

**BAUMOT** GROUP AG

**NH<sub>3</sub> –GENERATOR (B-NOX):**

AN UPGRADE FOR LDV(PC) AND BUSES

H. Middelman

9th VERT-Forum

15th March 2018, Dübendorf, Switzerland

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TWINTeC BAUMOT GROUP

## NEW SCR TECHNOLOGY:

NH<sub>3</sub> GENERATOR ENABLING ENHANCED NO<sub>x</sub> REDUCTION IN COMBINATION WITH A COMPACT PACKAGE AND VARIANT DIVERSITY

H. Middelmann / W. Dölling

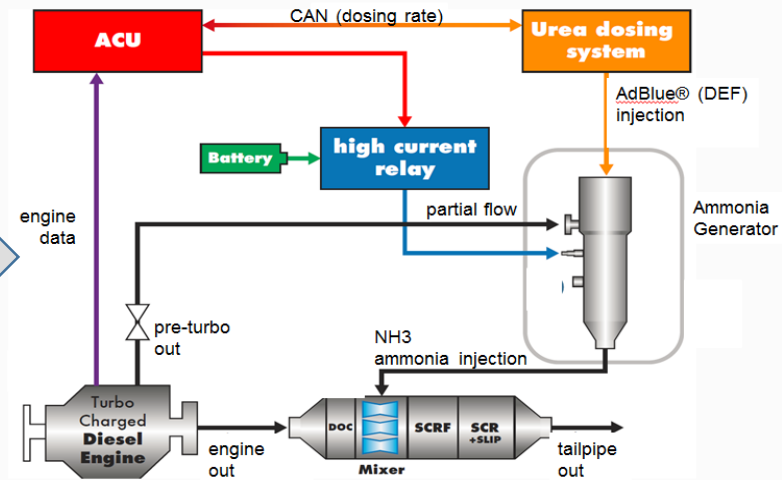
8th VERT-Forum

17th March 2017, Dübendorf, Switzerland

Concept

Results

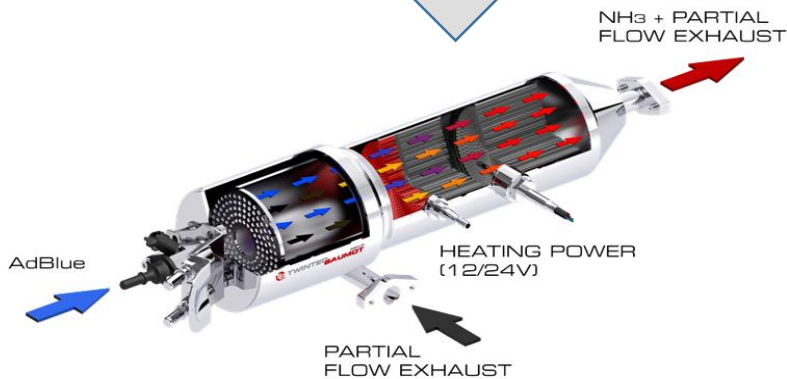
### 1.2 Overview: BNOx System Layout (Configuration: DOC, SCRf, SCR/AOC)



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### 1.3 Functions of the BNOx NH<sub>3</sub>-Generator

B  
N  
O  
x

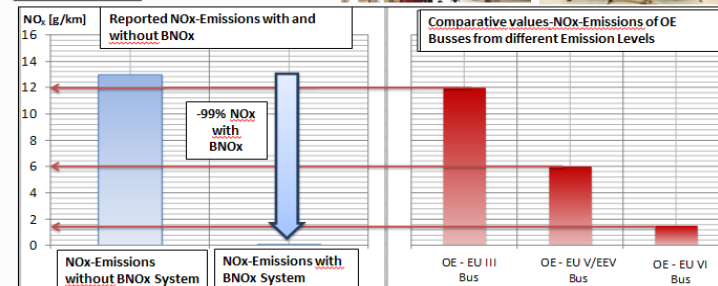


Dosing with traditional Urea/AdBlue®-doser – realtime NH<sub>3</sub> release

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### Referenz 3: international Retrofit program of 24 EU III school busses (UK) with BNOx

Bus Type	Vehixel School Bus / Iveco
Power	176 kW
Capacity	5.8 ltr
Passengers	80
Highest Weight	16 t
Emission Level	Euro III

