



Emissions test report

11 December 2018
Nick Molden

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Executive summary

This project was initiated to measure the emission benefits of Diesel+ when added to standard market diesel.

There was a significant reduction in PN of 59% when the Diesel+ additive was applied. There was also a substantial decrease in CO of 11%.

However, an average carbon dioxide emissions penalty of 4.2% was identified. In addition, there was a significant increase in nitrogen oxide emissions of 60% following the application of the additive.

Objectives

Emissions Analytics conducted on-road tests of a Mercedes Benz C220 diesel, to determine the real-world emissions before and after the deployment of Diesel+, Malcan Greentec's multifunctional diesel additive.

A PEMS system was used to collect real world emissions data for the following gasses:

- CO₂
- CO
- NO_x
- NO
- NO₂
- PN

The requirements for this project were defined as:

- One Euro 4 diesel car
- Real-world test route around Stokenchurch, Buckinghamshire, UK
- Using Emissions Analytics' SEMTECH-LDV
- Emissions Analytics to supply the vehicle and apply the additive as per the specifications
- Emissions Analytics to analyse data and present significance tests

The tests were successfully completed between 4 and 7 December.

Further details can be located at: <https://www.malcan-greentec.de/>

Test vehicle

Make	Model	VIN	Vehicle Registration	Mark	Model Year (VRM)
Mercedes-Benz	C Class	WDB203208ZF754751	KN55 DKU		2005

Fuel	Engine (litres)	size	Drivetrain	Power (PS)	Euro stage
Diesel	2.1		RWD	148	4

Derivative	Driving Setting
C220 Avantgarde SE	Normal

Front tyres	Rear Tyres
Powertrac City Racing	Accelera PH1-R

Methodology

Malcan Greentec's Diesel+ is a multifunctional additive which has been designed for use in all diesel trucks, buses and passenger vehicles to increase the cetane number, the indicator of the combustion speed of diesel fuel and the compression required for ignition. Diesel+ was designed to aid cleaning of the nozzles and injection line and reduce emissions.

The test cycle was made up of extra urban, rural and urban elements, which were each repeated up to 8 times in both baseline and experimental states.

The extra-urban cycle was 15.4 minutes in duration over 26.4 km at an average speed of 101 km/h. The urban cycle was 8.2 minutes in duration over 3.9 km at an average speed of 29 km/h. The rural cycle was 14 minutes over 13.0 km at an average speed of 56 km/h.

The vehicle was fuelled with standard forecourt EN590 diesel. The following formula for adding in Diesel+ was applied: 40ml Diesel+ per 10 litres of diesel, thereafter 280ml of Diesel+ was used for the test vehicle's 70 litre fuel tank.

Prior to testing, the following mileage accumulation was concluded. The first tank was run for 702 km with 280ml of Diesel+ additive. The second tank, also with 280ml of Diesel+, was driven for 497 km which left just over a quarter of a tank of fuel remaining.

Test cycle

The test cycle was made up of urban, rural and motorway elements, which were each repeated multiple times. The number of valid repeats was as follows:

	Baseline	Test 1	Test 2	Test 3	Total
Extra Urban	8	8	8	8	32
Rural	8	8	8	8	32
Urban	8	8	8	8	32

The combined “RDE” cycle is made up of an equal weighting by distance of the urban, rural and motorway elements.

Test routes



Equipment

Test equipment was the Sensors SEMTECH-LDV for gaseous emissions. Ambient conditions were measured with a weather station recording temperature, pressure and humidity. The flow tube was mounted on the exterior of the vehicle at the end of the tailpipe.

The SEMTECH-LDV, is Sensors' 5th generation PEMS. The system directly addresses the challenges created by the RDE-LDV standards recently promulgated by the European Union, which require that passenger cars be tested under real world conditions as part of the certification process. Further details can be found at: www.sensors-inc.com/



Equipment calibration

At the start and end of each cycle of tests the gaseous measurement equipment had a span and zero calibration performed, the former against calibration gas bottles of traceable provenance, and the latter on ambient air. The equipment specifications are show in Appendix 1.

The equipment also had current certificates of calibration compliance, for the linearity of the analyser and flow tube, from Sensors, Inc. Details can be found in Appendix 2.

In the following tables, a statistically significant change where the performance with the additive is better than without is shaded in green, whereas a worse performance with the additive is shaded in red.

