PN Emissions of Passengers Cars – Potentials of GPF's

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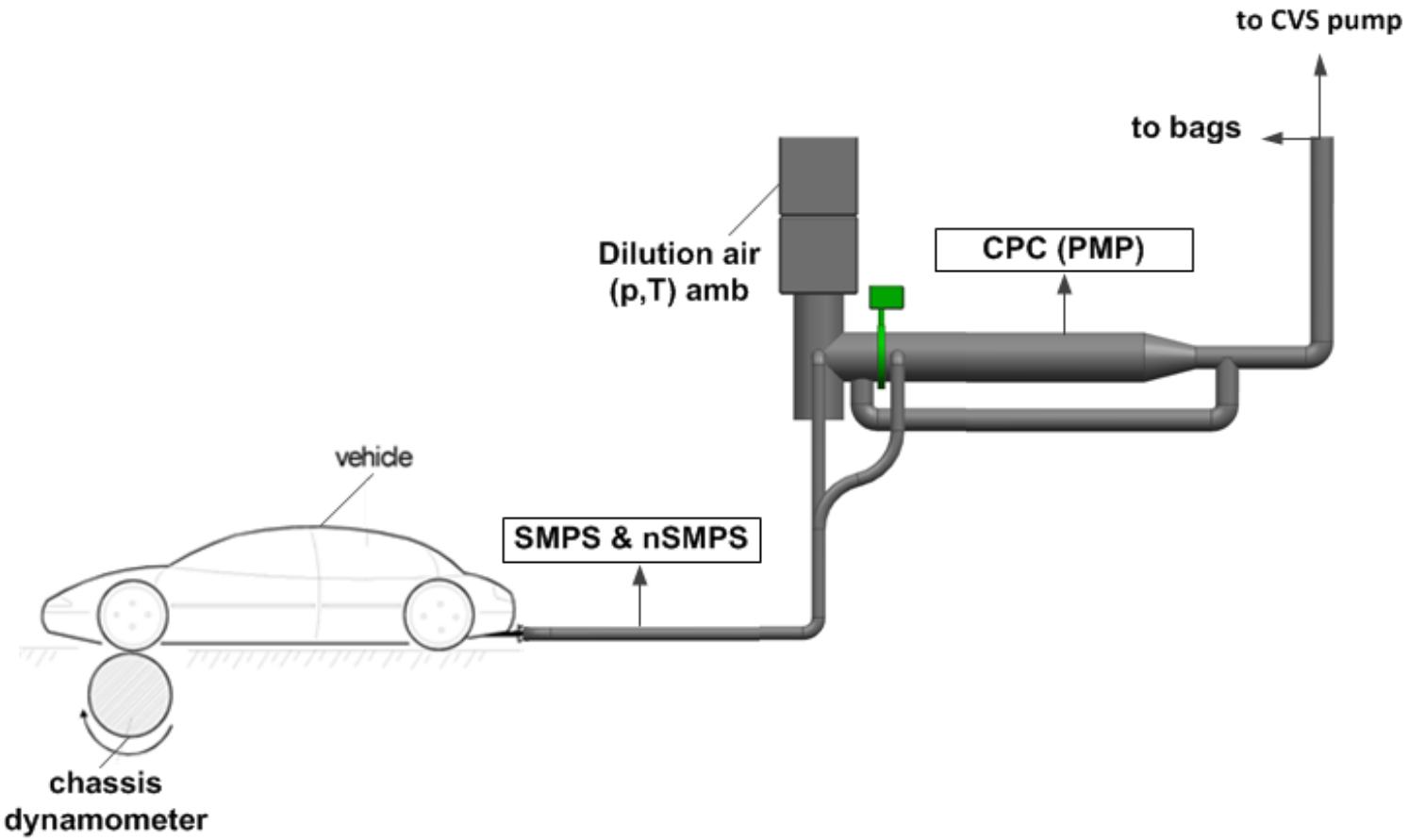
Test Equipment & Procedures

Sampling of Exhaust Gas for Analysis of Particles



PN-ANALYSIS

- **At steady state operation:**

  SMPS: DMA TSI 3081 & CPC TSI 3772 (10 - 429 nm)
  nSMPS: nDMA TSI 3085 & CPC TSI 3776 (2 - 64 nm)

- **At transient operation:**

  CPC TSI 3790 (PMP conform)

