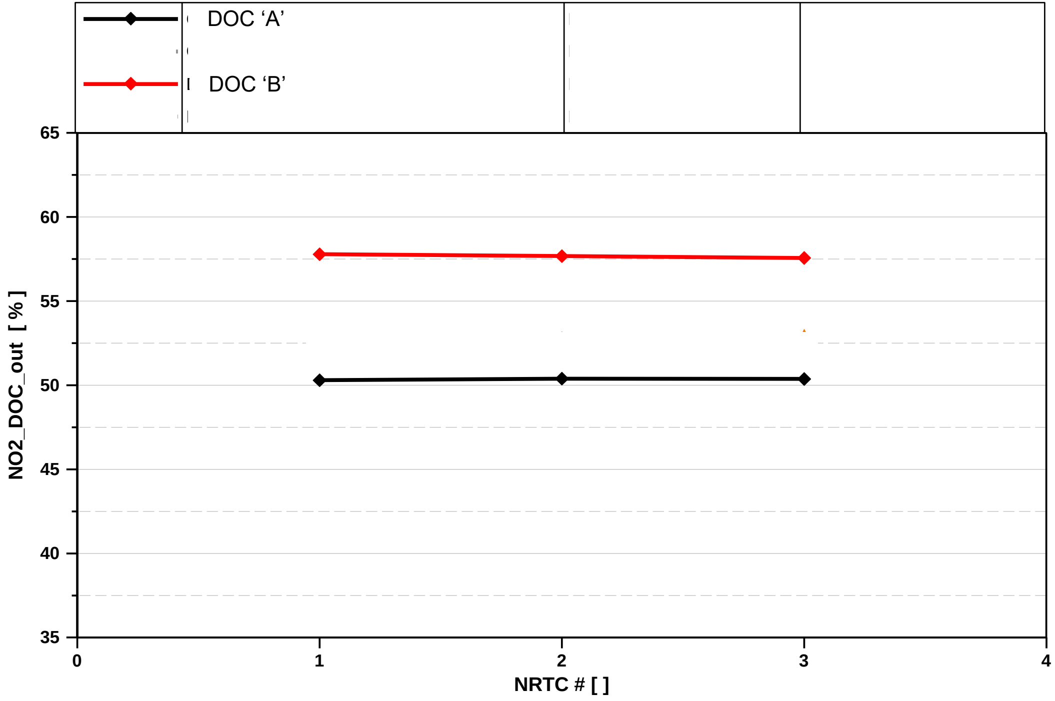

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NO_x conversion over SDPF, SCR and ASC with different dosing straegies

