

TNO report**TNO 2018 R10053****On-road emission measurements with PEMS
on a MERCEDES-BENZ ATEGO Euro VI N2
heavy-duty truck**

Anna van Buerenplein 1
2595 DA Den Haag
P.O. Box 96800
2509 JE The Hague
The Netherlands

www.tno.nl

T +31 88 866 00 00

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Author(s)	Robin Vermeulen, René van Gijlswijk, Sam van Goethem
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Summary

Commissioned by the Ministry of Infrastructure and Water management of The Netherlands, TNO Sustainable Transport and Logistics regularly performs measurements on heavy-duty vehicles to determine the in-service performance and durability of the tail-pipe emissions under representative driving conditions.

A Euro VI heavy-duty N2 class truck, the Mercedes-Benz Atego was tested with a Portable Emission Measurement System on the road (PEMS), driving various trips. The gaseous emissions were measured and analysed according to the in-service conformity method (Annex II of 582/2011/EC and amendments). With the standard PEMS protocol adapter no access to CAN/ECU data was possible. Therefore, for all but one test only the CO₂ based evaluation method was chosen. Because of the same reason for these test the engine coolant temperature was not available and therefore a warm up time of the coolant had to be assumed for these tests. For one of the tests CAN/ECU data was recorded with a separate device. The data (torque, engine speed, coolant temperature) was used for the work-based evaluation of the given test. It should be noted that the share of the sub-trip part characterized as 'rural' is smaller than required for an N2 trip according regulation 582/2011 amended by 64/2012. The test trips are therefore not fully conform the applicable requirements.

The conclusions drawn from the measurements with this specific vehicle are as follows:

- the Conformity Factor for NO_x over an N2 Euro VI trip is high and well above 1.5.
- the Conformity Factor for NO_x varies differs per trip and varies between 3.4 and 5.8 for trips with a payload of 55%.
- the Conformity Factors for CO and HC emission are well below 1.5 for all trips.

Generally, for in-service conformity checking, more than one vehicle should be tested and evaluated to determine whether the vehicle type is compliant with the in-service conformity requirements. In this programme only one vehicle was tested and therefore the results are indicative only.

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1 Introduction

Contracted by the Ministry of the Infrastructure and Water management, TNO runs the in-service emissions testing program for heavy-duty trucks and buses. In this program TNO measures on a regular basis the tail-pipe emissions of these vehicles, to investigate how clean they are in the real-world and if they comply with the formal European requirements. Data obtained within the programme leads to valuable insights in environmental performance of the heavy-duty vehicles in the real-world and trends thereof.

PEMS (Portable Emission Measurement System) is used to measure the regulated gaseous emissions (with the exception of NH₃, PM and PN) under real-world conditions. PEMS is also used to evaluate the in-service conformity of heavy-duty emissions (Euro VI, Regulation no (EC) 582/2011 and amendments). This procedure uses a special pass-fail method to evaluate the emissions performance which leads to a Conformity Factor for each regulated emission component. This report focusses on the results of the tests that have been performed to determine the in-service conformity factors.

2 Test program

The test methodology using PEMS to measure the regulated emissions according to Regulation EC 582/2011 and amendments is explained in [Spreen et al., 2016].

2.1 Test vehicle

The test vehicle was kindly provided by Plieger, and is shown in Figure 1. All 'Kundendienst' actions were executed. The vehicle is maintained by the owner.



Figure 1: Test vehicle, kindly provided by Plieger.

Table 1: Vehicle specifications.

Vehicle manufacturer		Daimler
Type		Atego 1218 - 967PKX2
Body		Rigid box
Vehicle Class [2007/46]		N2
Fuel		EN590, market diesel
Vehicle Identification Number		WDB9670251L889046
License plate number		93-BFG-7
Registration Date	[dd-mm-yyyy]	13-10-2014
Registration Country		Netherlands
Euro Class		Euro VI
Type Approval Number		e1*595*2009*64*2012A*0011*00
Vehicle empty mass in running order	[kg]	7345
Semi-trailer empty mass in running order	[kg]	n.a.
Vehicle combination empty mass in running order	[kg]	n.a.
Vehicle combination max technical permissible mass	[kg]	n.a.
Odometer at test start	[km]	90281
Configuration vehicle		-
Configuration axles		4X2

Table 2: Engine specifications.

Engine manufacturer		Daimler
Engine Code		OM934
Engine displacement	[cm ³]	5132
Maximum rated power	[kW] @ [rpm]	130@2200

2.2 Test trips

A number of test trips were driven. This report concerns the results of in-service conformity testing and therefore only presents the results of the applicable tests trips.

Table 3: Overview of the trips performed. The trips in bold are reported.

Test no.	Trip	Code	Payload [%]	Vehicle (combination) test mass [kg]
1	Euro VI trip N2 cold start	01_E6N2_55C	55	9920
2	Euro VI trip N2 warm start	02_E6N2_55W	55	9920
4	Euro VI trip N2 cold start	04_E6N2_55C	55	9920
5	TNO Reference trip	05_REF_55C	55	9920
6	Euro VI trip N2 warm start	06_E6N2_55W	55	9920
7	TNO Reference trip	07_REF_55W	55	9920
9	Euro VI trip N2	09_E6N2_10W	10	7840

3 Test results: in-service conformity with PEMS

Table 4 shows the test conditions and measurement results of all tests performed on the Mercedes-Benz Atego Euro VI N2 heavy-duty truck. The N2-trip was driven around Helmond.