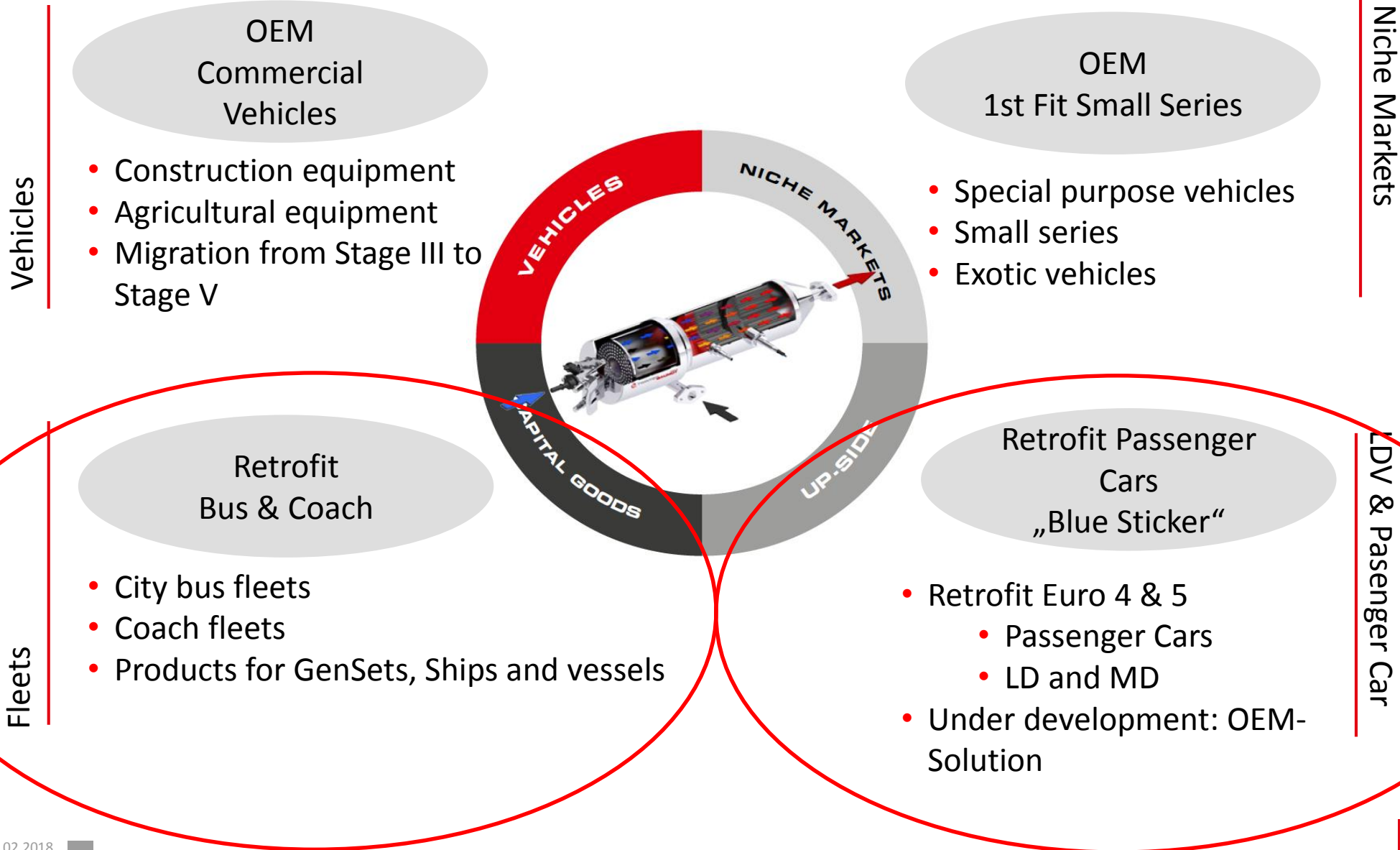


→ BNOx System eliminates NO<sub>x</sub> Emissions to virtually zero

→ reliable through 3 years fleet operation; follow up order received

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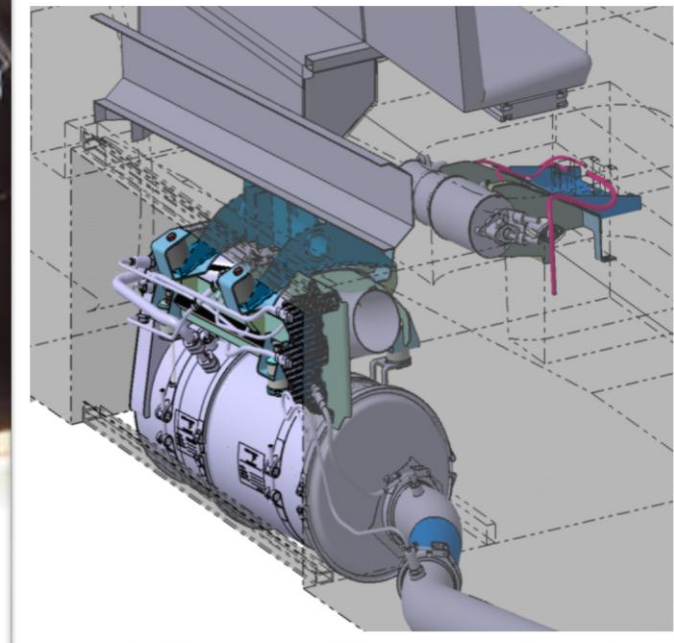
# B-NOX – UPGRADE IN THE DIFFERENT AREA



# PEMS Measurement proves it – SCR BNOx System significantly better than Euro VI

## Results of PEMS-Measurement e.g. University of Landshut, Dr. Ralph Pütz

- Especially in cold-running phase better than OEM Euro VI vehicles
- Space-optimized systems by SCRF solution enable easy series retrofitting
- Proven under standardized test conditions: Real NOx reduction > 98%
- Euro II-V vehicles retrofitted with NOx/PM achieve Euro VI emission levels
- Combination of high and low temperature SCR components ensures performance from 150 ° C exhaust gas temperature
- Retrofit in Cities starting e.g. London & Berlin



# Millbrook CVRAS Emission Test Results – Better Than EURO VI Level



Customer:	Baumot UK Ltd.
Customer Address:	Silverstone Park, Buckingham Road, Towcester, NN12 8FU
Test Purpose:	CRVAS Testing
Vehicle No:	MX12 LWS
Vehicle Type:	ADL E400
Engine:	Cummins ISB6.7
Transmission:	Auto
Fuel Type:	Pump Diesel
Fuel Batch No:	N/A
Millbrook Project No:	PT0323-002-01

• 99,8 % NOx Reduction – Below ULEZ emission requirements

requirements

• Below 3 ppm NH3 Slip – Dosing efficiency

• Below 40 mbar Backpressure – Fuel Consumption

Optimisation

• NO2 Optimised – Durability of catalyst ageing



Customer:	Baumot UK Ltd.
Customer Address:	Silverstone Park, Buckingham Road, Towcester, NN12 8FU
Test Purpose:	CRVAS Testing
Vehicle No:	YY16 YJU
Vehicle Type:	ADL E200
Engine:	Euro 6
Transmission:	Auto
Fuel Type:	Pump Diesel
Fuel Batch No:	N/A
Millbrook Project No:	PT0323-003-01

DYNAMOMETER SETTINGS	
INERTIA	8,982 kg
F°	179.70 N
F <sup>1</sup>	-3.5000 N/kmh
F <sup>2</sup>	0.15008 N/kmh <sup>2</sup>
F <sup>3</sup>	0.0004270 N/kmh <sup>3</sup>

Targets				
	NOx	NO <sub>2</sub>	PM	PN
Units:	g/km	g/km	g/km	g/km
Target	0.5g/km	0.1g/km	10mg/km	6E+11/km
Relative Limit	0.500	0.100	0.010	6.00E+11
Revised LUB	0.064	0.015	0.0034	8.34E+10
Combined result	13%	15%	34%	13.91%
Pass/Fail	Pass	Pass	Pass	Pass

CO <sub>2</sub>	CO <sub>2</sub> eq	NH <sub>3</sub>
g/km	g/km	ppm (Avg)
BAG	Calculated	FTIR
Target	Within +1% of Baseline result (+2% accuracy)	Less than 5% of total CO2 emissions
Relative Limit	758.0	5%
Revised LUB	737.8	2.167
Combined result	2.7%	1.55%
Pass/Fail	Pass	Pass

Targets							
	NOx	NO <sub>2</sub>	PM	PN	CO <sub>2</sub>	CO <sub>2</sub> eq	NH <sub>3</sub>
Units:	g/km	g/km	g/km	g/km	g/km	g/km	ppm (Avg)
Target	0.5g/km	0.1g/km	10mg/km	6E+11/km	Within +1% of Baseline result (+2% accuracy)	Less than 5% of total CO2 emissions	10ppm or lower
Relative Limit	0.500	0.100	0.010	6.00E+11	5%	5%	10.0
Revised LUB	0.134	0.049	0.0064	9.44E+10	1068.1	2.08%	1.163
Combined result	27%	49%	64%	15.74%	2.3%		12%
Pass/Fail	Pass	Pass	Pass	Pass	Pass	Pass	Pass

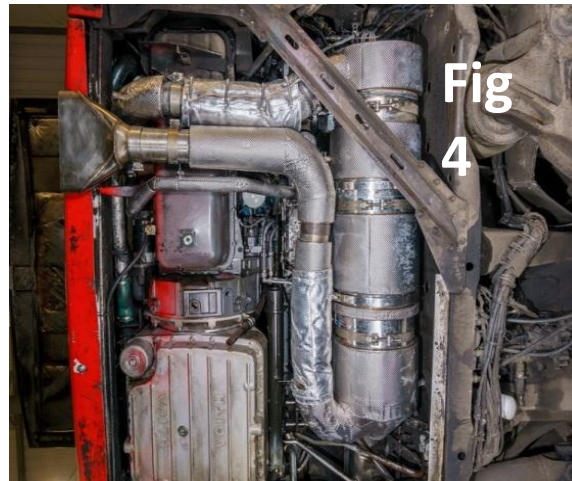
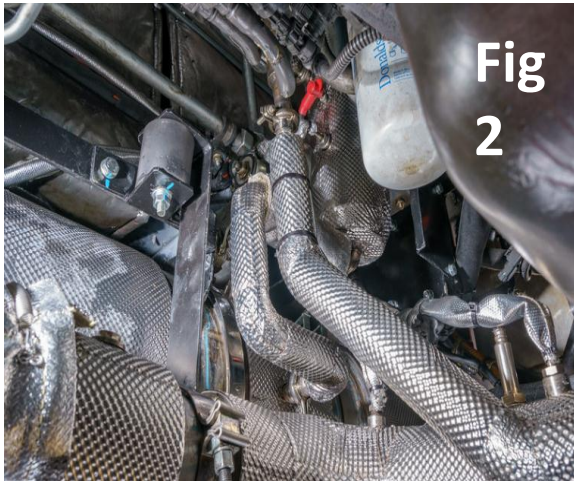
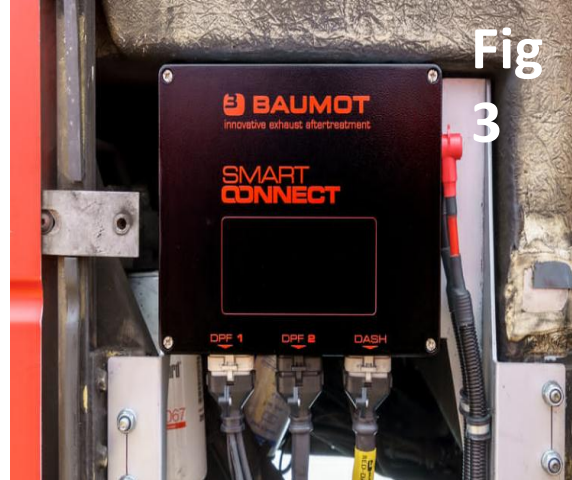
CO2 equivalence factors: CO2 : 1 - N2O : 298 - CH4 : 25,