Analysis

CO2 and CO

	CO ₂ g/km	CO g/km
Fuel A		
Urban	260.0	0.004
Rural	202.7	0.018
Extra Urban	184.1	0.002
Combined	215.6	0.008
Fuel B		
Urban	281.0	0.006
Rural	203.5	0.014
Extra Urban	189.3	0.001
Combined	224.6	0.007
Change – Fuel A vs Fuel B		
Urban	8.1%	47.4%
Rural	0.4%	-22.2%
Extra Urban	2.8%	-35.0%
Combined	4.2%	-11.1%
Statistical significance		
Urban	94.9%	84.6%
Rural	22.0%	95.7%
Extra Urban	99.2%	97.2%

NO, NO₂, NO_x

	NO g/km	NO ₂ g/km	NO _x g/km
Fuel A			
Urban	0.300	0.469	0.769
Rural	0.322	0.368	0.690
Extra Urban	0.230	0.248	0.479
Combined	0.284	0.362	0.646
Fuel B			
Urban	0.752	0.967	1.719
Rural	0.372	0.430	0.803
Extra Urban	0.283	0.297	0.579
Combined	0.469	0.565	1.034
Change – Fuel A vs Fuel B			
Urban	151.1%	105.9%	123.5%
Rural	15.7%	17.0%	16.4%
Extra Urban	22.7%	19.6%	21.1%
Combined	65.2%	56.0%	60.1%
Statistical significance			
Urban	99.6%	99.9%	99.9%
Rural	98.6%	94.1%	97.1%
Extra Urban	100.0%	100.0%	100.0%

PN

PN
#x10¹¹/km

Fuel A

Urban	191.1
Rural	170.1
Extra Urban	244.5
Combined	201.9

Fuel B

Urban	44.3
Rural	84.8
Extra Urban	120
Combined	83.1

Change – Fuel A vs Fuel B

Urban	-76.80%
Rural	-50.10%
Extra Urban	-50.90%
Combined	-58.90%

Statistical significance

Urban	99.90%
Rural	100.00%
Extra Urban	100.00%

Appendix 1 – Equipment specification

At the start, middle and end of each cycle of tests the gaseous measurement equipment had a span and zero calibration performed. The span calibration range was chosen to reflect the minimum to maximum emissions levels, as follows:


Channel	Unit	Value
CO	ppm	1212
CO ₂	%	12
O ₂	%	20.9
HC	ppm	2010
NO	ppm	1495
NO ₂	ppm	249
THC	ppm	244.2

Careful choice of calibration range is necessary to minimise measurement noise and therefore error. Zero calibration was performed on ambient air.

Gas bottles were sourced from Airgas, with known provenance to the national standards laboratory.

The equipment had current certificates of calibration compliance, for the linearity of the analyser and flow tube, from Sensors, Inc. Details can be found in Appendix 2. These certificates also show the serial numbers of test equipment.

Appendix 2 – Calibration certificates

Sensors Europe GmbH Feldheider Str. 60 40699 Erkrath Germany		Certificate Number: SE-LC-18-014 Test Date: 2018-03-13 Certificate Page: 1/5
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SEMTECH LINEARITY CHECK CERTIFICATE

Delivered to:	Emissions Analytics
	Wycombe Road
	HP14 3RJ Stokenchurch
	Buckinghamshire UK

SEMTECH Instrument checked information :

Test Date (MM/DD/YYYY):	3/13/2018		
LDV GAS Module Serial Number:	D16131430	GAS Software Version:	17.09B
NDIR Bench Serial Number:	128980	NDIR Bench Range:	8% CO, 18% CO2
NDUV Bench Serial Number:	138480	NDUV Bench Range:	3000ppm NO 1000ppm NO2

Equipment used for test:

LDV SCS Module Serial Number:	C16130963	SCS Software Version:	17.09B
Gas Divider:	HORIBA SGD-710C	Next Calibration Date:	03/07/19
Gas Divider Serial Number:	UDHH9DDD	DAkKS Certificate Number:	10756

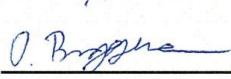
Gas Cylinder:

GAS	Bottle Value	Unit	Cylinder Supplier	Cylinder Identification Number	Analytical Accuracy	Filling Date	Stability since date of filling
CO	0.505	%	Westfalen AG	27600501507345	±1.00%	Nov-17	12 Month
CO2	16.000	%	Westfalen AG	27600501507345	±1.00%	Nov-17	12 Month
NO	1490	ppm	Westfalen AG	27600501507345	±1.00%	Nov-17	12 Month
NO2	899	ppm	Westfalen AG	27600503530187	±2.00%	Jul-17	12 Month

