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TNO report**TNO 2019 R10014 | Final****In-Service Conformity test on a Volvo FH420
LNG-diesel dual fuel truck with a Euro VI step-
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Summary

In the framework on the Netherlands in-service testing program for heavy-duty vehicles of the Ministry of Infrastructure and Water management TNO has conducted three on-road emission tests with PEMS on a N3 Euro VI Step-C truck conform Regulation EU No. 582/2011 [1] as amended by EU No. 2016/1718 [2], to verify that the vehicle meets the requirements concerning the applicable heavy duty vehicle in-service conformity emission regulations.

- For the three valid tests the 90% cumulative exhaust emissions conformity factors for NO_x, THC and CO are below the maximum allowed value of 1.5.
- The 90% cumulative NO_x conformity factors for test 1,2 and 3, determined according the work based method are 0.50, 0.33 and 0.32, and on average 0.38.
- The 90% cumulative NO_x conformity factors for test 1,2 and 3, determined according the CO₂ based method are 0.52, 0.33 and 0.33, and on average 0.39.

Considering the demonstrated validity of the measurements, the results of the measurements are interpreted as plausible. During testing, no anomalies were encountered. The CF results show that for both work- and CO₂ based window methods the limit of 1.5 was not exceeded for components NO_x, CO and THC (with application of the emission limits set for PI engines according to (EU) No.133/2014[3]).

The CF for PN has not yet been determined. This means the CF for PN are purely indicative and do not account for pass/fail. Notable is the strong decline in CF for PN during the course of the test program. It is unknown if a regeneration of the particulate filter took place before the start of the first test.

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1 Introduction

1.1 Background

The Ministry of Infrastructure and Water management has contracted TNO to conduct the in-service emissions testing programme for heavy duty vehicles. In this programme TNO tests on an annual basis a selection of vehicles of which the data is used to:

- Determine the emissions factors for heavy commercial vehicles
- Determine trends over the different EU standards and steps:
 - Are the vehicles getting sufficiently cleaner each generation/step in the real world?
 - Use the data and insights in Brussels in discussions about the improvement of the test procedures
- Screen the in-service conformity
- Assess new/alternative technologies
- Provide information to stakeholders. To help make purchase decisions for cleaner and more fuel efficient transport

In the framework of this programme in 2017 TNO has tested two articulated trucks that are running on LNG to determine the level of criteria pollutants and to determine the tank-to-wheel greenhouse gas emissions. Because the test sample of vehicles was small due to the fact that only few types of vehicles running on LNG were offered on the market it was then recommended to test additional vehicles when they would arrive on the market. Since September, 2018 Volvo Trucks offers a tractor with a dual fuel engine running on LNG as the main fuel.

A number of PEMS tests have been performed on one truck. The test programme contained in-service conformity tests according the applicable PEMS test requirement for testing the in-service conformity as well as additional tests that were focussed on typical representative driving conditions. The results of the in-service tests performed over the applicable N3 test cycle are discussed in this report. An overview of the results of all tests are presented and discussed in TNO report R10193[7].

1.2 Goal

Euro VI certified Heavy duty engines need to fulfil requirements with regard to the in-service conformity. Those requirements are laid down in EC Regulation (EU) No. 582/2011 [1] and amendments and prescribe PEMS tests to be performed under specified conditions to check the in-service conformity of the regulated gaseous emissions NO_x, CO and THC. In addition PN was measured as requested by the Ministry of Infrastructure and Water management as it is not regulated yet. The goal of the series of PEMS tests that were performed in the test programme in accordance with the requirements of the EC regulation was to check the in-service conformity of the subject, a Volvo FH420 with a dual fuel engine.

1.3 Assignor

The emissions tests were performed at the request of the Dutch Ministry of infrastructure and Water management.

1.4 Method of testing

To check the in-service conformity, three tests has been performed with a Portable Emissions Measurement System (PEMS) on a vehicle that was made available by a transport company. The vehicle has Vehicle Identification Number YV2RZ70A3JA829953. This vehicle is an N3 Euro VI Step-C vehicle with a dual fuel engine running on LNG-Diesel with an odometer reading of 19.990 km at intake of the vehicle. The tested vehicle is shown in Figure 1.

The tests have been performed conform Regulation (EU) No. 582/2011 [1] as amended by EU No. 2016/1718 [2] to verify that the vehicle meets the requirements concerning heavy duty vehicle ISC emission regulations. The emission test has been performed under the ISO 17025 accreditation of TNO Power Trains.

The engine is classified as a 1A Dual fuel engine, which means the average Gas Energy Ratio(GER) is not lower than 90% and does not idle using exclusively diesel and has no diesel mode. According to (EU) No.133/2014[3] the emission limits set for PI engines in annex I to regulation (EC) No. 595/2009[4] are applied.



Figure 1 The test subject, a Volvo FH420 tractor with a Euro VI step C certified '1A' dual fuel engine with LNG as the main fuel.

2 Test Setup

2.1 Test vehicle

The vehicle identification and engine certification label is shown in Figure 2 and 3. Locally available LNG and EN590 market fuel was used during the tests. Detailed information about the fuel and exhaust parameters can be found in Appendices B.4, C.4 and D.4.

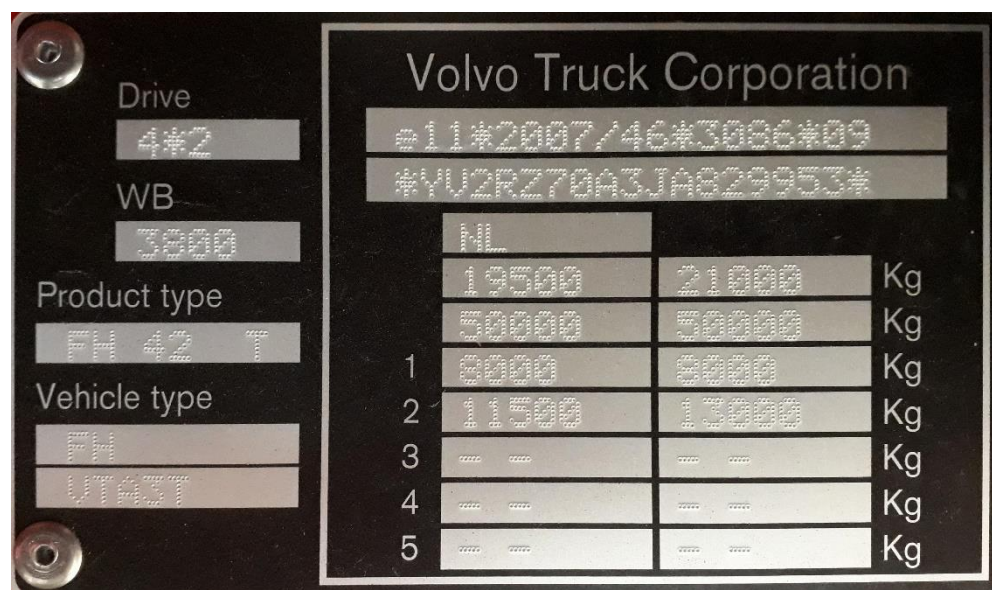


Figure 2 Vehicle identification of the tested vehicle.



Figure 3 Engine certification label.

2.1.1 *Vehicle information*

Table 1 lists the relevant information on the test vehicle.

Table 2 and Table 3 list the relevant information on the engine and aftertreatment system respectively.

The vehicle received a regular scheduled software update at the local dealer daily before the test programme. Information about the software and calibration identification on the engine and aftertreatment can be found in Table 4. It is unknown whether an DPF regeneration has taken place prior to testing.

Table 1 General information.

Model	Volvo FH420
Vehicle owner	Peter Appel Transport B.V.
License plate no.	77-BLB-4
EEC Type approval	595/2009*2016/1718C
Date of registration	04-07-2018
Odometer reading at intake vehicle	19990 km
Maximum technically permissible laden mass	21000 kg
Gross Train Weight (GTW)¹	46440 kg
Registered mass running order truck	8131 kg
Registered mass running order trailer	7400 kg
Loading capacity combination	34489 kg
Payload combination (53%)	16389 kg
Combination weight during test	31920 kg
Axle configuration	4 x 2
VIN (chassis number)	YV2RZ70A3JA829953
Wheelbase	3.8 m
Vehicle class	N3
Gearbox make + type	Volvo Sweden - AT2612F
Number of forward gears	12
Tyre make and type rear axle	Continental Hybrid HD3
Tyre size	315 / 70 / R22,5
Tyre test pressure	8.5 bar
Fuel tank capacity Diesel	195 l
Fuel tank capacity LNG	205 kg
AdBlue tank capacity	64 l

¹ The maximum GTW is limited due to the maximum axle loads of the combination as described in TNO report R10193[7].

Table 2 Engine information.

Engine type	G13C420 (LNG engine)
Fuel injection system	Combined Diesel/Gas Injector
Engine serial number	805066
Number of cylinders	6
Displacement	12.777 l
Euro Class	Euro VI
Turbo	Yes
Intercooler	Yes
EGR	Yes (Uncooled)

Table 3 Aftertreatment information.

Aftertreatment system (downstream)	Diesel Oxidation Catalyst (DOC)
	Diesel Particulate Filter (DPF)
	Selective Catalytic Reduction (SCR)
	Ammonia Slip Catalyst (ASC)
Consumable reagent	AdBlue

Table 4 Software versions and identifications.

	Engine Control Module	Aftertreatment Control Module
Software version	23338537	23385413
Software ID	23154053	23154361
Calibration ID	23154058	23154435

2.1.2 Test fuel

Before and during the tests the vehicle was fuelled with market fuel LNG at gas station 'Truckstop 8' in Eindhoven. See Annex A for detailed information on the LNG composition.

2.1.3 Vehicle payload

According to Annex 2, paragraph 4.1 of EU No. 2016/1718 [2], the vehicle payload shall be 10 – 100% of the maximum payload (in absence of statistics to demonstrate a representative payload for the vehicle). In order to be able to compare results with previously measured LNG trucks as mentioned in TNO report R10193[7], the specific load percentage results in 53%.

The specified load percentage of 53% results in a mass of the ballast load of 16389 kg. Therefore a combined test mass of 8131 kg (running order mass truck) + 7400 kg (running order mass trailer) + 16389 kg (loading mass) = 31920 kg (total test mass). Prior to testing, the total combination mass was measured as shown in Appendix G.

An artificial payload is used to load the combination to 53% payload (= 16389 kg). The load consisted of concrete blocks, a container filled with water and the measurement equipment. The payload is shown in Figure 4.



Figure 4 The vehicle payload inside of the trailer.

2.2 Equipment used

2.2.1 Gaseous emissions

The analyser that was used for measuring the gaseous emissions is the OBS-ONE-GS12 (PEMS) with serial number 63JNMN52. For its specifications see Table 5. Detailed information about the checks performed for the calibration of the gaseous analysers can be found in Appendix G.

The PEMS analyser installed in the vehicle is shown in Figure 5.

Table 5 OBS-ONE-GS12 specifications.

Gaseous component	Analyser	Range	Accuracy
THC	Flame Ionization Detector (FID)	0 – 10000 ppmC	Within $\pm 0.3\%$ of full scale or 2.0% of readings (whichever is larger)
CO	Non-Dispersive Infrared (NDIR)	0 – 10 %	Within $\pm 0.3\%$ of full scale or 2.0% of readings (whichever is larger)
CO₂	Non-Dispersive Infrared (NDIR)	0 – 20 %	Within $\pm 0.3\%$ of full scale or 2.0% of readings (whichever is larger)
NO	Chemi-Luminescence (CLD)	0 – 3000 ppm	Within $\pm 0.3\%$ of full scale or 2.0% of readings (whichever is larger)
NO_x	Chemi-Luminescence (CLD)	0 – 3000 ppm	Within $\pm 0.3\%$ of full scale or 2.0% of readings (whichever is larger)



Figure 5 The PEMS analyser mounted in the cabin of the truck.

2.2.2 Exhaust flow meter

The exhaust mass flow, pressure and temperature are measured with a Pitot Flow Meter Unit (PF) and flow tube as shown in Figure 6, for its specifications see Table 6. Detailed information about the calibration of the pitot flow module and tube can be found in Appendix E.

Table 6 Horiba Pitot Flow Meter specifications.

PF serial number	PG7RUL35
Flow tube serial number	150502F
Flow tube diameter	4 inch (F-tube)
Flow measurement range	0 – 30 m ³ /min
Flow measurement accuracy	Within ± 0.5 % of full scale or ± 2.0 % of readings (whichever is larger)
Exhaust temperature measurement range	0-800°C
Exhaust temperature accuracy	Within ± 2.0 % of full scale
Exhaust pressure measurement range	70-115 kPa (abs)
Exhaust pressure accuracy	Within ± 2.0 % of full scale
EFM Cable	Exhaust H/L Tube and Thermocouple Cable



Figure 6 The flow tube connected to the exhaust of the truck.

2.2.3 Particle Number Measurement

At the request of the Dutch Ministry of infrastructure and Water management, Particle Number (hereinafter PN) has been measured during the campaign using a PN-PEMS module. Table 7 shows its specifications. Detailed information about the checks performed for the calibration of the particle counter can be found in Appendix E.

Table 7 OBS-ONE-PN specifications

Detectable particle	Limited to 1 µm by inlet cyclone
Detection efficiency	<60% at 23 nm >60% at 50 nm
Particle concentration	Single particle counting (nominal 100:1 dilution) 1 000 : 50 000 000 particle/cm ³
Condensing liquid	99.5% isopropyl alcohol
Catalytic stripper	Efficiency >99.9% of 30 nm
Particle concentration accuracy	±15% compared to the standard
Environmental operating conditions	Temperature -10 – 40 °C Pressure 86 – 106 kPa
Sample interval	2 Hz

2.2.4 Other equipment

Table 8 lists the remaining equipment that was used to operate the measurement system.

Table 8 Other equipment.

System software	1.3.6
Horiba Post Processing software version	2.12.0
Power supply	Honda 20i EAAJ-1820185
Power terminal	24V Power supply
Power cable	Power Cable BATT24V to DC3 + DC4 to DC3 extension cable
GPS sensor	U-Blox ANN-MS-1-005 GPS Antenna
Weather station	Temp and RH sensor Horiba 61361448
Protocol adapter	Kvaser Leaf Light v2 73-30130-00685-0
Heated line	Single Heated Line 191°C
System battery	2x 12V 170 Ah 1000 A (EN)
Silverscan software version	6.22.36.28520
Silverscan CAN interface	Kvaser Leaf Light v2 018504

2.3 Test route

A test route was selected that meets the following requirements for a N3 category vehicle:

1. Target time share of urban, rural and motorway operation : 20, 25 and 55% ($\pm 5\%$) respectively;
2. A total cycle work between 4-7 times reference work (World Harmonized Transient Cycle work) or a total CO₂ mass between 4-7 times reference CO₂ mass (World Harmonized Transient Cycle CO₂ mass);
3. The assessment of trip composition shall start after the engine coolant temperature has reached 343 K (70°C) for the first time or after the coolant temperature is stabilized within ± 2 K over a period of 5 minutes whichever comes first but no later than 15 minutes.

All tests started with a cold engine(engine coolant temperature below 303 K(30°C)) as required in point 2.6.1. of EU No. 2016/1718 [2] . For more details see Appendices B.1, C.1 and D.1.

The route that was driven is shown in figure 7. To determine the start of the rural and motorway parts, the first acceleration method has been used. This means that the first acceleration above 55km/h indicates the beginning of the rural part, and the first acceleration above 75km/h indicates the start of the rural part.

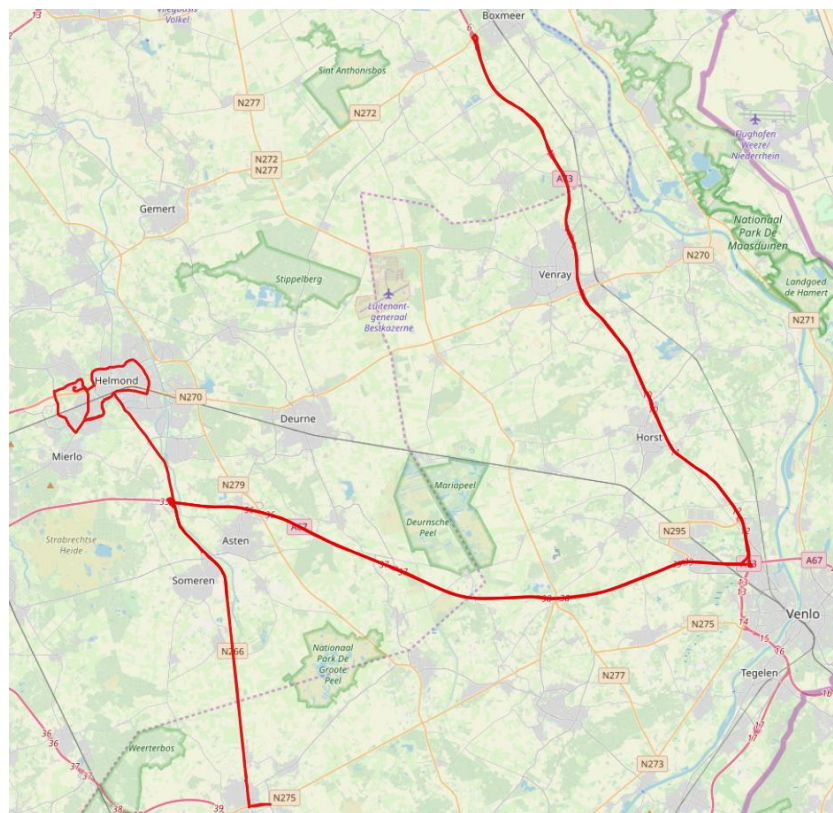


Figure 7 The test route.

2.4 OBD error check

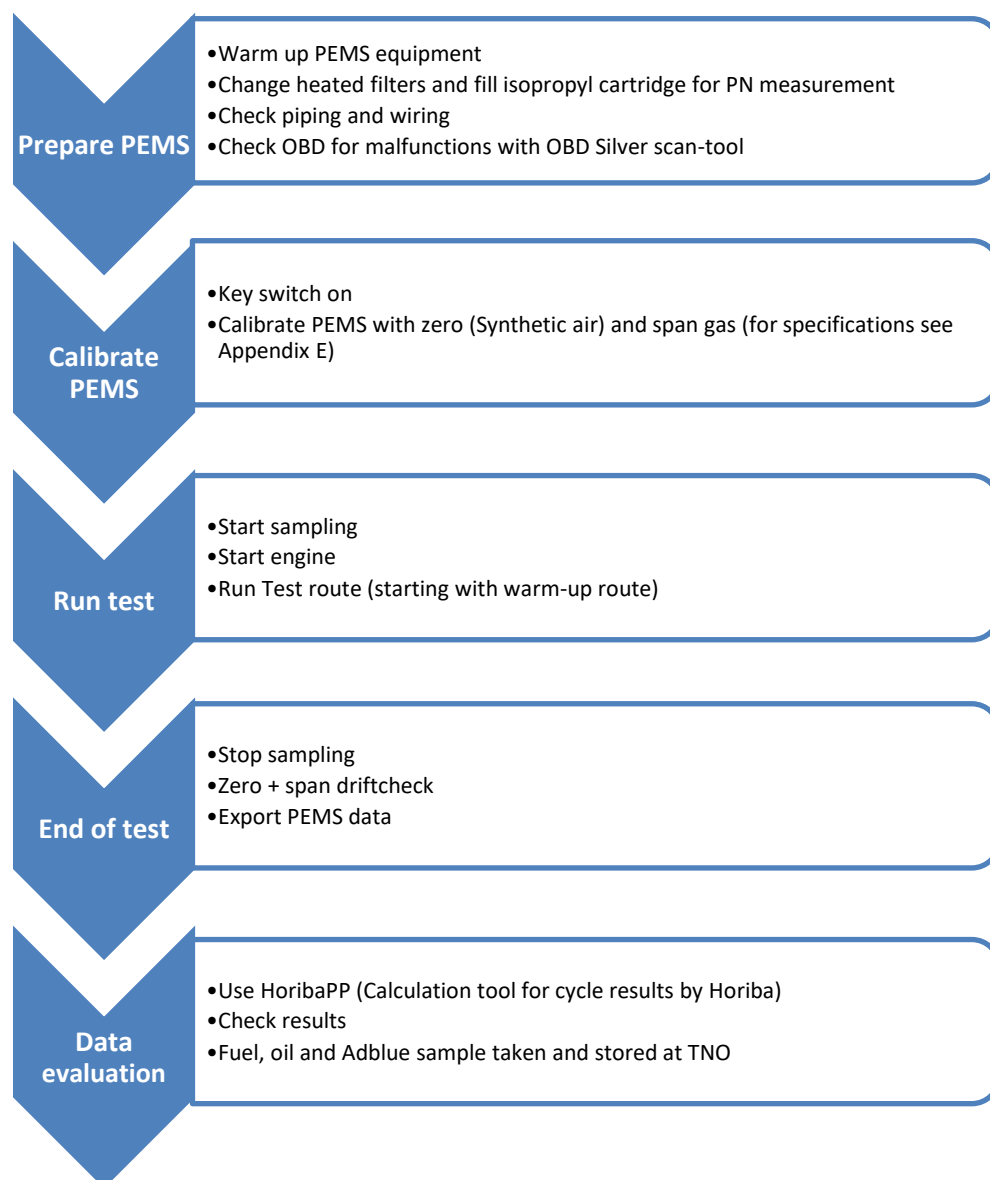
An OBD error check was performed by TNO prior to the first PEMS test. No active emission related error codes were found in the vehicle during the whole measurement programme.

