Environmental Management/GERnano

Investigation regarding the effects of GERnano in engine oil on emissions, fuel consumption and carbon deposits

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[1] translator's note: publisher information required under German law

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1 Motivation

GERnano noticed FSD GmbH in a TV documentary on the Dieselgate skandal, „Exclusiv im Ersten: Keine Luft zum Atmen (ARD)“[2]
After the screening of the documentary, GERnano got in touch with FSD Fahrzeugsystemdaten GmbH and offered to present the technology “GERnano”. This presentation by GERnano was given on 9th of Aug 2017 in Radeberg, Saxony. Summarizing, GERnano claimed the following positive effects in applications:

- Significant reduction of oil burn and longer drain intervals
- Cleaning of carbon deposits (caused by the EGR)
- Prevention of new carbon deposits
- Increase of engine power
- Fuel savings
- Reduction of NOx, HC and CO emissions (up to 30% reduction of NOx was the statement by Matthias Pahlke)
- Cleaning of friction surfaces in the engine
- Reduced wear and electrochemical corrosion of friction surfaces

2 Goals

Testing of GERnano effectiveness regarding the above claimed benefits

3 Test Work

3.1 Methods

3.1.1 Test Vehicle

For the testing the following vehicle was used:

Characteristics:	High mileage and carbon deposits
Producer:	VW
Type	Passat B6
Sales type:	3C5196
FIN:	WVWZZZ3CZ9E028732
Date of first registration:	28/07/2008
Engine identification:	CBAB
Power:	103 kW
Displacement:	1968 cm³
Fuel type:	Diesel
Emission standard:	EURO 4
Approval:	e1*2001/116*0307*16
Mileage:	approx 305,000 km

[2] Lit: “No air for breathing”; also: ‘no room to move’

3.1.2 Measurement Instruments and Tools

Portable emissions measurement systems by AVL 'GAS PEMS iS' and 'PN PEMS iS' were used.

3.1.3 Test Phases

The testing proceeded in six phases:

Table 1 Overview of the tested vehicle conditions

Phase	EGR	Oil Change	GERnano®	Trips	Comments
1	off	Yes	No	3	Testing effects on NOx without EGR
2	on	No	No	5	Normal condition
3	on	Yes	yes (2.0 ml/l oil)	4	So called 'cleaning phase'
4	on	No	yes (1.5 ml/l oil)	2	After changing oil
5	on	No	No [1]	5	After a further 1,500km
6	off	No	No [1]	3	Testing effects on NOx without EGR

[1] no additional GERnano applied

The test route was selected to include approximately equal proportions of freeway, country and city parts (Table 2) and to support reproducibility of measurements. The route is shown in Figure 1 Map of the test route in Google Maps

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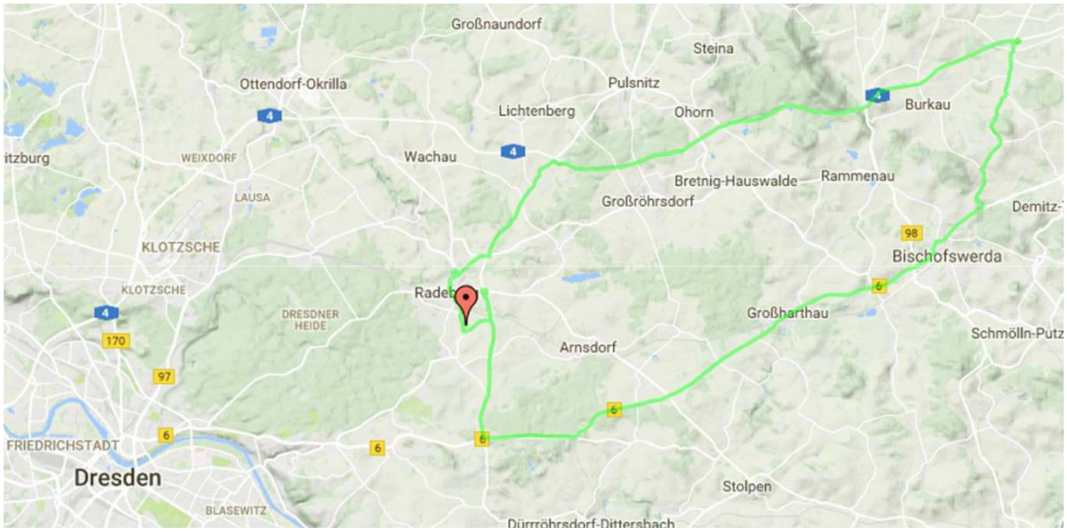