Linearity RDE Draft Regulation Acceptance Criteria:

Appx.2 – 3.2 Table 1. Linearity:

Appx.2 - 3.2 Table 1	Intercept	Slope a1	SEE	R ²
Gas Analyzers	≤0.5% max	0.99≤slope ≤1.01	≤1% max	≥0.998

Test Engineer: Olaf Brüggemann	Signature: 
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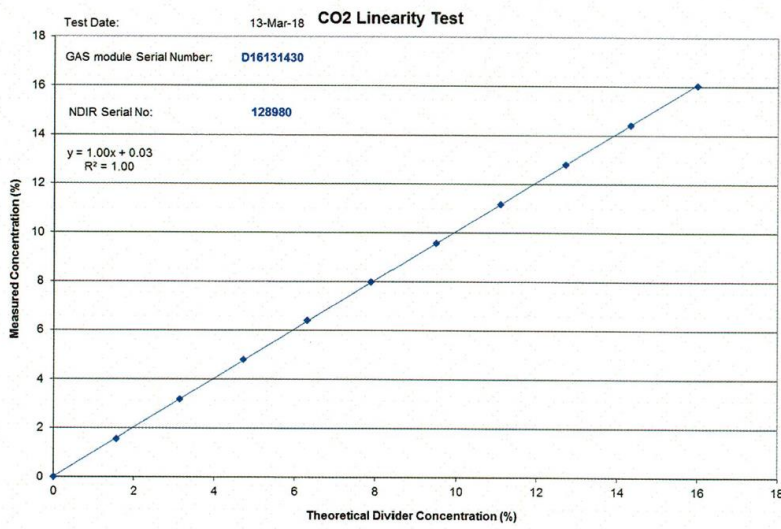


CO2 Test results:

CO ₂ - NDIR Serial Number:		128980		
Bottle Value %	HORIBA SGD-710C	Range (%)	Relative Error Limit (%)	Linearity range (%)
16.00	UDHH9DDD	18	2	16.00

RDE Reg. Appx. 2, 4.2.2 CO ₂ Accuracy Test Results					
shall not exceed 2% of reading or 0.3% of full scale, whichever is larger					
Divider Value %	Corrected Divider %	Measured %	Full Scale Error (%)	Relative Error of reading (%)	Status
0.00	0.00	0.00	-0.01		Pass
1.57	1.56	1.56	0.01	0.14	Pass
3.15	3.14	3.19	0.35	1.77	Pass
4.73	4.73	4.80	0.43	1.44	Pass
6.33	6.31	6.40	0.55	1.41	Pass
7.92	7.89	7.98	0.56	1.13	Pass
9.53	9.50	9.59	0.54	0.91	Pass
11.13	11.09	11.18	0.55	0.79	Pass
12.75	12.72	12.80	0.48	0.60	Pass
14.37	14.34	14.41	0.48	0.53	Pass
16.00	16.00	16.05	0.32	0.32	Pass
0.00	0.00	0.01	0.09		Pass

RDE 692/2008 Appx. 2, 3.2 Table 1 CO ₂ Linearity Test			
	Actual	Criteria	Status
Intercept	0.175	≤ 0.5% max	Pass
Slope	1.000	0.99 - 1.01	Pass
SEE	0.170	≤ 1% max	Pass
r ²	1.000	≥ 0.998	Pass