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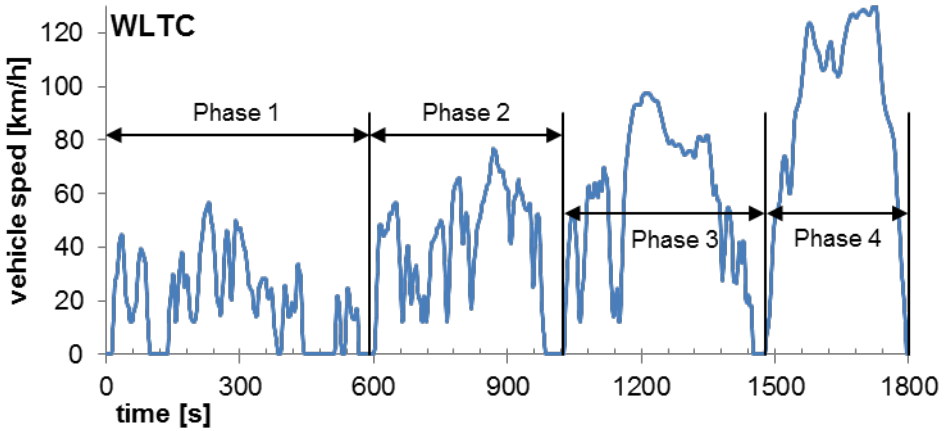
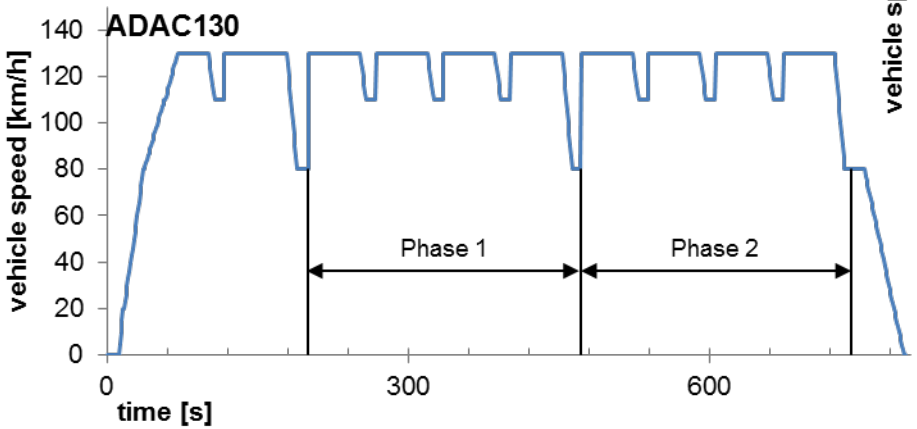
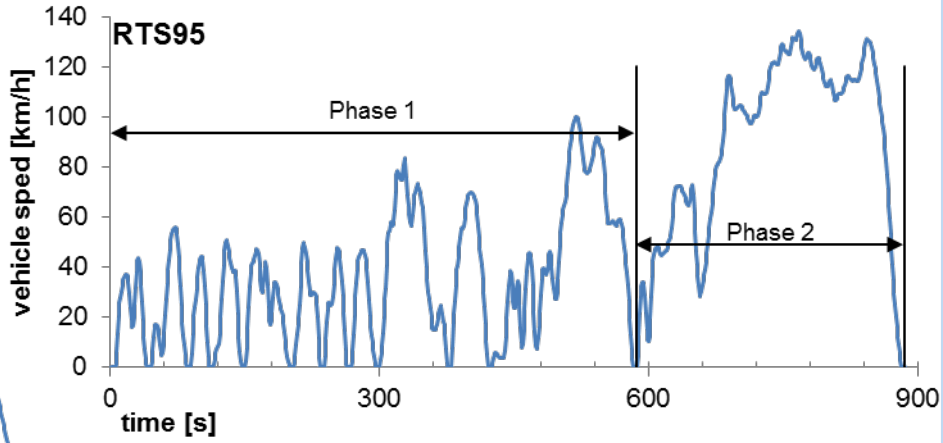
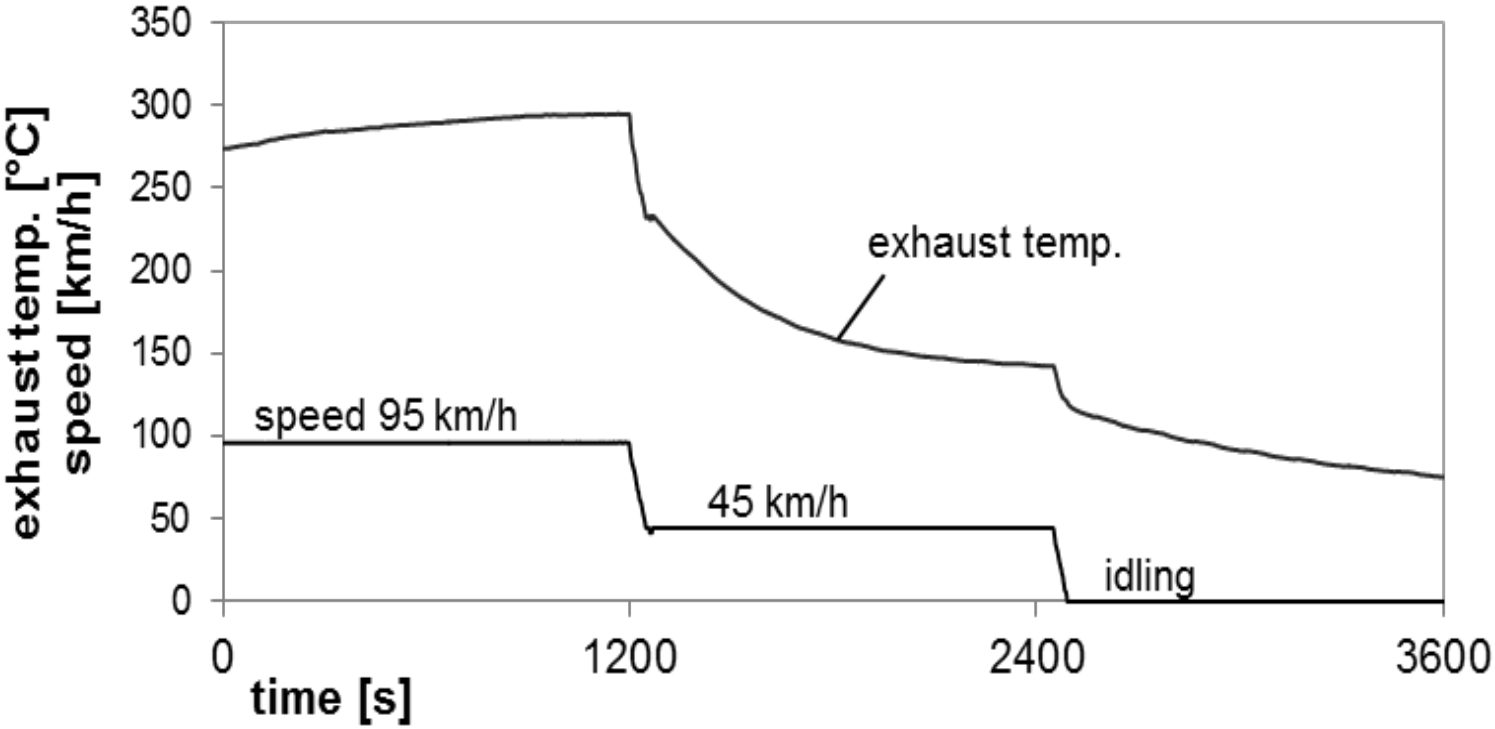
TRANSIENT DRIVING CYCLES WLTC, RTS 95 AND ADAC 130