Figure 1 Map of the test route in Google Maps

Table 2 Proportions of the various road types

Road type	Length (km)	Proportion
Freeway	~20	30.3%
Country	~35	53.0%
City	~11	16.7%
Total	~66	100%

The exhaust gas recirculation system was deactivated using the engine software in Phases 1 and 6 to achieve better comparability of the measurement results. Thus, the effects of GERnano can be evaluated independently of the exhaust gas recirculation. Further, the EGR control and regulation is not necessarily predictable and a deactivation can enable a better reproducibility of the measurement results.
Also performed before and after the GERnano application were compression pressure measurement sas well as engine power measurements.

3.2 Test Execution

3.2.1 Initial State

At the beginning of the tests, the engine components of the test vehicle were partially dismantled. In addition, the engine block, the turbocharger and the exhaust manifold were examined in the assembled state. All components were photographed in detail (see Appendices 1-3). The components showed heavy deposits of soot (Figure 2, Figure 3). Subsequently, all components were reinstalled without cleaning.
Before the initial measurement, a service with oil change (4 L engine oil) was carried out on the test vehicle. After measurements Phase 1 and 2, GERnano (2.0 ml / L engine oil) was added to the warmed-up engine. The engine was then idled for 5-10 minutes.

Figure 2 EGR valve with carbon deposits (initial state)

Figure 3 Intake ports of the cylinder head with carbon deposits (initial state)

3.2.2 Execution of Test Trips

The test runs of Phases 1, 2, 4-6 could be carried out as planned. During two test trips of Phase 3 the EFM (Exhaust Flow Meter) failed, so the conversion to X per km was not possible.

3.2.3 State of the Vehicle after Cleaning Phase

The air intake of the test vehicle including EGR was dismantled again after the Cleaning Phase (approx. 300 km) and the condition was documented. The surfaces of the components did not show material differences compared to the initial state. In addition, oil and oil filter were changed again, and GERnano (1.5 ml / L engine oil) was added to the warmed-up engine.

Figure 4 EGR-valve with carbon deposits (after Phase 3)

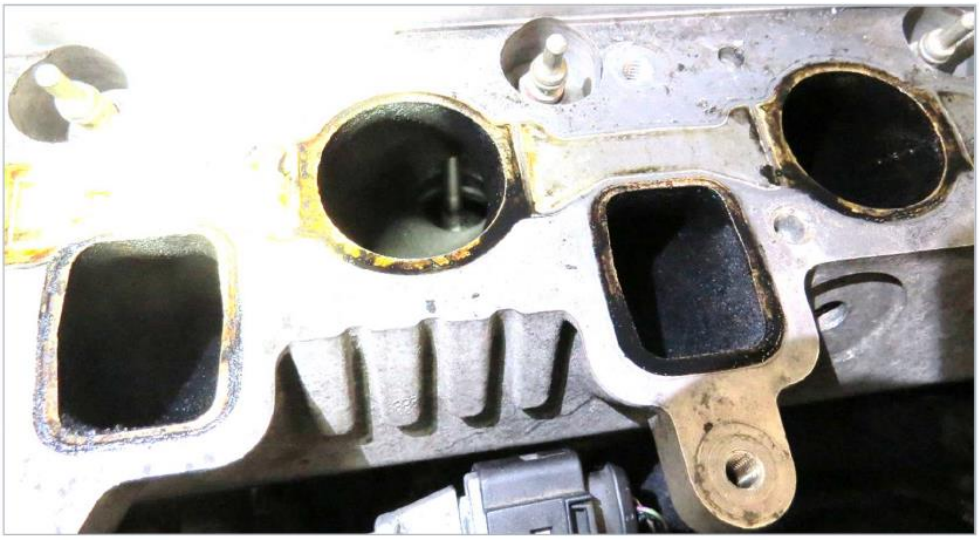

Figure 5 Intake ports of the cylinder head with carbon deposits (after Phase 3)

3.2.4 State of the Vehicle after all Test Trips

The intake and cylinder head of the test vehicle were dismantled after approx. 3500 km driven with GERnano and the condition of the components was documented. Again, no material changes from the initial state could be noticed. All photos of the components are provided as a digital attachment.