Software: Silver Scan-Tool 6.22.36.28250

Adapter: Kvaser Leaf Light v2 73-30130-00685-0

2.5 Test procedure

The figure below shows the daily test procedure in a flowchart:



2.6 Data processing

HoribaPP (Post Processing) version 2.12.0 has been used as data processing tool. The detailed test results for test 1, 2 and 3 can be found in Appendices B, C, and D respectively. The main results are discussed in the next section.

3 Results summary

3.1 Checks and conditions

Several data checks were performed in order to minimise measurement errors. Sections 3.1.1 to 3.1.3 show the result of these checks for analyser drift, odometer and test conditions respectively. In addition, a consistency check on the fuel flow was performed as described in section 3.1.4 including the brake-specific fuel consumption (hereinafter BSFC) of all three tests. The requirements regarding trip composition and trip characteristics are shown in section 3.1.5 and 3.1.6. Finally, in section 3.1.7, the full-load curve is used to determine if the measured torque values correlate with the full-load curve provided by the manufacturer.

3.1.1 Drift check

The analysers were calibrated prior to testing and checked for zero and span during periodic checks and after the test completed. During post-processing, the analyser drift was determined. If the difference between the pre and post-test results is equal to or greater than 2 % as determined during the drift check, the test shall be voided or the measured concentrations shall be corrected for drift. All drift values were below 2% of full-scale after the data were evaluated so no drift correction was applied.

The results of the drift checks are shown in Figure 8 to Figure 10.

	Channel	Zero			Span		
		Pre	Post	Drift [%FS]	Pre	Post	Drift [%FS]
CO [vol%]	MeasData_1Hz/GA_COConc	-0.000354	0.002208	0.025614	3.007269	3.021646	0.143770
CO2 [vol%]	MeasData_1Hz/GA_CO2Conc	0.008901	0.025682	0.083907	15.932550	15.944430	0.059400
NO [ppm]	MeasData_1Hz/GA_NOConc	0.570827	0.124470	-0.014879	2505.413000	2501.616000	-0.126567
NOx [ppm]	MeasData_1Hz/GA_NOxConc	0.951119	0.596754	-0.011812	2505.376000	2472.469000	-1.096900
THC [ppmC]	MeasData_1Hz/GA_THCConc	-0.061939	-0.013191	0.000487	973.590300	957.445600	-0.161447
CH4 [ppmC]	----						

Figure 8 Drift check test #1.

	Channel	Zero			Span		
		Pre	Post	Drift [%FS]	Pre	Post	Drift [%FS]
CO [vol%]	MeasData_1Hz/GA_COConc	0.000044	0.000516	0.004726	3.008180	3.004481	-0.036990
CO2 [vol%]	MeasData_1Hz/GA_CO2Conc	0.003032	0.016371	0.066699	15.940310	15.947780	0.037350
NO [ppm]	MeasData_1Hz/GA_NOConc	0.047349	0.089851	0.001417	2505.065000	2482.955000	-0.737000
NOx [ppm]	MeasData_1Hz/GA_NOxConc	-0.355943	1.986701	0.078088	2505.121000	2472.350000	-1.092367
THC [ppmC]	MeasData_1Hz/GA_THCConc	-0.081524	0.344893	0.004264	973.762900	942.236600	-0.315263
CH4 [ppmC]	----						

Figure 9 Drift check test #2.

	Channel	Zero			Span		
		Pre	Post	Drift [%FS]	Pre	Post	Drift [%FS]
CO [vol%]	MeasData_1Hz/GA_COConc	-0.000300	0.003219	0.035185	3.006424	3.024368	0.179440
CO2 [vol%]	MeasData_1Hz/GA_CO2Conc	-0.000790	0.018556	0.096732	15.947560	16.019940	0.361900
NO [ppm]	MeasData_1Hz/GA_NOConc	-0.165370	-0.356749	-0.006379	2506.466000	2484.649000	-0.727233
NOx [ppm]	MeasData_1Hz/GA_NOxConc	-0.848110	-1.090467	-0.008079	2505.453000	2464.862000	-1.353033
THC [ppmC]	MeasData_1Hz/GA_THCConc	-0.006278	0.102181	0.001085	973.746700	950.461600	-0.232851
CH4 [ppmC]	----						

Figure 10 Drift check test #3.

3.1.2 Odometer distance check

The odometer reading was recorded before and after each test. The travelled distance is compared to GPS and OBD data from the PEMS in Table 9. The results show that the vehicle odometer corresponds well to the calculated OBD distance.

Table 9 Odometer distance check against GPS data.

Test #	Odometer start	Odometer end	Odometer distance	OBD distance	GPS distance
	km	km	km	km	km
1	20095	20273	178	177.4	178.6
2 ²	20286	20477	191	190.5	191.8
3	21218	21395	177	175.9	177.0

3.1.3 Test conditions

The PEMS cycles with the test-vehicle were measured under the conditions as shown in Table 10. The conditions encountered are valid for ISC testing as set by EU No. 582/2011[1].

Table 10 Test conditions PEMS tests.

Test #	Date	Test definition	Cycle	Payload	Traffic	Ambient temp.	Weather
1	12-10-2018	PEMS test	N3	53%	Regular	24°C	Sunny
2	27-08-2018	PEMS test	N3	53%	Regular	24°C	Cloudy
3	30-08-2018	PEMS test	N3	53%	Regular	16°C	Cloudy

For more detailed test conditions see Appendices B.1, C.1 and C.1.

² The Urban duration for test 2 was 4 minutes longer than test 1. As the motorway duration ratio for test 1 was on the lower limit(50,5%), the decision was made to extend the Motorway part to avoid a failure on trip composition.

3.1.4 Fuel consistency check

The fuel consistency check was performed by TNO as shown in Figure 11. The consistency of the data was verified using a correlation between the measured fuel flow from the ECU and the fuel flow calculated from exhaust mass flow measured by the EFM and gaseous exhaust components that include carbon according to EU No. 2016/1718 [2].

In absence of a Diesel- and LNG fuel flow signal, a diesel equivalent signal is broadcasted by the ECU. A linear regression was performed for the measured and calculated fuel rate values which resulted in a regression coefficient $R^2 > 0.9$.

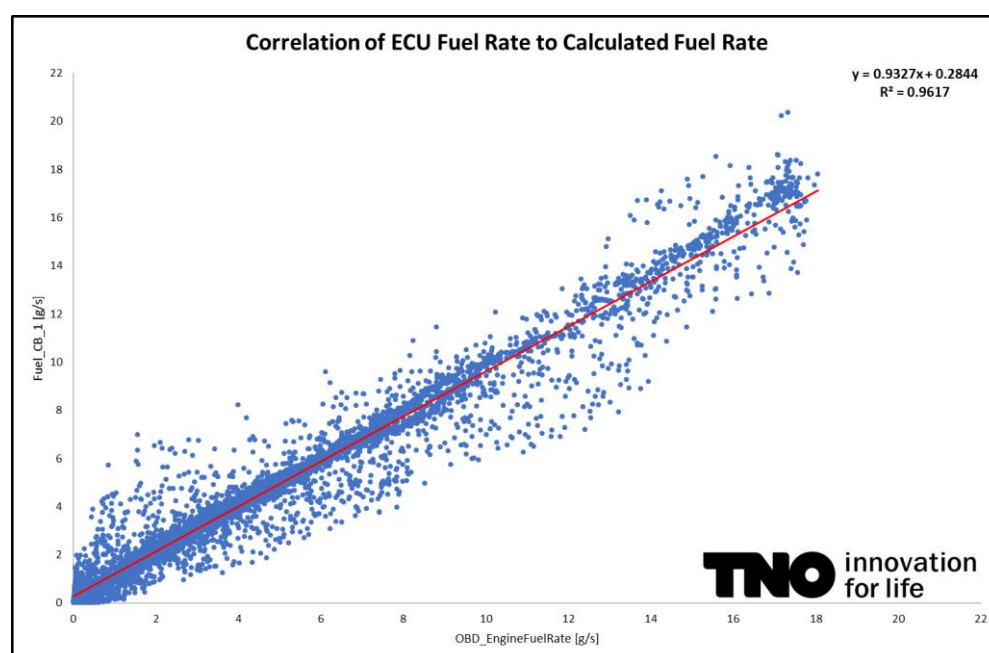


Figure 11 Correlation of ECU fuel rate to calculated fuel rate for test 1

The fuel consistency check result is valid for test 1, 2 and 3. The results are shown in Table 11 and in Appendices B.8, C.8 and D.8.

Table 11 Linear regression fuel rate correlation.

Test #	Slope	Intercept	Regression
	m	b	R^2
1	0.93	0.28	0.96
2	0.94	0.34	0.96
3	0.90	0.26	0.96

In addition to this fuel consistency check, the brake-specific fuel consumption was calculated by dividing the total fuel consumption (in grams) by the total cycle work (kWh). The result for the calculation from OBD and emission data are shown in Table 12.

Table 12 Brake specific fuel consumption.

Test #	BSFC from OBD	BSFC from emissions
	g/kWh	g/kWh
1	199.4	199.5
2	200.2	206.2
3	199.3	190.9

3.1.5 Trip composition

All trips meet the required trip composition requirements as set by EU No. 2016/1718[2] as seen in Table 13 to Table 15. The trip characteristics are shown in Table 16. The vehicle speed trace for the three tests is shown in Figure 12.

Table 13 Test compositions PEMS test #1.

Test # 1		Urban	Rural	Motorway
Average speed	km/h	27.8	60.6	79.4
Distance	km	19.5	41.9	113.0
Duration	h:min:s	0:42:05	0:41:30	1:25:21
Duration ratio	%	24.9	24.6	50.5
Target	%	20	25	55
Valid/invalid		Valid	Valid	Valid

Table 14 Test compositions PEMS test #2.

Test # 2		Urban	Rural	Motorway
Average speed	km/h	24.4	60.9	77.7
Distance	km	18.0	41.9	127.7
Duration	h:min:s	0:44:16	0:41:15	1:38:36
Duration ratio	%	24.0	22.4	53.6
Target	%	20	25	55
Valid/invalid		Valid	Valid	Valid

Table 15 Test compositions PEMS test #3.

Test # 3		Urban	Rural	Motorway
Average speed	km/h	25.6	59.6	80.6
Distance	km	17.5	41.9	113.0
Duration	h:min:s	0:40:53	0:42:11	1:24:05
Duration ratio	%	24.5	25.2	50.3
Target	%	20	25	55
Valid/invalid		Valid	Valid	Valid

Table 16 Trip characteristics all tests.

Test #	Accelerating time ratio	Decelerating time ratio	Cruising time ratio	Stop time ratio
	%	%	%	%
1	14.0	9.8	72.0	4.2
2	12.0	8.5	73.1	6.4
3	12.9	9.7	72.1	5.4

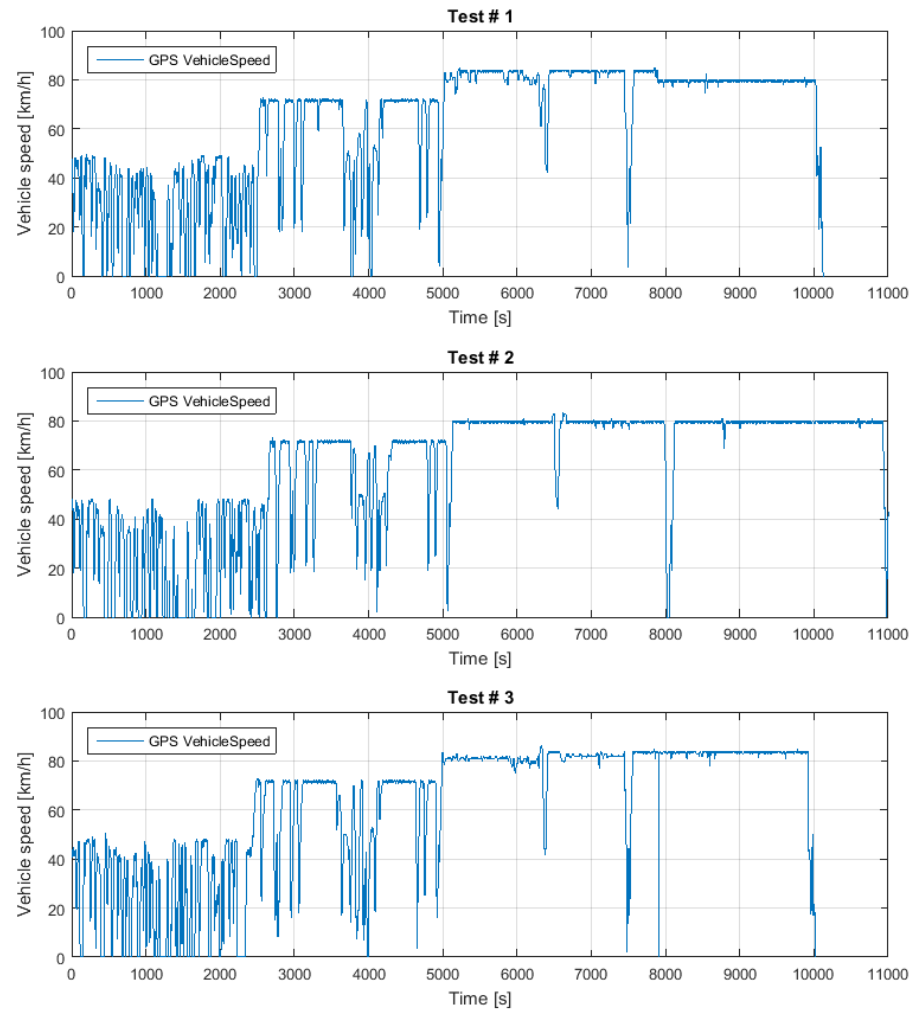


Figure 12 Vehicle speed trace for all tests.

3.1.6 Full load curve check

The torque data provided by the ECU was compared to the full load curve provided by Volvo. The first test is shown in Figure 13. The result of all tests can be found in Appendices B.10, C.10 and D.10. The red curve displays the provided full-load curve from Volvo, the blue dots are the measured ECU torque points during the test. The figure shows that the measured engine load is slightly higher in comparison with the full-load curve. According to ECE R49 revision 6 Amendment 1 [5] a correction is not necessary as the maximum ECU torque signal is within 7% of the provided full load curve.

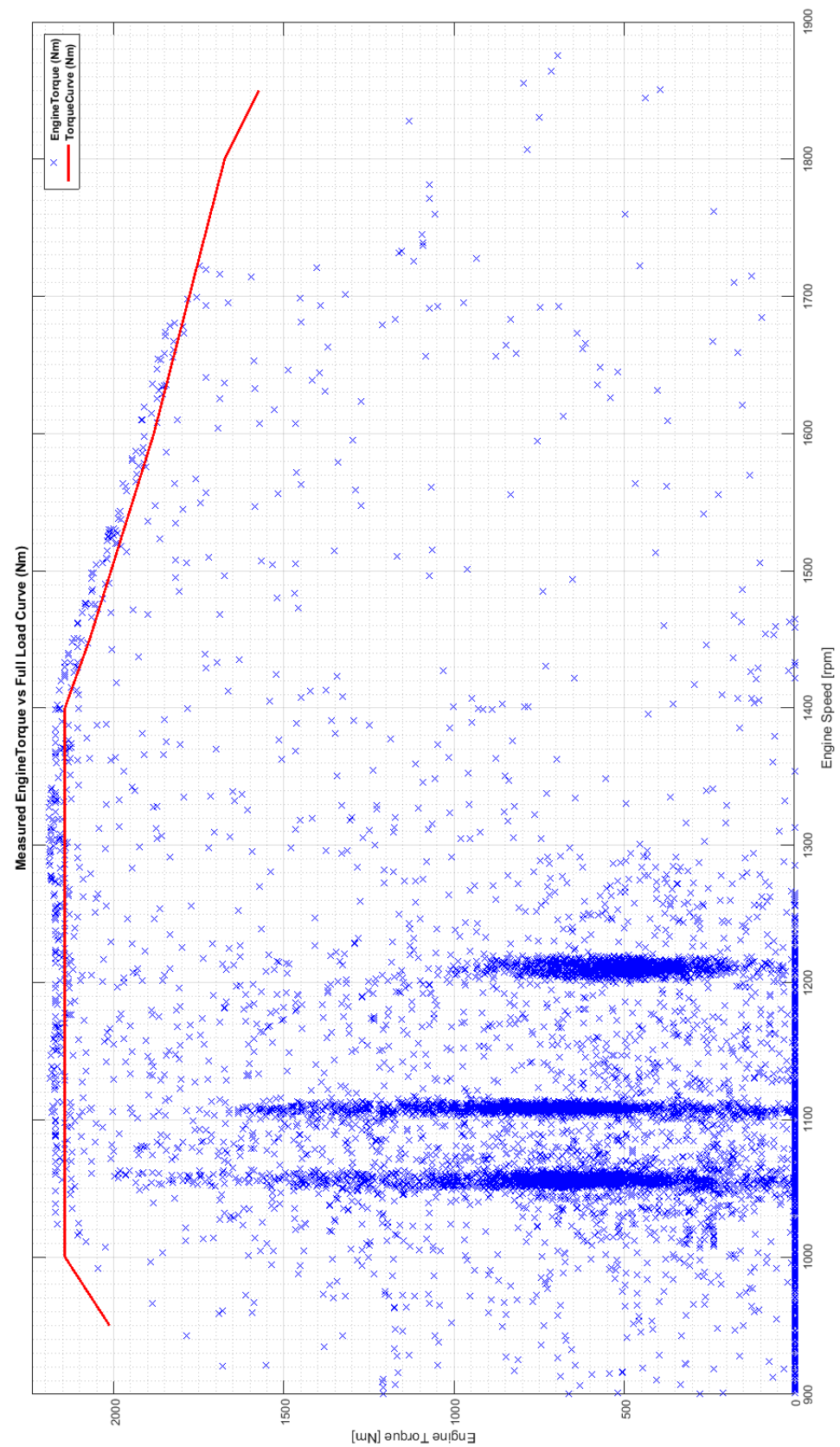


Figure 13 Full load curve check.

3.2 Emission results

The results of the emissions measurements and subsequent data processing are described in sections 3.2.1. to 3.2.3.

3.2.1 Brake specific emission

Table 17 shows the total cumulative gaseous and particulate emissions divided by the total cycle work. For the calculation of cycle work, all negative engine torque values are set to zero.

Table 17 Test evaluation: Total cycle emissions.

Test #	CO	CO ₂	THC	NO _x	PN	Cycle work	WHTC reference work ratio
	g/kWh	g/kWh	g/kWh	g/kWh	#/kWh	kWh	-
1	2.479	543.8	0.303	0.155	5.515e+11	213.5	6.4
2	2.720	564.4	0.301	0.115	3.234e+11	214.1	6.4
3	2.445	519.0	0.351	0.177	1.815e+11	213.8	6.4

For more detailed test results see appendix B.1, C.1 and D.1.

3.2.2 Conformity Factors

The CF (Conformity Factor) results for NO_x emission, for both work- and CO₂ window based methods are shown in Table 16 and Table 19.

Data was processed according to EU No.2016/1718 [2], which means that:

- Data evaluation starts after the coolant temperature has reached 70°C for the first time or after the temperature has stabilised within ± 2 K over a period of 5 minutes whichever comes first but no later than 15 minutes.
- Windows are marked valid when the average engine power exceeds the minimum power threshold of 20%. When the resulting share of valid windows is below 50%, the power threshold is lowered in steps of 1% (to a minimum of 15%) until the amount of valid windows exceeds 50%;
- From the resulting valid windows, per emission component the 10th percentile of the windows with the highest calculated emissions are discarded;
- The conformity factor is determined by dividing the resulting highest emission by the legislative limit for Positive Ignition(PI) engines, therefore the CH₄ limit was used for THC.

Table 17 and Table 19 show that the CF results for NO_x, THC and CO for both the work and CO₂ based window results are below the limit (CF 1.5) as demanded by EU No. 582/2011 [1].

The CF for PN has not yet been determined. This means the CF for PN as shown in Table 17 and Table 18 are purely indicative and does not account for pass/fail. Notable is the strong decline in CF for PN during the course of the test program. It is unknown if a regeneration of the particulate filter took place before the start of the first test.

For detailed information about the reference parameters that were used during the data processing, see Appendices B.5, B.6, C.5, C.6, D.5 and D.6.

Table 18 Test results: 90% cumulative percentile of the work-based exhaust emission conformity factors of the engine system tested.

	Work based window					
Test #	CO	THC ³	NO _x	PN ⁴	Valid windows	Power threshold
	CF	CF	CF	CF	%	%
1	0.57	0.65	0.50	2.33	93.5	20
2	0.65	0.63	0.33	1.39	93.9	20
3	0.77	0.77	0.32	0.53	91.2	20

Table 19 Test results: 90% cumulative percentile of the CO₂-based exhaust emission conformity factors of the engine system tested.