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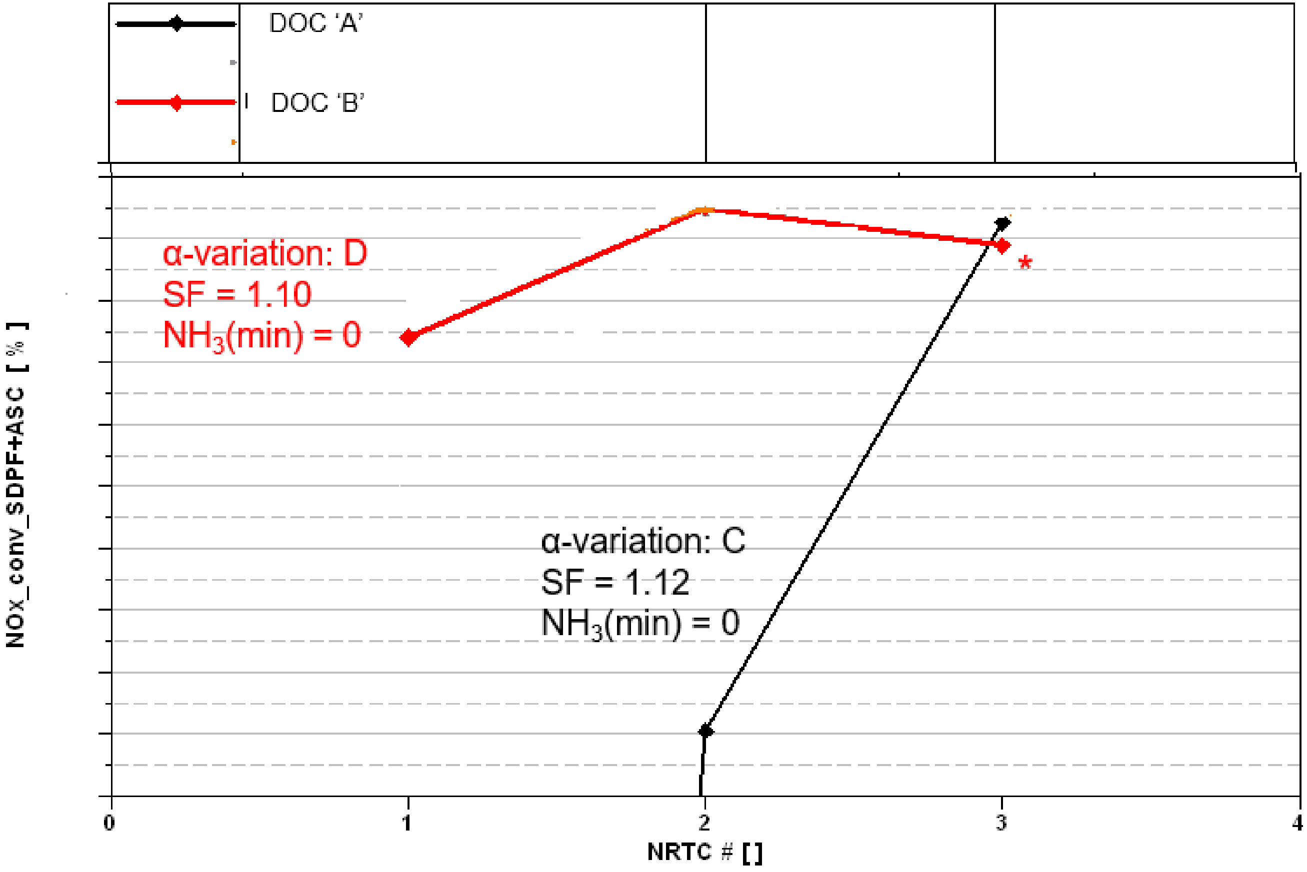
