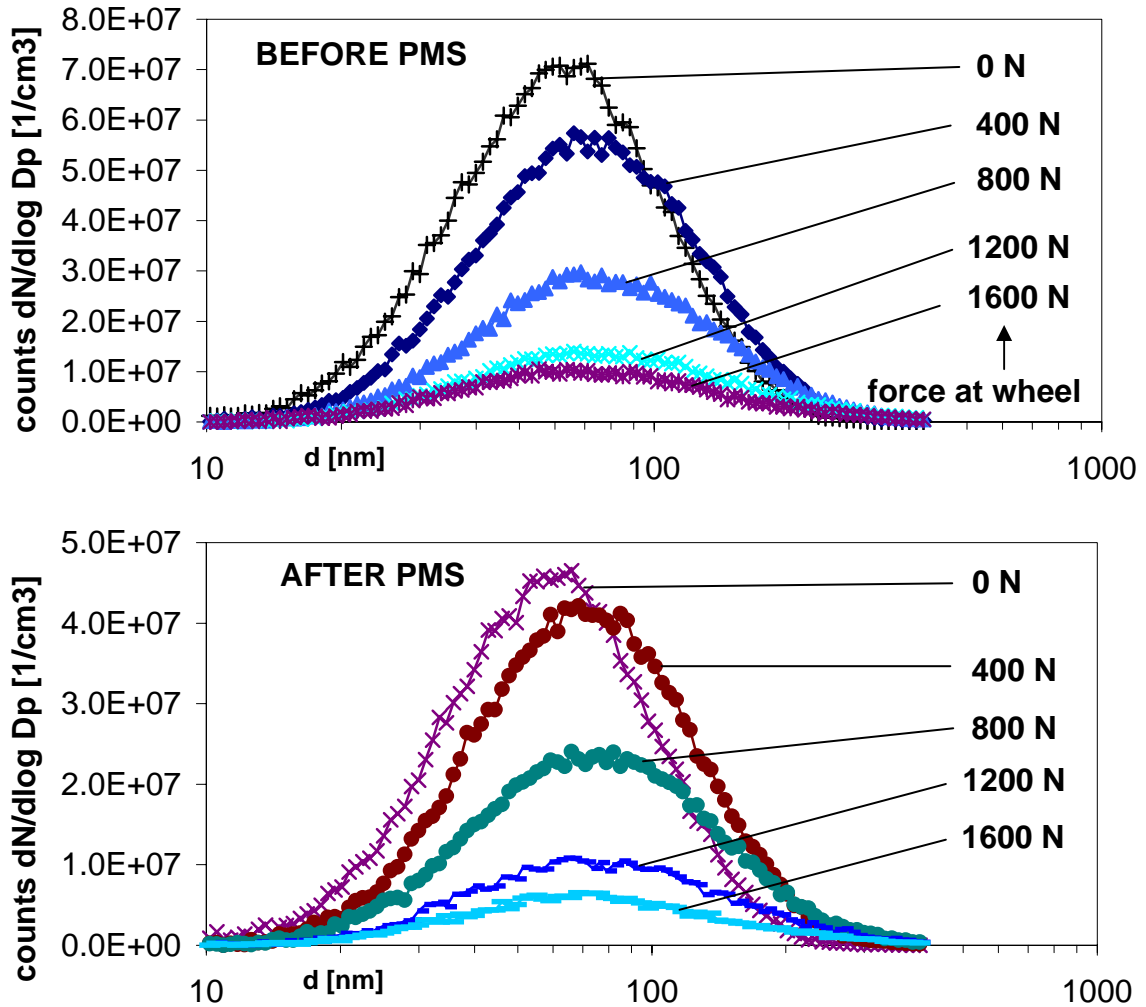


SMPS : nanoparticle filtration efficiency at 85 km/h with engine warm and engine load variations.

Measured before and after TWIN-TEC2-PMS; VW Passat 1.9 TDI; low sulfur diesel

SMPS PSD - spectra



Configuration	BEFORE		AFTER	
	SMPS	SMPS	SMPS	SMPS
	[10-400 nm]	[10-400 nm]	[10-400 nm]	[10-400 nm]
0 N	41435993	26595332		
400 N	34502314	25572602		
800 N	19179891	15941272		
1200 N	9688704	7343502		
1600 N	7232481	4277305		

Configuration	PZAG	
	SMPS [10-400 nm]	
	[%]	
0 N	35.82	
400 N	25.88	
800 N	16.89	
1200 N	24.21	
1600 N	40.86	

Configuration	w/o		AFTER	
	PM	PM	PM	PM
	[g/km]	[g/km]	[g/km]	[g/km]
0 N	0.0074	0.0077		
400 N	0.0189	0.0144		
800 N	0.0383	0.0187		
1200 N	0.0461	0.0169		
1600 N	0.0545	0.0149		

Configuration	PMAG	
	PM	
	[%]	
0 N	-4.05	
400 N	23.81	
800 N	51.17	
1200 N	63.34	
1600 N	72.66	

Procedure :
 10 min stabilization
 10 min measurements before PMS
 10 min measurements after PMS