	CO ₂ based window					
Test #	CO	THC ³	NO _x	PN ⁴	Valid windows	Power threshold
	CF	CF	CF	CF	%	%
1	0.57	0.65	0.52	2.41	91.1	20
2	0.64	0.61	0.33	1.30	93.3	20
3	0.83	0.81	0.33	0.57	89.4	20

For more detailed test results see appendices A.5 & 6, B.5 & 6 and C.5 & 6.

3.2.3 TNO binning results

TNO binning [6] has been performed on all tests.

The brake specific results of the binning method match the results as described in 3.2.1. since no data is discarded for the binning method.

Test # 1 : See appendix B.11 & B.12

Test # 2 : See appendix C.11 & C.12

Test # 3 : See appendix D.11 & D.12

The results of the binning method suggest that the highest NO_x emissions per amount of CO₂ can be found at relatively high engine loads (rural speed bins).

³ The window based THC emissions are divided by the limit for CH₄ set for PI(positive ignition) engines according to (EU) No.133/2014[3].

⁴ CF for PN is not regulated. Window based PN is divided by WHTC CI limit from Annex I of EC 595/2009

4 Conclusion

Three on-road emission tests were performed with PEMS on a N3 Euro VI Step-C truck conform Regulation (EU) No. 582/2011 [1] as amended by (EU) No. 2016/1718 [2] to verify that the vehicle meets the requirements concerning heavy duty vehicle in-service conformity emission regulations.

- For the three valid tests the 90% cumulative exhaust emissions conformity factors for NO_x, THC and CO are below the maximum allowed value of 1.5.
- The 90% cumulative NO_x conformity factors for test 1,2 and 3, determined according the work based method are 0.50, 0.33 and 0.32, and on average 0.38.
- The 90% cumulative NO_x conformity factors for test 1,2 and 3, determined according the CO₂ based method are 0.52, 0.33 and 0.33, and on average 0.39.

Considering the demonstrated validity of the measurements, the results of the measurements are interpreted as plausible. During testing, no anomalies were encountered. The CF results show that for both work- and CO₂ based window methods the limit of 1.5 was not exceeded for components NO_x, CO and THC(with application of the emission limits set for PI engines according to (EU) No.133/2014[3]).

The CF for PN has not yet been determined. This means the CF for PN are purely indicative and do not account for pass/fail. Notable is the strong decline in CF for PN during the course of the test program. It is unknown if a regeneration of the particulate filter took place before the start of the first test.

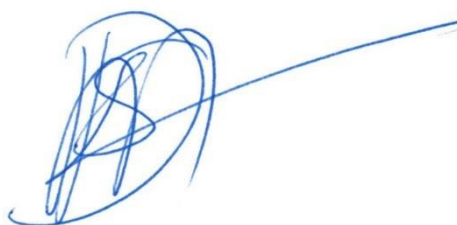
5 References

- [1] Commission Regulation (EU) No 582/2011, of 25 May 2011, implementing and amending Regulation (EC) No 595/2009 of the European Parliament and of the Council with respect to emissions from heavy duty vehicles (Euro VI) and amending Annexes I and III to Directive 2007/46/EC of the European Parliament and of the Council.
- [2] COMMISSION REGULATION (EU) 2016/1718 of 20 September 2016, amending Regulation (EU) No 582/2011 with respect to emissions from heavy-duty vehicles as regards the provisions on testing by means of portable emission measurement systems (PEMS) and the procedure for the testing of the durability of replacement pollution control devices
- [3] COMMISSION REGULATION (EU) No 133/2014 of 31 January 2014, amending, for the purposes of adapting to technical progress as regards emission limits, Directive 2007/46/EC of the European Parliament and of the Council, Regulation (EC) No 595/2009 of the European Parliament and of the Council and Commission Regulation (EU) No 582/2011
- [4] REGULATION (EC) No 595/2009 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 June 2009 on type-approval of motor vehicles and engines with respect to emissions from heavy duty vehicles (Euro VI) and on access to vehicle repair and maintenance information and amending Regulation (EC) No 715/2007 and Directive 2007/46/EC and repealing Directives 80/1269/EEC, 2005/55/EC and 2005/78/EC
- [5] United Nations Regulation No. 49 Revision 6 – Amendment 1, Uniform provisions concerning the measures to be taken against the emission of gaseous and particulate pollutants from compression-ignition engines and positive ignition engines for use in vehicles.
- [6] Heijne et al. 2016, Assessment of road vehicle emissions: methodology of the Dutch in-service testing programme, TNO report 2016 R11178.
- [7] Vermeulen et al. 2019, Emissions testing of a Euro VI LNG-diesel dual fuel truck in the Netherlands, TNO report 2019 R10193

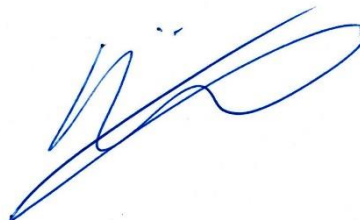
6 Signature

Helmond, April 12, 2019

TNO

A handwritten signature in blue ink, consisting of a large, stylized 'M' with a long horizontal stroke extending to the right.

Martijn Stamm
Head of department

A handwritten signature in blue ink, featuring a stylized 'M' and 'N' with a long horizontal stroke extending to the right.

Maarten Nijenhuis
Author

A Test fuel

 Maasvlakteweg 993 Maasvlakte Tel: +31 181 79 90 00	Slot start date-time:	2018-10-04 15:00:00
	Slot end date-time:	2018-10-04 16:30:00

Slot ID number / Slot ID number:	Weegbrug volgnummer / Weighbridge sequence number:
SNV_1008101	2017003090

LNG Leverancier klant / Customer's LNG Supplier: Shell Western LNG B.V. Carel van Bylandtlaan 30 2596 HR The Hague The Netherlands NL	Product: UN1972 Aardgas, Sterk Gekoeld, Vloeibaar, 2.1, (B/D) Natural Gas, Refrigerated Liquid, 2.1, (B/D)												
Klant / Customer: Shell Nederland Verkoopmaatschappij B.V. Weena 70 3012 CM Rotterdam NL	Ticket Datum / Ticket Date: 2018-10-04												
Kenteken Truck / License plate truck: 36-BFF-7	Ticket Tijd / Ticket Time: 15:51:53												
Kenteken Trailer / License plate trailer: ON-80-PG	Compositie / Composition (Vol %): Methane 93.846 Neo Pentane 0.002 Ethane 5.144 Iso Pentane 0.006 Propane 0.600 Hexane 0.000 Normal Butane 0.137 Carbon dioxide 0.000 Iso Butane 0.138 Nitrogen 0.126 Normal Pentane 0.002												
Container ID (if applicable, e.g. HOYU 434433 3): Not Applicable	<table border="1"> <tr> <td>GHV (MJ/Kg):</td> <td>LHV (MJ/kg):</td> <td>Methane nr:</td> <td>Temp. LNG (°C):</td> </tr> <tr> <td>54.933</td> <td>49.596</td> <td>80.970</td> <td>-157.620</td> </tr> <tr> <td colspan="2"></td> <td>DIN EN 16726</td> <td></td> </tr> </table>	GHV (MJ/Kg):	LHV (MJ/kg):	Methane nr:	Temp. LNG (°C):	54.933	49.596	80.970	-157.620			DIN EN 16726	
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54.933	49.596	80.970	-157.620										
		DIN EN 16726											
Afleveradres 1 / Delivery address 1: Shell retail station Waalwijk Nederland	<table border="1"> <tr> <td>GHV (kWh/kg):</td> <td>WI (MJ/Nm3):</td> <td>Dens. (kg/m3):</td> <td>Dens. (kg/Nm3):</td> </tr> <tr> <td>15.259</td> <td>54.583</td> <td>437.491</td> <td>0.764</td> </tr> </table>	GHV (kWh/kg):	WI (MJ/Nm3):	Dens. (kg/m3):	Dens. (kg/Nm3):	15.259	54.583	437.491	0.764				
GHV (kWh/kg):	WI (MJ/Nm3):	Dens. (kg/m3):	Dens. (kg/Nm3):										
15.259	54.583	437.491	0.764										
Afleveradres 2 / Delivery address 2: Shell retail station Eindhoven Nederland	<table border="1"> <tr> <td>Tot. energie geladen / Total energy loaded (MWh)</td> <td>S (mg/Nm3)</td> </tr> <tr> <td>297.248</td> <td>0.000</td> </tr> </table>	Tot. energie geladen / Total energy loaded (MWh)	S (mg/Nm3)	297.248	0.000								
Tot. energie geladen / Total energy loaded (MWh)	S (mg/Nm3)												
297.248	0.000												
Afleveradres 3 / Delivery address 3: -	Gewicht VOOR laden / Weight BEFORE loading: 21700 kg LB02 3914 2018-10-04 14:58												
Naam & handtekening Chauffeur / Driver name & signature: Peter Verkooijen	Gewicht NA laden / Weight AFTER loading: 41180 kg LB02 3915 2018-10-04 15:51												
Naam & handtekening Operator / Operator name & signature: A. Voogt	Netto gewicht geladen / Net weight loaded: 19480 kg												

Cooldown service:
No
Commentaar / Comments:

B Test # 1

B.1 Emission report



Emission Report

Test

Test ID : 148

Test Date : 2018/10/12

Test Start : 10:56:51

Test End : 14:13:22

Driver : Ricardo

Comment :

Vehicle

Vehicle Name : 77-BLB-4

Vehicle Type : N3

Fuel Type : CNG

Description : L731_Volvo_

Device

Cell Name : OBS-ONE

Cell Description :

Emission (Include Cold Start)

	Total Mass	Unit	Mass / Distance	Unit	Mass / Work (*4)	Unit	Conc. Max.	Conc. Ave.	Unit
CO	699.5	g	3.916	g/km	3.209	g/kWh	2.932	0.03857	vol%
CO2	1.222E5	g	684.0	g/km	560.4	g/kWh	9.703	3.839	vol%
THC	72.08	g	0.4035	g/km	0.3306	g/kWh	845.6	78.83	ppmC
CH4	—	g	—	g/km	—	g/kWh	—	—	ppmC
NMHC	—	g	—	g/km	—	g/kWh	—	—	ppmC
NO (*1)	25.93	g	0.1452	g/km	0.1190	g/kWh	965.2	13.21	ppm
NO2 (*2)	30.90	g	0.1730	g/km	0.1418	g/kWh	223.3	5.989	ppm
NOx	56.83	g	0.3182	g/km	0.2607	g/kWh	982.3	18.92	ppm
PM	—	g	—	g/km	—	g/kWh	— (*3)	— (*3)	mm/cm3
PN	1.22E14	#	6.81E11	#/km	5.58E11	#/kWh	3.65E6 (*3)	6.69E4 (*3)	#/cm3

Fuel Economy	32.3	L/100km
--------------	------	---------

(*1) : NO mass is calculated by molecular weight.

(*2) : NO2 mass is subtracted NO mass from NOx mass.

NO and NOx mass are calculated by molecular weight.

(*3) : at 0degC

(*4) : Mass / Work and Total Work is not corrected data.

Trip Summary

	Max.	Ave.	Unit
Velocity GPS	85.4	58.6	km/h
Velocity OBD	85.0	58.2	km/h
Velocity EIU	—	—	km/h
Eng. Speed	1876	1054	rpm
Eng. Torque	—	—	Nm
Eng. Power	324.2	69.7	kW

Total Distance	178.612	km
Total Work (*4)	217.994	kWh

Total Trip Duration	3:02:53	h:min:s
Stop Duration	12:04	min:s
Number of Stop	—	#
Trip Maximum Speed	85.43	km/h
Min. Coolant Temp	293.2	K
Max. Coolant Temp	357.2	K

Trip Condition

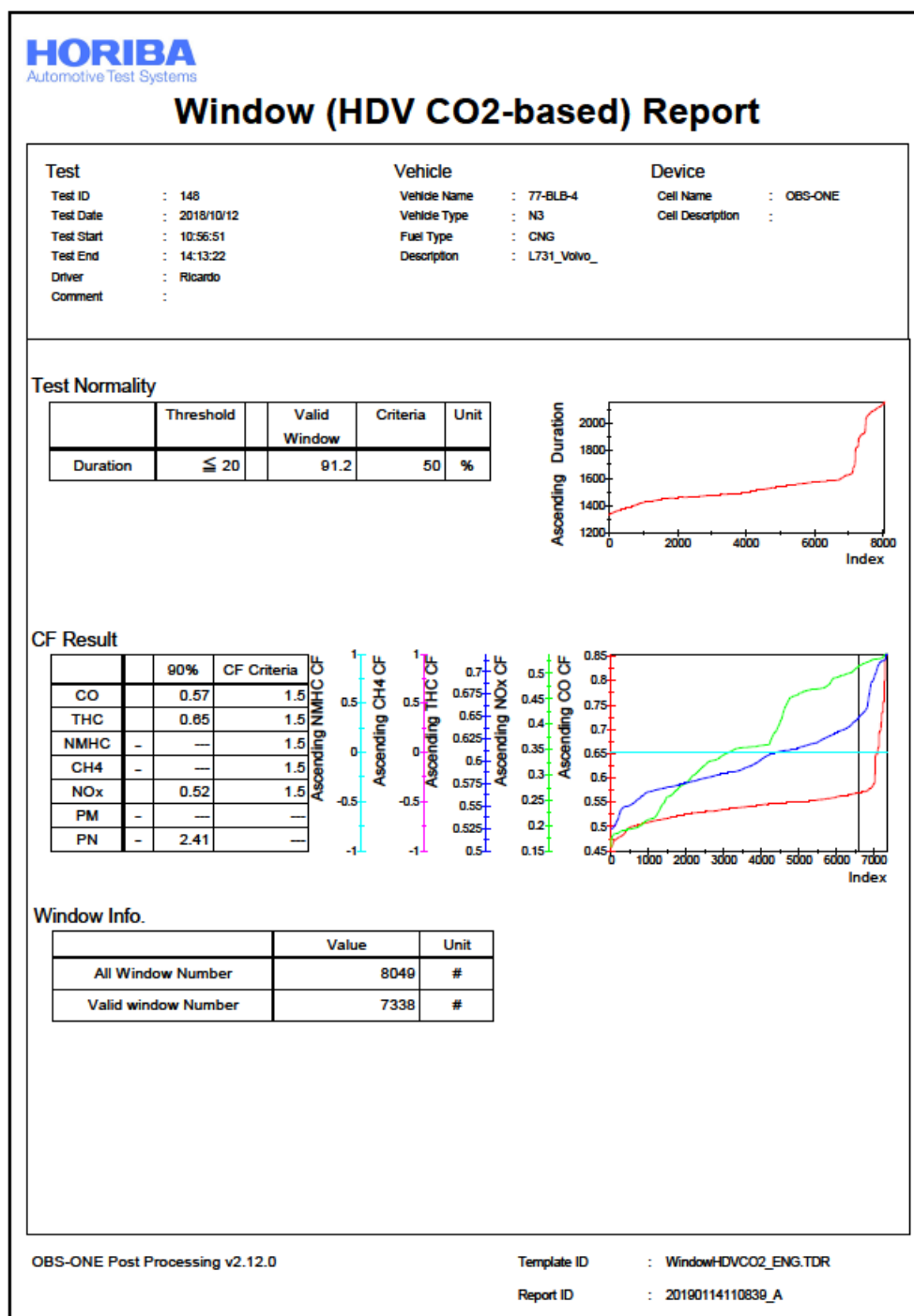
	Min.	Max.	Ave.	Unit
Temperature	294.6	300.5	297.0	K
R.H.	44.8	64.8	55.6	%
Pressure	101.5	101.9	101.7	kPa
Altitude	9.6	43.3	25.8	m

OBS-ONE Post Processing v2.12.0

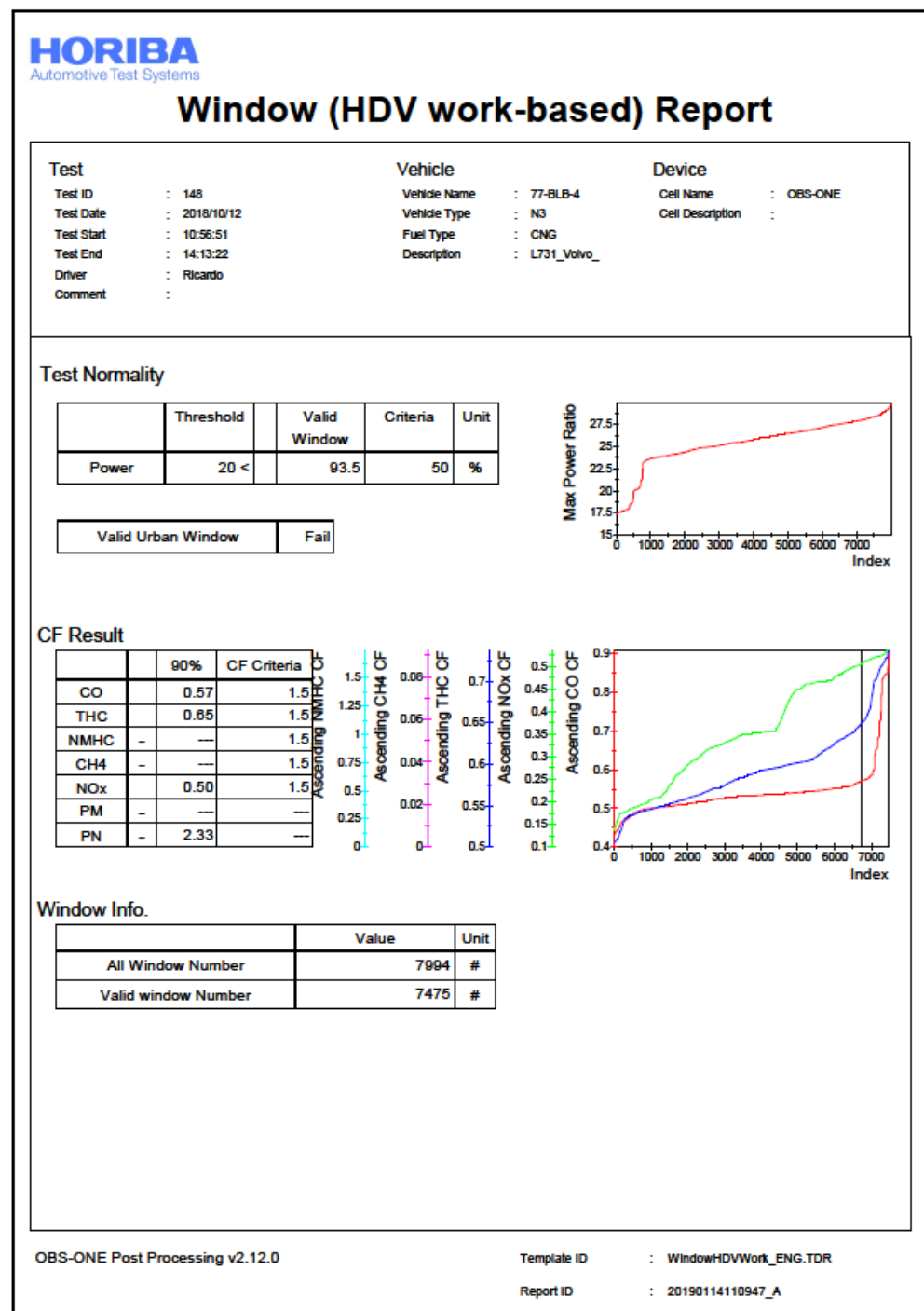
Template ID : Emission_EC_ENG.TDR

Report ID : 20190114110729_A

B.2 CO2-based report



B.3 Work-based report



B.4 Parameter emission report



Parameter Report (Emission)

Test	Vehicle	Device
Test ID : 148	Vehicle Name : 77-BLB-4	Cell Name : OBS-ONE
Test Date : 2018/10/12	Vehicle Type : N3	Cell Description :
Test Start : 10:56:51	Fuel Type : CNG	
Test End : 14:13:22	Description : L731_Volvo_	
Driver : Ricardo		
Comment :		