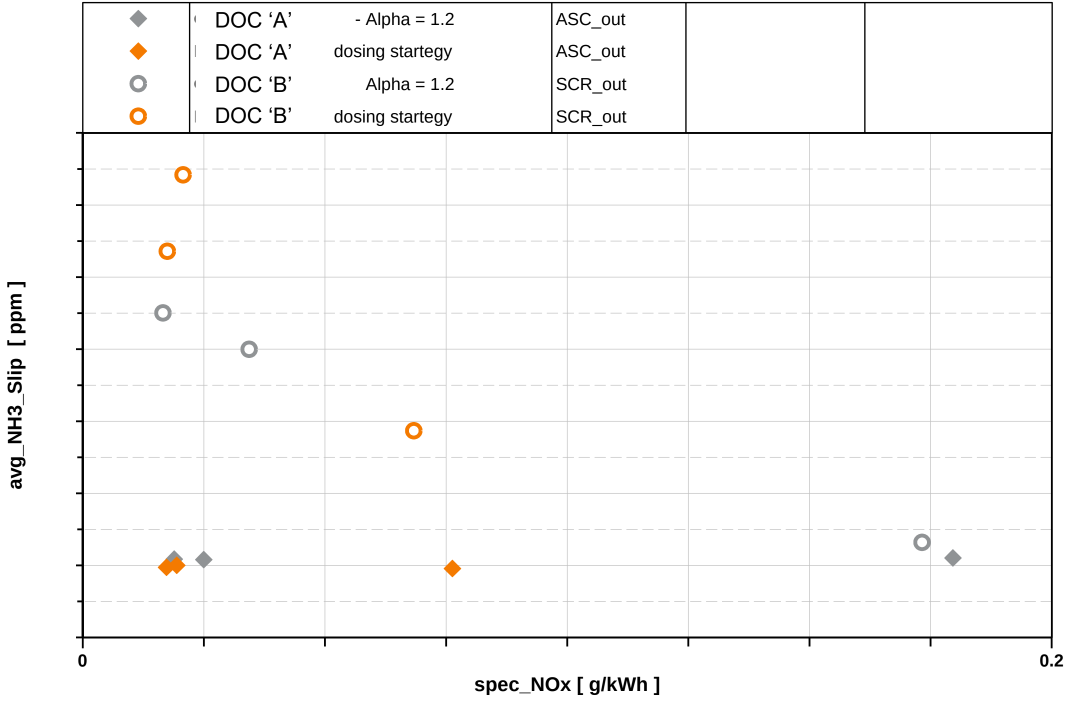
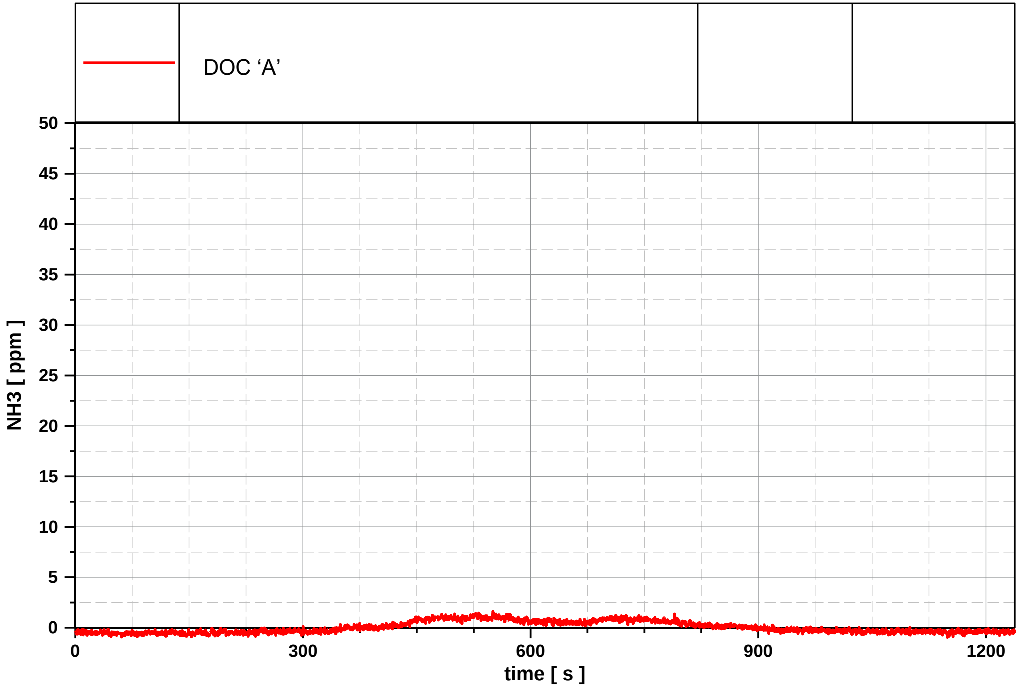