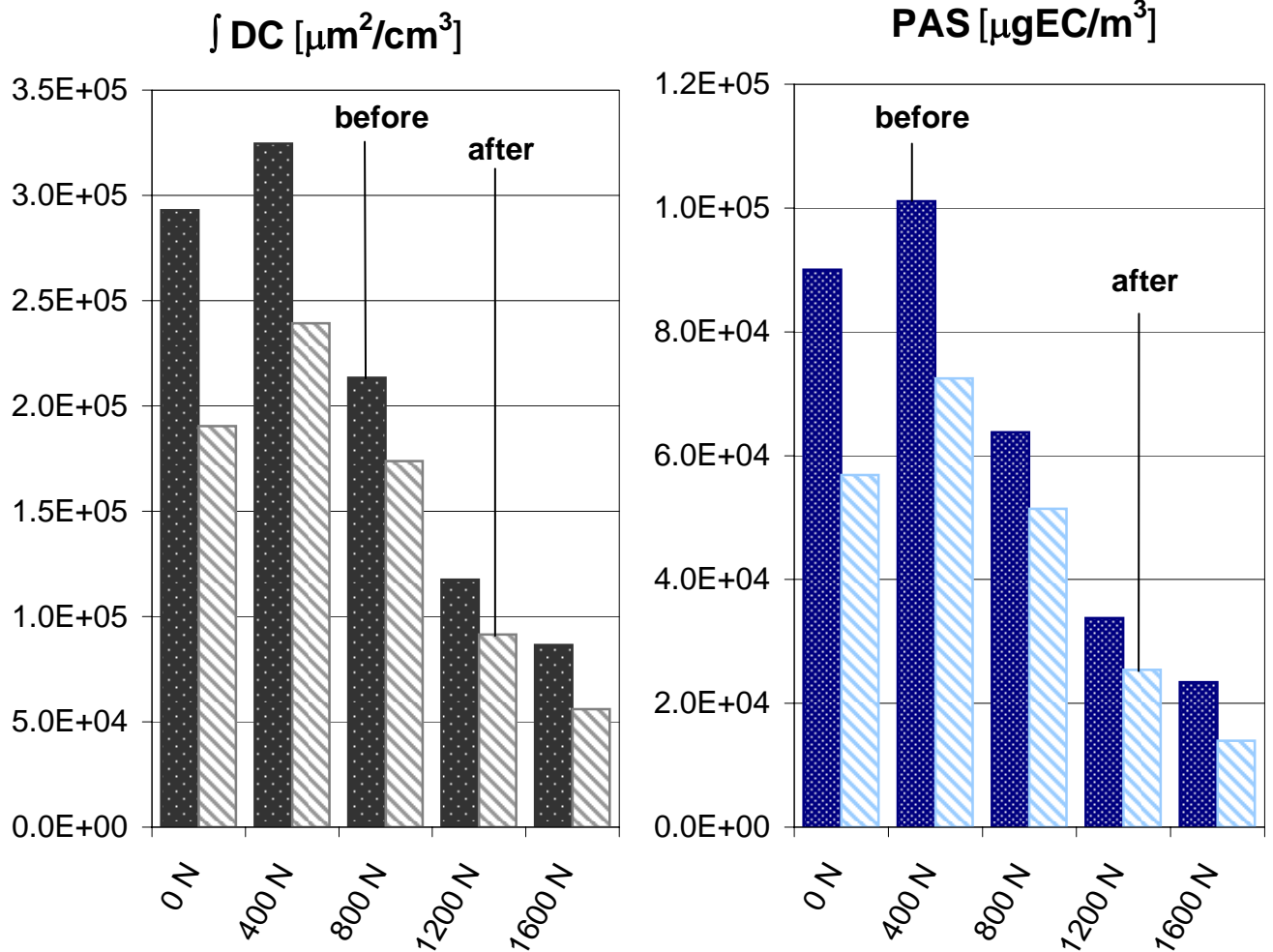
NanoMet : nanoparticle filtration efficiency at 85 km/h with engine warm and engine load variations.

Before and after TWIN-TEC2-PMS; VW Passat 1.9 TDI; low sulfur diesel

Driving cycle : 85 km/h const.

Configuration	BEFORE		AFTER		PZAG	
	∫ DC *)	∫ PAS *)	∫ DC *)	∫ PAS *)	DC	PAS
	[$\mu\text{m}^2/\text{cm}^3$]	[$\mu\text{gEC}/\text{m}^3$]	[$\mu\text{m}^2/\text{cm}^3$]	[$\mu\text{gEC}/\text{m}^3$]	[%]	[%]
0 N	292991	90057	190398	56868	35.02	36.85
400 N	324533	101096	239258	72500	26.28	28.29
800 N	213391	63759	173800	51428	18.55	19.34
1200 N	117443	33783	91501	25398	22.09	24.82
1600 N	86516	23406	55987	13931	35.29	40.48

*) ... integral average value of 7.5 min.



Procedure :
 10 min stabilization
 10 min measurements before PMS
 10 min measurements after PMS

NO_x emissions by constant speed 85 km/h with different wheel loads, before and after PMS.

TWIN-TEC2-PMS; 6th gear; n=1710 rpm; low sulfur diesel; hot NO_x-measurement.

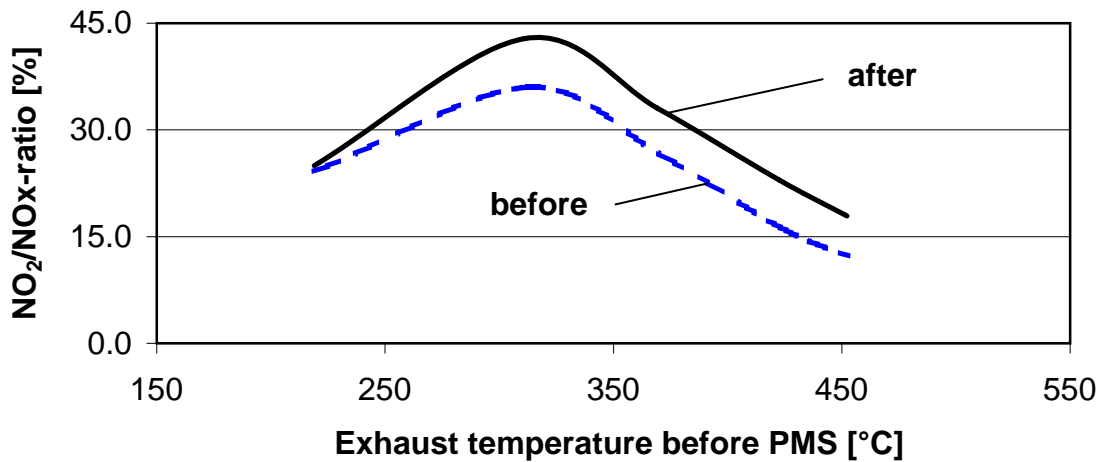
BEFORE PMS

Fwheel	V	T b. PMS	T a. PMS	NO ₂	NO _x	NO ₂ /NO _x -ratio
[N]	[km/h]	[°C]	[°C]	[ppm]	[ppm]	[%]
4	85.6	219.0	190.9	9.6	39.9	24.2
400	85.4	312.5	296.5	69.0	191.7	36.0
800	85.2	369.8	357.8	124.8	467.8	26.7
1200	85.0	423.1	409.7	151.6	931.8	16.3
1599	84.8	452.7	439.2	147.6	1203.3	12.3

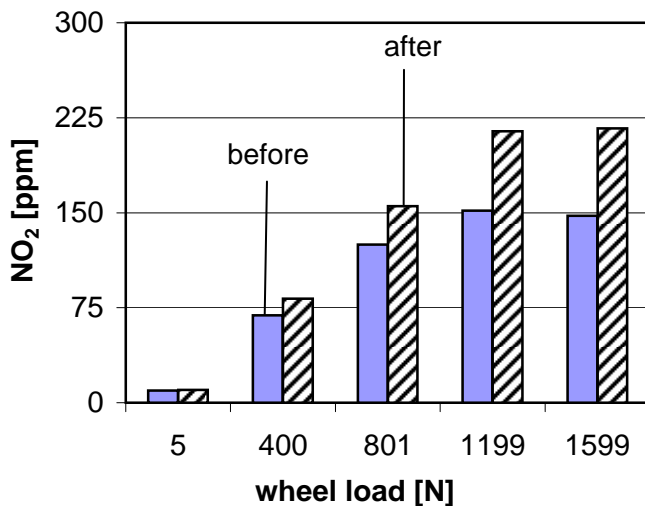
AFTER PMS

Fwheel	V	T b. PMS	T a. PMS	NO ₂	NO _x	NO ₂ /NO _x -ratio
[N]	[km/h]	[°C]	[°C]	[ppm]	[ppm]	[%]
5	85.6	219.0	192.1	10.0	40.0	25.0
400	85.4	311.1	296.5	82.2	192.0	42.8
801	85.2	368.8	357.6	155.2	468.4	33.1
1199	85.0	422.4	410.0	214.4	932.3	23.0
1599	84.8	452.3	438.8	216.6	1209.5	17.9