STEADY STATE CYCLE (SSC) AND TAILPIPE TEMPERATURE OF A VEHICLE WITH (MPI)



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PN Emissions:
Diesel DPF vs CNG vs GPF

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Vehicle	Peugeot 4008 1.6 HDi SST	Audi A3 Sportback g-tron	Renault 18 Break
Engine code	9HD / 9H05	CPWA	J7T-718
Number and arrangement of cylinders	4 / in line	4 / in line	4 / in line
Displacement cm^3	1560	1395	2164
Power kW	84 @ 3600 rpm	81 @ 6000 rpm	74 @ 5000 rpm
Torque Nm	270 @ 1750 rpm	200 @ 1500 rpm	162 @ 2000 rpm
Injection type	DI	DI / MPI	MPI
Curb weight kg	1462	1355	1110
Gross vehicle weight kg	2060	1820	1585
Drive wheel	Front-wheel drive	Front-wheel drive	Front-wheel drive
Gearbox	m6	m6	m5
First registration	12.04.2013	14.12.2015	01.04.1985
Exhaust	EURO 5b	EURO 6b	EURO 0

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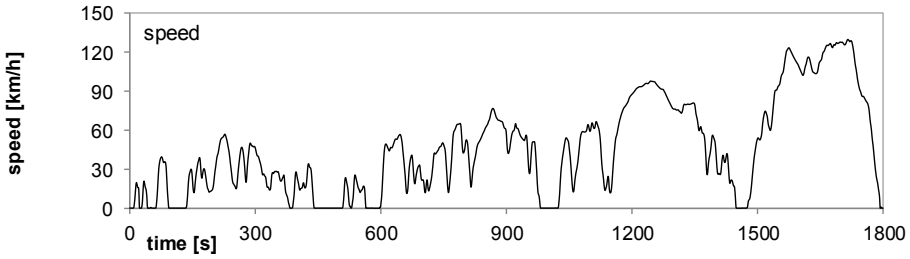
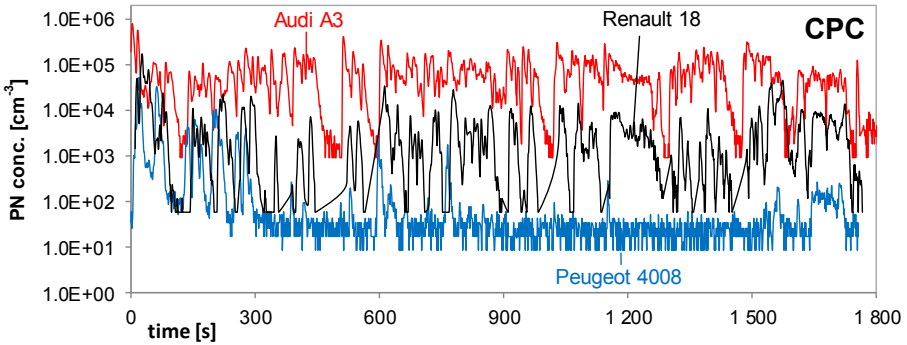
PN-Emissions in WLTC cold : Diesel DPF vs CNG & gasoline GPF.

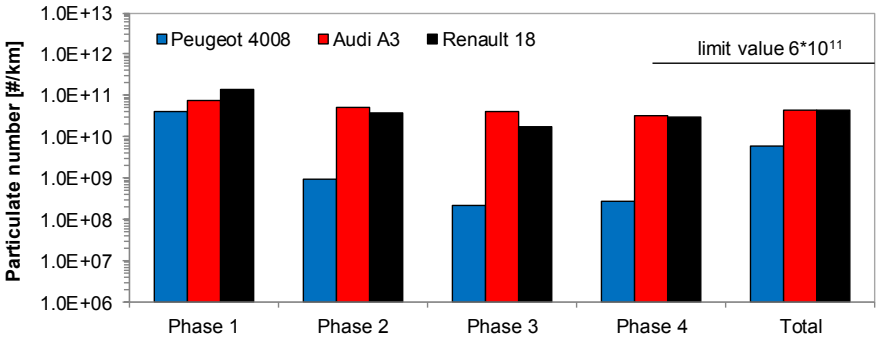
Peugeot 4008 1.6 HDi STT; DOC+DPF; fuel: diesel