Compiling Engineer: *M Sims* Date: 11.01.2016 Approving Engineer: *Devis* Date: 16.01.2016

CO2 equivalence factors: CO2 : 1 - N2O : 298 - CH4 : 25,

Compiling Engineer: *M Sims* Date: 12.01.2016 Approving Engineer: *Devis* Date: 15.01.2018

# The BNOx Production Components – OE-Quality for Retrofit



**Fig 1:** High Quality Cable Harness Connection

**Fig 2:** BNOx Vehicle Installation Retrofit Kit

**Fig 3:** Intelligent Power Control / ECU

**Fig 4:** Serial System Layout

# *Retrofit is an Economical Solution*

- Buy new busses for fleet renewal:  
Cost: 250 kGBP / Bus
- Renewal time: 5 – 8 years  
to achieve EU VI (or smaller) emissions for the complete fleet

➔ High cost

➔ Long time to achieve effect

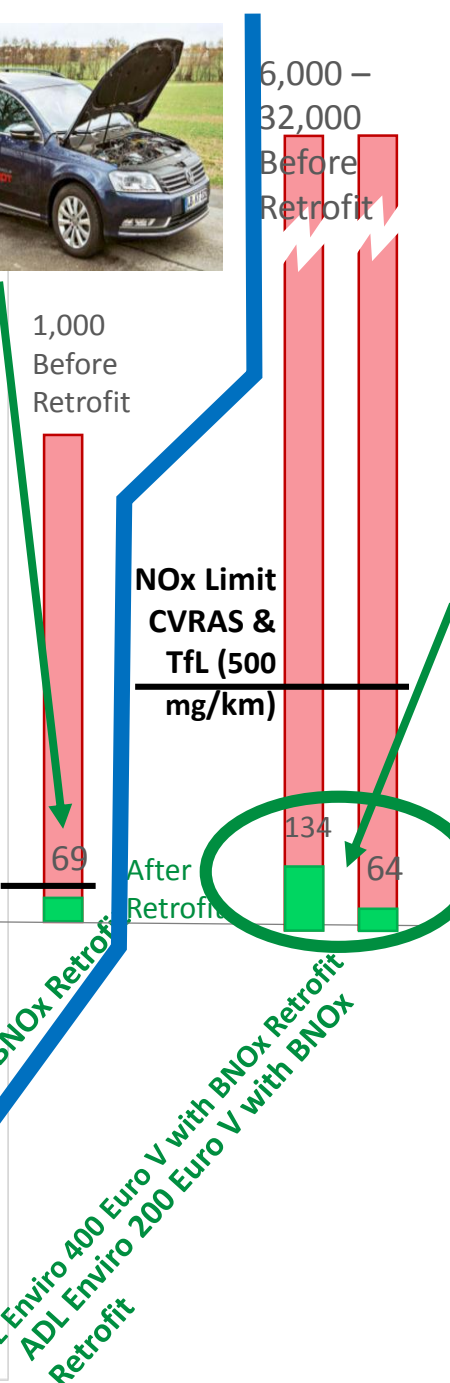
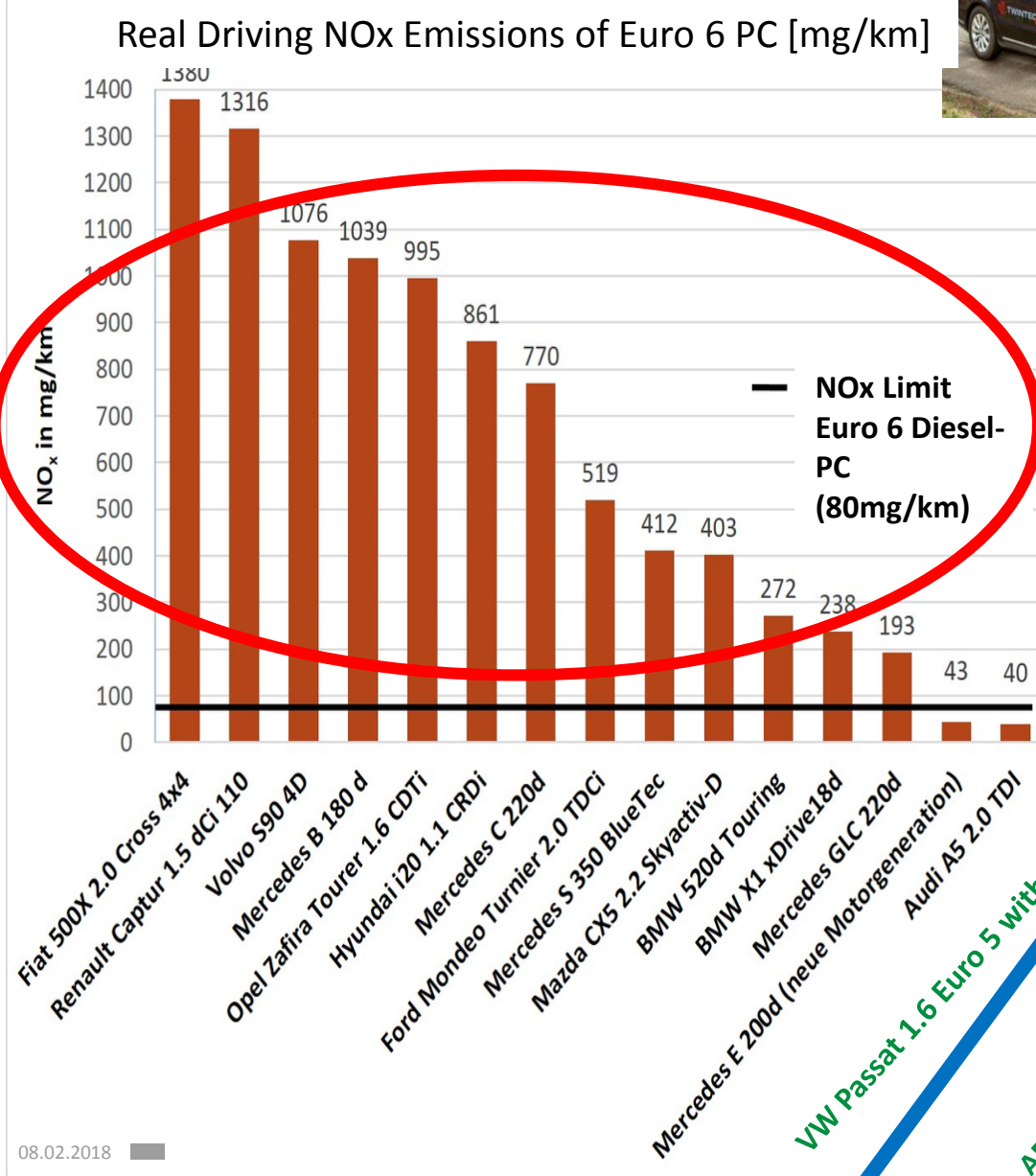
- Retrofit existing fleet w. BNOx:  
Cost: <20 kGBP / Bus
- Renewal time: < 1 year  
to achieve < EU VI emissions for the complete fleet