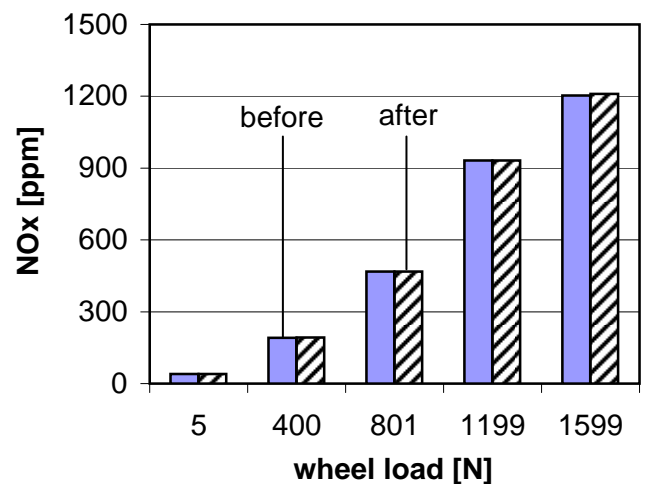
NO₂/NO_x-ratio before and after TWIN-TEC2-PMS



NO₂ before and after TWIN-TEC2-PMS



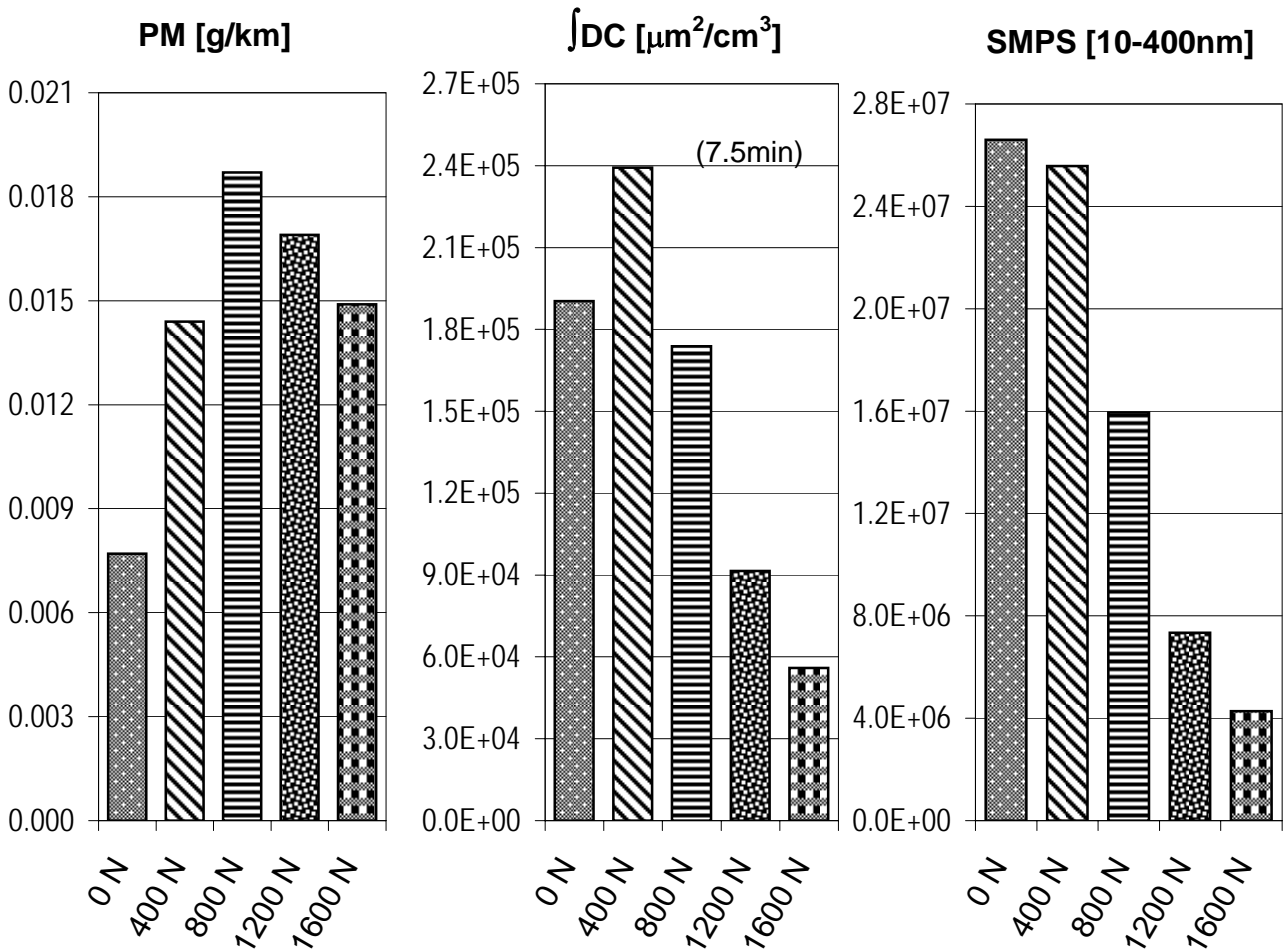
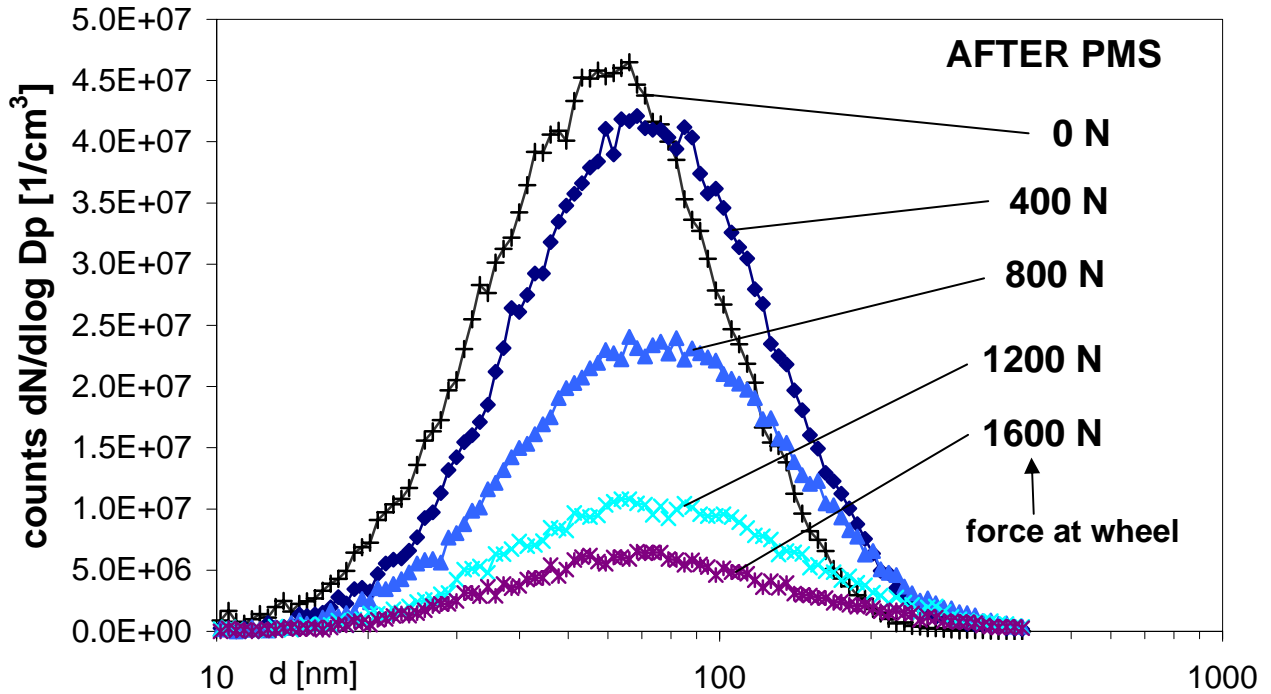
NO_x before and after TWIN-TEC2-PMS