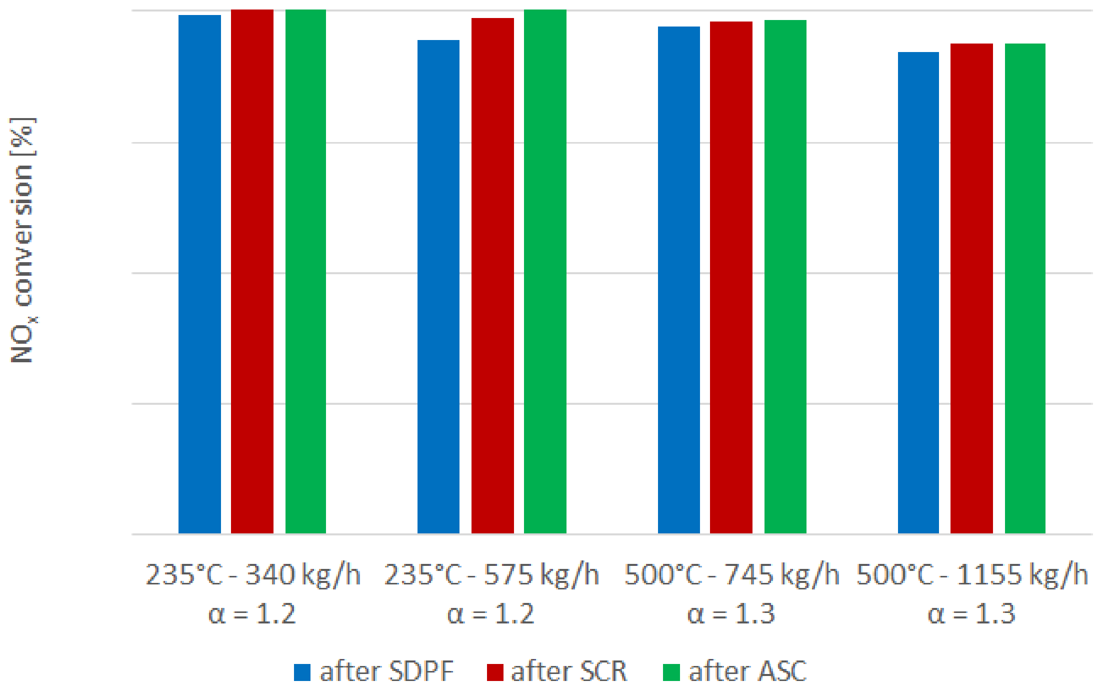
NH_3 slip and NO_x after SCR and ASC for different DOC technologies