➔ 12 ... 15 times cheaper

➔ immediate effect on air quality

# How Clean is a Retrofitted Bus with a Baumot BNOx System?

## Passenger Car Emissions



Millbrook CVRAS, TfL MLTB



Bus Emissions After BNOx Retrofit

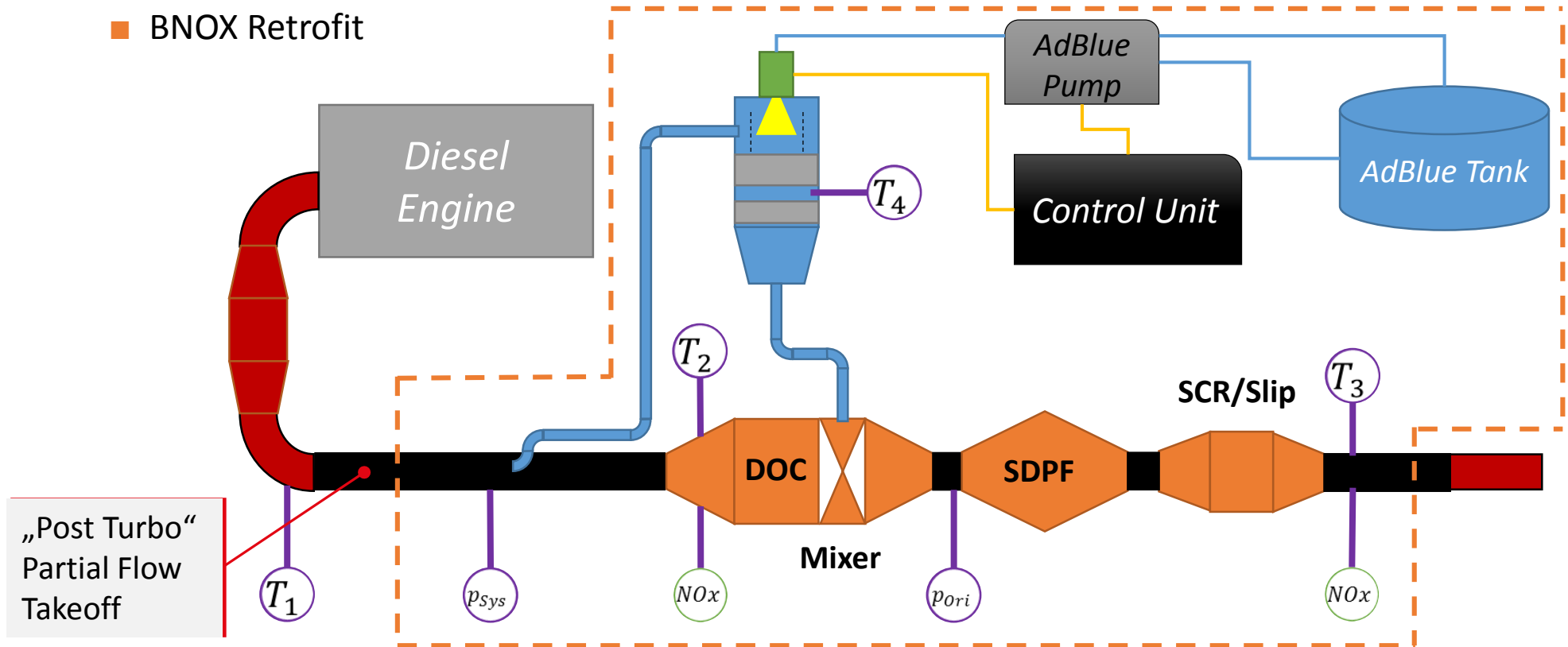
Source: <http://www.duh.de/eki-ergebnisse/>



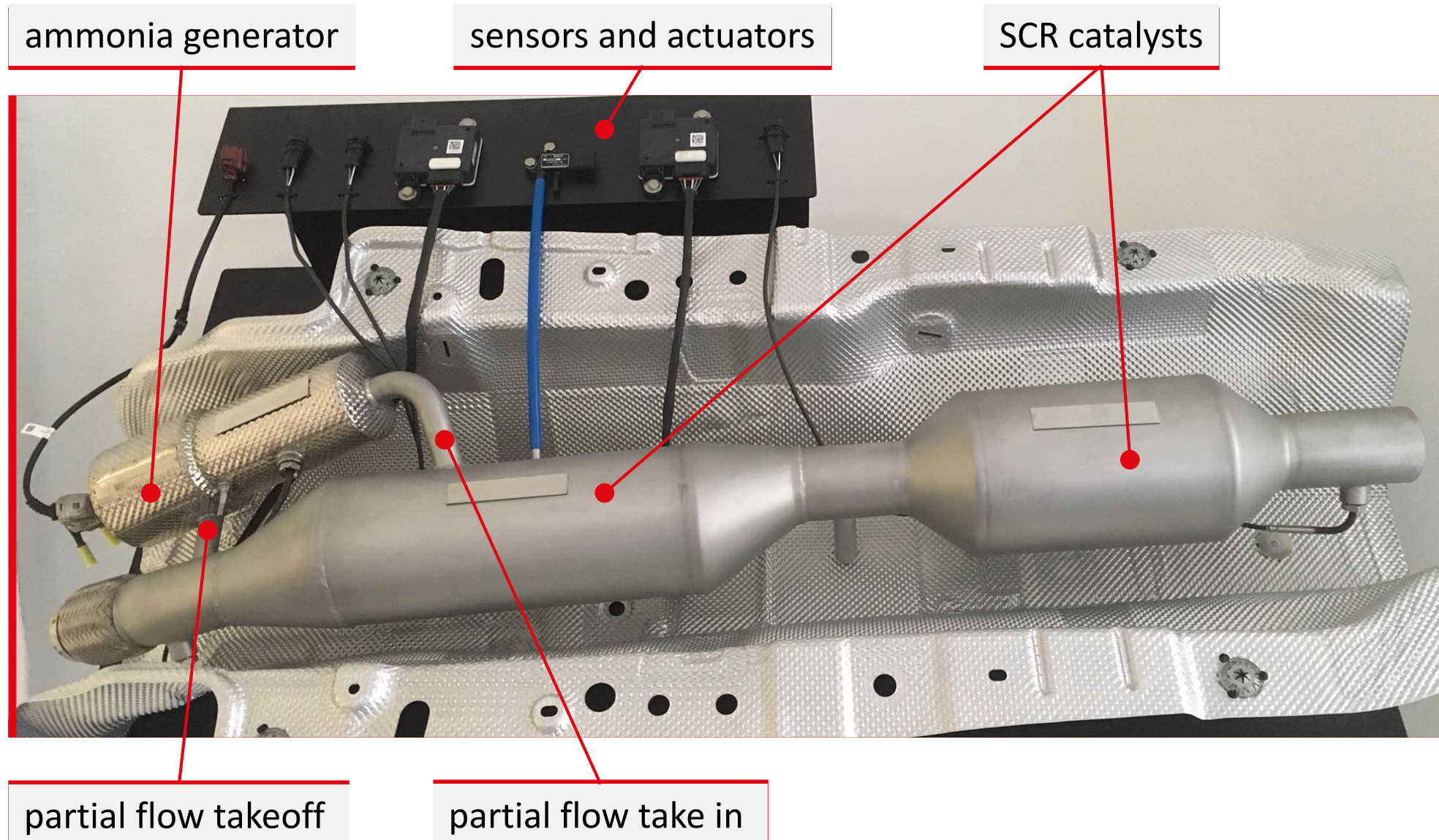
# PASSENGER CAR BNO<sub>x</sub> SYSTEM LAYOUT