Basic Calc. Parameter

<table> <tr><td colspan="2">Pitot Parameter</td></tr> <tr><td>Tube Data 1</td><td></td></tr> <tr><td>Pitot Type & Serial No</td><td>Type F</td></tr> <tr><td>Tube Data 2</td><td></td></tr> <tr><td>Pitot Type & Serial No</td><td>—</td></tr> <tr><td colspan="2">Exhaust Parameter</td></tr> <tr><td>H/C</td><td>3.850</td></tr> <tr><td>O/C</td><td>0.000</td></tr> <tr><td>S/C</td><td>0.000</td></tr> <tr><td>N/C</td><td>0.000</td></tr> <tr><td>Density [kg/m3] (at 20degC)</td><td>1.1797</td></tr> <tr><td colspan="2">Fuel Parameter</td></tr> <tr><td>H/C</td><td>3.850</td></tr> <tr><td>O/C</td><td>0.000</td></tr> <tr><td>S/C</td><td>0.000</td></tr> <tr><td>N/C</td><td>0.000</td></tr> <tr><td>Fuel Mass Fraction [g/g]</td><td>0.756</td></tr> <tr><td>Density [kg/L]</td><td>0.7780</td></tr> <tr><td>Lower Heating Value [kJ/kg]</td><td>49573.00</td></tr> <tr><td colspan="2">Engine Parameter</td></tr> <tr><td>Combustion Efficiency [%]</td><td>42.00</td></tr> <tr><td colspan="2">PM Parameter</td></tr> <tr><td>Correction Factor</td><td>—</td></tr> <tr><td>Tare Weight</td><td>0.0000</td></tr> <tr><td>Loaded Weight</td><td>0.0000</td></tr> <tr><td colspan="2">Device Delay Time</td></tr> <tr><td>MEXA Transformation Time [s]</td><td>6.2</td></tr> <tr><td>PTFM Transformation Time [s]</td><td>0.2</td></tr> <tr><td>PFFPM Transformation Time [s]</td><td>0.0</td></tr> <tr><td>PFFPN Transformation Time [s]</td><td>0.0</td></tr> </table>	Pitot Parameter		Tube Data 1		Pitot Type & Serial No	Type F	Tube Data 2		Pitot Type & Serial No	—	Exhaust Parameter		H/C	3.850	O/C	0.000	S/C	0.000	N/C	0.000	Density [kg/m3] (at 20degC)	1.1797	Fuel Parameter		H/C	3.850	O/C	0.000	S/C	0.000	N/C	0.000	Fuel Mass Fraction [g/g]	0.756	Density [kg/L]	0.7780	Lower Heating Value [kJ/kg]	49573.00	Engine Parameter		Combustion Efficiency [%]	42.00	PM Parameter		Correction Factor	—	Tare Weight	0.0000	Loaded Weight	0.0000	Device Delay Time		MEXA Transformation Time [s]	6.2	PTFM Transformation Time [s]	0.2	PFFPM Transformation Time [s]	0.0	PFFPN Transformation Time [s]	0.0	<table> <tr><td colspan="2">Data Correction</td></tr> <tr><td>Drift Correction</td><td>OFF</td></tr> <tr><td>Time Alignment</td><td>OFF</td></tr> <tr><td>Gain & Offset</td><td>OFF</td></tr> <tr><td>Band Filtering</td><td>OFF</td></tr> <tr><td colspan="2">Hangup Correction Parameter</td></tr> <tr><td>Used Type</td><td>OBS</td></tr> <tr><td>Value</td><td>0.00</td></tr> <tr><td>Dry<->Wet Convert</td><td>Inactive</td></tr> <tr><td colspan="2">Temperature and Humidity Correction Parameter</td></tr> <tr><td>NOx</td><td>OFF</td></tr> <tr><td>PM</td><td>OFF</td></tr> <tr><td>Combustion System</td><td>Compression Ignition</td></tr> <tr><td colspan="2">Data Source</td></tr> <tr><td>Sampling Rate</td><td>1Hz</td></tr> <tr><td>OBD Protocol</td><td>ISO27145</td></tr> <tr><td>Vehicle Speed</td><td>GPS_VehicleSpeed</td></tr> <tr><td>Exhaust Flow</td><td>PF_ExhaustFlowRate</td></tr> <tr><td colspan="2">Calc. Type</td></tr> <tr><td>Mass Calculation Method</td><td>Density</td></tr> <tr><td>Power</td><td>FrictionTorque</td></tr> <tr><td>Work</td><td>FrictionTorque</td></tr> <tr><td>Negative Torque to Zero</td><td>Active</td></tr> </table>	Data Correction		Drift Correction	OFF	Time Alignment	OFF	Gain & Offset	OFF	Band Filtering	OFF	Hangup Correction Parameter		Used Type	OBS	Value	0.00	Dry<->Wet Convert	Inactive	Temperature and Humidity Correction Parameter		NOx	OFF	PM	OFF	Combustion System	Compression Ignition	Data Source		Sampling Rate	1Hz	OBD Protocol	ISO27145	Vehicle Speed	GPS_VehicleSpeed	Exhaust Flow	PF_ExhaustFlowRate	Calc. Type		Mass Calculation Method	Density	Power	FrictionTorque	Work	FrictionTorque	Negative Torque to Zero	Active
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Work	FrictionTorque																																																																																																										
Negative Torque to Zero	Active																																																																																																										

OBS-ONE Post Processing v2.12.0

Template ID : ParameterEmission_ENG.TDR
 Report ID : 20190114110729_C

B.5 Parameter CO2-based report

Test		Vehicle		Device	
Test ID	: 148	Vehicle Name	: 77-BLB-4	Cell Name	: OBS-ONE
Test Date	: 2018/10/12	Vehicle Type	: N3	Cell Description	:
Test Start	: 10:56:51	Fuel Type	: CNG		
Test End	: 14:13:22	Description	: L731_Volvo_		
Driver	: Ricardo				
Comment	:				

Window Method Parameter

Reference Quantity		Ambient Conditions	
CO2 [g]	18300.00	Atmospheric Press. [kPa]	ON
Max. Power [kW]	315.00		82.5
Criteria	Custom	Ambient Temp. [degC]	ON
Judgement of Acceptance	(EU) 2018/1718		-7
Threshold Limit		Cold Start	
Upper Limit [%]	20	Until Coolant Temp. for the first time [degC]	ON
Lower Limit [%]	15		70
Upper Duration [s]	1909	After Engine Start [min]	ON
Lower Duration [s]	2545		15
All Window Valid Ratio [%]	50	Engine Start Threshold [rpm]	ON
CF Limit			50
CO	1.5	Coolant Temperature Stabilization	ON
THC	1.5	Stabilization Time [min]	5
NMHC	1.5	Stabilization Temp. [degC]	2
CH4	1.5	Base Channel	
NOx	1.5	CO2 Mass	MASS_1/CO2_MASS_1
Emission Limit Setting		Work	
Selected Emission Limit	Custom-WHTC		Work_1/Work_Zero
CO [mg/kWh]	4000	Power	Power_1/FrictionTorque_Zero
THC [mg/kWh]	500		
NMHC [mg/kWh]	---	Vehicle Speed	MeasData_1Hz/GPS_VehicleSpeed
CH4 [mg/kWh]	---		
NOx [mg/kWh]	480		
PM [mg/kWh]	10		
PN [#kWh]	6.0E11		

OBS-ONE Post Processing v2.12.0

Template ID

: ParameterWindowHDVCO2_ENG.TDR

Report ID

: 20190114110839_C

B.6 Parameter work-based report



Parameter Report

(MAW HDV Work)

Test	Vehicle	Device
Test ID : 148	Vehicle Name : 77-BLB-4	Cell Name : OBS-ONE
Test Date : 2018/10/12	Vehicle Type : N3	Cell Description :
Test Start : 10:56:51	Fuel Type : CNG	
Test End : 14:13:22	Description : L731_Volvo_	
Driver : Ricardo		
Comment :		

Window Method Parameter

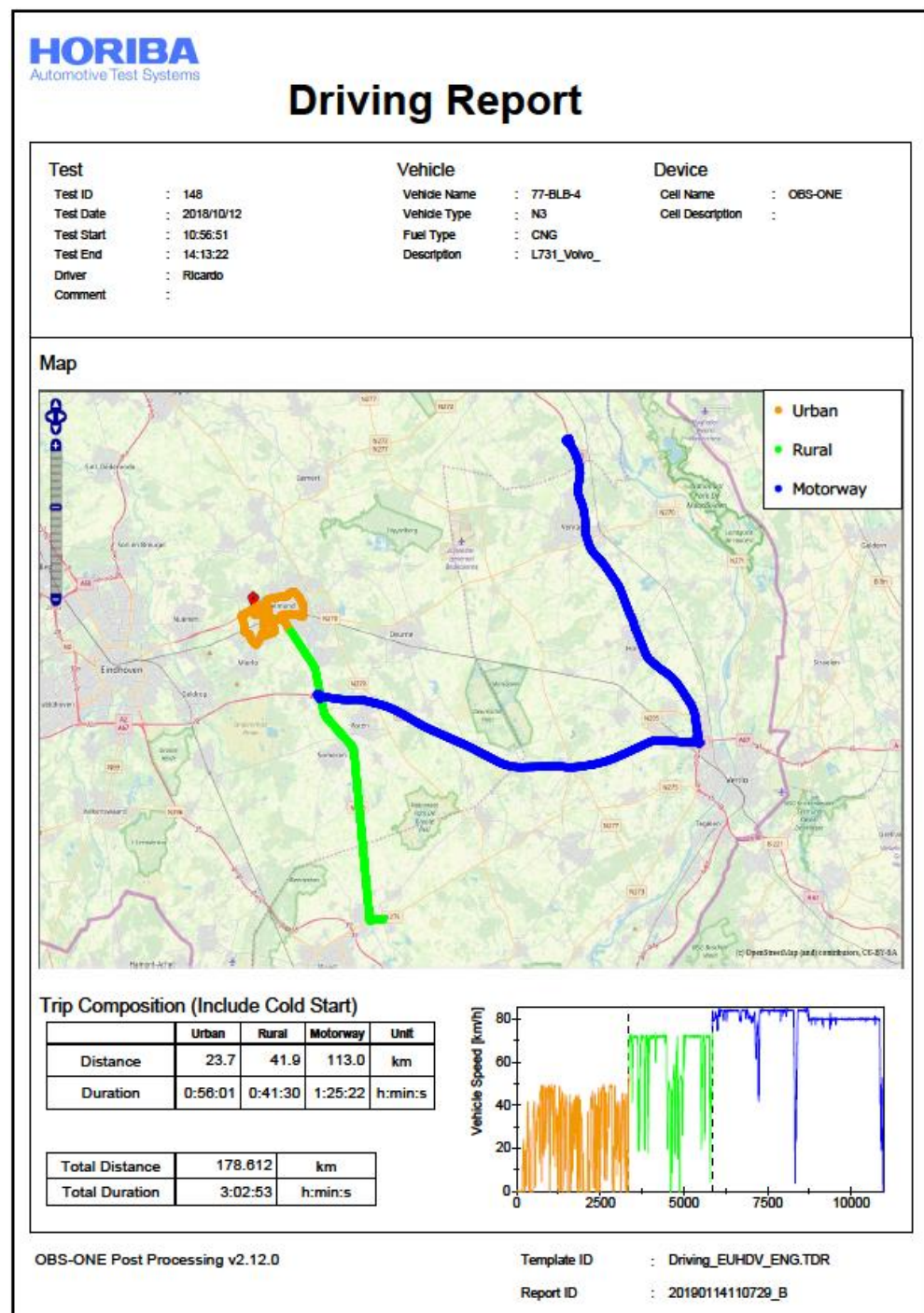
Reference Quantity Work [kWh] : 33.40 Max. Power [kW] : 315.00 Criteria : Custom Judgement of Acceptance : (EU) 2018/1718 Threshold Limit Upper Limit [%] : 20 Lower Limit [%] : 15 All Window Valid Ratio [%] : 50 CF Limit CO : 1.5 THC : 1.5 NMHC : 1.5 CH4 : 1.5 NOx : 1.5	Ambient Conditions Atmospheric Press. [kPa] : ON 82.5 Ambient Temp. [degC] : ON -7 Cold Start Until Coolant Temp. for the first time [degC] : ON 70 After Engine Start [min] : ON 15 Engine Start Threshold [rpm] : ON 50 Coolant Temperature Stabilization : ON Stabilization Time [min] : 5 Stabilization Temp. [degC] : 2
--	--

Emission Limit Setting Selected Emission Limit : Custom-WHTC CO [mg/kWh] : 4000 THC [mg/kWh] : 500 NMHC [mg/kWh] : --- CH4 [mg/kWh] : --- NOx [mg/kWh] : 480 PM [mg/kWh] : 10 PN [#kWh] : 6.0E11	Base Channel CO2 Mass : MASS_1/CO2_MASS_1 Work : Work_1/Work_Zero Power : Power_1/FrictionTorque_Zero Vehicle Speed : MeasData_1Hz/GPS_VehicleSpeed
---	--