NH_3 during a NRTC cycle



Maximum NO_x conversion after SDPF, SCR and ASC



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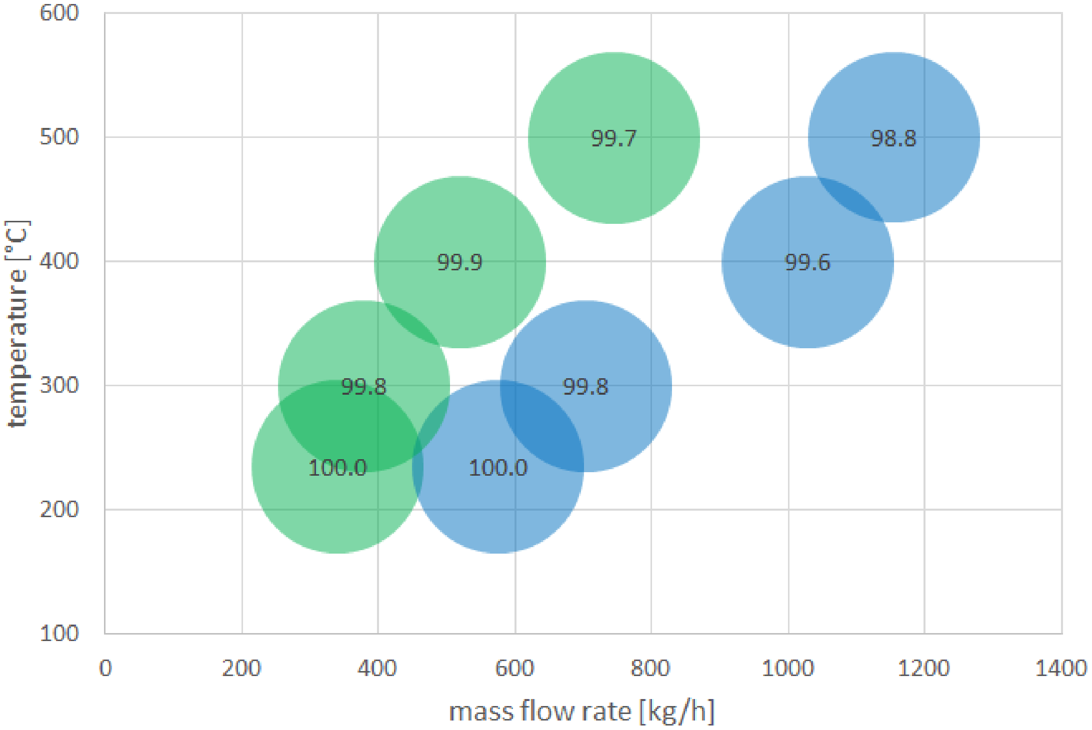
NO_x conversion in dependence of temperature and mass flow rate



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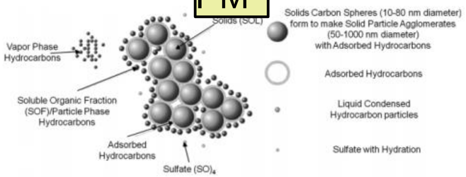
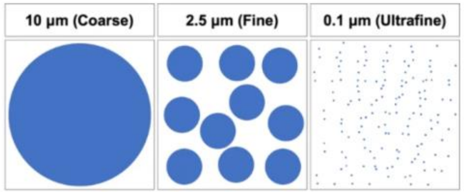
TREM V Mainstream

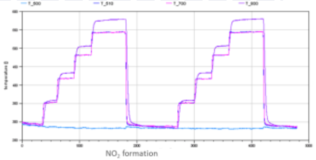
	Trem IV	Trem V	Solution
PM	0.025	0.015	DPF
PN	NA	$1X10^{12}$	
	HC/CO & SOF	HC/CO & SOF Heat Up NO2 make	DOC