Figure 6 Disassembled EGR valve with carbon deposits (after Phase 6)

Figure 7 Intake ports of cylinder head with carbon deposits (after Phase 6)

4 Evaluation of Tests

4.1 Analysis of Trip Logs

During the trips 7, 8, 16 and 19, the engine control activated the regeneration of the diesel particulate filter. During the additional injection and the burning of soot in the filter, emission levels increase. For this reason, these trips were not included in the global evaluation; parts of these trips could be evaluated subsequently.

Table 3 Averages of Measurements with AVL Concerto V4.8

Measurements	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6
Trip Count	3	3	2	2	3	3
Trip Length in km	66.3	66.5	66.4	66.3	66.3	67.7
Fuel consumption in L/100km	5.4	5.9	5.7	5.3	5.3	4.7
Revolutions in rpm	1522	1524	1500	1522	1520	1467
Torque in Nm	37.6	40.3	39.8	39	40.1	35.3
Power in Nm	6.4	6.8	6.6	6.6	6.8	5.7
Work in kWh	7	7.6	7.6	7.3	7.6	7.1
Exhaustgas Mass in kg	132.2	97.1	97.6	92.1	91.9	133.8
Outside Temperatur in °C	17.4	14.8	15.7	18.1	12.1	17.6
Humidity in %	0.6	0.7	0.7	0.7	0.8	0.6
CO2 in g/km	144	156	149	140	141	124
CO in g/km	0.07	0.06	0.07	0.06	0.06	0.04
NO in g/km	1.15	0.49	0.42	0.33	0.33	1.07
NO2 in g/km	0.24	0.12	0.11	0.06	0.1	0.17
NOX in g/km	1.39	0.61	0.53	0.42	0.43	1.2
Velocity in km/h	60.3	59.8	57.9	59.8	59.3	55.2
Proportion City	31.8%	30.5%	32.5%	29.9%	34.7%	36.5%
Proportion Country	33.3%	33.6%	37.5%	39.4%	34.2%	31.1%
Proportion Freeway	34.9%	35.9%	30.0%	30.6%	31.1%	32.3%

The data (Table 3) shows a clear reduction of all measured emissions after the application of GERnano in comparison to the initial state. CO values (Appendix 4) fluctuate considerably more than any other emission values, however this can be explained by the very low level of CO emissions. Should changes in CO emissions be relevant, further measurements are required to gain reliable data (test bench).

Table 4 Summary of emissions reductions after GERnano application

Changes in emissions	CO2	NO	NO2	NOx
Activated EGR	- 9.5%	- 32.7%	- 17.5%	- 29.8%
Deactivated EGR	- 14.3%	- 6.8%	- 30.0%	- 13.9%