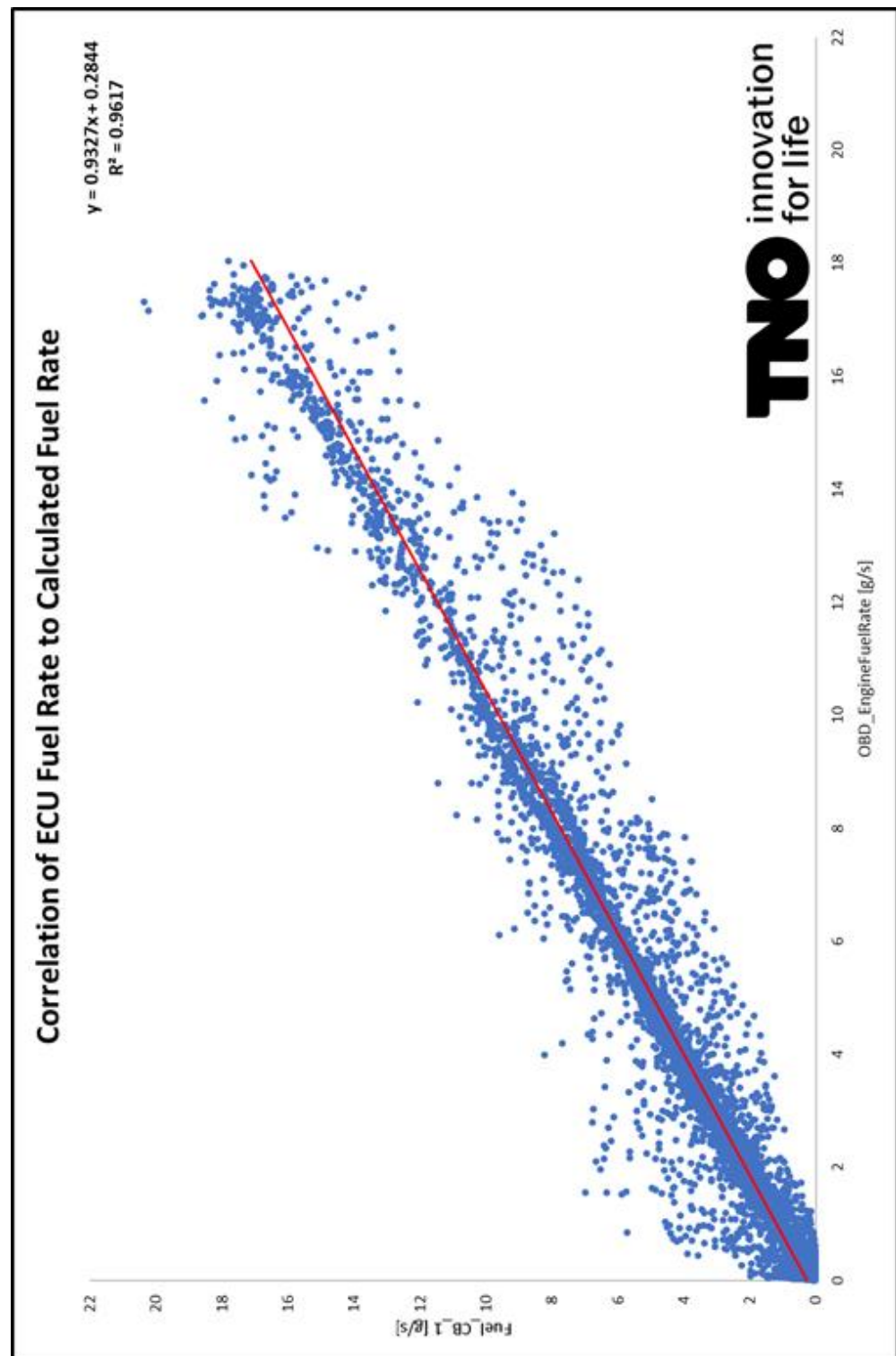
OBS-ONE Post Processing v2.12.0

Template ID : ParameterWindowHDVWork_ENG.TDR
 Report ID : 20190114110947_G

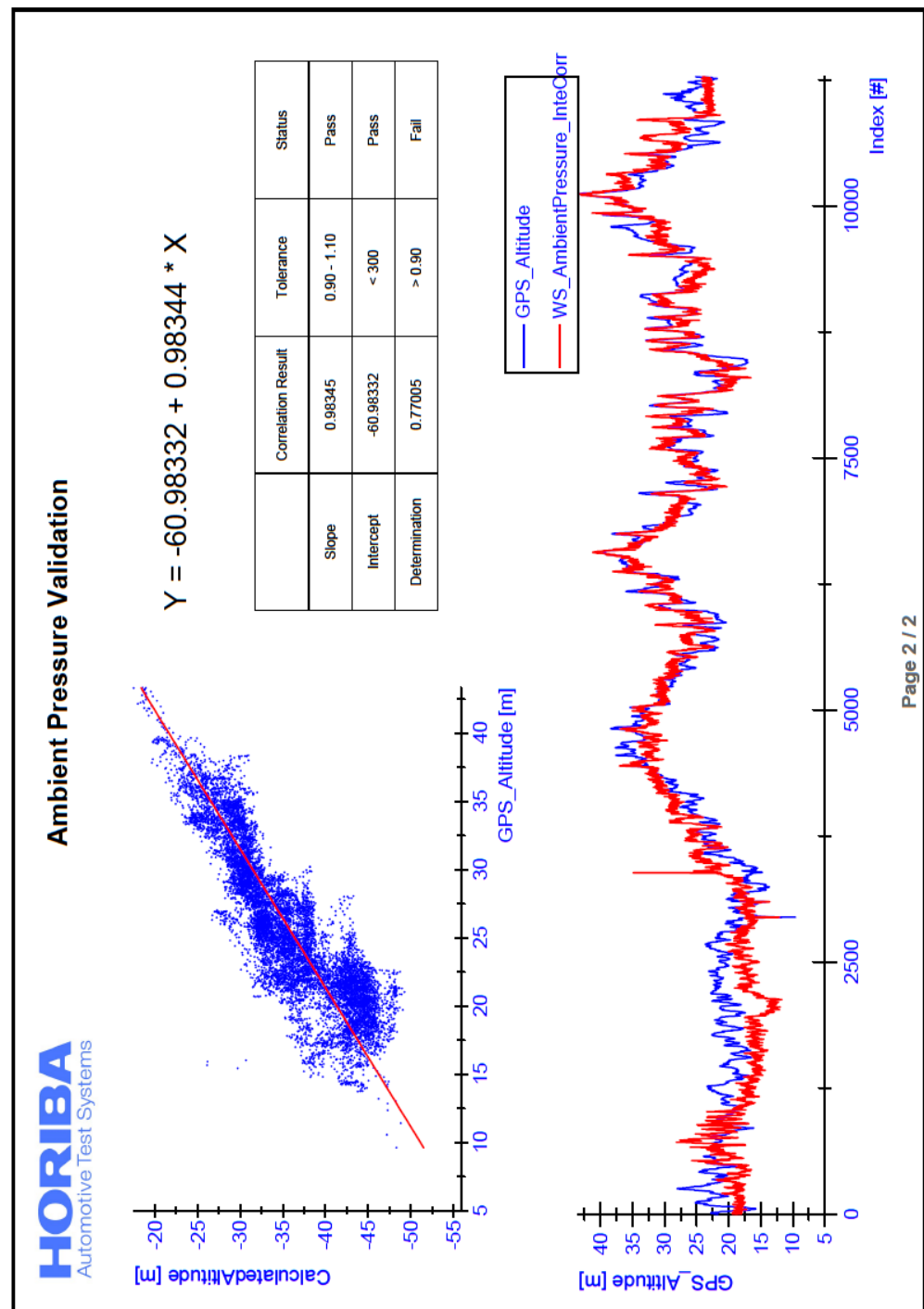
B.7 Driving report



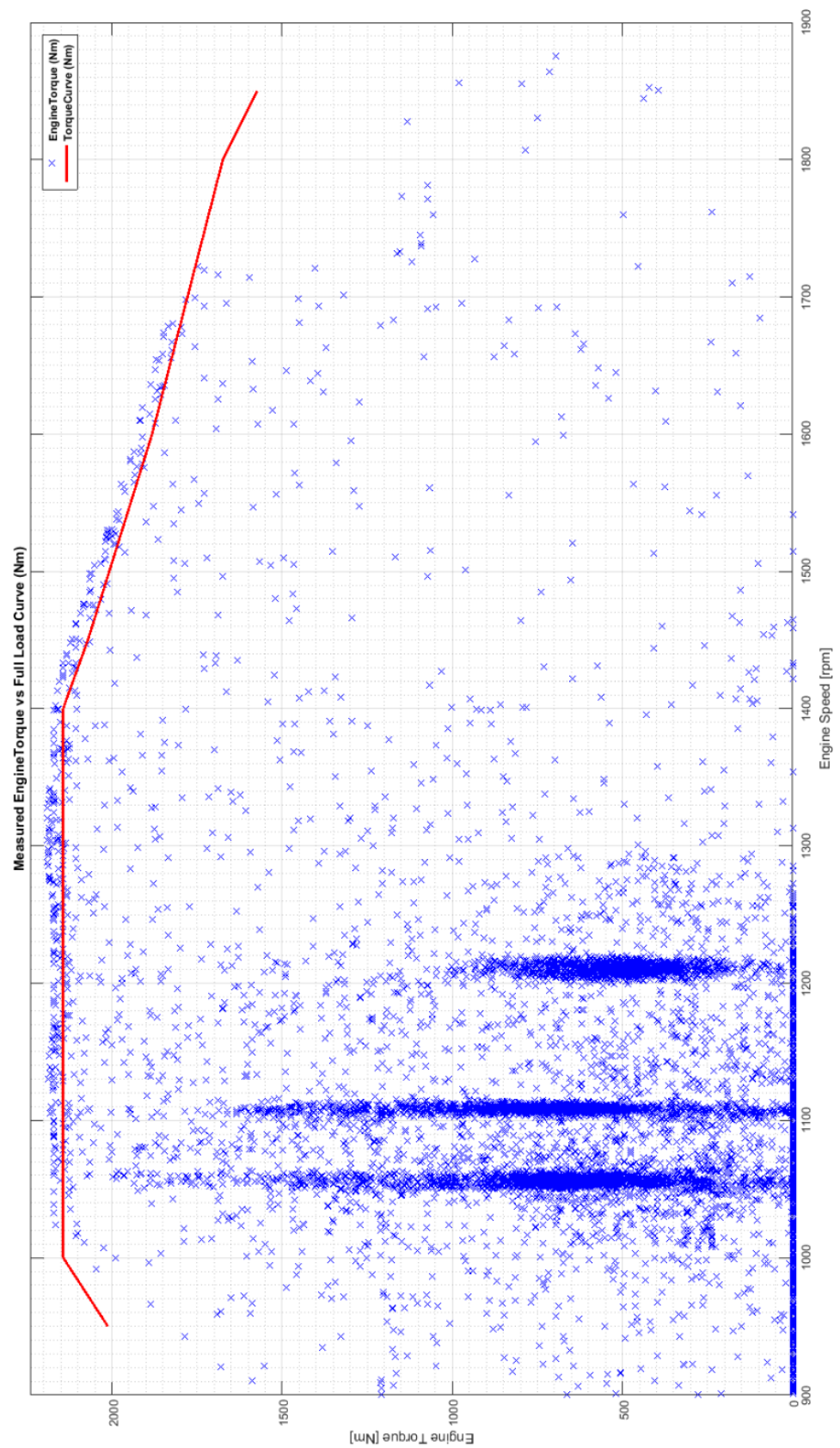
B.8 Fuel rate correlation



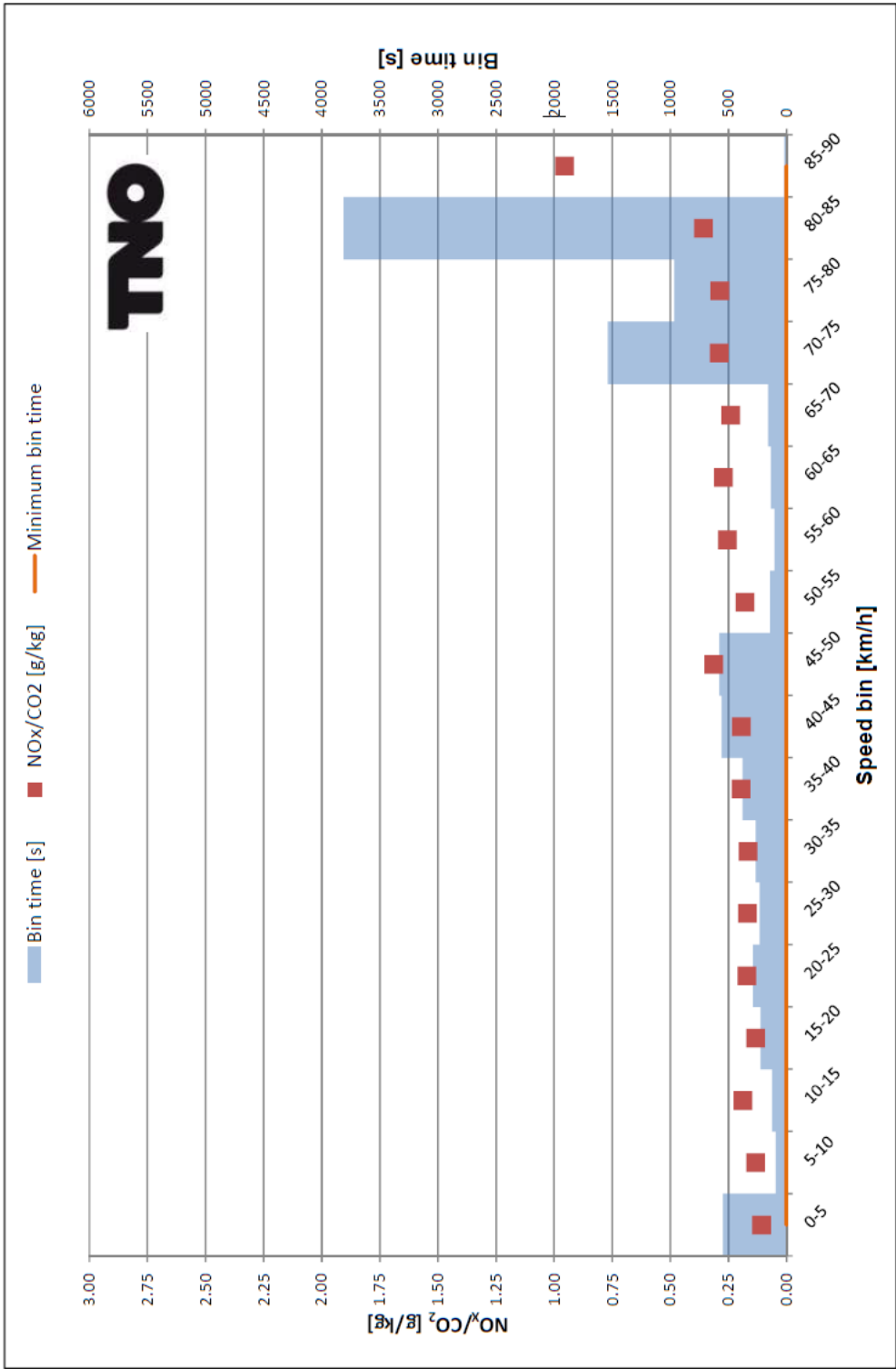
B.9 Ambient pressure validation



B.10 Torque curve correlation



B.11 Binning graph



B.12 Binning results

General		
Filename		L731_02
Test #		1
Trip		N3
Payload	[%]	48

Trip data		
Time	[s]	10137
Distance	[km]	174.41
Average Speed	[km/h]	61.9

Results 1				
Totals	[g/km]	[g/tonkm]	[g/kWh]	g/kgCO2
CO2	666	20.9	544	1000
CO	3.04	0.10	2.48	4.56
NOx	0.19	0.01	0.15	0.28
HC	0.37	0.01	0.30	0.56
NO2	0.06	0.00	0.05	0.10

Results 2	[km/h]	0...<50	>=50...<75	>=75
PEMS bins				
Avg speed in bin	[km/h]	28.4	69.0	81.7
CO2	[g/km]	1279	660	522
CO	[g/km]	8.1	2.2	2.1
NOx	[g/km]	0.25	0.18	0.18
HC	[g/km]	0.7	0.4	0.3
NO2	[g/km]	0.1	0.1	0.1
Time	[s]	3272	2070	4795
Time relative	[%]	32%	20%	47%
NOx/CO2	[g/kg]	0.20	0.27	0.34

General																							
Filename		L731_02																					
Test #		1																					
Trip		N3																					
Payload		48																					
		[%]																					
Bins		[km/h]	Total																				
				0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	75-80	80-85	85-90		
Bin time		[s]	10137	547	90	123	221	286	228	264	377	557	579	142	101	134	156	1537	964	3812	19		
Bin time share		[%]	100%	5%	1%	1%	2%	3%	2%	3%	4%	5%	6%	1%	1%	1%	2%	15%	10%	38%	0%		
Distance		[km]	174.41	0.09	0.19	0.43	1.08	1.79	1.73	2.38	3.95	6.57	7.65	2.06	1.61	2.33	2.95	30.72	21.25	87.18	0.45		
Work		[kWh]	213.50	1.21	1.40	2.63	3.88	6.16	6.60	7.97	9.78	11.55	9.32	3.73	3.84	4.91	6.30	28.66	22.96	82.55	0.03		
Power		[kW]	75.82	7.99	55.95	77.06	63.24	77.56	104.15	108.70	93.40	74.66	57.98	94.49	137.03	131.99	145.49	67.12	85.75	77.96	6.11		
Speed		[km/h]	61.9	0.6	7.4	12.5	17.6	22.5	27.4	32.4	37.7	42.5	47.6	52.3	57.5	62.5	68.0	72.0	79.3	82.3	85.3		
Exhaust temp		[K]	558.1	546.5	548.6	551.6	552.2	548.9	552.0	555.1	554.8	554.8	546.4	551.3	554.1	555.5	554.6	559.2	562.3	563.3	572.5		
Coolant temp		[K]	353.9	354.4	354.2	354.2	354.1	353.5	353.6	353.9	354.0	354.2	353.3	354.5	354.3	354.1	354.6	353.8	353.9	354.0	353.5		
NOx/CO2		[g/kg]	0.28	0.11	0.13	0.19	0.13	0.17	0.17	0.17	0.20	0.19	0.31	0.18	0.25	0.27	0.24	0.29	0.29	0.36	0.95		
CO2		[g/s]	11.45	1.96	7.75	8.93	11.19	10.99	15.24	14.98	14.13	11.12	9.75	14.15	19.73	18.70	19.46	10.83	12.78	11.67	1.17		
CO		[g/s]	0.05	0.06	0.30	0.26	0.12	0.05	0.04	0.04	0.04	0.04	0.04	0.00	0.01	0.01	0.05	0.04	0.05	0.05	0.02		
NOx		[g/s]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00		
HC		[g/s]	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00		
NO2		[g/s]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
CO2		[g/km]	666	12055	3760	2570	2288	1760	2004	1664	1348	943	737	974	1235	1077	1030	542	580	510	49		
CO		[g/km]	3.04	354.61	147.36	73.76	23.90	7.21	5.75	4.12	3.75	3.11	3.13	2.69	3.16	2.36	2.40	2.09	2.09	2.17	0.80		
NOx		[g/km]	0.19	1.29	0.50	0.48	0.30	0.30	0.34	0.28	0.26	0.18	0.23	0.17	0.31	0.29	0.25	0.16	0.17	0.18	0.05		
HC		[g/km]	0.37	25.61	3.77	2.04	1.20	0.82	0.75	0.64	0.51	0.46	0.45	0.43	0.50	0.34	0.32	0.41	0.27	0.29	0.04		
NO2		[g/km]	0.06	0.75	0.16	0.18	0.11	0.15	0.15	0.13	0.12	0.09	0.16	0.05	0.08	0.06	0.04	0.05	0.05	0.05	0.03		
CO2		[g/kWh]	544	885	499	417	637	510	527	496	545	536	605	539	518	510	481	581	536	539	689		
CO		[g/kWh]	2.48	26.03	19.54	11.98	6.65	2.09	1.51	1.23	1.52	1.77	2.57	1.49	1.33	1.12	1.12	2.24	1.94	2.29	11.18		
NOx		[g/kWh]	0.15	0.09	0.07	0.08	0.08	0.09	0.09	0.08	0.11	0.10	0.19	0.10	0.13	0.14	0.12	0.17	0.15	0.19	0.66		
HC		[g/kWh]	0.30	1.88	0.50	0.33	0.34	0.24	0.20	0.19	0.21	0.26	0.37	0.24	0.21	0.16	0.15	0.44	0.25	0.30	0.61		
NO2		[g/kWh]	0.05	0.06	0.02	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.13	0.03	0.03	0.03	0.02	0.06	0.05	0.06	0.42		

C Test # 2

C.1 Emission report



Emission Report

Test

Test ID : 149

Test Date : 2018/10/15

Test Start : 10:36:14

Test End : 14:06:59

Driver : Ricardo

Comment :

Vehicle

Vehicle Name : 77-BLB-4

Vehicle Type : N3

Fuel Type : CNG

Description : L731_Volvo_

Device

Cell Name : OBS-ONE

Cell Description :

Emission (Include Cold Start)

	Total Mass	Unit	Mass / Distance	Unit	Mass / Work (*4)	Unit	Conc. Max.	Conc. Ave.	Unit
CO	701.2	g	3.656	g/km	3.198	g/kWh	2.589	0.03811	vol%
CO2	1.270E5	g	662.2	g/km	579.2	g/kWh	9.020	3.914	vol%
THC	72.51	g	0.3781	g/km	0.3308	g/kWh	7301	80.09	ppmC
CH4	—	g	—	g/km	—	g/kWh	—	—	ppmC
NMHC	—	g	—	g/km	—	g/kWh	—	—	ppmC
NO (*1)	23.25	g	0.1212	g/km	0.1061	g/kWh	1136	12.22	ppm
NO2 (*2)	26.59	g	0.1387	g/km	0.1213	g/kWh	143.0	4.389	ppm
NOx	49.84	g	0.2599	g/km	0.2273	g/kWh	1138	16.40	ppm
PM	—	g	—	g/km	—	g/kWh	— (*3)	— (*3)	mm/cm3
PN	7.04E13	#	3.67E11	#/km	3.21E11	#/kWh	2.49E6 (*3)	3.89E4 (*3)	#/cm3

Fuel Economy	31.3	L/100km
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(*1) : NO mass is calculated by molecular weight.

(*2) : NO2 mass is subtracted NO mass from NOx mass.

NO and NOx mass are calculated by molecular weight.

(*3) : at 0degC

(*4) : Mass / Work and Total Work is not corrected data.

Trip Summary

	Max.	Ave.	Unit
Velocity GPS	84.0	58.3	km/h
Velocity OBD	83.5	57.9	km/h
Velocity EIU	—	—	km/h
Eng. Speed	1978	1030	rpm
Eng. Torque	—	—	Nm
Eng. Power	324.3	65.1	kW

Total Distance	191.762	km
Total Work (*4)	219.226	kWh

Total Trip Duration	3:17:27	h:min:s
Stop Duration	15:46	min:s
Number of Stop	—	#
Trip Maximum Speed	84.02	km/h
Min. Coolant Temp	273.2	K
Max. Coolant Temp	357.2	K

Trip Condition

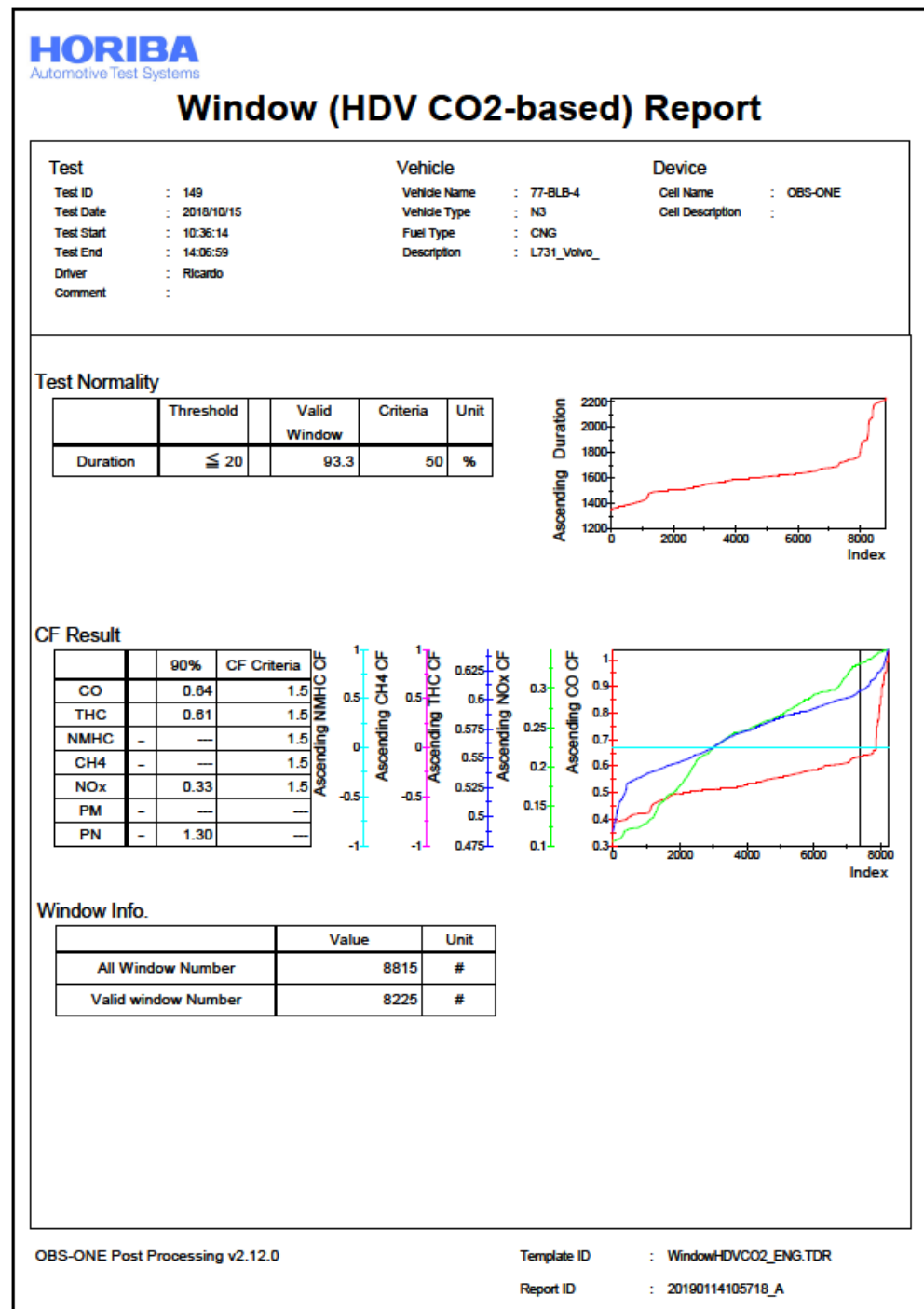
	Min.	Max.	Ave.	Unit
Temperature	293.3	300.2	296.7	K
R.H.	34.0	56.7	43.4	%
Pressure	100.9	101.2	101.1	kPa
Altitude	14.5	42.0	25.7	m

OBS-ONE Post Processing v2.12.0

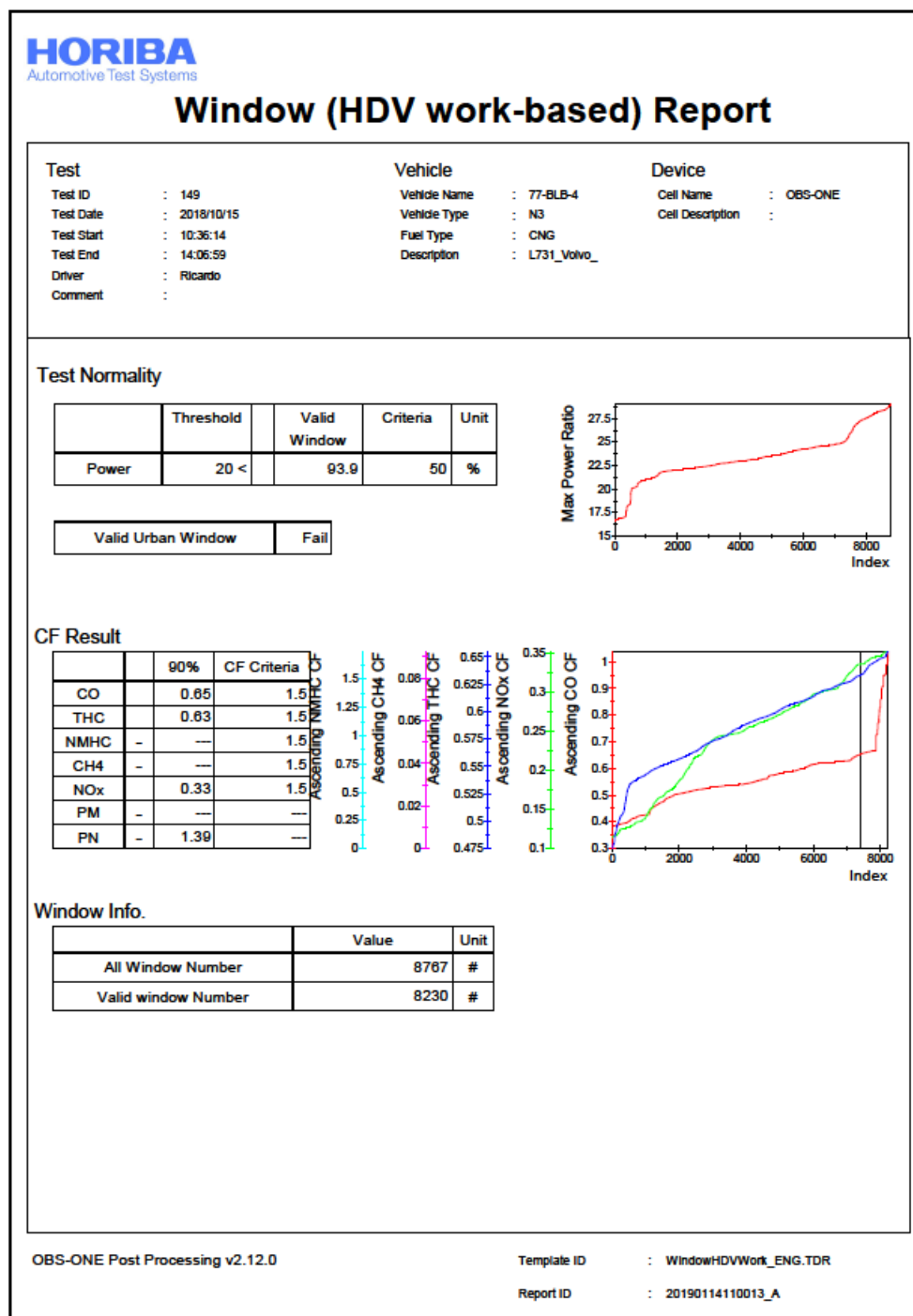
Template ID : Emission_EC_ENG.TDR

Report ID : 20190114110132_A

C.2 CO2-based report



C.3 Work-based report



C.4 Parameter emission report



Parameter Report (Emission)