Audi A3 Sportback g-tron; 3-way catalyst; fuel: CNG

Renault 18; 3-way catalyst & GPF; fuel: gasoline







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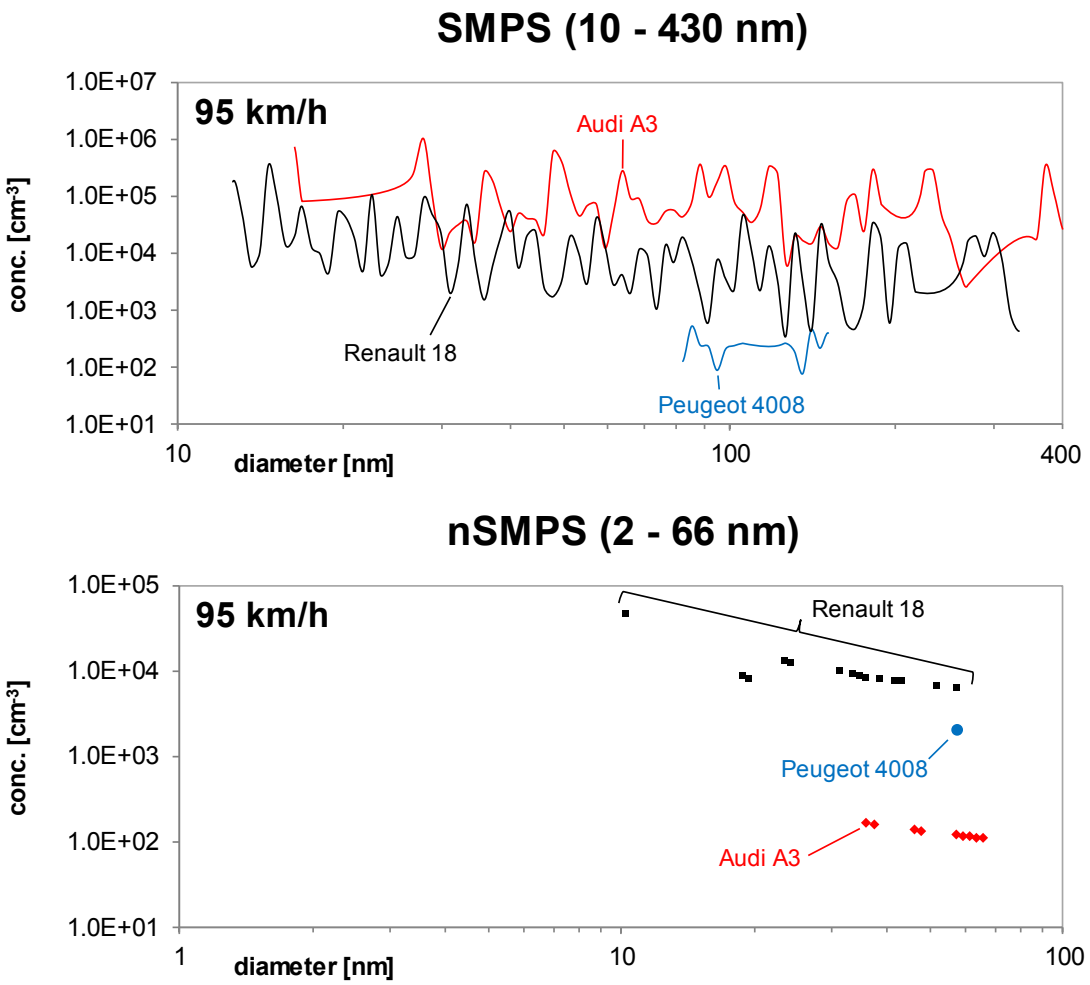
SMPS & nSMPS Particle Scans at constant speed: Diesel DPF vs CNG & gasoline GPF.

Peugeot 4008 1.6 HDi STT; DOC+DPF; fuel: diesel
Audi A3 Sportback g-tron; 3-way catalyst; fuel: CNG
Renault 18; 3-way catalyst & GPG; fuel: gasline



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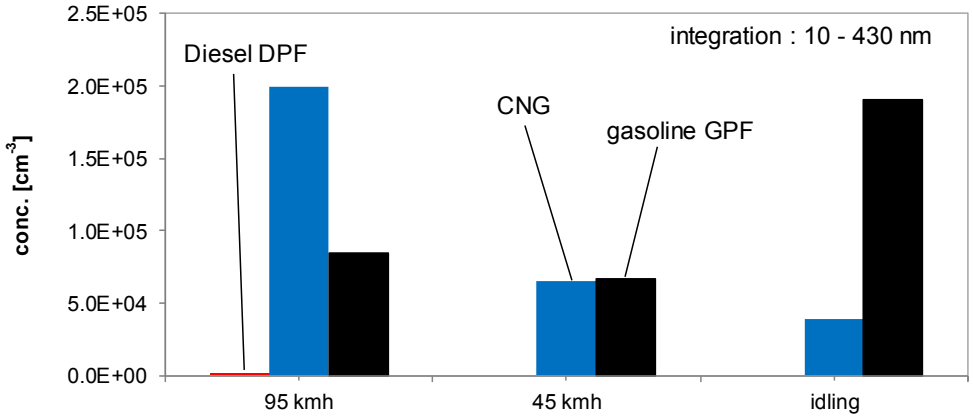
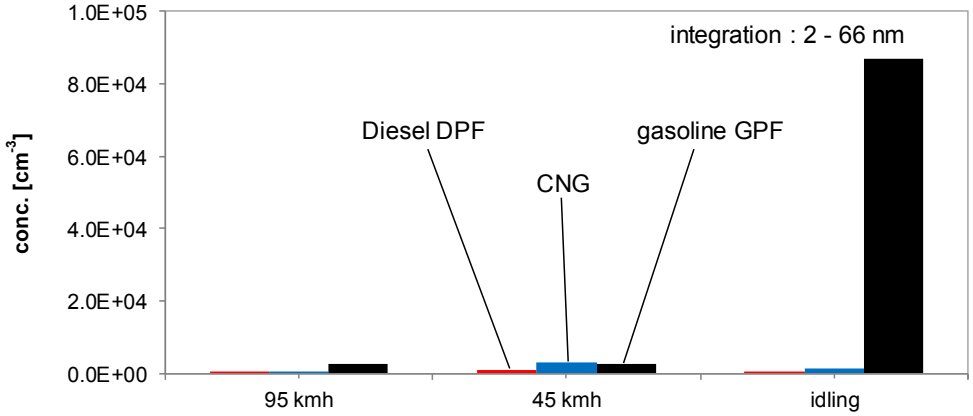
PN-Emissions at constant speeds: Diesel DPF vs CNG & gasoline GPF.