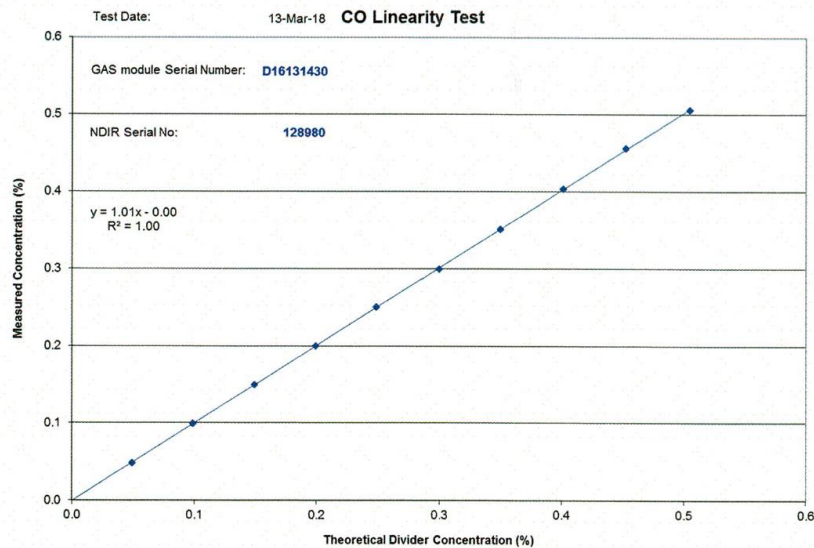


CO Test results:

CO - NDIR Serial Number:		128980		
Bottle Value %	HORIBA SGD-710C	Range (%)	Relative Error Limit (%)	Linearity range
0.505	UDHH9DDD	8	2	0.505

RDE Reg. Appx. 2, 4.2.2 CO Accuracy Test Results					
shall not exceed 2% of reading or 0.3% of full scale, whichever is larger					
Divider Value %	Corrected Divider %	Measured %	Full Scal Error (%)	Relative Error of reading (%)	Status
0.0000	0.0000	-0.0006	-0.1135		Pass
0.0496	0.0493	0.0487	-0.1305	-1.337	Pass
0.0994	0.0991	0.0991	0.0097	0.049	Pass
0.1494	0.1492	0.1504	0.2278	0.771	Pass
0.1996	0.1993	0.1999	0.1258	0.319	Pass
0.2500	0.2491	0.2499	0.1519	0.308	Pass
0.3006	0.2998	0.2996	-0.0420	-0.071	Pass
0.3514	0.3502	0.3509	0.1529	0.220	Pass
0.4024	0.4015	0.4030	0.3132	0.394	Pass
0.4536	0.4525	0.4557	0.6279	0.701	Pass
0.5050	0.5050	0.5057	0.1301	0.130	Pass
0.0000	0.0000	-0.0016	-0.3158		Pass

RDE 692/2008 Appx. 2, 3.2 Table 1 CO Linearity Test			
	Actual	Criteria	Status
Intercept	0.141	≤ 0.5% max	Pass
Slope	1.010	0.99 - 1.01	Pass
SEE	0.170	≤ 1% max	Pass
r²	1.000	≥ 0.998	Pass



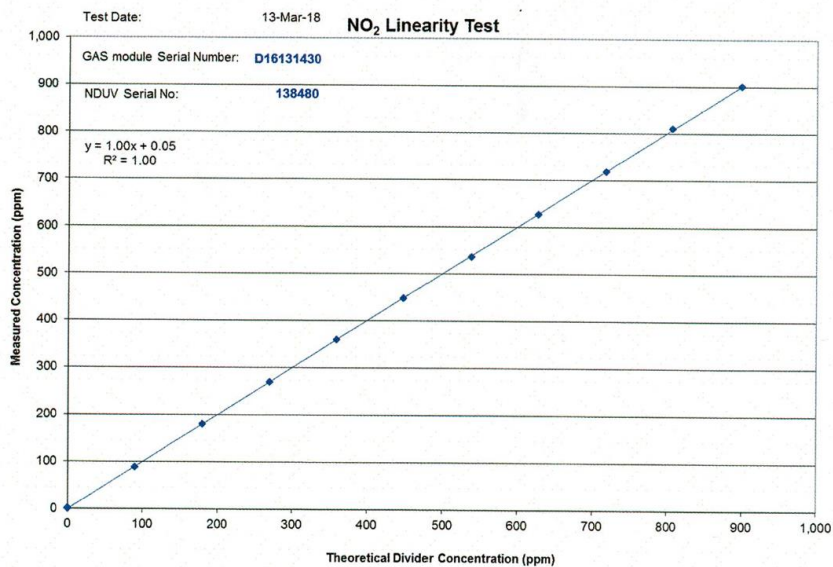


NO₂ Test Results:

NDUV Serial Number:		138480		
NO₂ Bottle Value ppm	HORIBA SGD-710C	Range	Relative Error Limit %	Linearity range
899	UDHH9DDD	1000	2	899