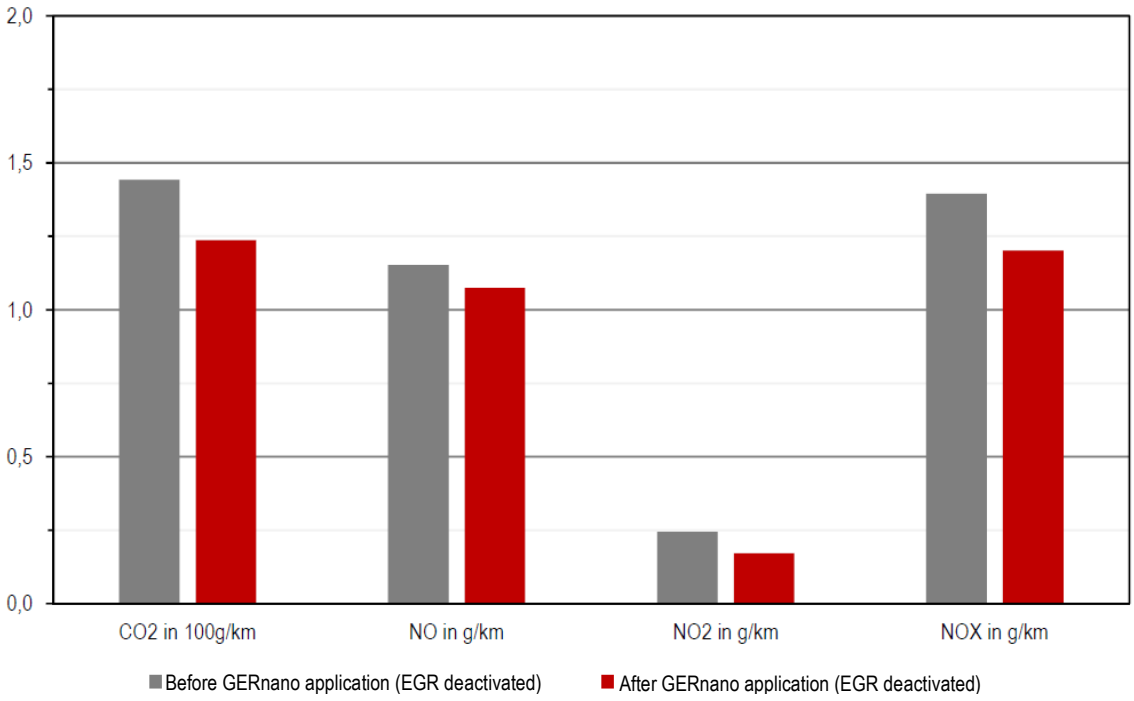

Figure 8 Comparison of emissions with de-activated EGR before and after GERnano application

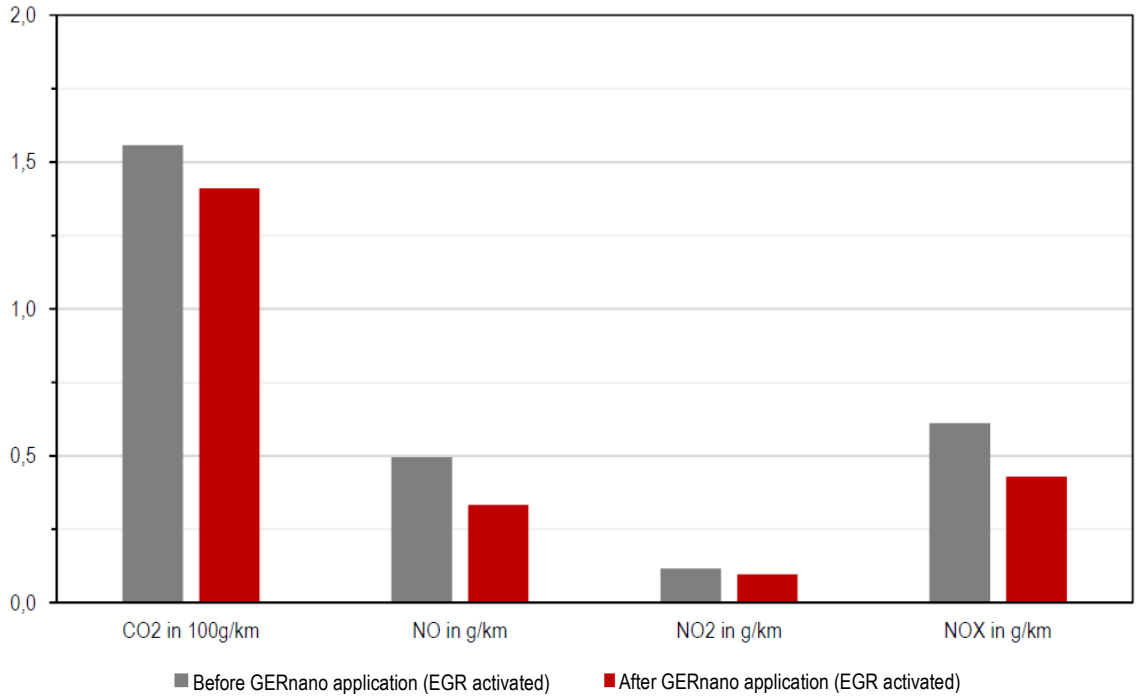

Figure 9 Comparison of emissions with activated EGR before and after GERnano application

4.2 Analysis of Cleaning Effect on Carbon Deposits

The condition of the engine components is shown in Figure 10 to Figure 15. In the engine, the cylinder bores of the two outer pistons show the strongest changes (Figure 10). Existing deposits have been removed (red marks); considering the subsequent compression measurements a connection with GERnano can be suspected.
Considering the remaining components in the intake manifold and the EGR (Fig. 11-15) a cleaning effect in these parts is not apparent. Small areas seem to have changed, however at this stage (after 3500km) cleaning cannot be recognize clearly.