Peugeot 4008 1.6 HDi STT; DOC+DPF; fuel: diesel
Audi A3 Sportback g-tron; 3-way catalyst; fuel: CNG
Renault 18; 3-way catalyst & GPF; fuel: gasline

SMPS (10 - 430 nm)



nSMPS (2 - 66 nm)



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PN Emissions MPI with GPF / cGPF / 4WC

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Vehicle	Fiat Panda 4x4 TwinAir	Renault 18 Break	Renault Mégane Scénic RX4
Engine code	312A7000	J7T-718	F4RC7
Number and arrangement of cylinders	2 / in line	4 / in line	4 / in line
Displacement cm^3	875	2164	1998
Power kW	66.2 @ 5500 rpm	74 @ 5000 rpm	101.5 @ 5500 rpm
Torque Nm	145 @ 1900 rpm	162 @ 2000 rpm	188 @ 3750 rpm
Injection type	MPI	MPI	MPI
Curb weight kg	1200	1110	1495
Gross vehicle weight kg	1585	1585	1990
Drive wheel	Allrad	Front-wheel drive	AWD
Gearbox	m6	m5	m5
First registration	13.04.2017	01.04.1985	09.01.2001
Exhaust	EURO 6b	EURO 0	EURO 3

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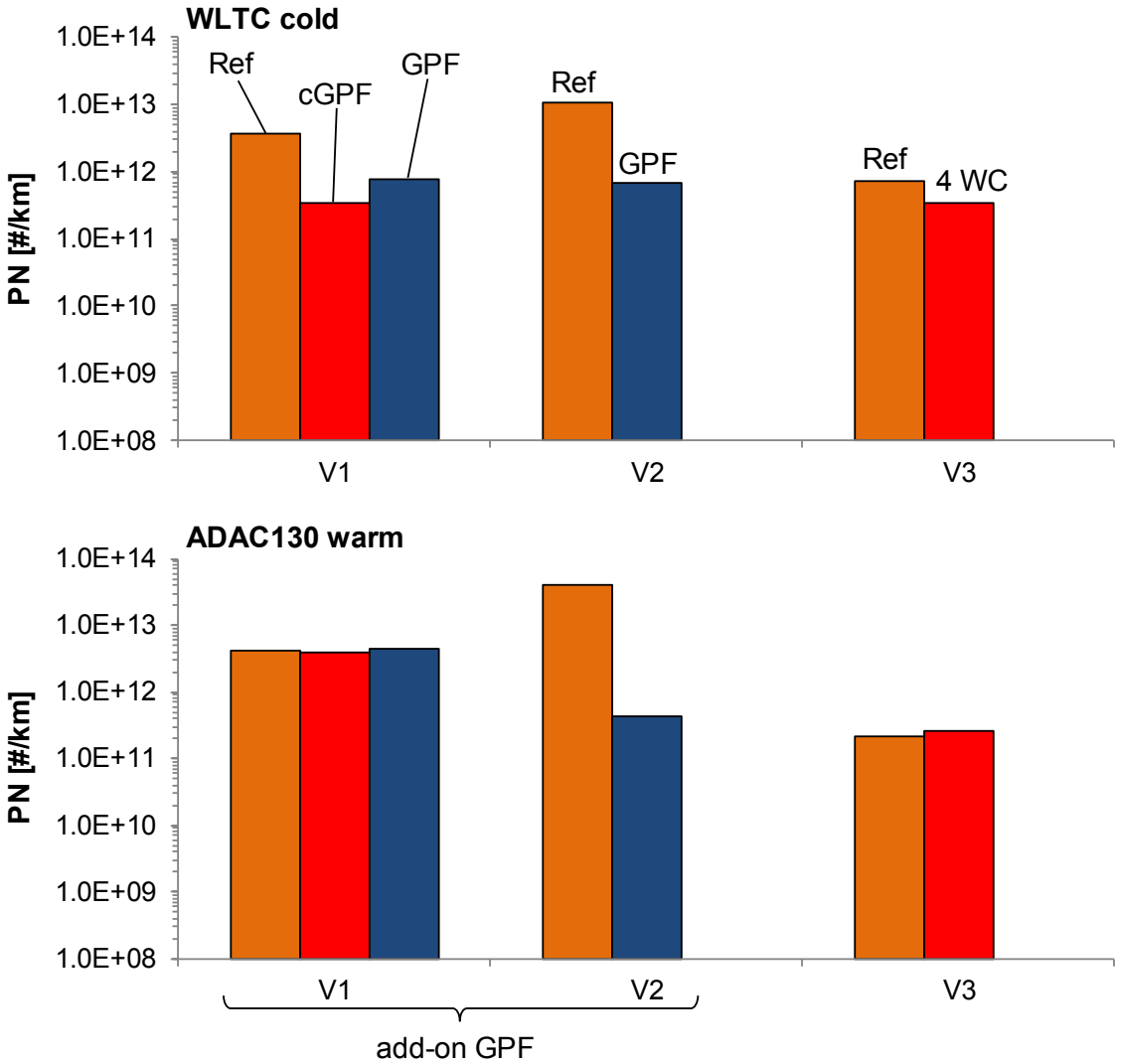
COMPARISON OF THE PN EMISSIONS OF 3 MPI VEHICLES IN DIFFERENT DRIVING CYCLES. REF. (W/O GPF), WITH CGPF / 4WC AND GPF.