RDE Reg. Appx. 2, 4.2.2 NO ₂ Accuracy Test Results					
shall not exceed 2% of reading or 0.3% of full scale, whichever is larger					
Divider Value ppm	Corrected Divider ppm	Measured ppm	Full Scale Error (&)	Relative Error of reading (%)	Status
0.0	0.0	0.1	0.014		Pass
89.9	89.4	88.7	-0.077	-0.77	Pass
179.8	179.2	179.6	0.045	0.23	Pass
269.7	269.3	270.4	0.122	0.41	Pass
359.6	359.0	359.6	0.073	0.18	Pass
449.5	447.9	447.8	-0.010	-0.02	Pass
539.4	538.0	536.7	-0.135	-0.23	Pass
629.3	627.1	627.5	0.048	0.07	Pass
719.2	717.5	719.7	0.244	0.31	Pass
809.1	807.1	811.1	0.443	0.49	Pass
899.0	899.0	901.0	0.222	0.22	Pass
0.0	0.0	2.0	0.222		Pass

RDE Reg. Appx. 2, 3.2 Table 1 NO ₂ Linearity Test Results			
	Actual	Criteria	Status
Intercept	0.006	≤ 0.5% max	Pass
Slope	1.000	0.99 - 1.01	Pass
SEE	0.150	≤ 1% max	Pass
r²	1.000	≥ 0.998	Pass



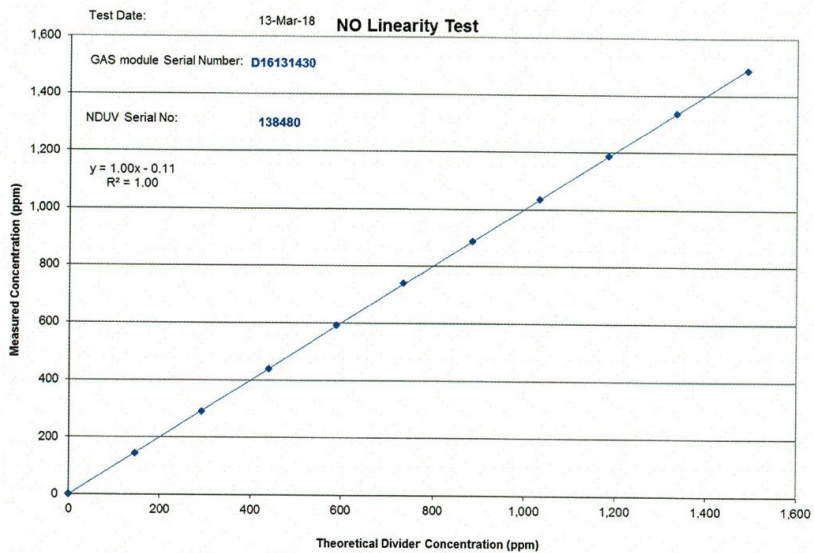


NO Test Results:

NDUV Serial Number:		138480		
Bottle Value ppm	HORIBA SGD-710C	Range (ppm)	Relative Error Limit (%)	Linearity range
1490	UDHH9DDD	3000	2	1490

RDE Reg. Appx. 2, 4.2.2 NO Accuracy Test Results					
shall not exceed 2% of reading or 0.3% of full scale, whichever is larger					
Divider Value ppm	Corrected Divider ppm	Measured ppm	Full Scale Error (%)	Relative Error % of reading	Status
0.0	0.0	0.0	0.003		Pass
146.4	145.5	143.2	-0.156	-1.6	Pass
293.4	292.4	289.3	-0.207	-1.1	Pass
440.9	440.3	440.5	0.009	0.0	Pass
589.1	588.0	591.4	0.224	0.6	Pass
737.7	735.1	739.4	0.289	0.6	Pass
887.0	884.7	886.8	0.143	0.2	Pass
1036.9	1033.2	1035.3	0.140	0.2	Pass
1187.3	1184.5	1186.8	0.151	0.2	Pass
1338.4	1335.1	1338.0	0.195	0.2	Pass
1490.0	1490.0	1487.7	-0.157	-0.2	Pass
0.0	0.0	0.7	0.050		Pass

RDE Reg. Appx. 2, 3.2 Table 1 NO Linearity Test Results			
	Actual	Criteria	Status
Intercept	-0.007	≤ 0.5% max	Pass
Slope	1.000	0.99 - 1.01	Pass
SEE	0.162	≤ 1% max	Pass
r²	1.000	≥ 0.998	Pass



Appendix 3 – Vehicle set up and test photos