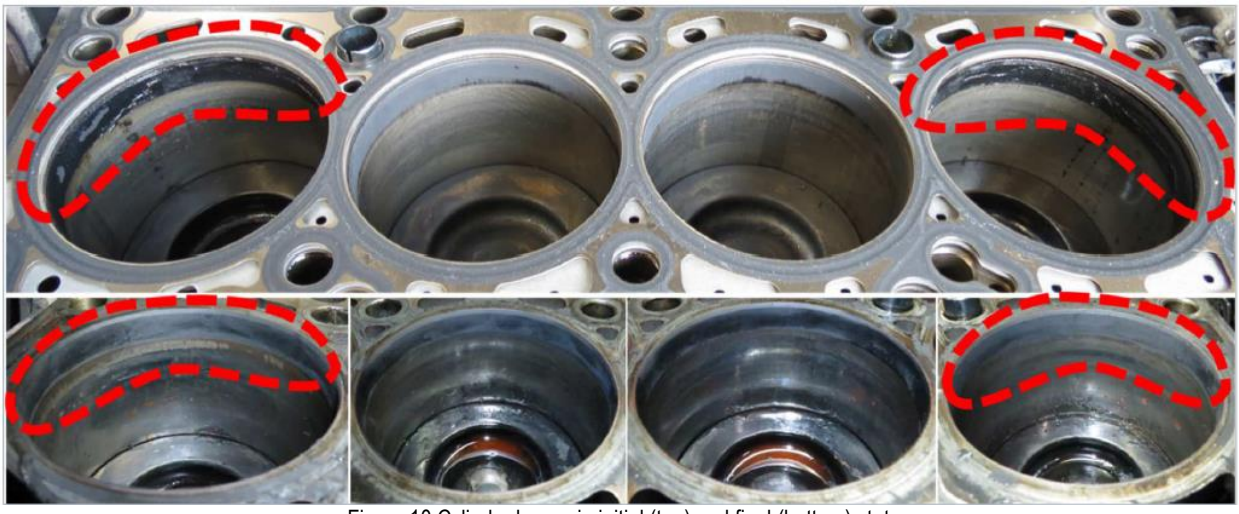

Figure 10 Cylinder bores in initial (top) and final (bottom) state

Figure 11 Intake and outlet ports in initial state (left) and final state (right)

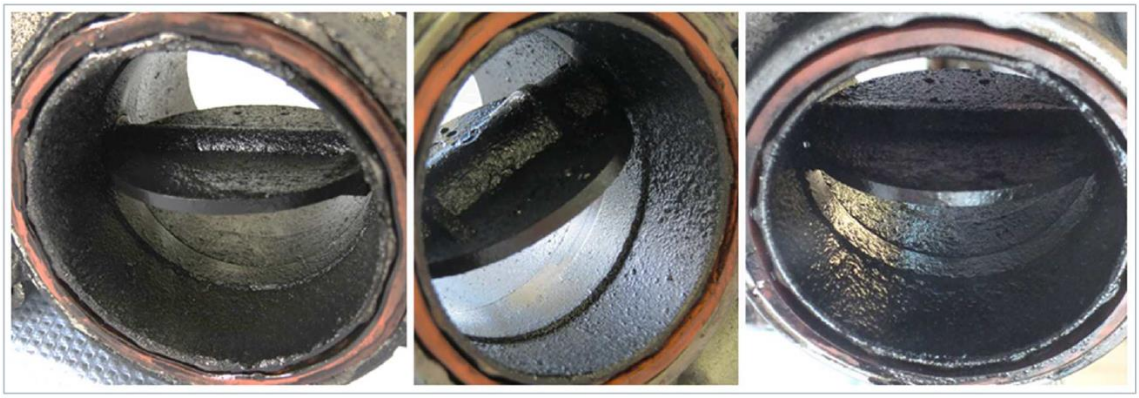

Figure 12 Throttle valve in initial state, after phase 3 and in final state (left to right), view from the front

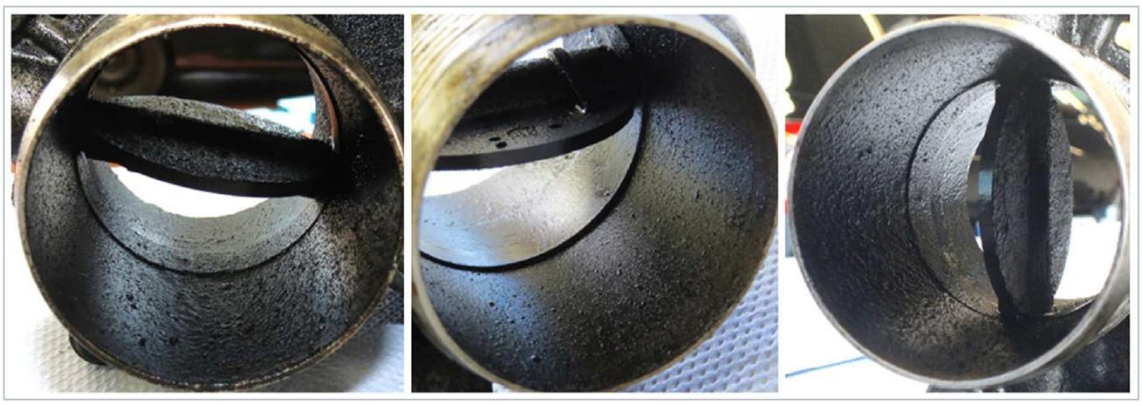

Figure 13 Throttle valve in initial state, after phase 3 and in final state (left to right), view from the back