Test	Vehicle	Device
Test ID : 149	Vehicle Name : 77-BLB-4	Cell Name : OBS-ONE
Test Date : 2018/10/15	Vehicle Type : N3	Cell Description :
Test Start : 10:36:14	Fuel Type : CNG	
Test End : 14:06:59	Description : L731_Volvo_	
Driver : Ricardo		
Comment :		

Basic Calc. Parameter

Pitot Parameter Tube Data 1 Pitot Type & Serial No Type F Tube Data 2 Pitot Type & Serial No —	Data Correction Drift Correction OFF Time Alignment OFF Gain & Offset OFF Band Filtering OFF	
Exhaust Parameter H/C 3.850 O/C 0.000 S/C 0.000 N/C 0.000 Density [kg/m3] (at 20degC) 1.1797	Hangup Correction Parameter Used Type OBS Value 0.00 Dry<->Wet Convert Inactive	Temperature and Humidity Correction Parameter NOx OFF
Fuel Parameter H/C 3.850 O/C 0.000 S/C 0.000 N/C 0.000 Fuel Mass Fraction [g/g] 0.756 Density [kg/L] 0.7780 Lower Heating Value [kJ/kg] 49573.00	PM OFF Combustion System Compression Ignition	Data Source Sampling Rate 1Hz OBD Protocol ISO27145 Vehicle Speed GPS_VehicleSpeed Exhaust Flow PF_ExhaustFlowRate
Engine Parameter Combustion Efficiency [%] 42.00	Calc. Type Mass Calculation Method Density	
PM Parameter Correction Factor — Tare Weight 0.0000 Loaded Weight 0.0000	Power FrictionTorque Work FrictionTorque Negative Torque to Zero Active	
Device Delay Time MEXA Transformation Time [s] 6.2 PTFM Transformation Time [s] 0.2 PFPM Transformation Time [s] 0.0 PFPN Transformation Time [s] 0.0		

OBS-ONE Post Processing v2.12.0

Template ID : ParameterEmission_ENG.TDR
 Report ID : 20190114110132_C

C.5 Parameter CO2-based report



Parameter Report (MAW HDV CO2)

Test		Vehicle		Device	
Test ID	: 149	Vehicle Name	: 77-BLB-4	Cell Name	: OBS-ONE
Test Date	: 2018/10/15	Vehicle Type	: N3	Cell Description	:
Test Start	: 10:36:14	Fuel Type	: CNG		
Test End	: 14:06:59	Description	: L731_Volvo_		
Driver	: Ricardo				
Comment	:				

Window Method Parameter

Reference Quantity		Ambient Conditions	
CO2 [g]	18300.00	Atmospheric Press. [kPa]	ON
Max. Power [kW]	315.00		82.5
Criteria	Custom	Ambient Temp. [degC]	ON
Judgement of Acceptance	(EU) 2018/1718		-7
Threshold Limit		Cold Start	
Upper Limit [%]	20	Until Coolant Temp. for the first time [degC]	ON
Lower Limit [%]	15		70
Upper Duration [s]	1909	After Engine Start [min]	ON
Lower Duration [s]	2545		15
All Window Valid Ratio [%]	50	Engine Start Threshold [rpm]	ON
CF Limit			50
CO	1.5	Coolant Temperature Stabilization	ON
THC	1.5	Stabilization Time [min]	5
NMHC	1.5	Stabilization Temp. [degC]	2
CH4	1.5	Base Channel	
NOx	1.5	CO2 Mass	MASS_1/CO2_MASS_1
Emission Limit Setting			
Selected Emission Limit	Custom-WHTC	Work	Work_1/Work_Zero
CO [mg/kWh]	4000		
THC [mg/kWh]	500	Power	Power_1/FrictionTorque_Zero
NMHC [mg/kWh]	—		
CH4 [mg/kWh]	—	Vehicle Speed	MeasData_1Hz/GPS_VehicleSpeed
NOx [mg/kWh]	480		
PM [mg/kWh]	10		
PN [#kWh]	6.0E11		

OBS-ONE Post Processing v2.12.0

Template ID : ParameterWindowHDVCO2_ENG.TDR
 Report ID : 20190114105718_C

C.6 Parameter work-based report



Parameter Report

(MAW HDV Work)

Test	Vehicle	Device
Test ID : 149	Vehicle Name : 77-BLB-4	Cell Name : OBS-ONE
Test Date : 2018/10/15	Vehicle Type : N3	Cell Description :
Test Start : 10:36:14	Fuel Type : CNG	
Test End : 14:06:59	Description : L731_Volvo_	
Driver : Ricardo		
Comment :		

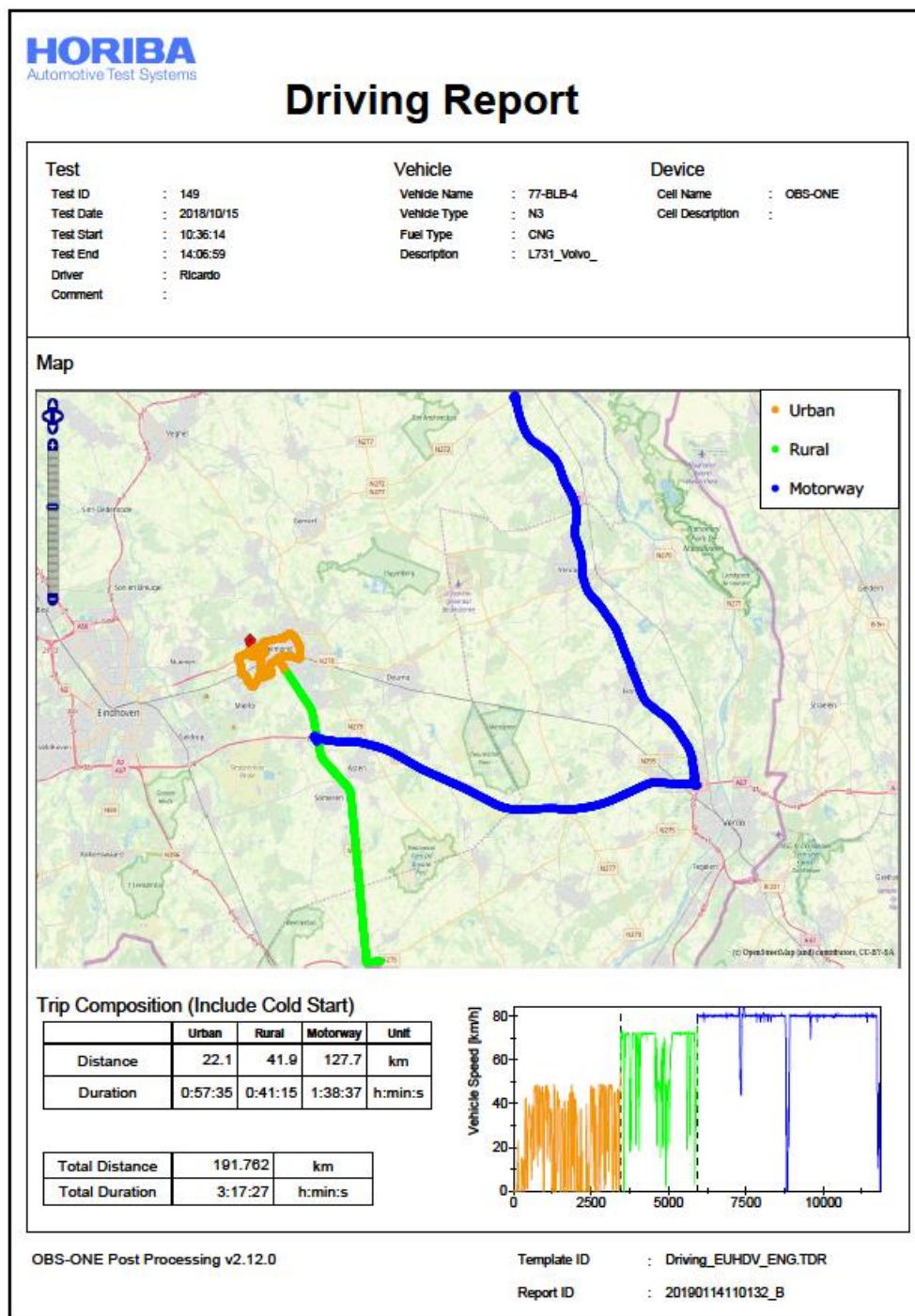
Window Method Parameter

Reference Quantity Work [kWh] : 33.40 Max. Power [kW] : 315.00 Criteria : Custom Judgement of Acceptance : (EU) 2016/1718 Threshold Limit Upper Limit [%] : 20 Lower Limit [%] : 15 All Window Valid Ratio [%] : 50 CF Limit CO : 1.5 THC : 1.5 NMHC : 1.5 CH4 : 1.5 NOx : 1.5 Emission Limit Setting Selected Emission Limit : Custom-WHTC CO [mg/kWh] : 4000 THC [mg/kWh] : 500 NMHC [mg/kWh] : --- CH4 [mg/kWh] : --- NOx [mg/kWh] : 480 PM [mg/kWh] : 10 PN [#kWh] : 6.0E11	Ambient Conditions Atmospheric Press. [kPa] : ON 82.5 Ambient Temp. [degC] : ON -7 Cold Start Until Coolant Temp. for the first time [degC] : ON 70 After Engine Start [min] : ON 15 Engine Start Threshold [rpm] : ON 50 Coolant Temperature Stabilization : ON Stabilization Time [min] : 5 Stabilization Temp. [degC] : 2 Base Channel CO2 Mass : MASS_1/CO2_MASS_1 Work : Work_1/Work_Zero Power : Power_1/FrictionTorque_Zero Vehicle Speed : MeasData_1Hz/GPS_VehicleSpeed
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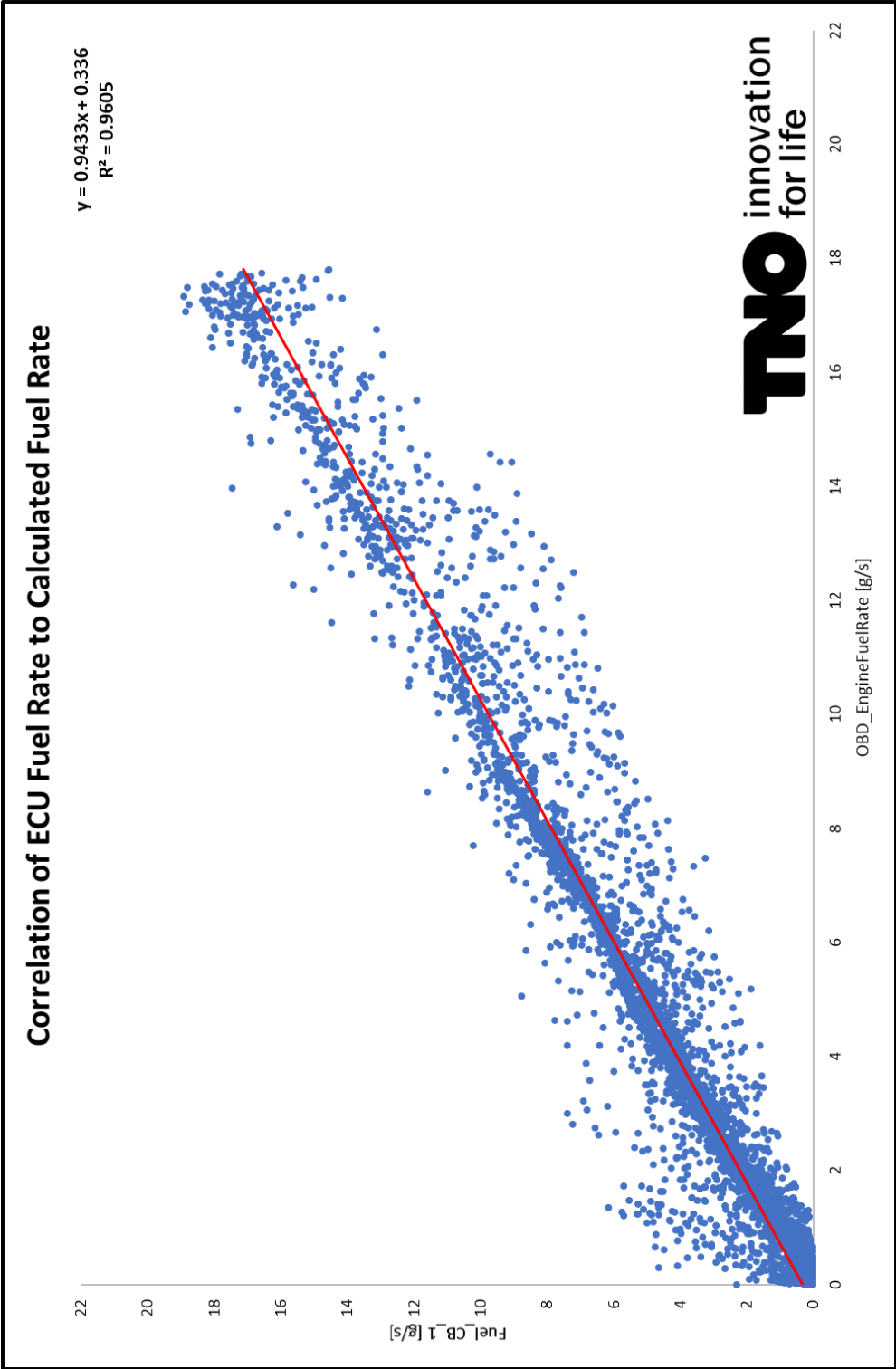
OBS-ONE Post Processing v2.12.0