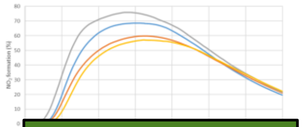
PM

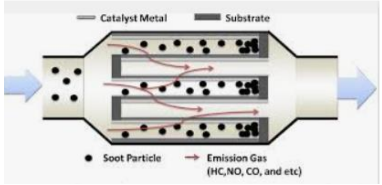


PN





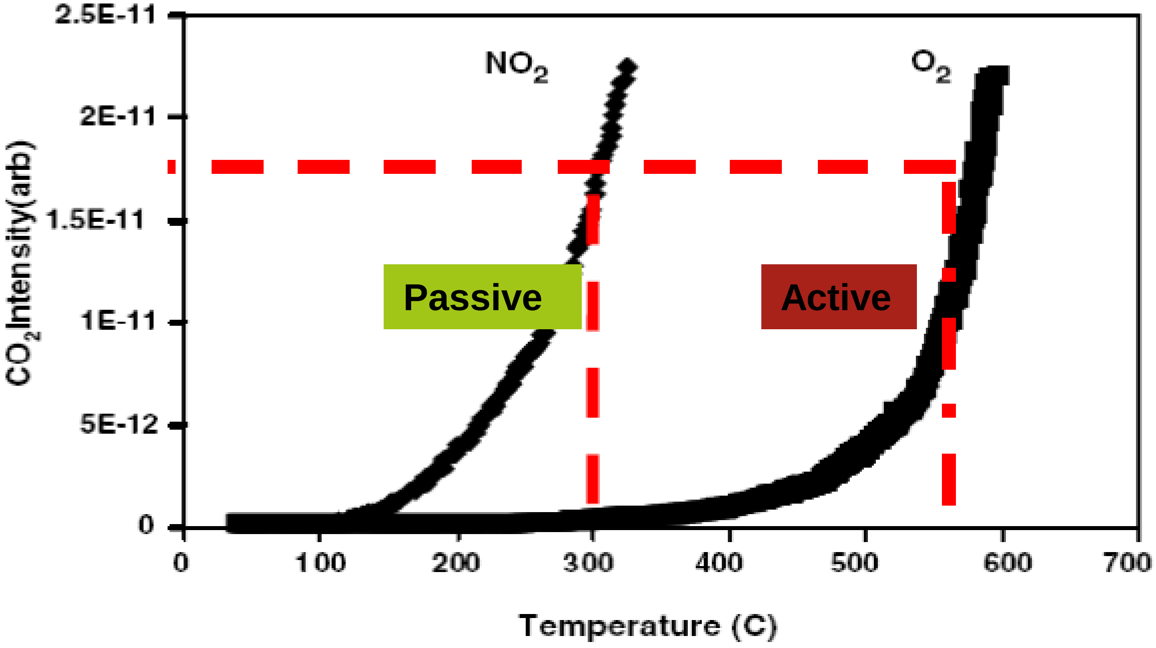




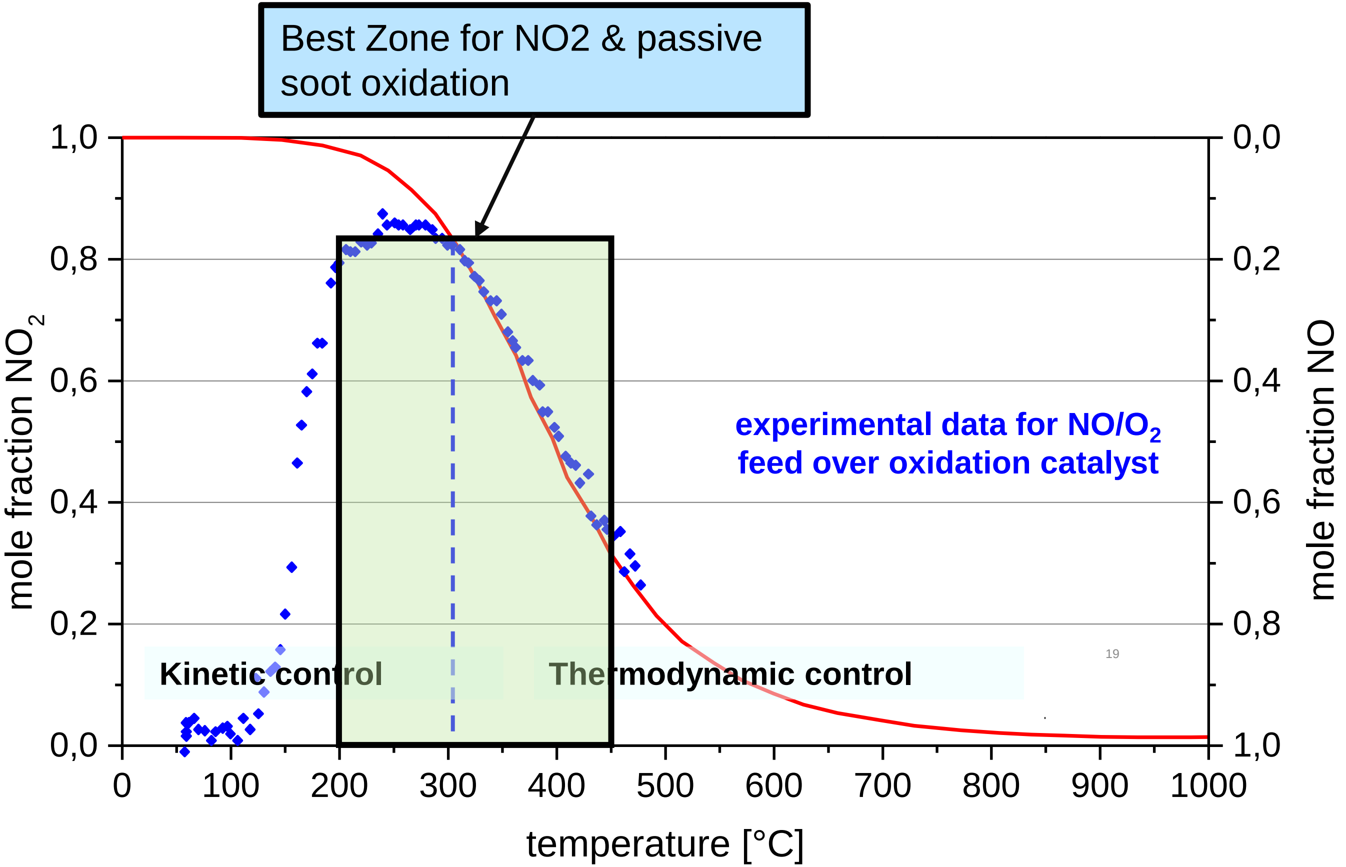
DPF

cDPF Regenerations (Passive/Active)