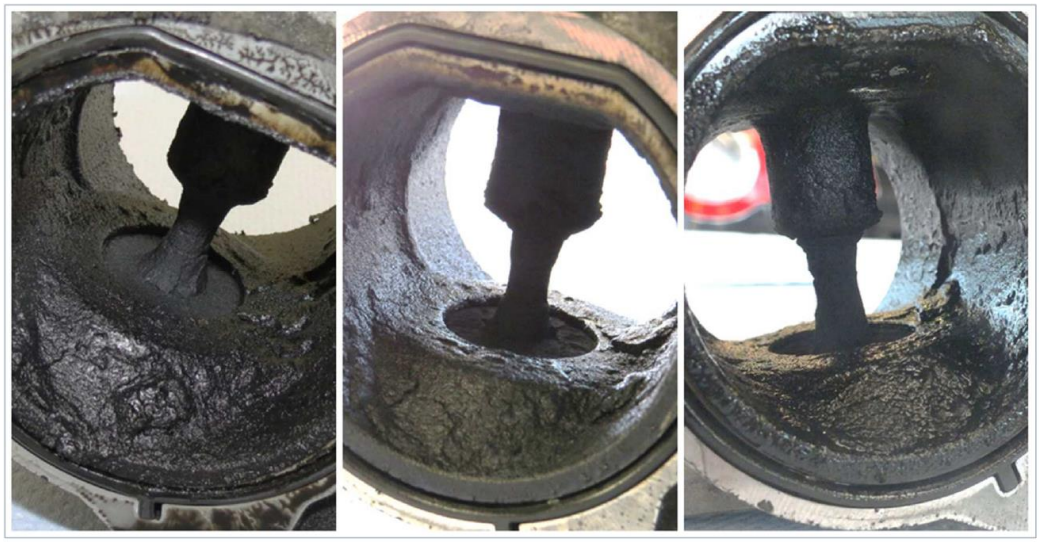

Figure 14 EGR valve in initial state, after phase 3 and in final state (left to right), view from the front

Figure 15 EGR valve in initial state, after phase 3 and in final state (left to right), view from the back

4.3 Analysis of Engine Performance

For further assessment of the effects of the GERnano application, performance measurements were carried out on the test vehicle before and after the test trips (Figure 16). These showed an increase in both torque and power over almost the entire range of RPM (Table 5).