3-WAY CATALYST / 4-WAY GPF; FUEL: GASOLINE.



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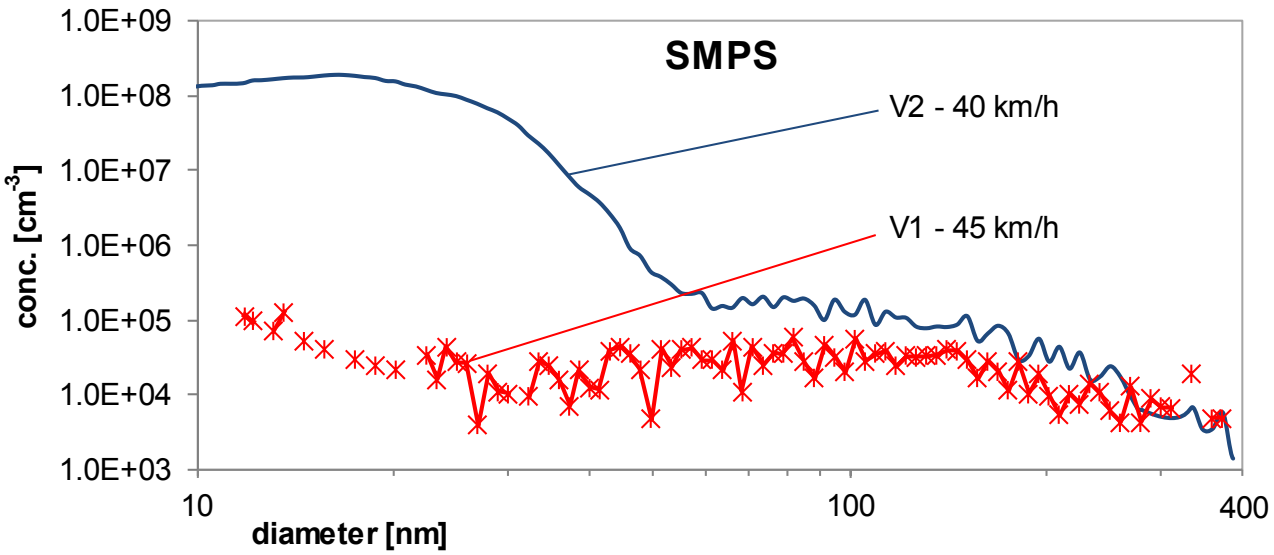
COMPARISON OF PARTICLES SIZE DISTRIBUTIONS (PSD) OF TWO MPI VEHICLES IN STATE OF REFERENCE AT CONSTANT SPEEDS 40 / 45 KM/H.

V1 AND V2; 3-WAY CATALYST; FUEL: GASOLINE



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4WC Filtration Efficiency with Stronger Coating

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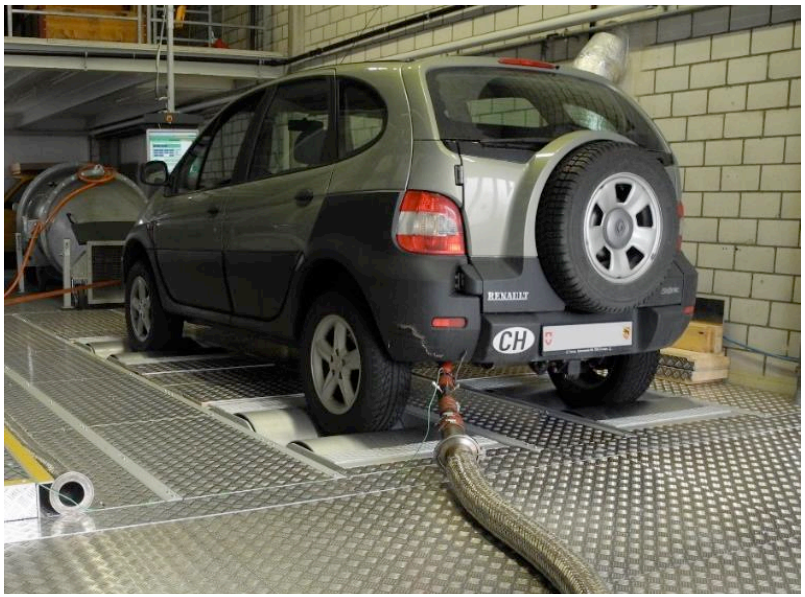

Vehicle	Renault Mégane Scénic RX4
Engine code	F4RC7
Number and arrangement of cylinders	4 / in line
Displacement cm^3	1998
Power kW	101.5 @ 5500 rpm
Torque Nm	188 @ 3750 rpm
Injection type	MPI
Curb weight kg	1495
Gross vehicle weight kg	1990
Drive wheel	AWD
Gearbox	m5
First registration	09.01.2001
Exhaust	EURO 3