- High DeNO<sub>x</sub> activity even at low exhaust temperatures due to direct ammonia dosing
- Retrofit System completely in the underfloor
- Partial flow takeoff for ammonia generation post turbo in front of DOC in the underfloor

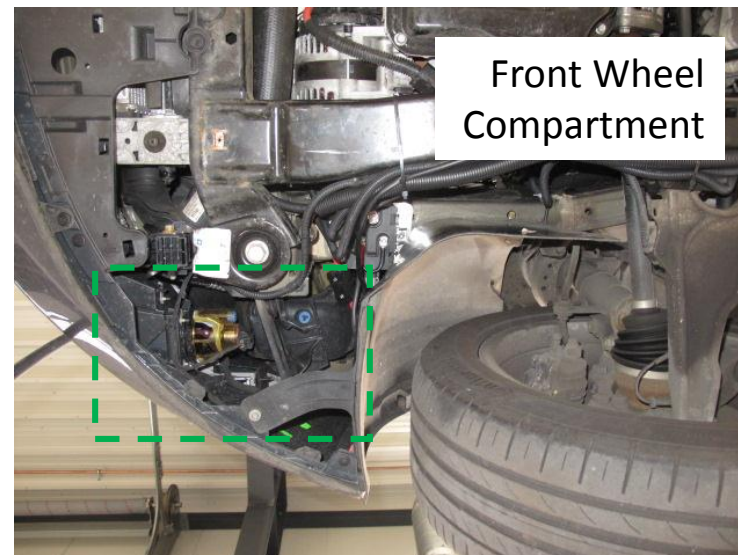
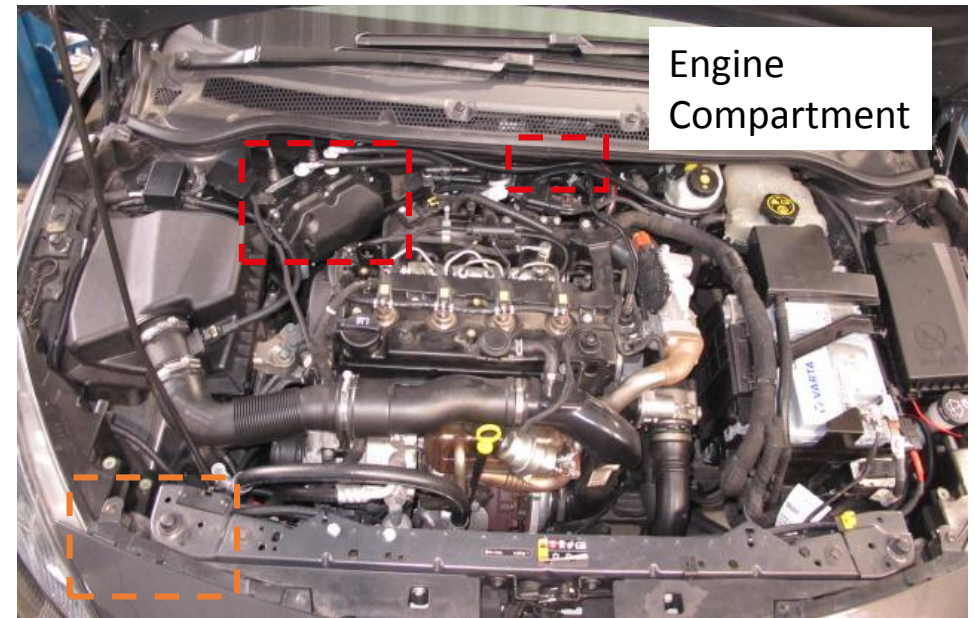
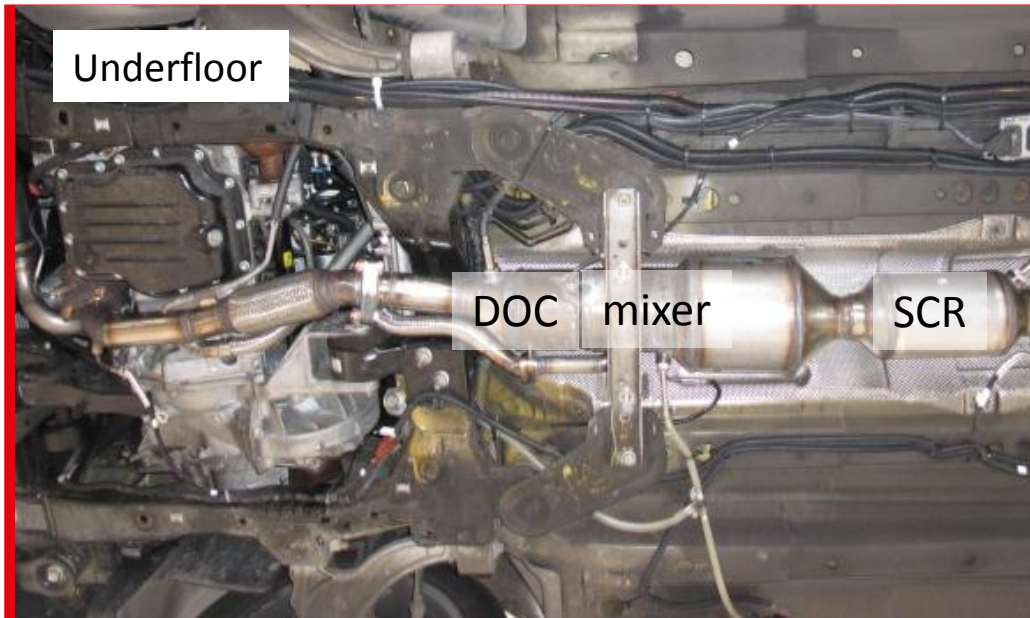
- Original Components
- BNO<sub>x</sub> Retrofit