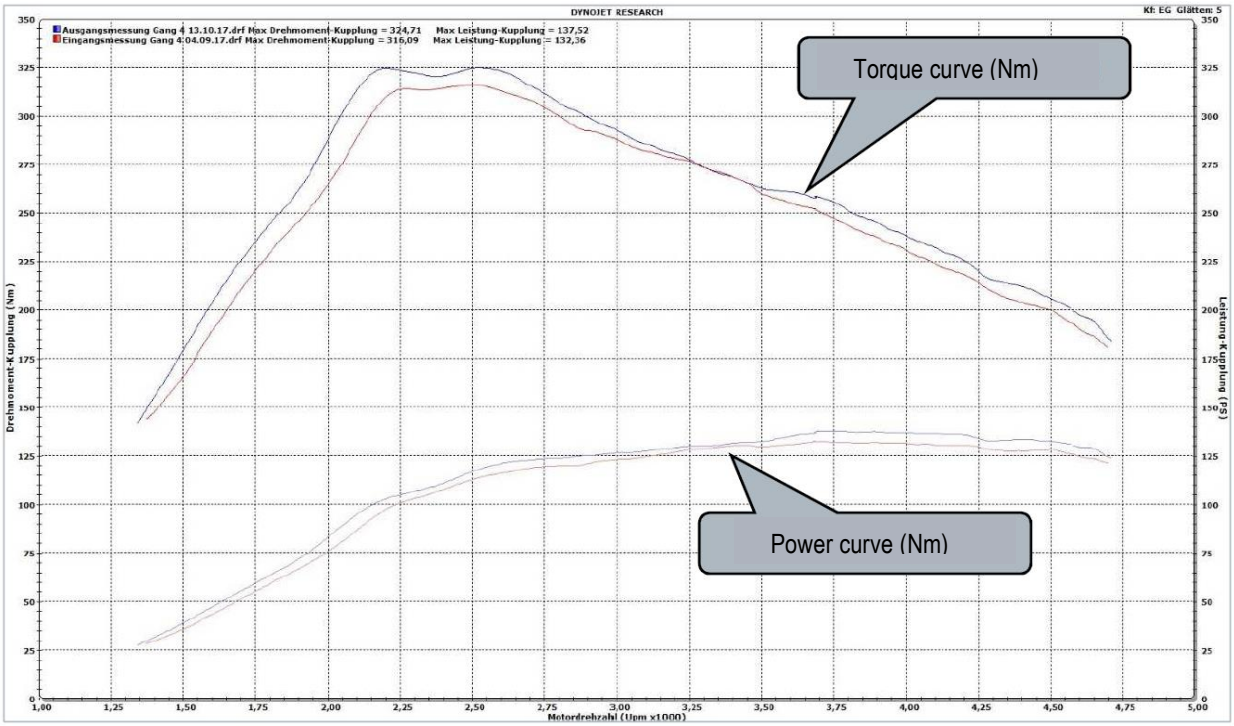

Figure 16 Performance measurements in Initial State (red) und Final State (red).
Initial State: 04/09/17, 4th gear, 20.67°C ambient temperature, 989.92 mbar pressure, 36% humidity
Final State: 13/10/17, 4th gear, 21.66°C ambient temperature, 998.99 mbar pressure 33% humidity

Table 5 Performance measurements before and after GERnano application

States	Initial State	Final State	Change (abs.)	Change (rel.)
Max. Torque	316.09 Nm	324.71 Nm	+ 8.62 Nm	+ 2.73 %
Max. Power	132.36 PS	137.52 PS	+ 5.16 Nm	+ 3.90 %

Also measured were the compression pressures per cylinder before and after the testing. The compression values of all cylinders in the initial state correspond to those of a used engine above the wear limit. The compression values in the final state, however, are in the range of a new engine (Table 6, Appendix 5). Presumably the claimed effects on the friction surfaces (cleaning and reduced friction) of the additive reduced the frictional losses in the engine. This might have resulted in better contact pressure of the piston rings onto the cylinder treads, which would explain the increase in the compression pressures, as well as the increased maximum torque and power.

Table 6 Compression before and after application of GERnano

State	Cylinder 1	Cylinder 2	Cylinder 3	Cylinder 4
Before	23.0 bar	23.5 bar	23.5 bar	23.0 bar
After	25.0 bar	26.0 bar	25.5 bar	25.5 bar

4.4 Analysis of Acceleration Results on a Subsection of Test Trips

Analysis of trip data in a subsection of the test route that allows steady driving gave the following results. In this section, the vehicle was accelerated from 70 to 100 km / h by means of the vehicle cruise control. The exhaust gas recirculation was deactivated during the trips shown in the figure below (Phases 1 and 6). However, this comparison did not show a significant reduction in NOX emissions as established in Section 4.1.