Particle mass and nanoparticles at const. speed 85 km/h, warm, with engine load variations.

with TWIN-TEC2-PMS; VW Passat 1.9 TDI; low sulfur diesel

SMPS PSD - spectra



Comparison of emissions during the measurements of nanoparticles by engine load variations

Low sulfur diesel; CO, HC, NOx bag values

VW Passat 1.9 TDI

w/o PMS

Driving cycle : 85 km/h const., warm

Configuration	CO [g/km]	HC [g/km]	NOx [g/km]	PM [g/km]	∫ DC *) [μm ² /cm ³]	∫ PAS *) [μgEC/m ³]	SMPS [10-400 nm]
0 N	0.004	0.008	0.041	0.0074	288881	105098	3.57E+07
400 N	0.010	0.008	0.331	0.0189	212401	76953	2.11E+07
800 N	0.017	0.014	1.030	0.0383	126780	44778	1.06E+07
1200 N	0.033	0.013	2.402	0.0461	59223	18689	4.45E+06
1600 N	0.053	0.007	3.242	0.0545	65968	20492	4.48E+06

*) ... integral average value of 7.5 min.

TWIN-TEC2-PMS

Driving cycle : 85 km/h const., warm, after PMS

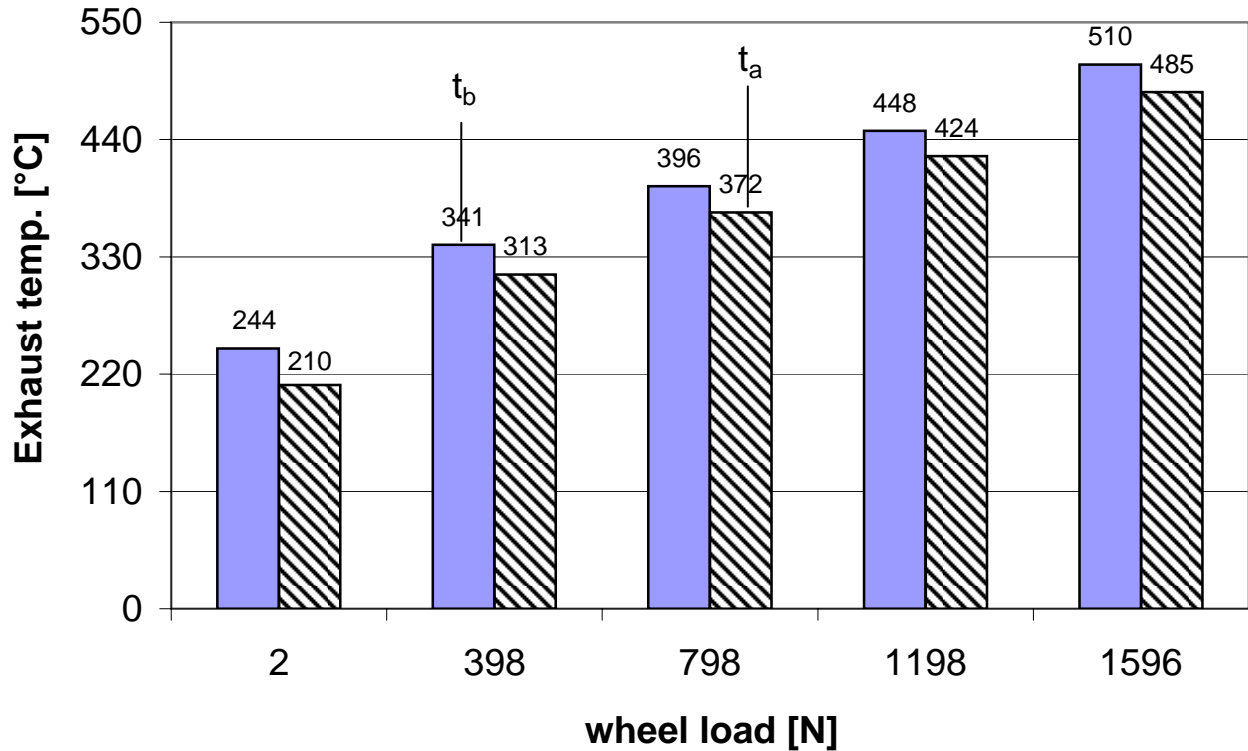
Configuration	CO [g/km]	HC [g/km]	NOx [g/km]	PM [g/km]	∫ DC *) [μm ² /cm ³]	∫ PAS *) [μgEC/m ³]	SMPS [10-400 nm]
0 N	0.004	0.008	0.028	0.0077	190398	56868	2.66E+07
400 N	0.005	0.002	0.281	0.0144	239258	72500	2.56E+07
800 N	0.008	0.001	0.929	0.0187	173800	51428	1.59E+07
1200 N	0.019	0.002	2.290	0.0169	91501	25398	7.34E+06
1600 N	0.026	0.003	3.475	0.0149	55987	13931	4.28E+06

*) ... integral average value of 7.5 min.