Template ID : ParameterWindowHDVWork_ENG.TDR
 Report ID : 20190114110013_C

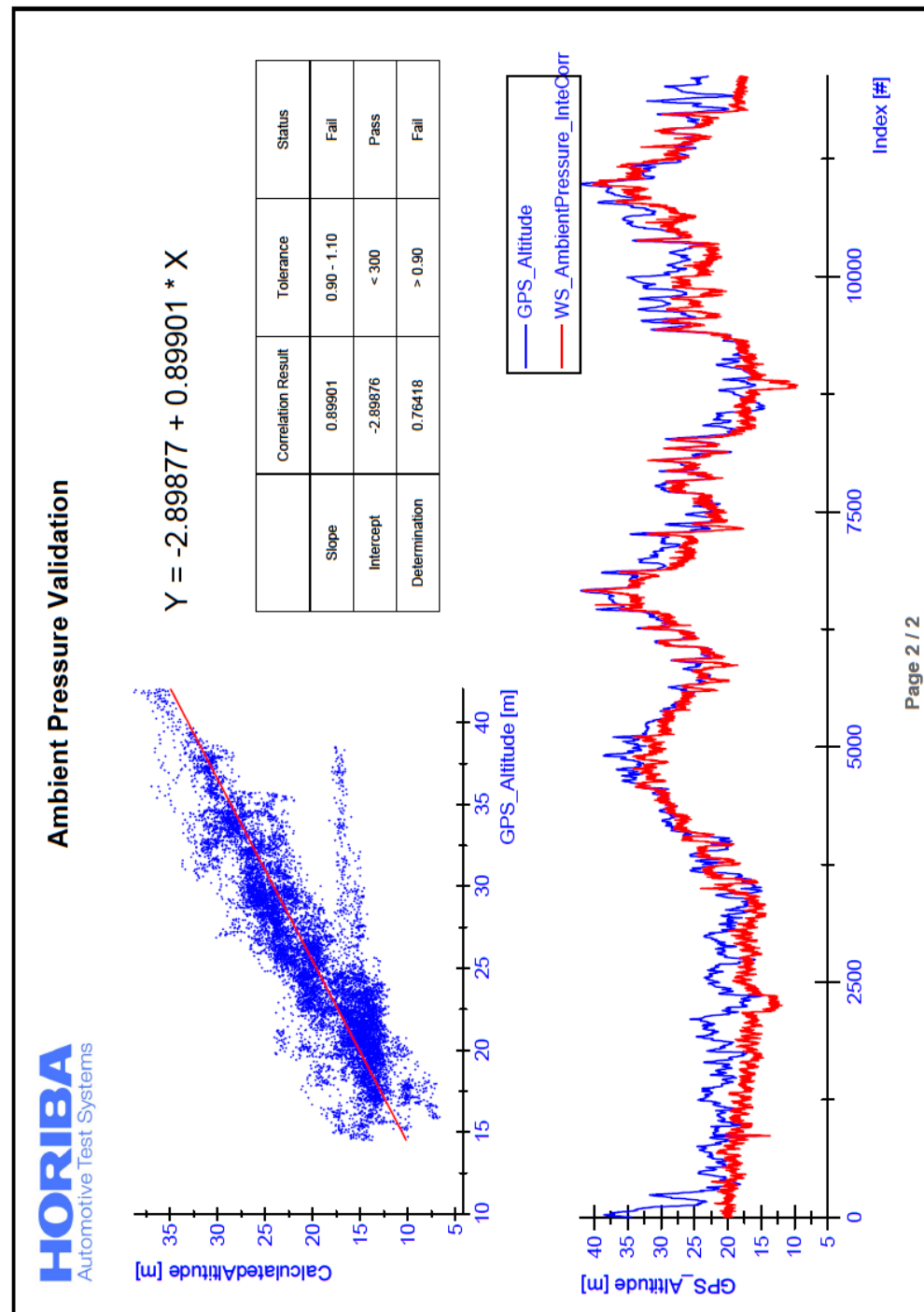
C.7 Driving report



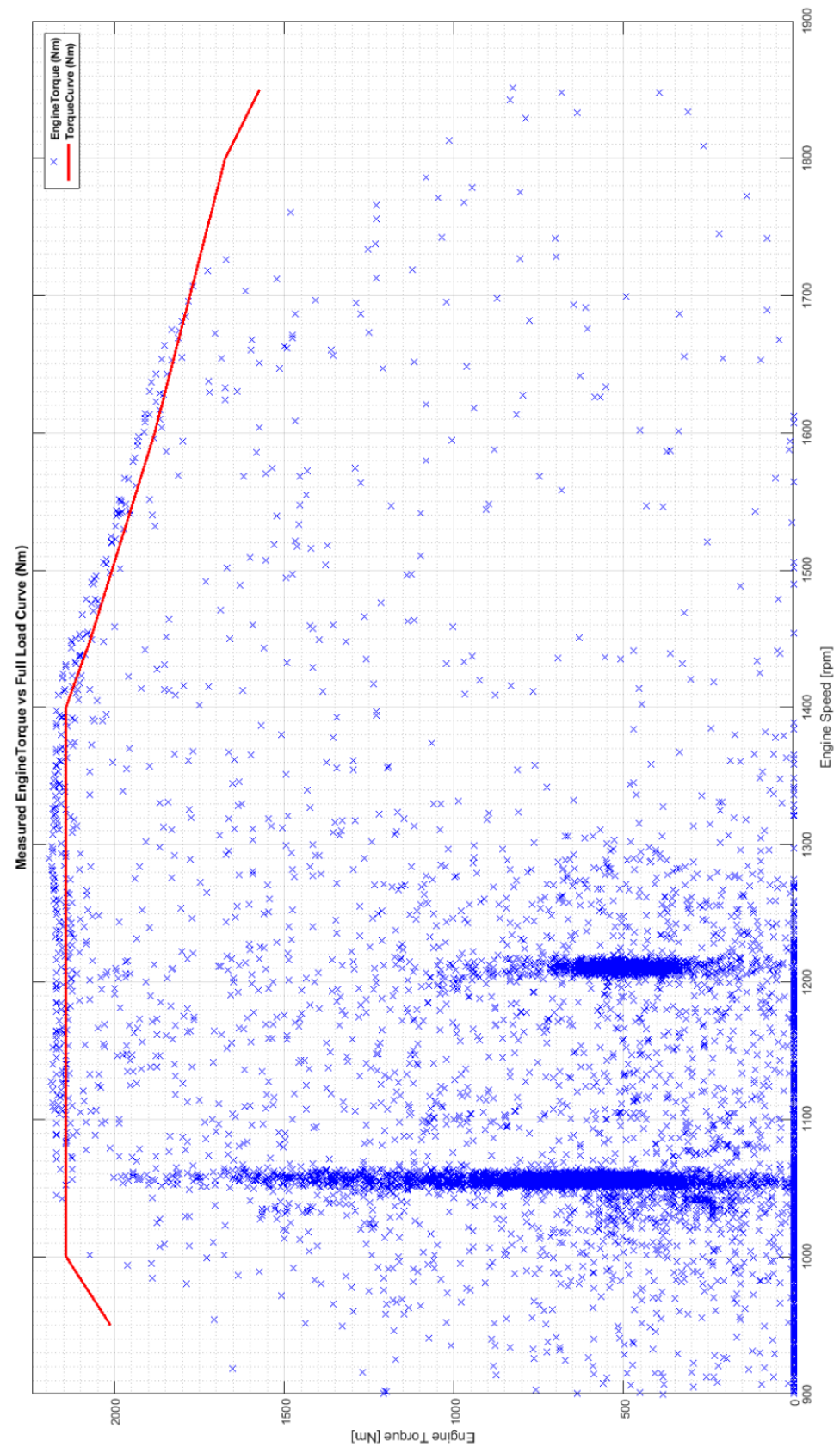
C.8 Fuel rate correlation



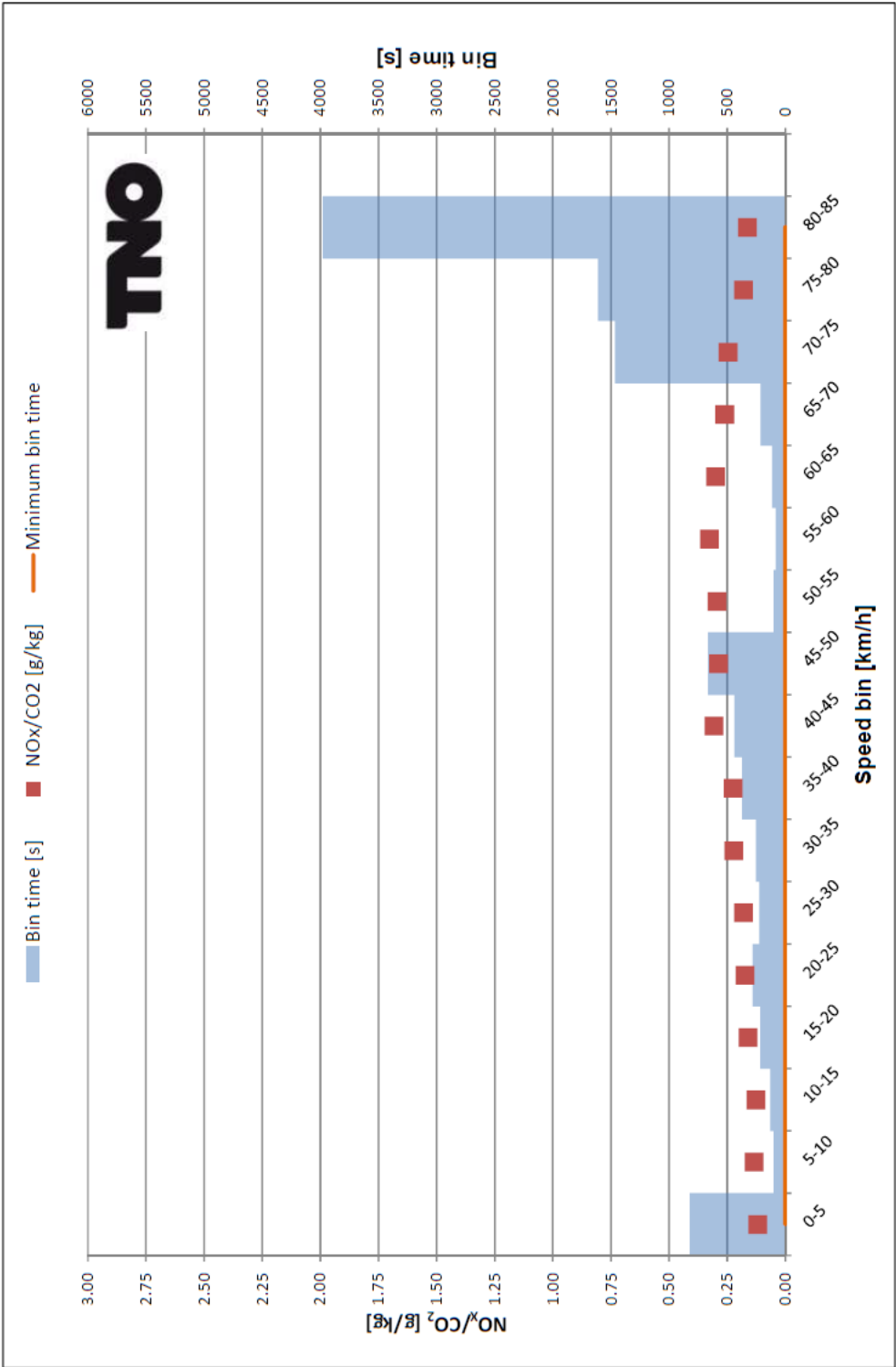
C.9 Ambient pressure validation



C.10 Torque curve correlation



C.11 Binning graph



C.12 Binning results

General		
Filename		L731_03
Test #		2
Trip		N3
Payload	[%]	48

Trip data		
Time	[s]	11045
Distance	[km]	187.59
Average Speed	[km/h]	61.1

Results 1				
Totals	[g/km]	[g/tonkm]	[g/kWh]	g/kgCO2
CO2	644	20.2	564	1000
CO	3.10	0.10	2.72	4.82
NOx	0.13	0.00	0.11	0.20
HC	0.34	0.01	0.30	0.53
NO2	0.05	0.00	0.04	0.08

Results 2	[km/h]	0...<50	>=50...<75	>=75
PEMS bins				
Avg speed in bin	[km/h]	26.1	69.3	80.1
CO2	[g/km]	1342	656	499
CO	[g/km]	9.9	2.0	2.1
NOx	[g/km]	0.30	0.17	0.08
HC	[g/km]	0.7	0.4	0.3
NO2	[g/km]	0.2	0.1	0.0
Time	[s]	3486	1971	5588
Time relative	[%]	32%	18%	51%
NOx/CO2	[g/kg]	0.22	0.26	0.17

General																							
Filename	L731_03																						
Test #	2																						
Trip	N3																						
Payload	48																						
Bins	[km/h]	Total																					
			0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	75-80	80-85				
Bin time	[s]	11045	821	100	126	214	278	224	252	371	437	663	100	81	113	212	1465	1610	3978	#N/A			
Bin time share	[%]	100%	7%	1%	1%	2%	3%	2%	2%	3%	4%	6%	1%	1%	1%	2%	13%	15%	36%	#N/A			
Distance	[km]	187.59	0.10	0.21	0.44	1.05	1.73	1.70	2.29	3.85	5.19	8.72	1.44	1.29	1.96	3.98	29.29	35.63	88.71	#DIV/0!			
Work	[kWh]	214.13	1.64	1.68	2.59	3.97	6.45	6.59	8.09	8.93	10.40	10.70	3.38	3.71	4.42	6.21	27.06	36.93	71.39	#DIV/0!			
Power	[kW]	69.79	7.19	60.55	74.05	66.72	83.51	105.86	115.64	86.67	85.64	58.08	121.79	164.75	140.91	105.43	66.50	82.57	64.61	#DIV/0!			
Speed	[km/h]	61.1	0.4	7.4	12.5	17.6	22.4	27.4	32.7	37.4	42.7	47.4	52.0	57.4	62.5	67.6	72.0	79.7	80.3	#DIV/0!			
Exhaust temp	[K]	555.9	544.4	550.6	553.2	551.2	549.7	554.3	552.7	553.0	551.9	550.5	554.9	554.2	557.2	558.7	561.9	558.4	557.7	#DIV/0!			
Coolant temp	[K]	353.9	354.3	354.4	354.4	353.8	353.5	354.0	353.8	354.0	353.9	354.0	354.3	354.4	354.7	354.8	353.7	353.9	353.9	#DIV/0!			
NOx/CO2	[g/kg]	0.20	0.12	0.13	0.13	0.16	0.17	0.18	0.22	0.22	0.31	0.29	0.29	0.33	0.30	0.26	0.24	0.18	0.16	#N/A			
CO2	[g/s]	10.94	1.87	7.90	8.75	12.43	11.31	15.74	15.86	13.74	12.69	9.84	17.62	22.34	20.41	14.89	10.82	12.64	10.47	#DIV/0!			
CO	[g/s]	0.05	0.06	0.39	0.29	0.16	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	#DIV/0!			
NOx	[g/s]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	#DIV/0!			
HC	[g/s]	0.01	0.00	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	#DIV/0!			
NO2	[g/s]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	#DIV/0!			
CO2	[g/km]	644	16051	3847	2510	2542	1815	2068	1748	1323	1069	748	1220	1400	1176	793	541	571	470	#DIV/0!			
CO	[g/km]	3.10	484.97	190.63	83.73	33.12	7.35	6.50	4.59	4.12	3.59	2.87	2.69	2.72	2.53	2.39	1.85	2.11	2.03	#DIV/0!			
NOx	[g/km]	0.13	1.90	0.51	0.32	0.40	0.31	0.37	0.39	0.29	0.33	0.21	0.36	0.46	0.35	0.21	0.13	0.10	0.08	#DIV/0!			
HC	[g/km]	0.34	33.04	4.13	2.00	1.27	0.78	0.71	0.58	0.51	0.44	0.42	0.40	0.42	0.29	0.30	0.37	0.27	0.26	#DIV/0!			
NO2	[g/km]	0.05	1.12	0.08	0.05	0.13	0.14	0.15	0.20	0.15	0.21	0.13	0.17	0.21	0.14	0.07	0.05	0.03	0.02	#DIV/0!			
CO2	[g/kWh]	564	937	470	425	671	488	535	494	571	533	610	521	488	521	509	586	551	584	#DIV/0!			
CO	[g/kWh]	2.72	28.32	23.29	14.19	8.74	1.98	1.68	1.30	1.78	1.79	2.34	1.15	0.95	1.12	1.54	2.00	2.04	2.52	#DIV/0!			
NOx	[g/kWh]	0.11	0.11	0.06	0.05	0.11	0.08	0.10	0.11	0.13	0.16	0.18	0.15	0.16	0.16	0.13	0.14	0.10	0.09	#DIV/0!			
HC	[g/kWh]	0.30	1.93	0.50	0.34	0.34	0.21	0.18	0.16	0.22	0.22	0.34	0.17	0.15	0.13	0.20	0.40	0.26	0.33	#DIV/0!			
NO2	[g/kWh]	0.04	0.07	0.01	0.01	0.03	0.04	0.04	0.06	0.06	0.10	0.10	0.07	0.07	0.06	0.05	0.05	0.03	0.03	#DIV/0!			

D Test # 3

D.1 Emission report



Emission Report

Test

Test ID : 157

Test Date : 2018/10/24

Test Start : 11:27:11

Test End : 14:41:07

Driver : Ricardo

Comment :

Vehicle

Vehicle Name : 77-BLB-4

Vehicle Type : N3

Fuel Type : CNG

Description : L731_Volvo_

Device

Cell Name : OBS-ONE

Cell Description :

Emission (Include Cold Start)

	Total Mass	Unit	Mass / Distance	Unit	Mass / Work (*4)	Unit	Conc. Max.	Conc. Ave.	Unit
CO	619.5	g	3.500	g/km	2.817	g/kWh	2.325	0.03544	vol%
CO2	1.175E5	g	664.1	g/km	534.5	g/kWh	9.380	3.681	vol%
THC	82.11	g	0.4639	g/km	0.3734	g/kWh	537.9	88.60	ppmC
CH4	—	g	—	g/km	—	g/kWh	—	—	ppmC
NMHC	—	g	—	g/km	—	g/kWh	—	—	ppmC
NO (*1)	28.43	g	0.1606	g/km	0.1293	g/kWh	1812	16.62	ppm
NO2 (*2)	56.52	g	0.3193	g/km	0.2570	g/kWh	475.3	12.65	ppm
NOx	84.94	g	0.4799	g/km	0.3863	g/kWh	2114	28.68	ppm
PM	—	g	—	g/km	—	g/kWh	— (*3)	— (*3)	mm/cm3
PN	3.91E13	#	2.21E11	#/km	1.78E11	#/kWh	3.06E6 (*3)	2.08E4 (*3)	#/cm3

Fuel Economy	31.3	L/100km
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(*1) : NO mass is calculated by molecular weight.

(*2) : NO2 mass is subtracted NO mass from NOx mass.
NO and NOx mass are calculated by molecular weight.

(*3) : at 0degC

(*4) : Mass / Work and Total Work is not corrected data.

Trip Summary

	Max.	Ave.	Unit
Velocity GPS	87.3	58.8	km/h
Velocity OBD	86.2	58.4	km/h
Velocity EIU	—	—	km/h
Eng. Speed	2077	1058	rpm
Eng. Torque	—	—	Nm
Eng. Power	324.9	71.3	kW

Total Distance	177.010	km
Total Work (*4)	219.914	kWh

Total Trip Duration	3:00:45	h:min:s
Stop Duration	12:44	min:s
Number of Stop	—	#
Trip Maximum Speed	87.28	km/h
Min. Coolant Temp	273.2	K
Max. Coolant Temp	356.2	K

Trip Condition

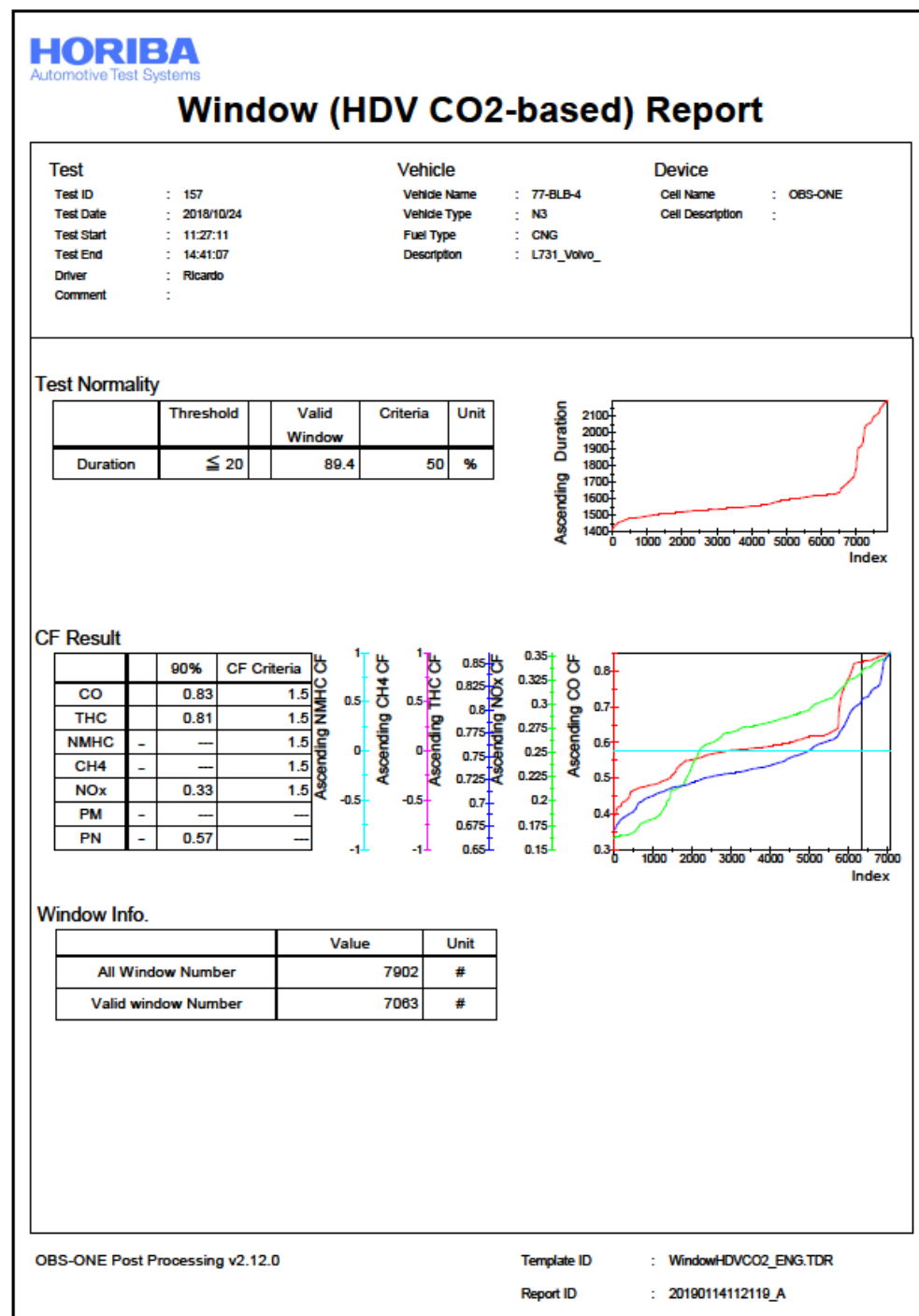
	Min.	Max.	Ave.	Unit
Temperature	288.0	290.7	289.1	K
R.H.	72.7	88.5	80.0	%
Pressure	102.1	102.5	102.4	kPa
Altitude	12.3	41.0	25.7	m

OBS-ONE Post Processing v2.12.0

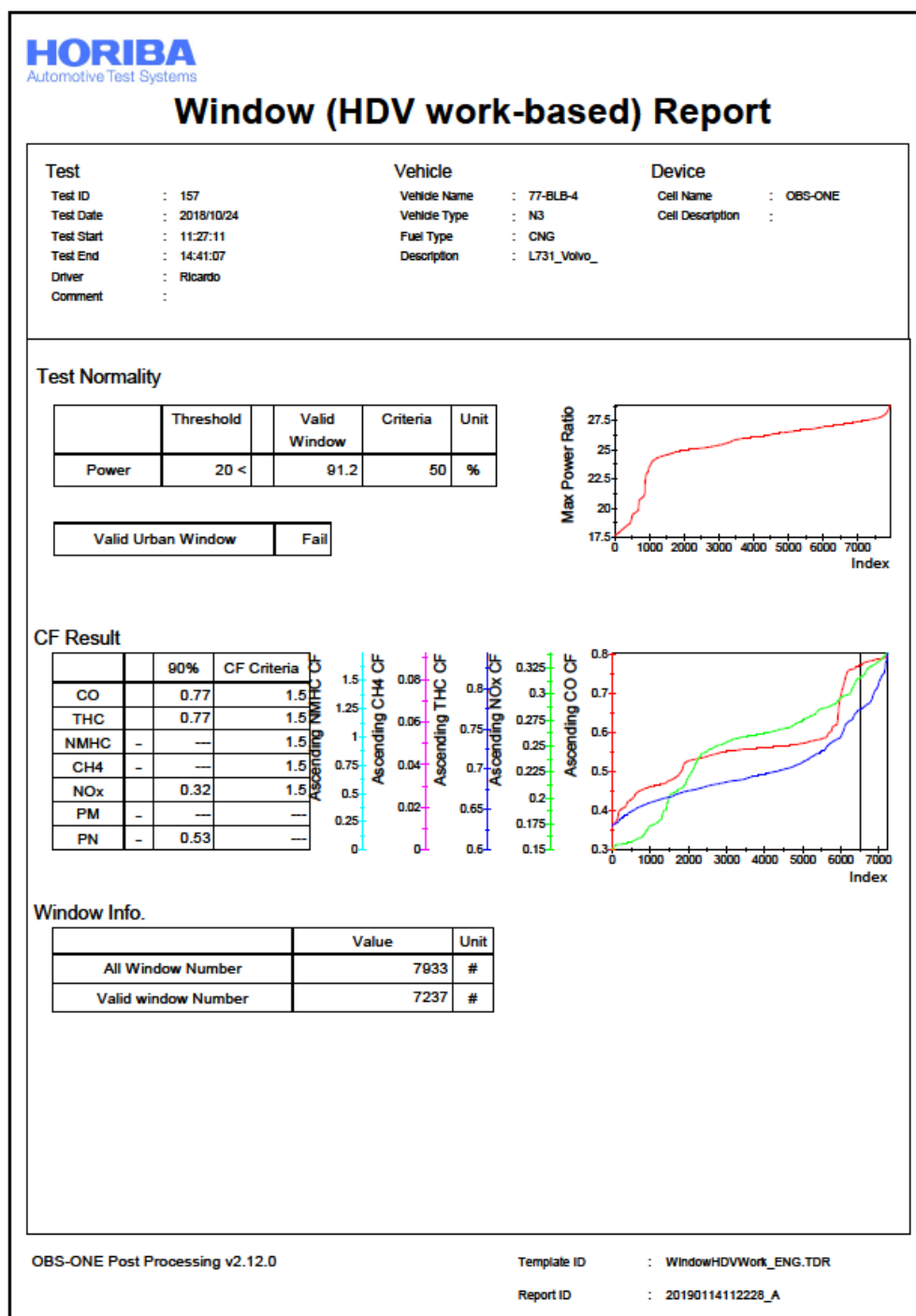
Template ID : Emission_EC_ENG.TDR

Report ID : 20190114111844_A

D.2 CO2-based report



D.3 Work-based report



D.4 Parameter emission report



Parameter Report (Emission)