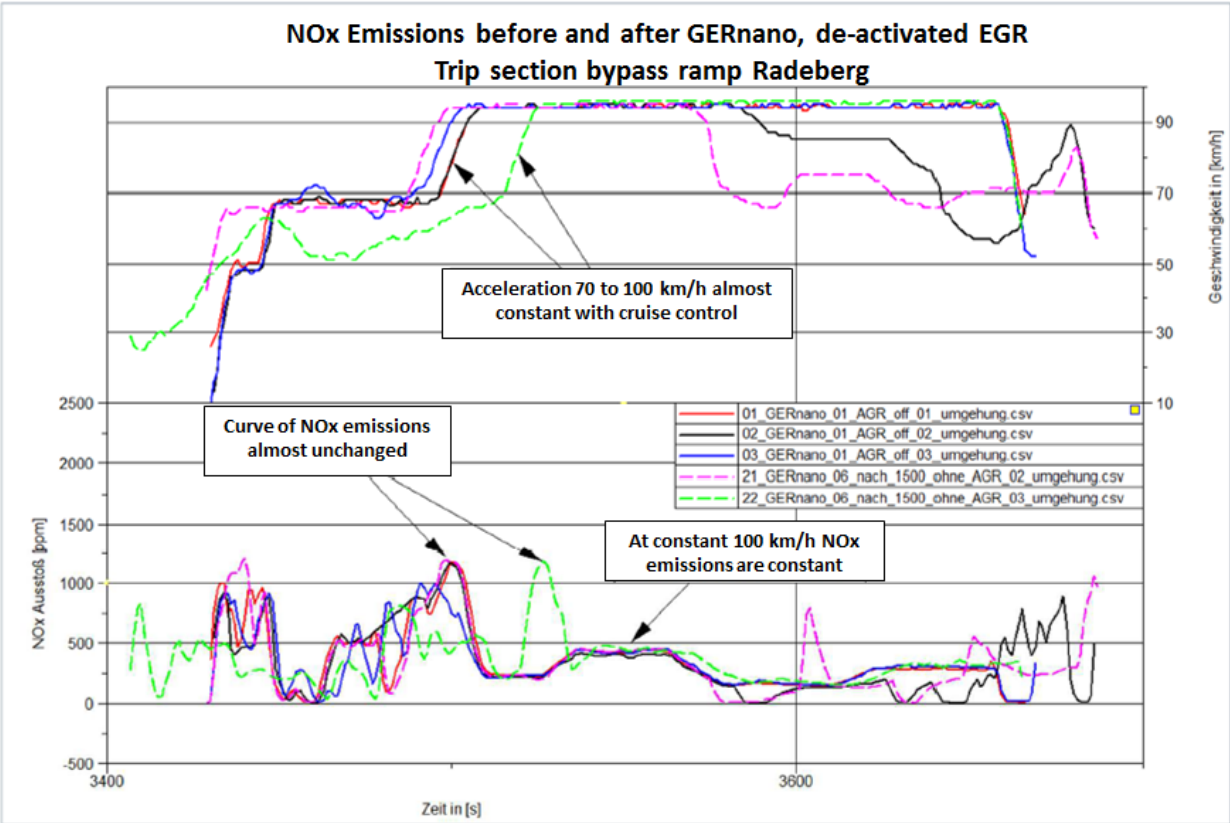

Figure 17 NOX emissions before and after GERnano application during acceleration test

5 Summary

The investigation confirmed the claimed effects of GERnano in principle. During the test trips, all measured emissions did improve. Especially the reduction of NOX emissions during the trip series with activated EGR by approx. 30%, as well as the reduction in fuel consumption, has to be highlighted. However, this effect could only be identified in the global data assessment. When analyzing a subsection of the test route, no differences could be detected before and after GERnano application. This might suggest that the reduction of emissions on longer trips can be explained by the higher engine performance after the application. The cleaning phase of GERnano would lead to reduced friction on the piston, a higher compression pressure and thus higher efficiency of the treated engine.

An effect of the lubricant additive on the combustion process (micro spark plugs) cannot be detected with the carried out experiments. The claimed cleaning effect could be observed only on the surfaces of the cylinder bores. Other engine components did not clearly show a cleaning effect. No conclusions can be made regarding reduced oil consumption and prevention of carbon deposits based on the results of the PEMS trips. The RDE trips carried out are not suitable for investigating individual effects of GERnano. For this, dedicated tests on an engine test bench would be required.

In the discussion with representatives of GERnano regarding the cleaning effects, they were confident that the surfaces would be cleaned completely by further operation. The small rate of cleaning that occurred during this study could be explained by the engine, which consumes very little oil. Therefore, the additive GERnano would only enter the combustion chamber and the EGR in very small amounts. The cleaning could be significantly accelerated by an application in the fuel, with 1 ml GERnano concentrate added to 50 L diesel.

FSD will continue to monitor development of the surface deposits as it continues using the vehicle. To verify the results of this study, test should be performed on additional vehicles. Individual properties can be proven on the respective test stand types. Should the significant reduction in fuel consumption and NOx be confirmed, and a positive emissions assessment be granted (changed composition of the exhaust), then GERnano can contribute to a lower pollutant exposure of people and the environment.

6 Appendices

- Appendix 1: Photos of the engine components in phase 0 (initial state, JPG)
- Appendix 2: Photos of the engine components in phase 3 (after cleaning phase, JPG)
- Appendix 3: Photos of the engine components in phase 6 (final state, JPG)
- Appendix 4: Measured data and evaluation (XLSX, PDF)
- Appendix 5: Compression test (PDF)