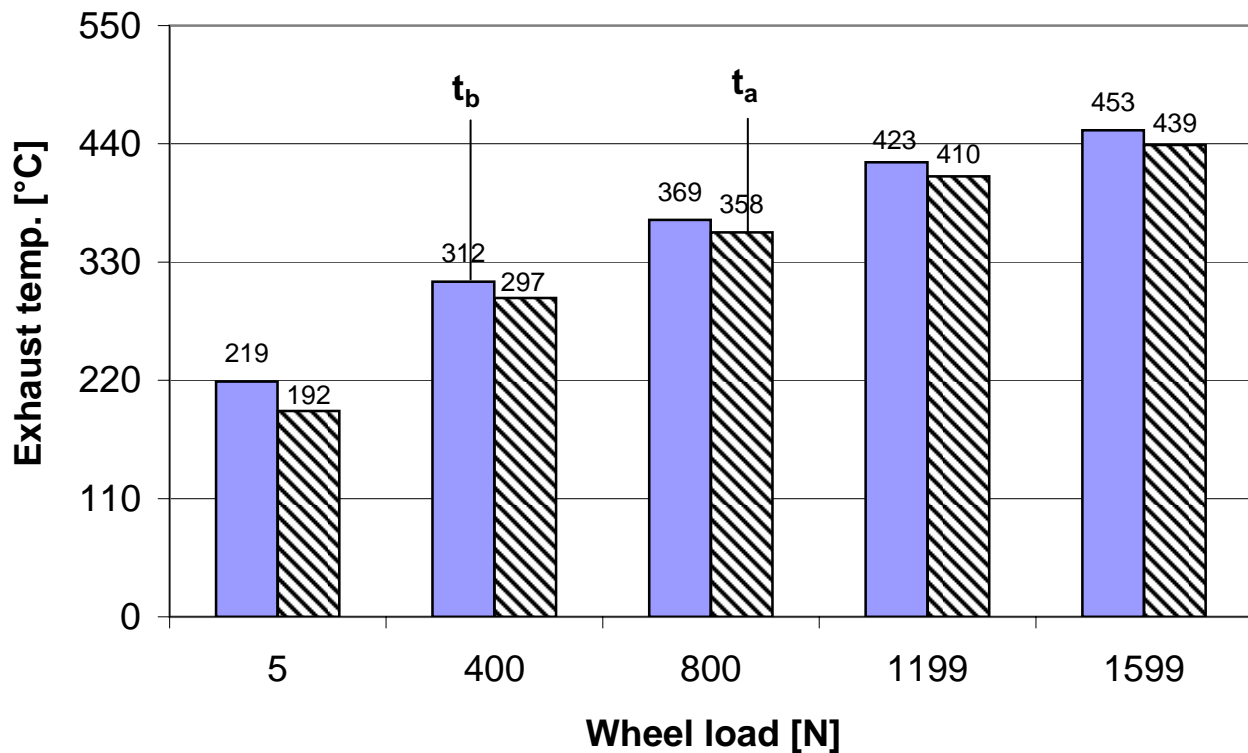
Temperatures before / after TWIN-TEC PMS.

VW Passat 1.9 TDI; low sulfur diesel

Load steps TWIN-TEC 1



Load steps TWIN-TEC 2



Comparison of limited and non limited emissions during different driving cycles

w/o and with TWIN-TEC2-PMS; low sulfur diesel; CO, HC, NOx bag values

VW Passat 1.9 TDI

1st day, w/o

Total cycle values

Cycle	CO	HC	NOx	PM	∫ DC *)	CPC	∫ PAS *)
	[g/km]	[g/km]	[g/km]	[g/km]	[$\mu\text{m}^2/\text{cm}^3$]	[TPN]	[$\mu\text{gEC}/\text{m}^3$]
NEFZ c.	0.209	0.054	0.331	0.032	47354	5.27E+13	13813
NEFZ w.	0.043	0.018	0.325	0.027	42166	4.81E+13	11477

*) ... integral average value

1st day, with TWIN-TEC2 PMS

Cycle	CO	HC	NOx	PM	∫ DC *)	CPC	∫ PAS *)
	[g/km]	[g/km]	[g/km]	[g/km]	[$\mu\text{m}^2/\text{cm}^3$]	[TPN]	[$\mu\text{gEC}/\text{m}^3$]
NEFZ c.	0.268	0.060	0.308	0.018	21120	2.66E+13	5719
NEFZ w.	0.008	0.003	0.311	0.018	25353	2.78E+13	6858

*) ... integral average value

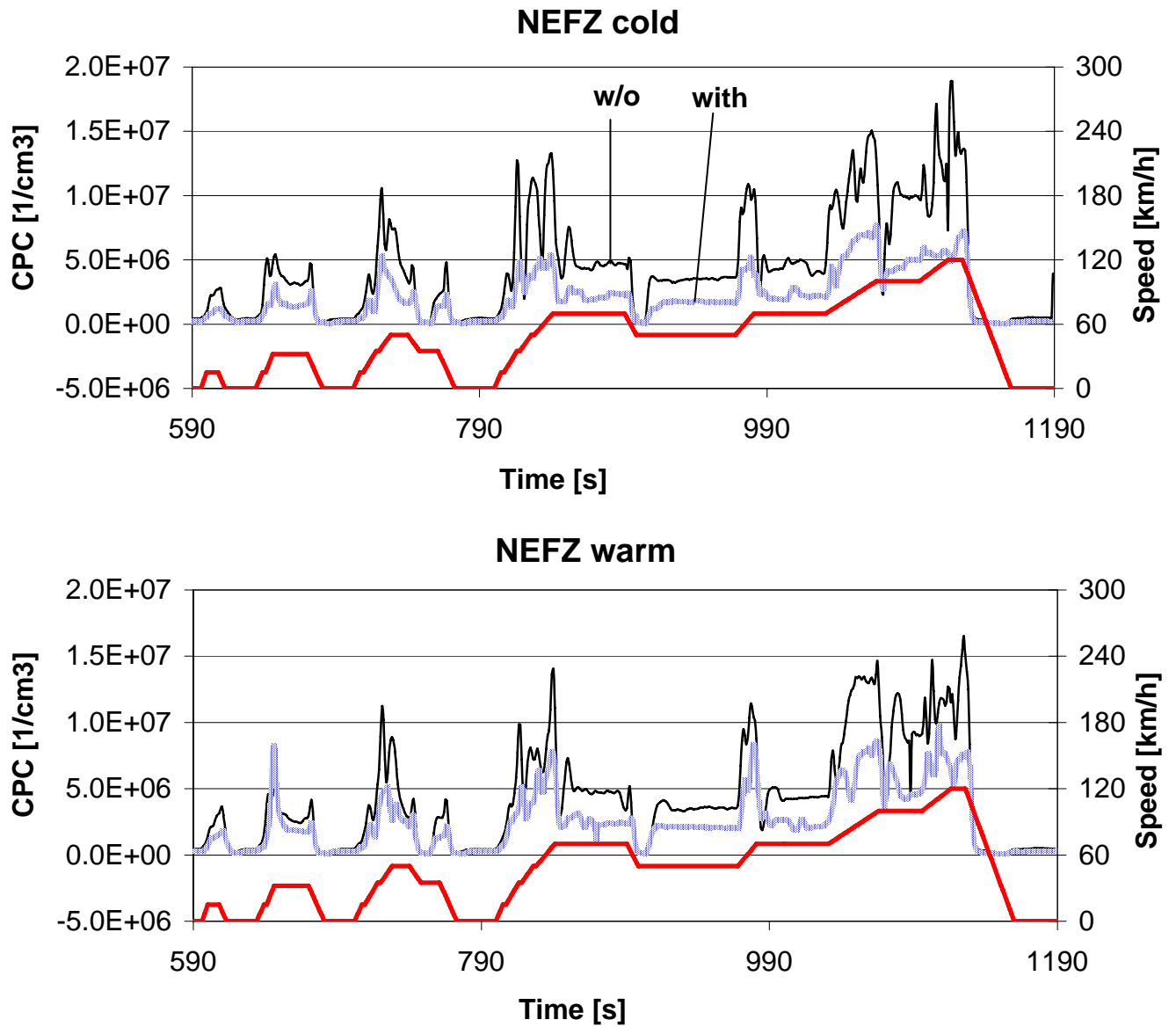
Exhaust emissions conversion rate and filtration efficiency