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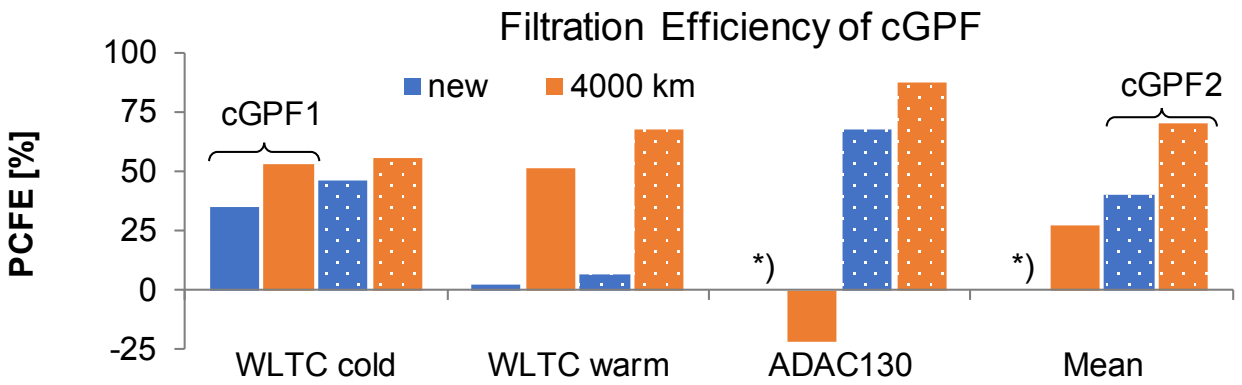
FILTRATION EFFICIENCY OF TWO GPF'S (4WC) WITH IDENTICAL SUBSTRATE, BUT DIFFERENT COATING.

CGPF1 (BASE COATING), CGPF2 (STRONGER COATING); RENAULT MÉGANE SCÉNIC RX4; 4WC; FUEL: GASOLINE.



*) no values with cGPF1 new

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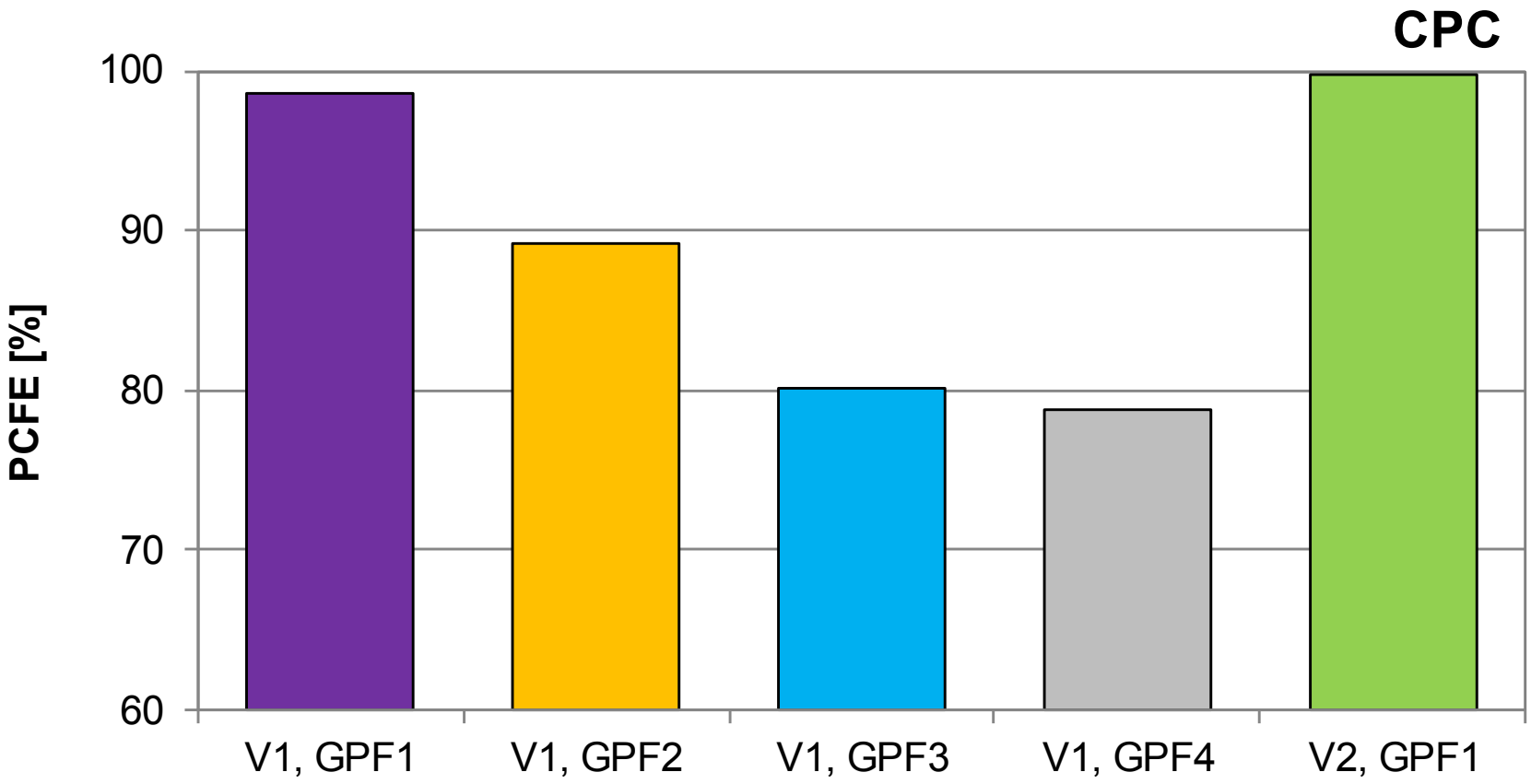
Some findings with Gasoline Cars