In the Netherlands, most rural roads have a speed limit of 80 km/h, which is higher than the designated speed bin for rural driving in the regulation (50-75 km/h). The speed that is normally driven on such rural roads by heavy-duty vehicles is around 80 km/h and this speed is used for the PEMS test. It is possible to drive slower than the limit during testing, but TNO didn't prefer to do that. As a consequence, the share of the trip characterized as 'rural' (see Table 4) is smaller than required in the European standard, in which the required shares for urban/rural/highway for N2 are 45%/25%/30%.

Table 4: overview of the results over the N2 trips with 55% payload.

TNO vehicle code		MB147				
		01_E6N2_55C	02_E6N2_55W	04_E6N2_55C	04_E6N2_55C with CAN/ECU data	06_E6N2_55W
TNO test code						
Date		25-02-2016	25-02-2016	3-2-2016	3-2-2016	3-3-2016
Test type		PEMS	PEMS	PEMS	PEMS	PEMS
Test trip	Name	N2	N2	N2	N2	N2
Start, coolant temperature	[Celcius]	Cold, n.a.	Warm, n.a.	Cold, n.a.	Cold, 9	Warm, n.a
T ambient	[Celcius]	-1.3	6.3	6.7	6.7	4.3
p baro	[kPa]	101.3	101.4	99.9	99.9	99.8
Weather conditions (dry, rain, snow, wind, ..)		Dry	Dry	Windy	Windy	Some rain
Traffic conditions (free flow, congestion, ...)		Stop at rail road crossing	Regular	Regular	Regular	Behind slow traffic
Special conditions (...)						
Vehicle combination test mass weighted	[kg]	~9920	~9920	~9920	~9920	~9920
Vehicle combination test mass percentage	[%]	55	55	55	55	55
Trip share urban	[%]	51	45	45	45	44
Trip share rural	[%]	9	9	9	9	14
Trip share motorway	[%]	40	46	46	46	42
Reference work	[kWh]	n.a.	n.a.	n.a.	12.6	n.a.
Reference CO ₂ mass used	[kg]	7.7	7.7	7.7	8.5	7.7
Minimum work window average power	[%]	n.a.	n.a.	n.a.	20%	n.a.
Maximum CO ₂ mass window duration	[s]	1530	1530	1530	1530	1530
Work window: percentage of valid windows	[%]	n.a.	n.a.	n.a.	91.1	n.a.
CO ₂ mass window: percentage of valid windows	[%]	80	97	93	79.2	88
Fuel consumption consistency ratio	[-]	n.a.	n.a.	n.a.	n.a.	n.a.

work window conformity factor CO	[-]	n.a.	n.a.	n.a.	0.20	n.a.
work window conformity factor THC	[-]	n.a.	n.a.	n.a.	0.01	n.a.
work window conformity factor NMHC	[-]	n.a.	n.a.	n.a.	n.a.	n.a.
work window conformity factor CH4	[-]	n.a.	n.a.	n.a.	n.a.	n.a.
work window conformity factor NOx	[-]	n.a.	n.a.	n.a.	3.45	n.a.
CO ₂ window conformity factor CO	[-]	0.19	0.20	0.20	0.23	0.09
CO ₂ window conformity factor THC	[-]	0.07	0.04	0.01	0.01	0.04
CO ₂ window conformity factor NMHC	[-]	n.a.	n.a.	n.a.	n.a.	n.a.
CO ₂ window conformity factor CH4	[-]	n.a.	n.a.	n.a.	n.a.	n.a.
CO ₂ window conformity factor NOx	[-]	5.54	5.83	3.37	3.67	4.59
Maximum conformity factor according 582/2011/EC and amendments	[-]	1.5	1.5	1.5	1.5	1.5
Remarks		No CAN data, engine warm up time was estimated.	No CAN data, engine warm up time was estimated. DPF regeneration at end of MW part	No CAN data, engine warm up time was estimated.	Engine coolant temperature, torque and engine speed logged simultaneously from CAN	No CAN data, engine warm up time was estimated. Partly hindered by agricultural vehicle in the rural part (driving about 50 km/h)

4 Conclusions

A Euro VI heavy-duty N2 class truck, the Mercedes-Benz Atego was tested in a tractor semi-trailer combination with a Portable Emission Measurement System on the road (PEMS), driving various trips. The gaseous emissions were measured and analysed according to the in-service conformity method (Annex II of 582/2011/EC and amendments). It should be noted that the share of the sub-trip part characterized as 'rural' is smaller than required for an N2 trip according regulation 582/2011 amended by 64/2012. The test trips are therefore not fully conform the applicable requirements.

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5 References

- [Spreen et al., 2016] Spreen J.S., et al., *Assessment of road vehicle emissions: methodology of the Dutch in-service testing programmes*, TNO report TNO 2016 R11178, 20 October 2016
- [Vermeulen et al., 2016] Vermeulen R.J., et al., *The Netherlands In-Service Emissions Testing Programme for Heavy-Duty Vehicles 2015-2016 Annual Report*, TNO report TNO 2016 R11270, 10 October 2016

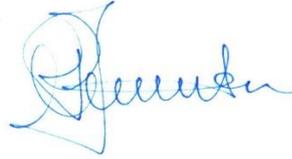
6 Signature

The Hague, 1 February 2018

TNO

A handwritten signature in blue ink, appearing to read 'Goethem', with a long horizontal stroke extending to the right.

Sam van Goethem
Projectleader

A handwritten signature in blue ink, appearing to read 'Vermeulen', with a large, stylized initial 'V'.

Robin Vermeulen
Author