Cycle	K _{CO}	K _{HC}	K _{NOx}	PMFE	DCFE	CPCFE	PASFE
	[%]	[%]	[%]	[%]	[%]	[%]	[%]
NEFZ c.	-28.2	-11.1	6.9	43.8	55.4	49.6	58.6
NEFZ w.	81.4	83.3	4.3	34.1	39.9	42.2	40.2
AVERAGE	26.6	36.1	5.6	38.9	47.6	45.9	49.4

FE... Filtration efficiency (TWIN-TEC2)

CPC nanoparticle count concentrations in NEFZ driving cycles

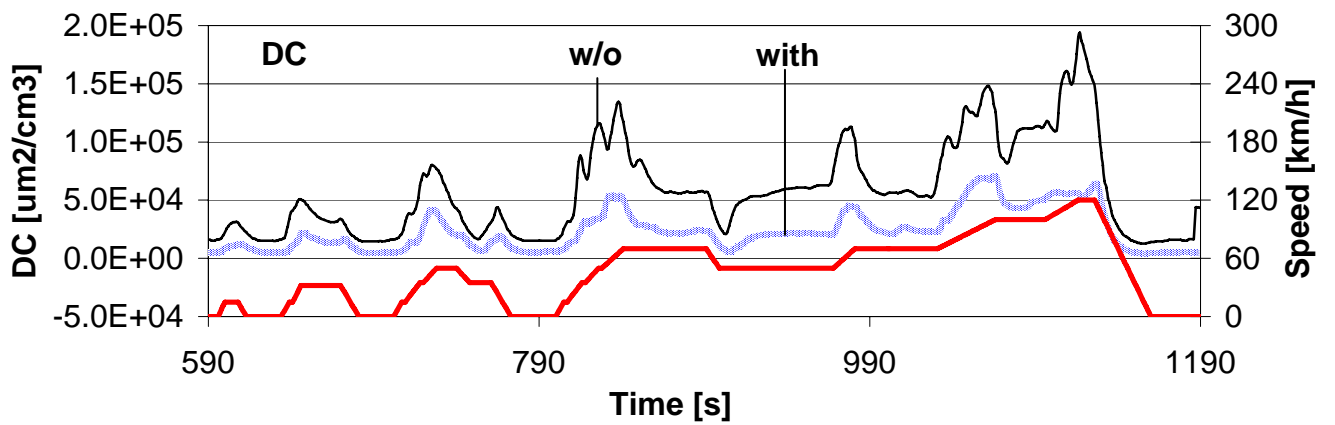
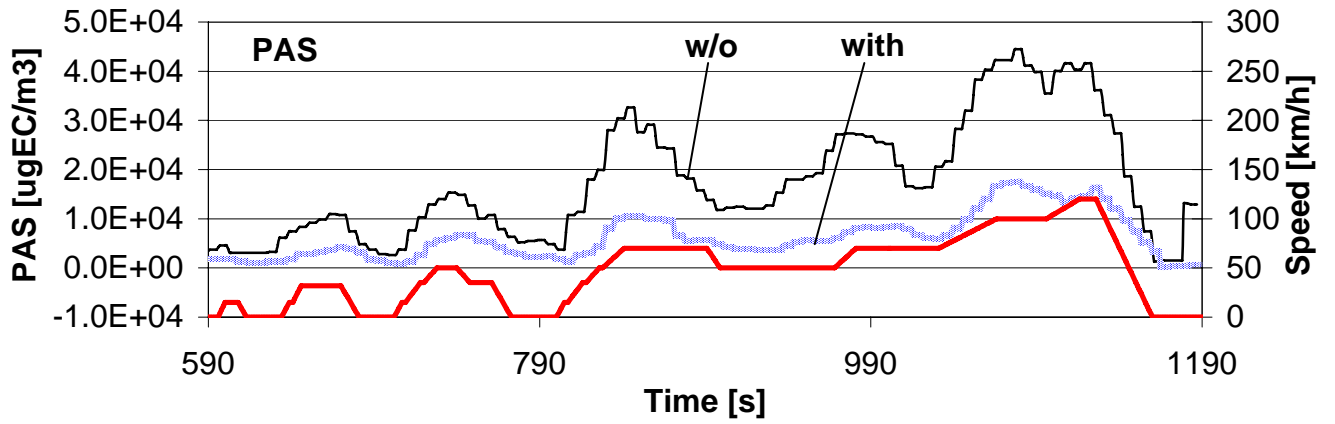
w/o and with TWIN-TEC2-PMS; VW Passat 1.9 TDI; low sulfur diesel