# PASSENGER CAR **BNO<sub>x</sub>** SYSTEM

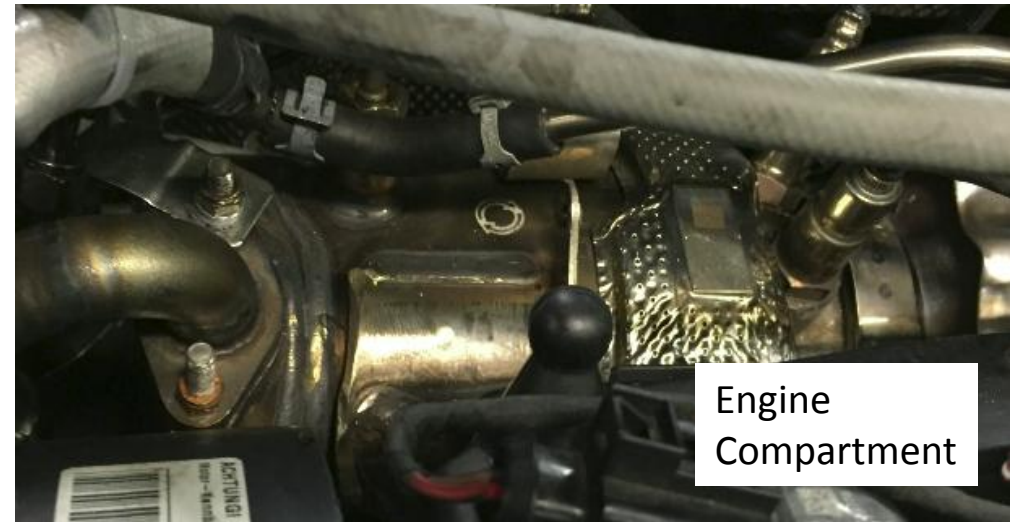


# VEHICLE INTEGRATION OPEL ASTRA

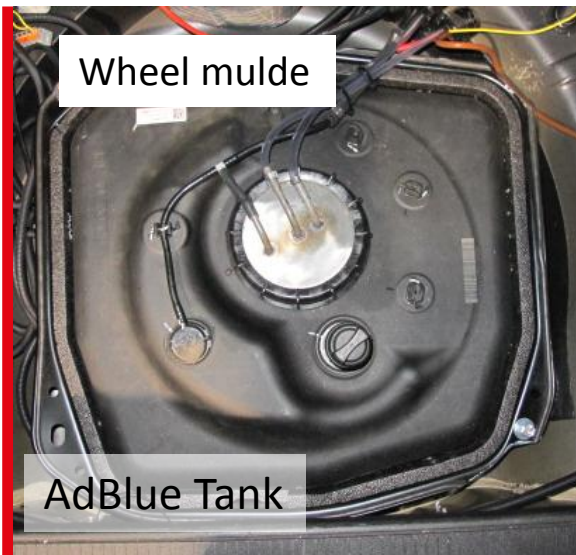


- Dosing Module
- Exhaust Controls

# VEHICLE INTEGRATION **VW PASSAT**

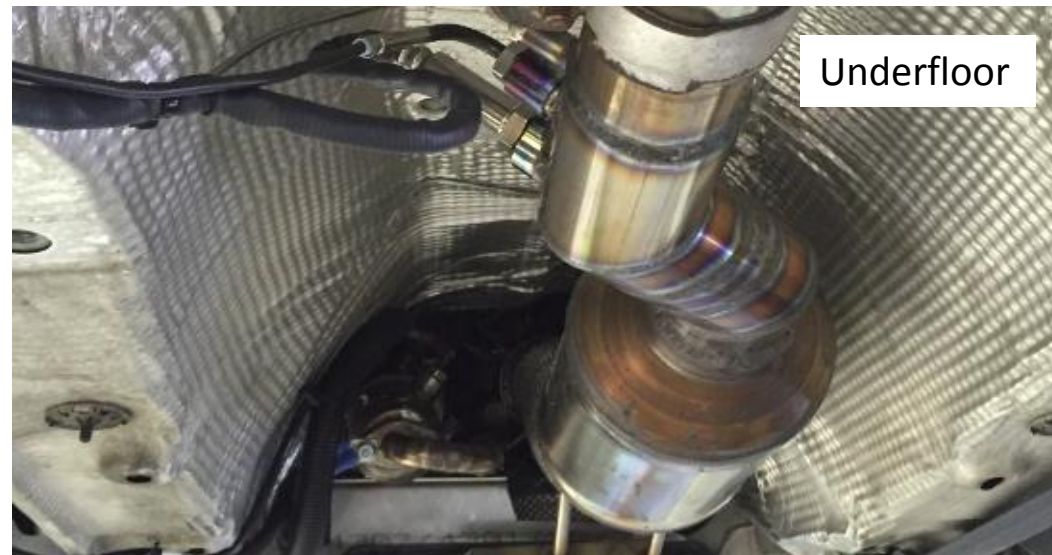


Engine  
Compartment



Wheel mulde

AdBlue Tank

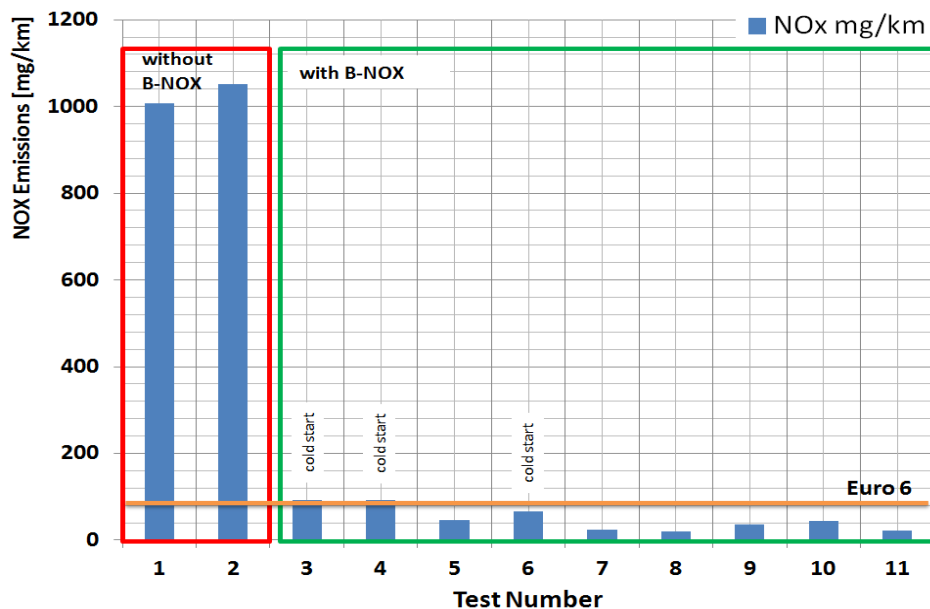


Underfloor

# RDE TESTING RESULTS FOR VW PASSAT AND OPEL ASTRA

(BOTH EURO 5 WITH DOC/DPF RETROFITTED WITH A BNOx SYSTEM)

**DUH Berlin – VW Passat:**

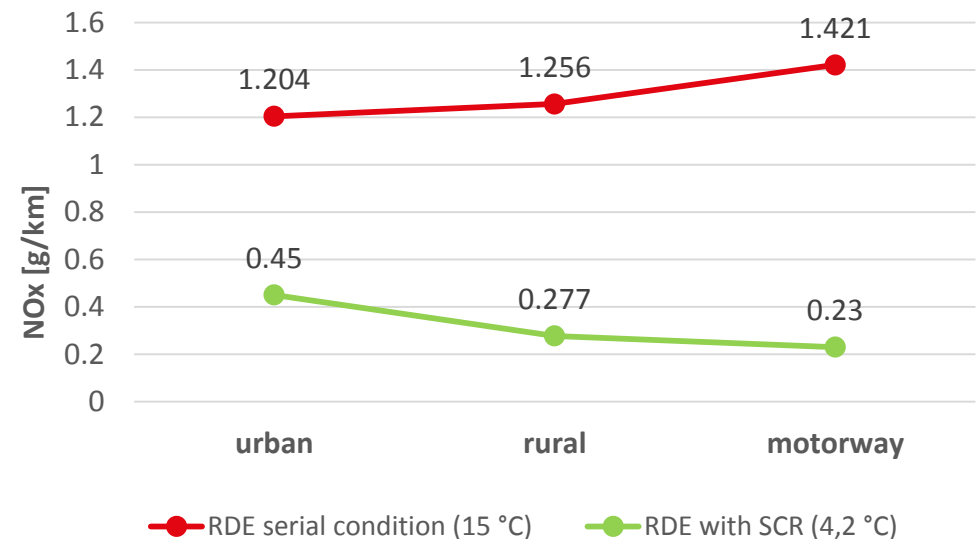


Average NOx in mg/km w/o SCR:  
**1030 mg/km**

Average NOx in mg/km with BNOx:  
**50 mg/km**

**NOx-Reduction: 95,1%**

**ADAC Landsberg - Opel:**



Average NOx in mg/km at 4.2°C w/o SCR:  
**1828 mg/km**

Average NOx in mg/km at 4.2°C with BNOx:  
**320 mg/km**

**NOx-Reduction: 85,1%**

# FTP TESTING RESULTS FOR OPEL ASTRA

(EURO 5 WITH DOC/DPF RETROFITTED WITH A BNOx SYSTEM)