PCFE'S OF THE INVESTIGATED GPF'S IN WLTC HOT



SAE 2017-01-1004

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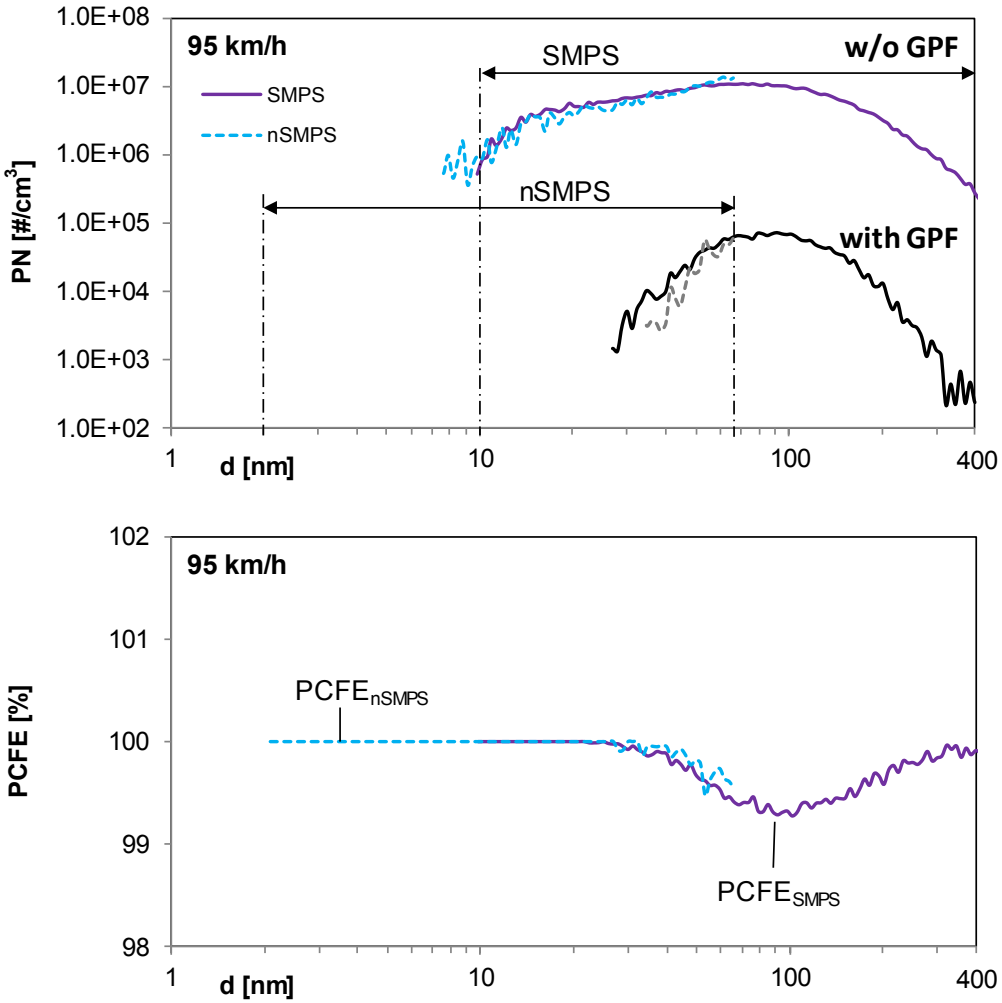
EXAMPLE OF PSD'S WITH SMPS & NSMPS AND PARTICLE COUNTS FILTRATION EFFICIENCY (PCFE) WITH V1, GPF 1 AT 95 KM/H



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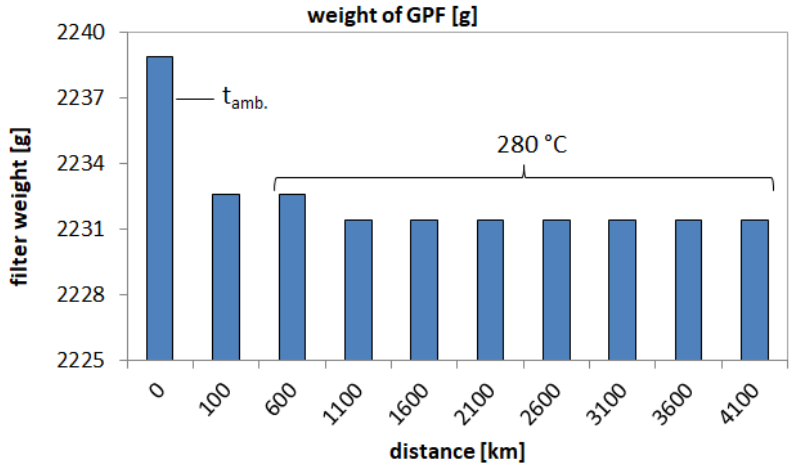
ATTEMPT OF SOOT-LOADING OVER 4100 KM IN REAL DRIVING; ADD-ON-GPF (UNCOATED); V2

Weighing of GPF



GPF entrance after 2100 km

Conclusions (1)

- The modern SI-vehicles with MPI can emit a considerable amount of PN and PM. In an extreme case, the PN-emission was in the range of Diesel car (without DPF).
- With the GPF's with better filtration quality, it is possible to lower the emissions below the actual European limit value of 6.0×10^{11}#/km.
- The PN-filtration efficiency of actually used GPF's is significantly lower than the efficiency of right-quality DPF's.

Conclusions (2)

- The improvement of GPF filtration efficiency by coating alone is not sufficient.
- The variant Diesel + DPF offers the highest filtration quality, the lowest PN-emissions and it is considered by the authors as a recommendable bench-mark.
- A modern CNG car would still have remarkable PN-reduction potentials with a right-quality GPF.


Thank you for
your attention !