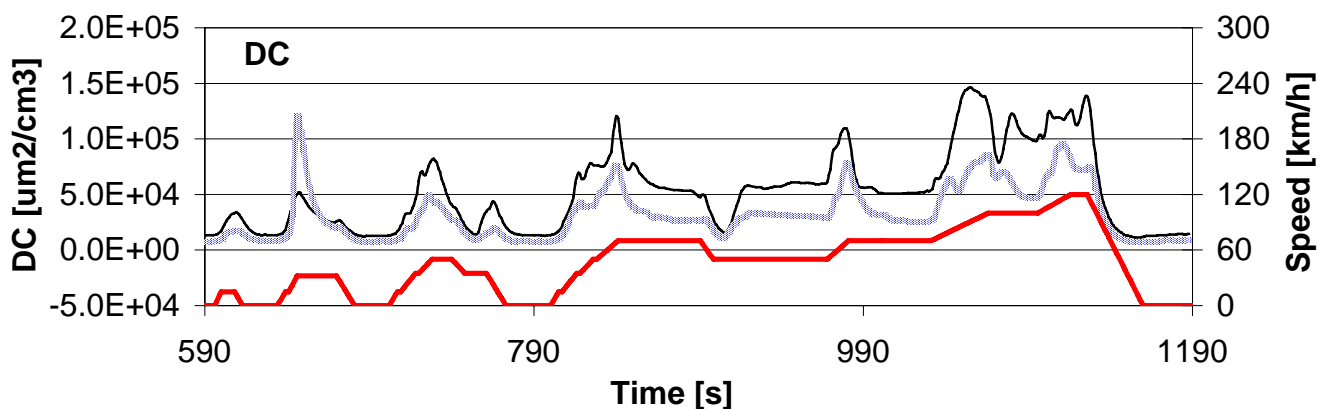
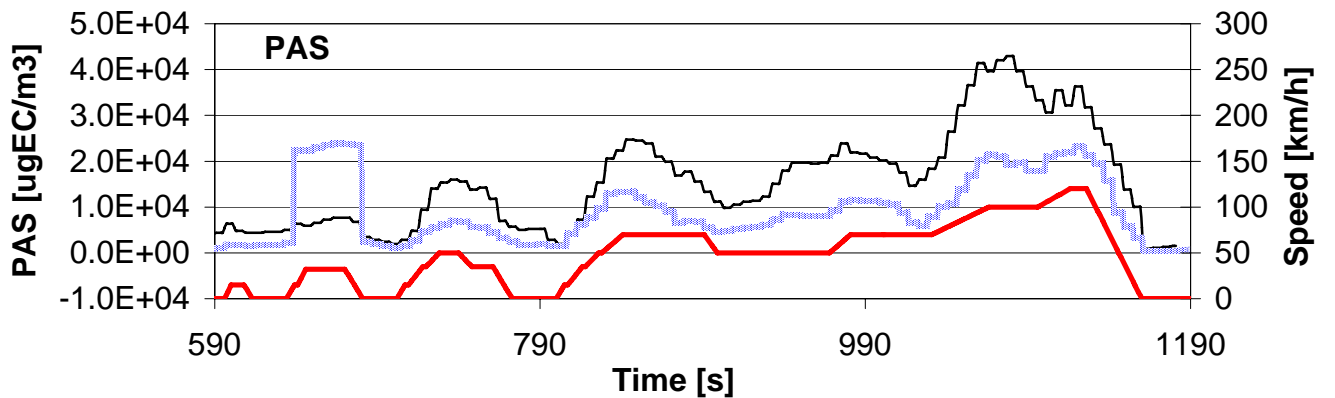
NanoMet signals PAS / DC in NEFZ driving cycles

w/o and with TWIN-TEC2-PMS; VW Passat 1.9 TDI; low sulfur diesel

NEFZ cold



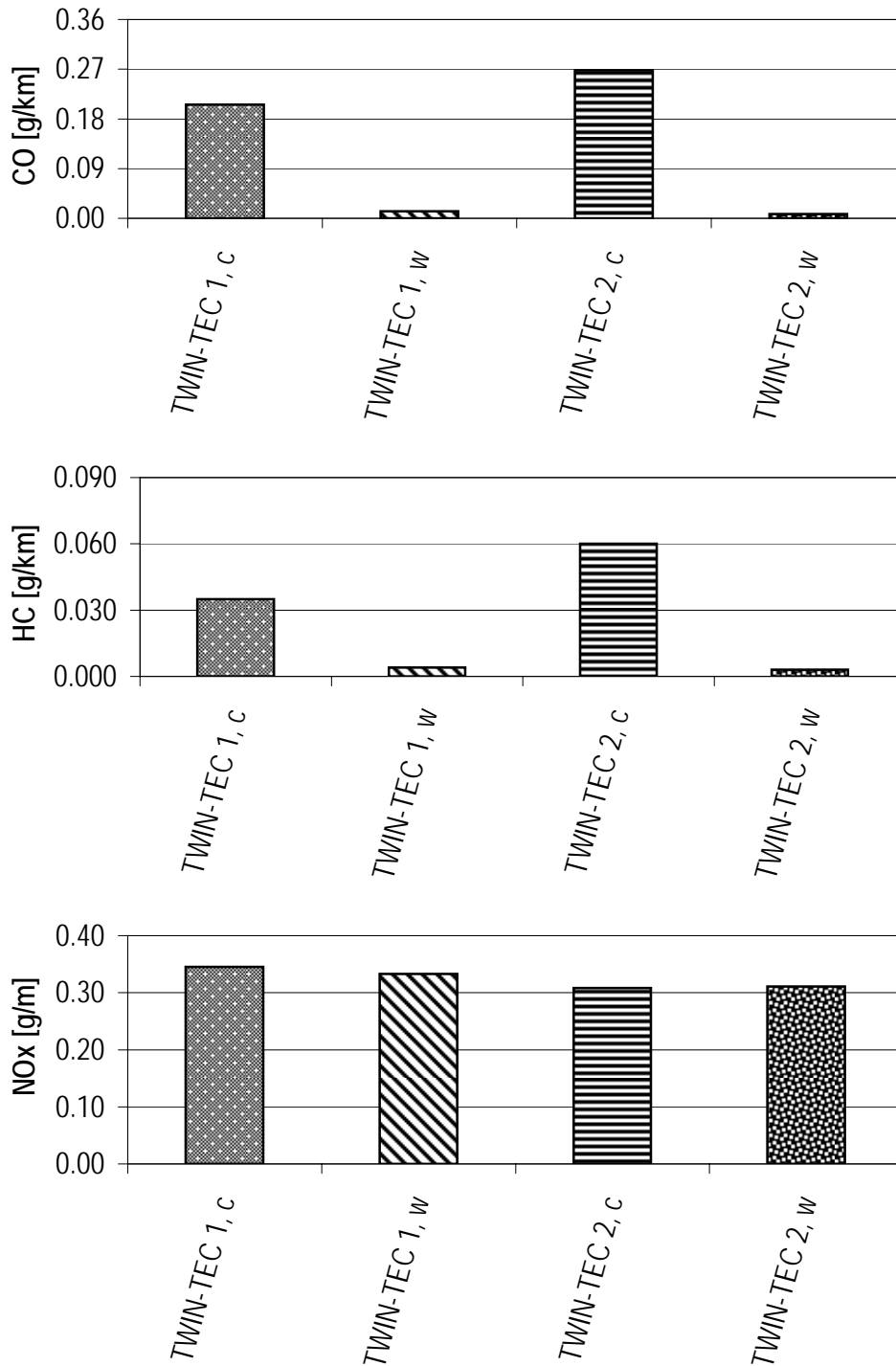
NEFZ warm



Comparison of limited and non limited emissions during the NEFZ driving cycle with engine cold and warm.