<b>ADAC</b>	Technik Zentrum Landsberg	AADAC_180228_001
<b>8032592</b>	<b>FTP75</b>	<b>A1_180301_001</b>
Prüfkennz. — Auftragsmessung TwinTec FTP75	<b>Berechnungsgrundlagen</b>	CVS-Stufe ———— 9,0 m3/min
Auftraggeber — ADAC	Gesetzgeber ———— EU5	Partikelfluß ———— 35,0 l/min
Abteilung ———— TECHNIKZENTRUM	Bezugstemp. ———— 273,15 K	
Kontierung ———— INTERN	Bezugsdruck ———— 1013,3 mbar	
<b>Fahrzeugdaten</b>		<b>Kraftstoffdaten</b>
Fahrzeugvariante ———— BASIS		Kraftstoffart ———— Diesel EU 2005
Hersteller / Modell ———— OPEL / ASTRA SPORTS TOURER 1.7 CDTI		Batch-Nr. ———— UE10513A53
Getriebe ———— M6		Berechnungsvorschrift ———— DIESEL
Schaltpunktabelle ———— manual-6 / manual-6 / manual-6		Dichte ———— 0,8343 g/cm3
Tachostand (vor Test) ———— 86051 km		Kohlenstoffanteil ———— 86,46 %
Reifendruck ———— 2,3 bar	Fahrgestellnummer	NHV ———— 18552 btu/lb
Reifendimension ————	W0LPD8EK9D8032592	H / O-Anteil ———— 13,54 / 0 %
<b>Prüfstandseinstellungen</b>		<b>weitere Daten</b>
Rollendurchmesser ———— 1219,2 mm		Fahrer ———— MK
Schwungmasse ———— 3,750 lb		Bediener ———— ADAC
LAP-ID / ftd.Nr. ———— BASIS / Homologation, Gewicht nach SMK		AUX-Tabelle ———— OHNE
Prüfstandseinst. F0/F1/F2 ———— -12,200 / -0,22840 / 0,032510		Meßbereichumschaltung ———— DIESEL MODAL57
(N / N/(km/h) / N/(km/h)**2)		Gebläsekennlinie ———— 1
CD Tabelle ————		minimale Öltemperatur ————
		maximale Öltemperatur ————
<b>Freigabetext</b> ————		
Testbem. ————		
Auftraggeber ———— Kaltstart, AC off		
Testoptionen - BAG,CVS,DIESEL_DILMDL,FRONT,,HFID,,PMSAM,,COLDVEH,,		
NEBAG,,BYPASS,,NEDIL,,BYPASS,.....		

Phasenergebnisse										
	HC	CO	CO2	NOx	NO	NO2	NMHC	CH4	Verbrauch	Partikel
	[g/km]	[g/km]	[g/km]	[g/km]	[g/km]	[g/km]	[g/km]	[g/km]	[l/100km]	[g/km]
<b>Phase 1</b>										
<b>Beutel</b>	0,055	0,348	144,338	0,211	0,127	0,016			5,51	
<b>Modal</b>	0,055	0,339	144,496	0,211	0,131	0,039			5,51	
<b>Phase 2</b>										
<b>Beutel</b>	0,019	0,020	150,546	0,011	0,006	0,001			5,72	
<b>Modal</b>	0,018	0,020	153,405	0,010	0,006	0,003			5,83	
<b>Phase 3</b>										
<b>Beutel</b>	0,012	0,017	123,926	0,057	0,034	0,004			4,71	
<b>Modal</b>	0,012	0,017	125,777	0,056	0,035	0,014			4,78	
<b>Beutel</b>										
<b>Modal</b>										
<b>Grenzwert</b>	[g/km]	[g/km]		[g/km]			[g/km]	[g/km]		[g/km]
<b>EU5DI</b>		0,50		0,08						0,0045
<b>Ergebnis % des Grenzwertes:</b>		17,44		80,88						3,17
<b>Gesamtergebnisse</b>										
<b>Beutel</b>	0,025	0,087	141,94	0,085	0,039	0,005		0,089	5,40	0,0001
	0,02453	0,08718	141,93954	0,06470	0,03889	0,00494		NMHC+NOx		
<b>verdünnt</b>										
<b>Modal</b>	0,024	0,085	143,97	0,084	0,040	0,013		0,088	5,47	
								NMHC+NOx		
<b>Ablaufzeiten</b>										
Testbeginn	10:17:47	Uhr	Start Fahrkurve	10:31:37						Uhr
Testende	11:21:57	Uhr	Ende Fahrkurve	11:12:26						Uhr
									Testdatum	01.03.2018

# FTP TESTING RESULTS FOR VW PASSAT (EURO 5 WITH DOC/DPF RETROFITTED WITH A BNOx SYSTEM)

<b>ADAC</b>	Technik Zentrum Landsberg	AADAC_180228_002
...120388	<b>FTP75</b>	A1_180301_000
PrüfKennz. — Auftragsmessung TwinTec FTP75	<b>Berechnungsgrundlagen</b>	CVS-Stufe ————— 9,0 m3/min
Auftraggeber — ADAC	Gesetzgeber ———— EU5	Partikelfluß ————— 30,0 l/min
Abteilung ——— TECHNIKZENTRUM	Bezugstemp. ———— 273,15 K	
Kontierung ——— INTERN	Bezugsdruck ———— 1013,3 mbar	
<b>Fahrzeugdaten</b>		<b>Kraftstoffdaten</b>
Fahrzeugvariante ——— BASIS		Kraftstoffart ————— Diesel EU 2005
Hersteller / Modell ——— VW / PASSAT VARIANT 1.6 TDI		Batch-Nr. ————— UE10513A53
Getriebe ————— M6		Berechnungsvorschrift — DIESEL
Schaltpunktabelle ——— manual-6 / manual-6 / manual-6		Dichte ————— 0,8343 g/cm3
Tachostand (vor Test) ——— 45204 km		Kohlenstoffanteil ——— 86,46 %
Relfendruck ————— 2,2 bar	Fahrgestellnummer	NHV ————— 18552 btu/lb
Relfendimension —————	WWZZZ3CZEE120388	H / O-Anteil ————— 13,54 / 0 %
<b>Prüfstandseinstellungen</b>		<b>weitere Daten</b>
Rolldurchmesser ———— 1219,2 mm		Fahrer ————— MK
Schwungmasse ————— 3,875 lb		Bediener ————— ADAC
LAP-ID / lfd.Nr. ——— BASIS / Homologation, SMKL 3875 lbs FT		AUX-Tabelle ————— OHNE
Prüfstandseinst. F0/F1/F2 — 46,740 / -0,24120 / 0,026370		Meßbereichumschaltung DIESEL MODAL5
CD Tabelle —————	(N / Ni(km/h) / Ni(km/h)**2)	Gebläsekenlinie ————— 1
<b>Freigabetext</b> —		minimale Öltemperatur —
Testbem. —————		maximale Öltemperatur —
Auftraggeber — Kaltstart, AC off		
Testoptionen - BAG,CVS,DIESEL,DLM01,.....,FRONT,,HFID,,FMSAM,,COLDVEH,....		
NEBAG,,NOCERT,,NEDIL,,BYPASS,.....		