cDPF Regeneration Mechanisms



Oxidising NO to NO_2: Kinetic And Thermodynamic Control



Soot Oxidation Rate

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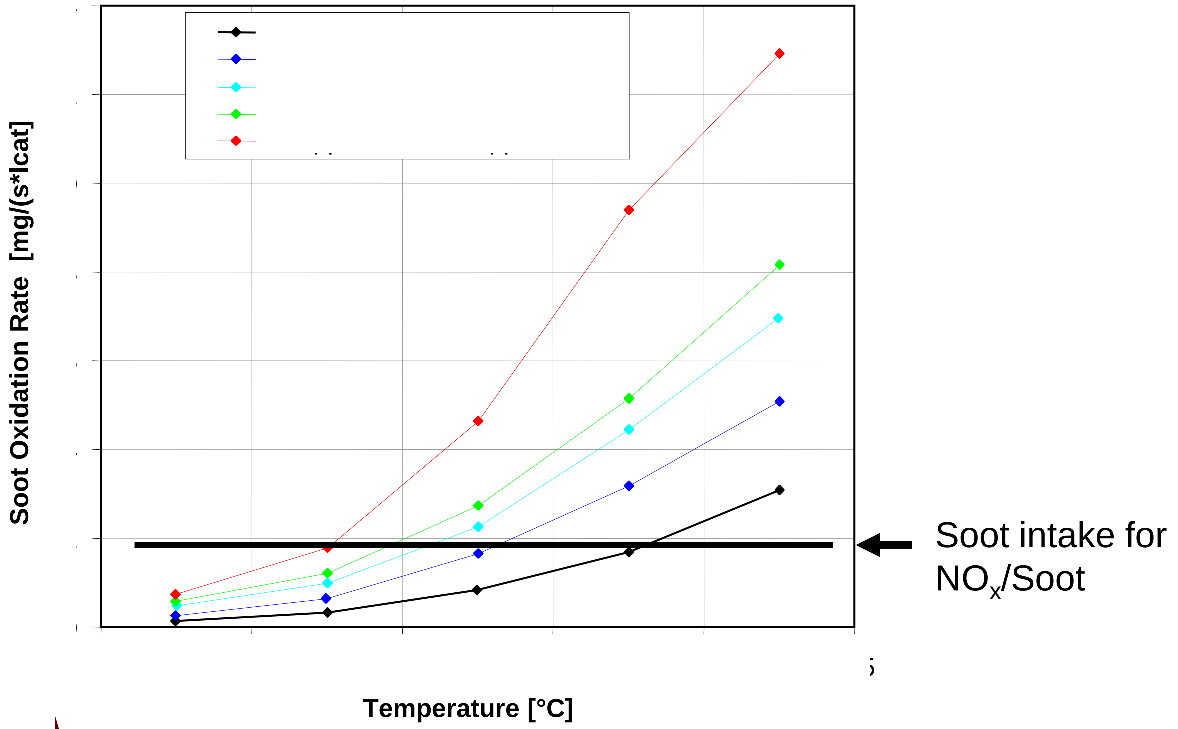
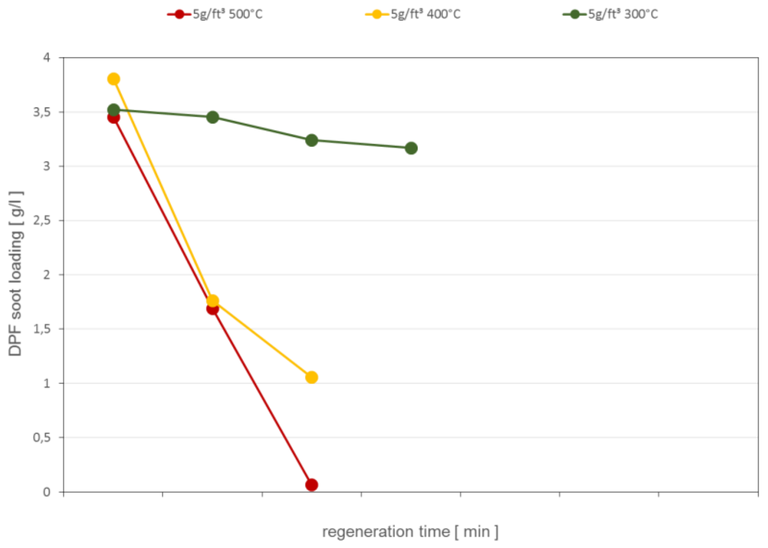
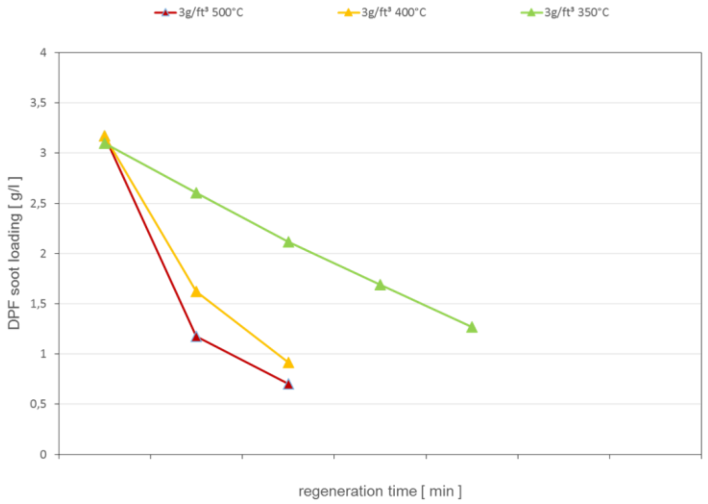


Drivers for Soot Burn Rate are Temperature (>300°C) & NO_2 concentration

All regenerations





Conclusion

- For Greater than 56Kw, SDPF can be thought of for compact packaging size for construction applications with high performing DeNOx system

- For tractor less than 56Kw , the cDPF is a critical element however the regeneration strategy is the must criterion to conclude for right PGM, Ratio of DOC & cDPF

- The tractor application mapping is key to decide the DPF regeneration strategy umicore

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