with TWIN-TEC-PMS; VW Passat 1.9 TDI; low sulfur diesel

1st day



TWIN-TEC 1, c... TWIN-TEC-PMS from manufacturer, with cold start

TWIN-TEC 1, w... TWIN-TEC-PMS from manufacturer, with engine warm

TWIN-TEC 2, c... TWIN-TEC-PMS from market, with cold start

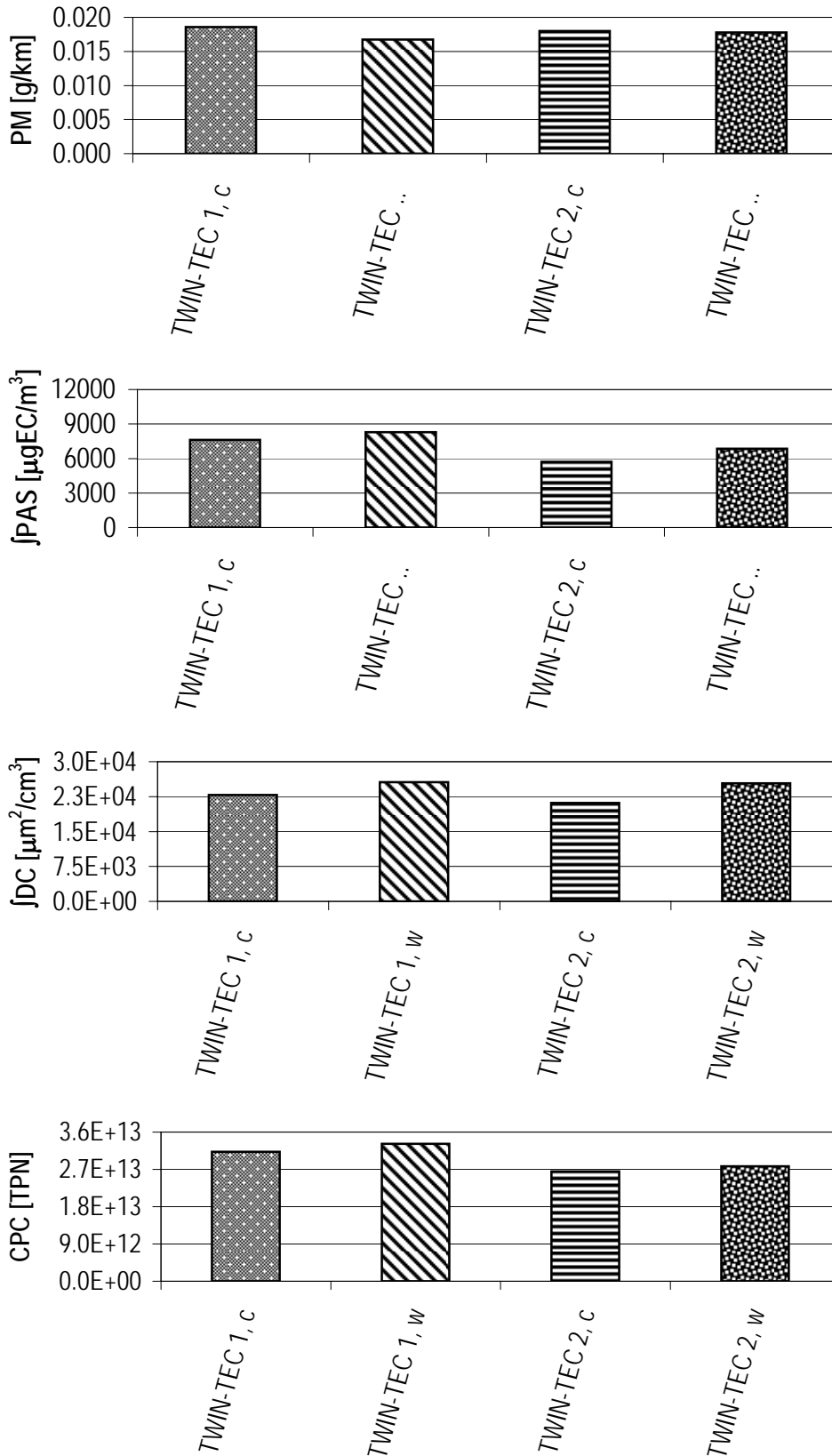
TWIN-TEC 2, w... TWIN-TEC-PMS from market, with engine warm

TPN... Total Particle Number [particle/km]

Comparison of limited and non limited emissions during the NEFZ driving cycle with engine cold and warm.

with TWIN-TEC-PMS; VW Passat 1.9 TDI; low sulfur diesel

1st day



Comparison of limited and non limited emissions during different driving cycles

with TWIN-TEC2-PMS; low sulfur diesel; CO, HC, NOx bag values

VW Passat 1.9 TDI

Total cycle values

Cycle	CO [g/km]	HC [g/km]	NOx [g/km]	PM [g/km]	∫ DC *) [μm ² /cm ³]	CPC [TPN]	∫ PAS *) [μgEC/m ³]
NEFZ c.	0.268	0.060	0.308	0.018	21120	2.66E+13	5719
NEFZ w.	0.008	0.003	0.311	0.018	25353	2.78E+13	6858

*) ... integral average value

Values "phase per phase"

Configuration	Meas- nr										
	CO [g/km]	CO ₂ [g/km]	HC [g/km]	NOx [g/km]	PM [g/km]	Conso [l/100km]	Distance [m]	Vol (CVS) [m ³]	∫ DC *) [μm ² /cm ³]	CPC [TPN]	∫ PAS *) [μgEC/m ³]
NEFZ c.	0.268	160.475	0.060	0.308	0.0180	6.03	11015		21120	2.66E+13	5719
NEFZ, 1st phase	0.717	221.987	0.155	0.320	0.0294	8.38	4050	106.980	17211	3.63E+13	4637
NEFZ, 2nd phase	0.008	124.707	0.005	0.301	0.0113	4.67	6965	54.910	28723	2.09E+13	7823
NEFZ w.	0.008	150.105	0.003	0.311	0.0178	5.63	11060		25353	2.78E+13	6858
NEFZ, 1st phase	0.229	194.755	0.006	0.327	0.0257	7.31	4101	106.250	18985	3.32E+13	5152
NEFZ, 2nd phase	0.006	123.793	0.001	0.302	0.0131	4.64	6959	54.460	37738	2.45E+13	10177

Backpressure with TWIN-TEC 1 / TWIN-TEC 2-PMS

VW Passat 1.9 TDI; low sulfur diesel

Load steps TWIN-TEC 1 / TWIN-TEC 2