Phasenergebnisse										
	HC	CO	CO2	NOx	NO	NO2	NMHC	CH4	Verbrauch	Partikel
	[g/km]	[g/km]	[g/km]	[g/km]	[g/km]	[g/km]	[g/km]	[g/km]	[l/100km]	[g/km]
<b>Phase 1</b>										
<b>Beutel</b>	0,021	0,506	144,133	0,208	0,122	0,021			5,50	
<b>Modal</b>	0,019	0,486	144,445	0,202	0,126	0,034			5,51	
<b>Phase 2</b>										
<b>Beutel</b>	0,007	0,024	147,358	0,027	0,016	0,003			5,60	
<b>Modal</b>	0,005	0,023	149,877	0,026	0,016	0,007			5,69	
<b>Phase 3</b>										
<b>Beutel</b>	0,007	0,090	134,527	0,090	0,055	0,006			5,11	
<b>Modal</b>	0,007	0,085	136,991	0,091	0,057	0,018			5,21	
<b>Beutel</b>										
<b>Modal</b>										
<b>Grenzwert</b>	[g/km]	[g/km]		[g/km]			[g/km]	[g/km]		[g/km]
<b>EU6DI</b>		0,50		0,08						0,0045
<b>Ergebnis % des Grenzwertes</b>		28,38		102,01						

Gesamtergebnisse										
	HC	CO	CO2	NOx	NO	NO2	NMHC	HC + NOx	Verbrauch	Partikel
	[g/km]	[g/km]	[g/km]	[g/km]	[g/km]	[g/km]	[g/km]	[g/km]	[l/100km]	[g/km]
<b>Beutel</b>	0,010	0,142	143,15	0,082	0,048	0,007		0,091	5,44	
	0,00979	0,14192	143,15121	0,08161	0,04824	0,00750		NMHC+NOx		
<b>verdünnt</b>										
<b>Modal</b>	0,009	0,136	145,20	0,080	0,050	0,016		0,089	5,52	
								NMHC+NOx		

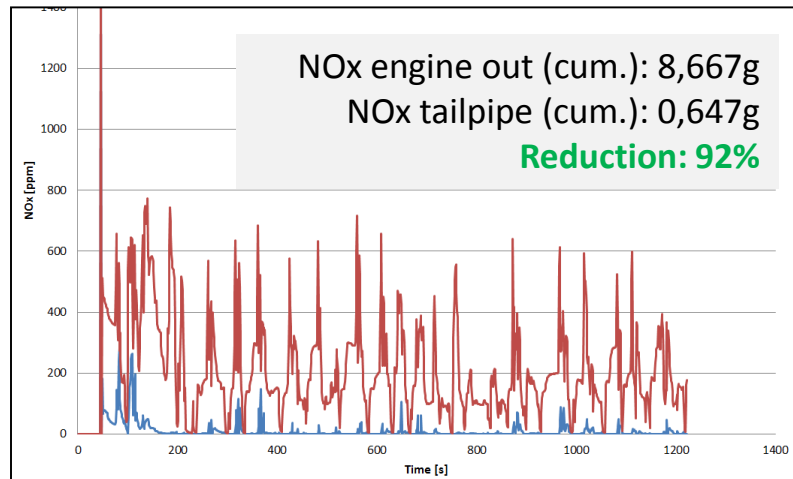
  

Ablaufzeiten										
Testbeginn	08:44:12	Uhr	Start Fahrkurve	09:00:06	Uhr	Testdatum	01.03.2018			
Testende	09:59:06	Uhr	Ende Fahrkurve	09:43:53	Uhr					

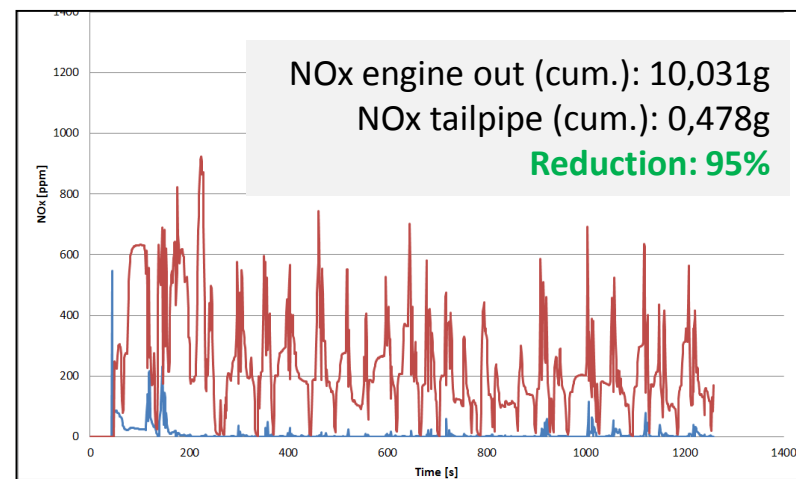
# FTP TESTING RESULTS **VW PASSAT** WITH DENOX PERFORMANCE

(EURO 5 WITH DOC/DPF RETROFITTED WITH A BNOx SYSTEM)

VW PASSAT PRE-CONDITIONING 1

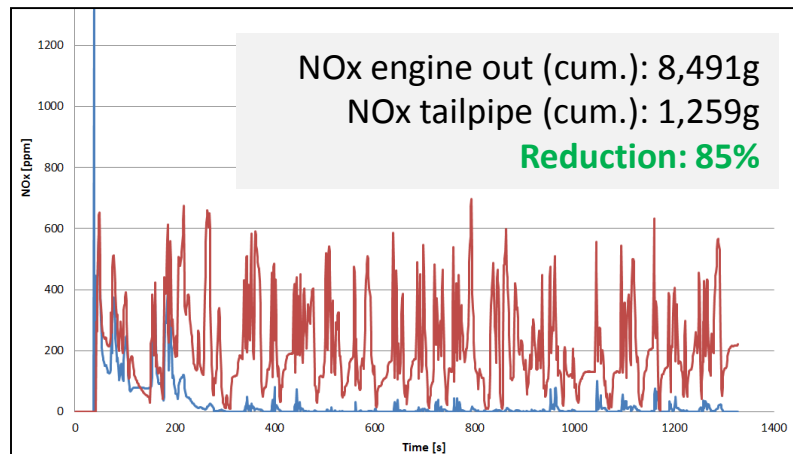


VW PASSAT PRE-CONDITIONING 2

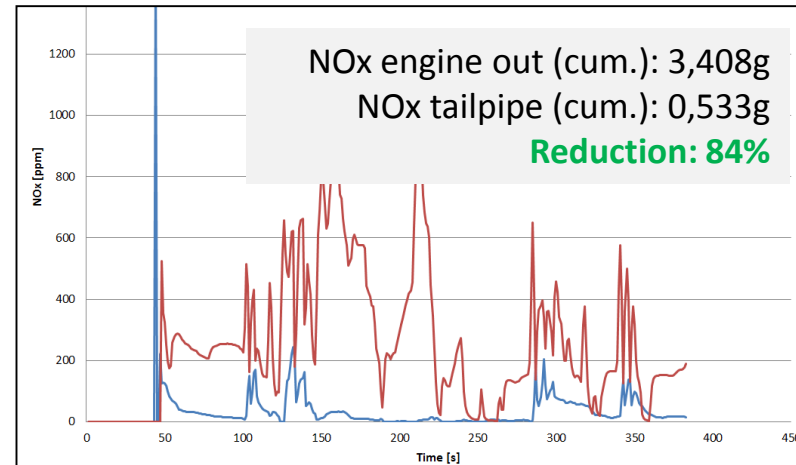


- NOx engine out
- NOx tailpipe

VW PASSAT FTP 75 PART 1



VW PASSAT FTP 75 PART 2





# Summary – Baumot BNOx

- **Retrofit solutions available now**
- **Use of standard AdBlue (no cartridges)**
- **Achieve EU VI emission level**
- **TfL MLTB & CVRAS approved**
- **Better than EU VI and most EU 6 PC's**
- **Cleanest Transportation Method**
- **High efficiency at low temperature for best inner city performance**
- **Cost effective**
- **Full warranty and OE Quality**
- **Short implementation time**