Test	Vehicle	Device
Test ID : 157	Vehicle Name : 77-BLB-4	Cell Name : OBS-ONE
Test Date : 2018/10/24	Vehicle Type : N3	Cell Description :
Test Start : 11:27:11	Fuel Type : CNG	
Test End : 14:41:07	Description : L731_Volvo_	
Driver : Ricardo		
Comment :		

Basic Calc. Parameter

Pitot Parameter Tube Data 1 Pitot Type & Serial No Type F Tube Data 2 Pitot Type & Serial No — Exhaust Parameter H/C 3.850 O/C 0.000 S/C 0.000 N/C 0.000 Density [kg/m3] (at 20degC) 1.1797 Fuel Parameter H/C 3.850 O/C 0.000 S/C 0.000 N/C 0.000 Fuel Mass Fraction [g/g] 0.758 Density [kg/L] 0.7780 Lower Heating Value [kJ/kg] 49573.00 Engine Parameter Combustion Efficiency [%] 42.00 PM Parameter Correction Factor — Tare Weight 0.0000 Loaded Weight 0.0000 Device Delay Time MEXA Transformation Time [s] 6.2 PTFM Transformation Time [s] 0.2 PFFPM Transformation Time [s] 0.0 PFPN Transformation Time [s] 0.0	Data Correction Drift Correction OFF Time Alignment OFF Gain & Offset OFF Band Filtering OFF Hangup Correction Parameter Used Type OBS Value 0.00 Dry<->Wet Convert Inactive Temperature and Humidity Correction Parameter NOx OFF PM OFF Combustion System Compression Ignition Data Source Sampling Rate 1Hz OBD Protocol ISO27145 Vehicle Speed GPS_VehicleSpeed Exhaust Flow PF_ExhaustFlowRate Calc. Type Mass Calculation Method Density Power FrictionTorque Work FrictionTorque Negative Torque to Zero Active
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OBS-ONE Post Processing v2.12.0

Template ID : ParameterEmission_ENG.TDR

Report ID : 20190114111844_C

D.5 Parameter CO2-based report

Test		Vehicle		Device	
Test ID	: 157	Vehicle Name	: 77-BLB-4	Cell Name	: OBS-ONE
Test Date	: 2018/10/24	Vehicle Type	: N3	Cell Description	:
Test Start	: 11:27:11	Fuel Type	: CNG		
Test End	: 14:41:07	Description	: L731_Volvo_		
Driver	: Ricardo				
Comment	:				

Window Method Parameter			
Reference Quantity		Ambient Conditions	
CO2 [g]	18300.00	Atmospheric Press. [kPa]	ON
Max. Power [kW]	315.00		82.5
Criteria	Custom	Ambient Temp. [degC]	ON
Judgement of Acceptance	(EU) 2016/1718		-7
Threshold Limit		Cold Start	
Upper Limit [%]	20	Until Coolant Temp. for the first time [degC]	ON
Lower Limit [%]	15		70
Upper Duration [s]	1909	After Engine Start [min]	ON
Lower Duration [s]	2545		15
All Window Valid Ratio [%]	50	Engine Start Threshold [rpm]	ON
CF Limit			50
CO	1.5	Coolant Temperature Stabilization	ON
THC	1.5	Stabilization Time [min]	5
NMHC	1.5	Stabilization Temp. [degC]	2
CH4	1.5	Base Channel	
NOx	1.5	CO2 Mass	MASS_1/CO2_MASS_1
Emission Limit Setting			
Selected Emission Limit	Custom-WHTC	Work	Work_1/Work_Zero
CO [mg/kWh]	4000	Power	Power_1/FrictionTorque_Zero
THC [mg/kWh]	500	Vehicle Speed	MeasData_1Hz/GPS_VehicleSpeed
NMHC [mg/kWh]	---		
CH4 [mg/kWh]	---		
NOx [mg/kWh]	480		
PM [mg/kWh]	10		
PN [#kWh]	6.0E11		

OBS-ONE Post Processing v2.12.0	Template ID	: ParameterWindowHDVCO2_ENG.TDR
	Report ID	: 20190114112119_C

D.6 Parameter work-based report



Parameter Report

(MAW HDV Work)

Test	Vehicle	Device
Test ID : 157	Vehicle Name : 77-BLB-4	Cell Name : OBS-ONE
Test Date : 2018/10/24	Vehicle Type : N3	Cell Description :
Test Start : 11:27:11	Fuel Type : CNG	
Test End : 14:41:07	Description : L731_Volvo_	
Driver : Ricardo		
Comment :		

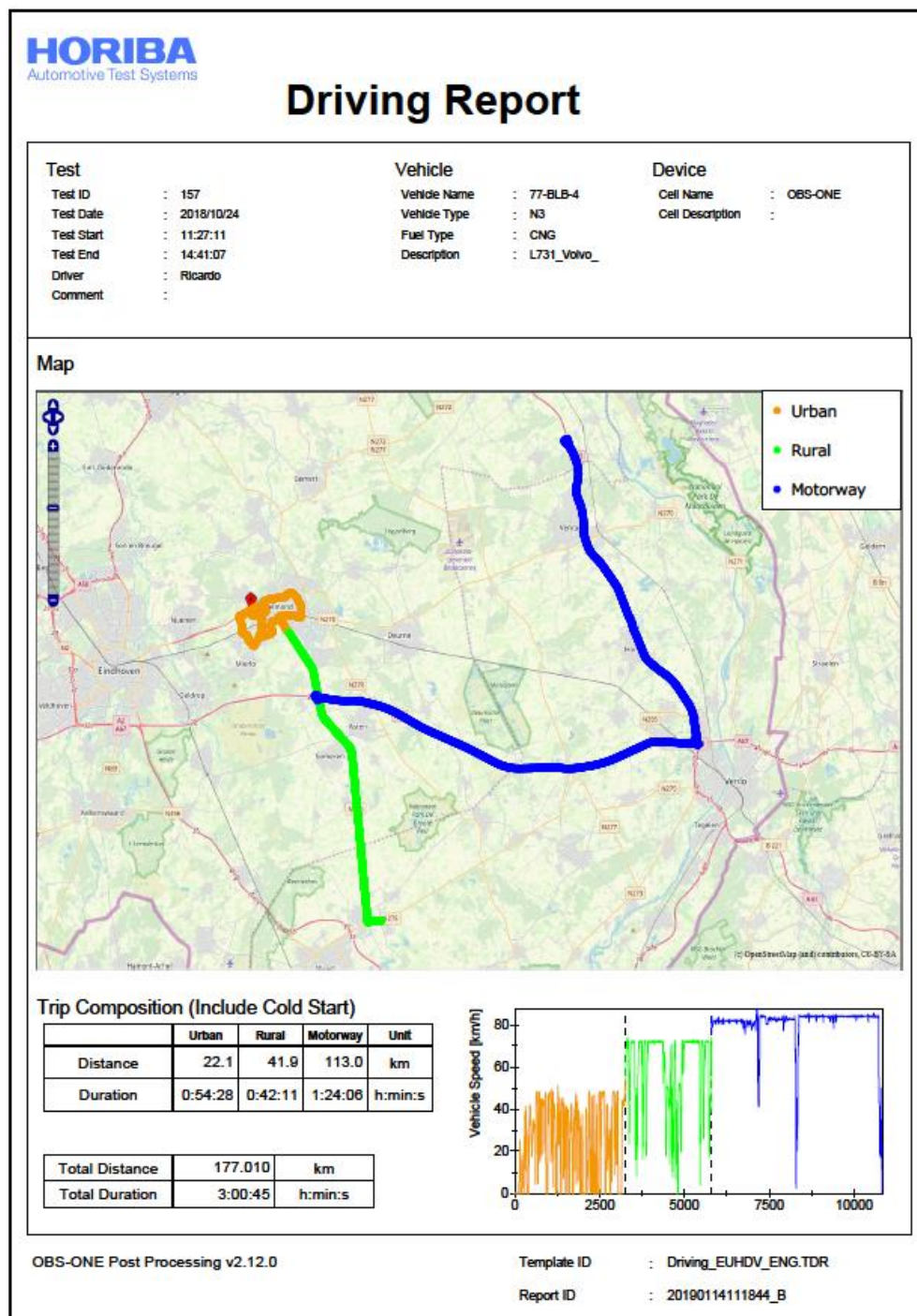
Window Method Parameter

Reference Quantity Work [kWh] : 33.40 Max. Power [kW] : 315.00 Criteria : Custom Judgement of Acceptance : (EU) 2016/1718 Threshold Limit Upper Limit [%] : 20 Lower Limit [%] : 15 All Window Valid Ratio [%] : 50 CF Limit CO : 1.5 THC : 1.5 NMHC : 1.5 CH4 : 1.5 NOx : 1.5 Emission Limit Setting Selected Emission Limit : Custom-WHTC CO [mg/kWh] : 4000 THC [mg/kWh] : 500 NMHC [mg/kWh] : --- CH4 [mg/kWh] : --- NOx [mg/kWh] : 480 PM [mg/kWh] : 10 PN [#kWh] : 6.0E11	Ambient Conditions Atmospheric Press. [kPa] : ON 82.5 Ambient Temp. [degC] : ON -7 Cold Start Until Coolant Temp. for the first time [degC] : ON 70 After Engine Start [min] : ON 15 Engine Start Threshold [rpm] : ON 50 Coolant Temperature Stabilization : ON Stabilization Time [min] : 5 Stabilization Temp. [degC] : 2 Base Channel CO2 Mass : MASS_1/CO2_MASS_1 Work : Work_1/Work_Zero Power : Power_1/FrictionTorque_Zero Vehicle Speed : MeasData_1Hz/GPS_VehicleSpeed
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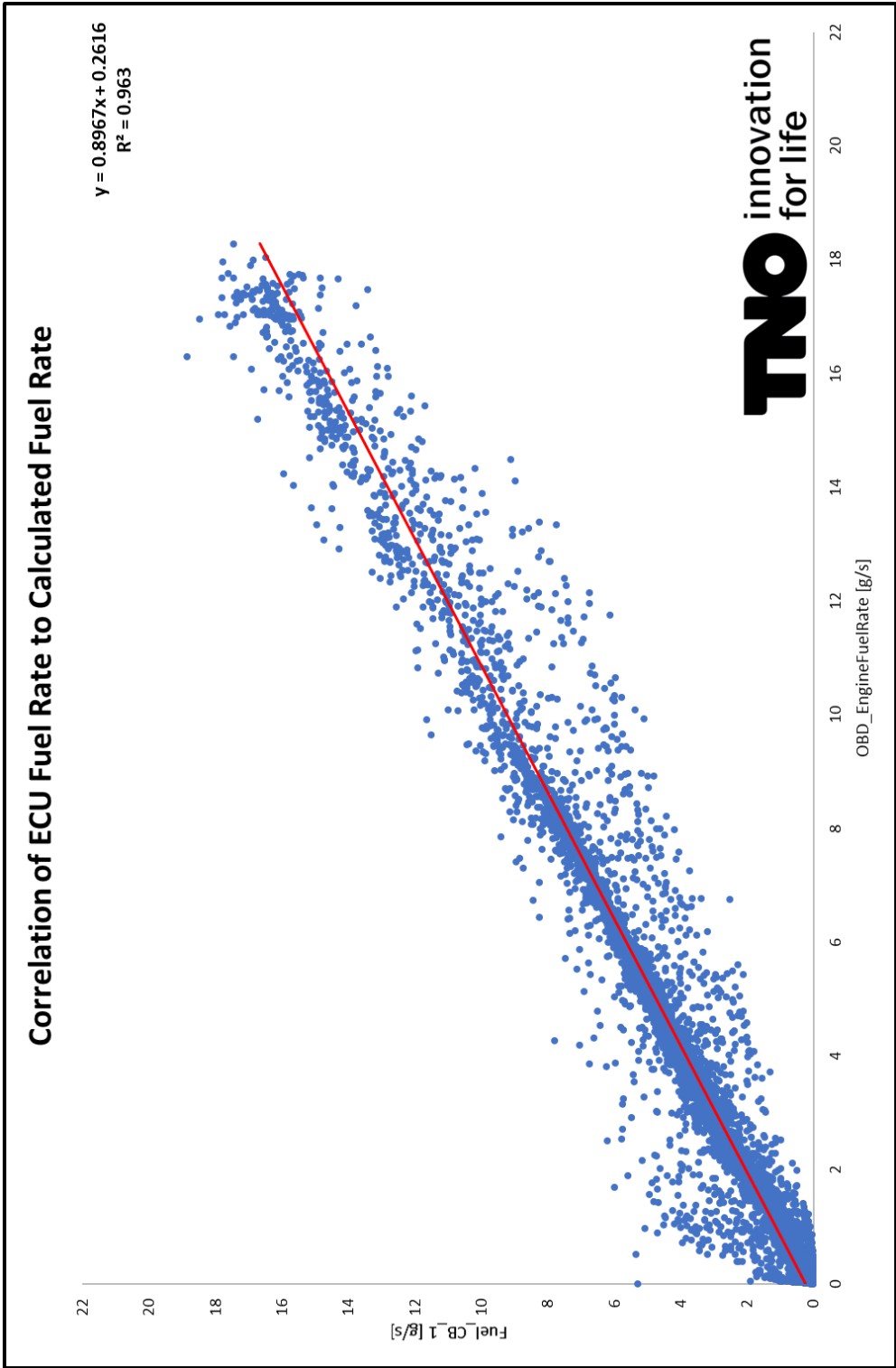
OBS-ONE Post Processing v2.12.0

Template ID : ParameterWindowHDVWork_ENG.TDR
 Report ID : 20190114112228_C

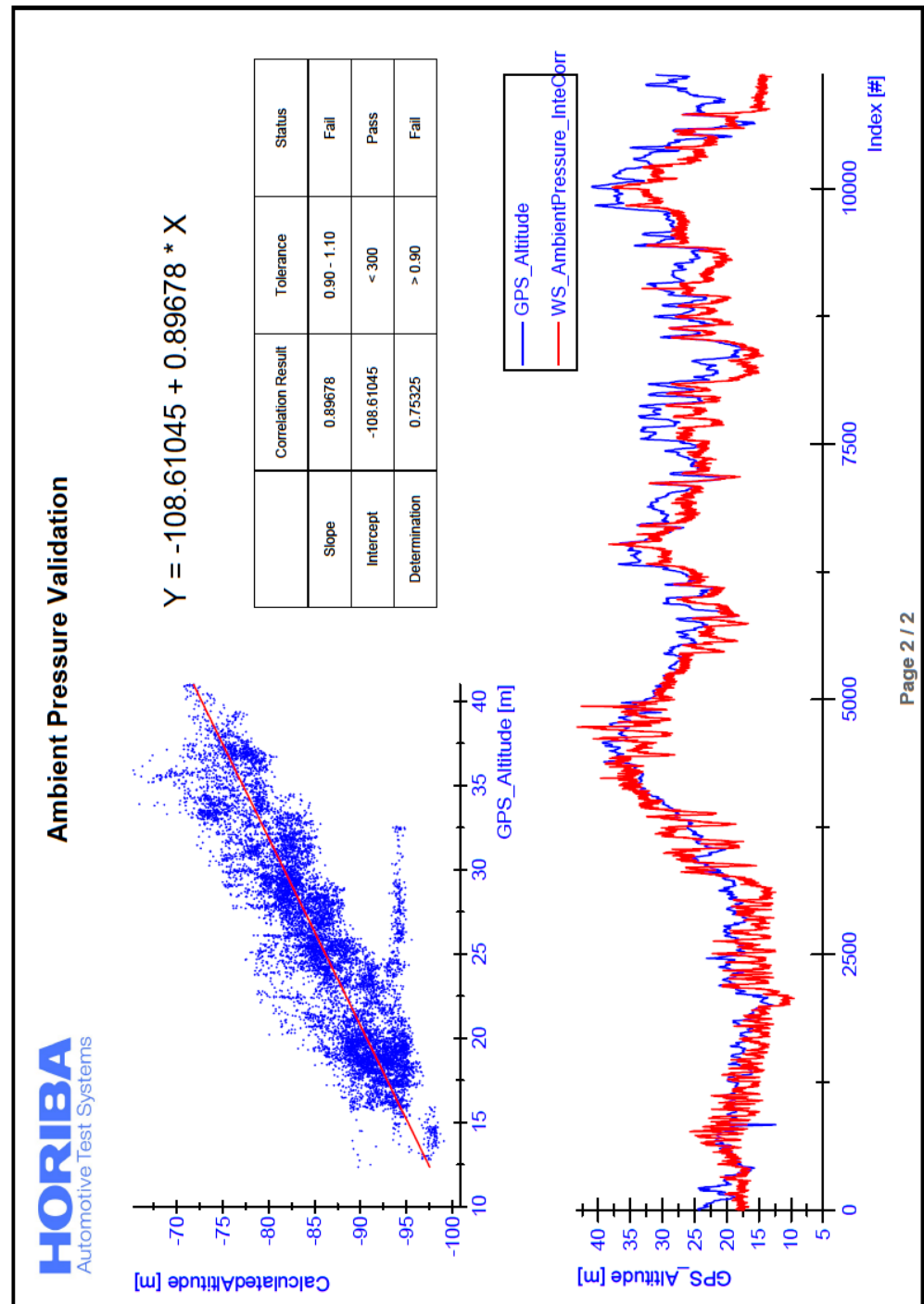
D.7 Driving report



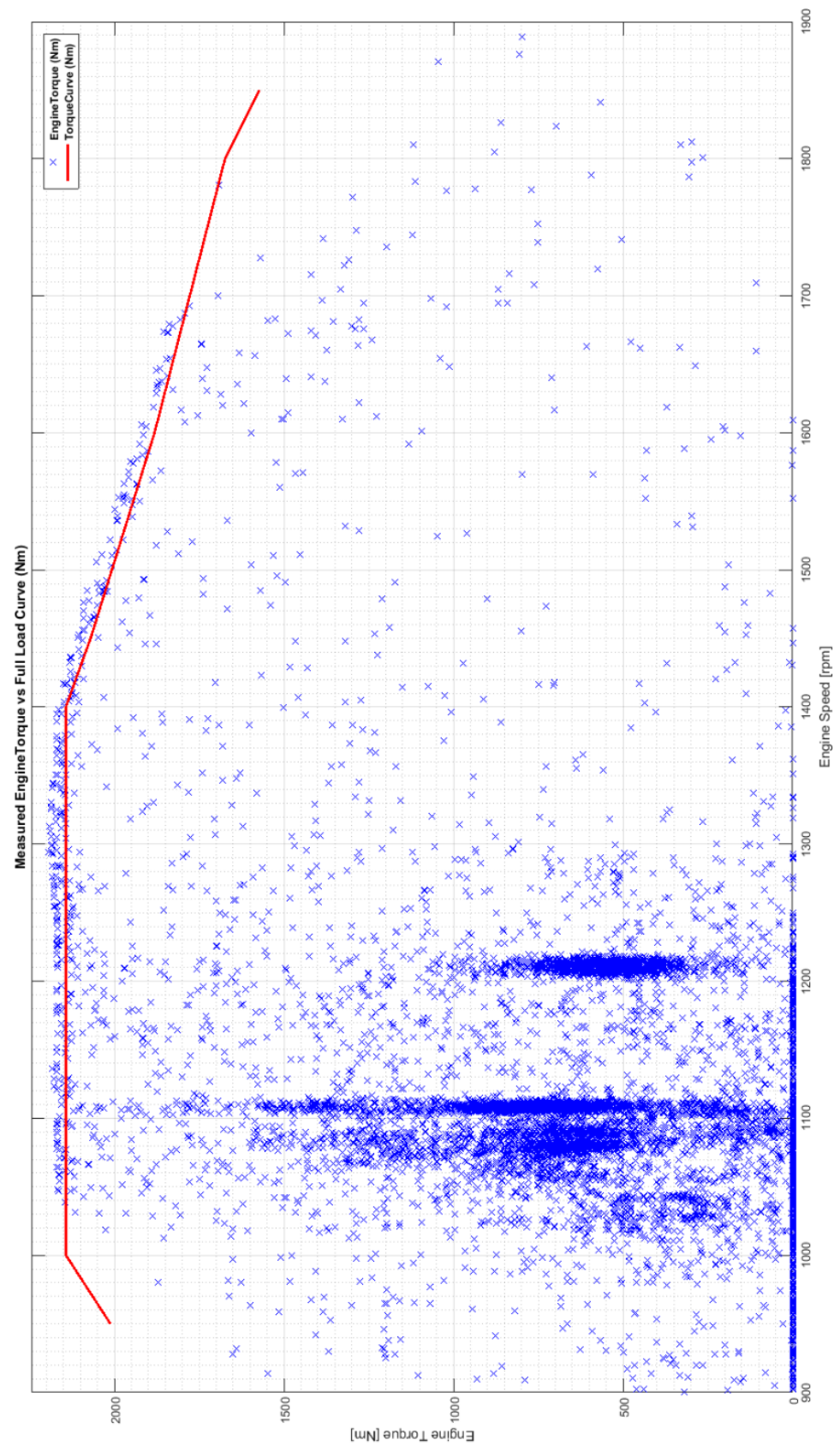
D.8 Fuel rate correlation



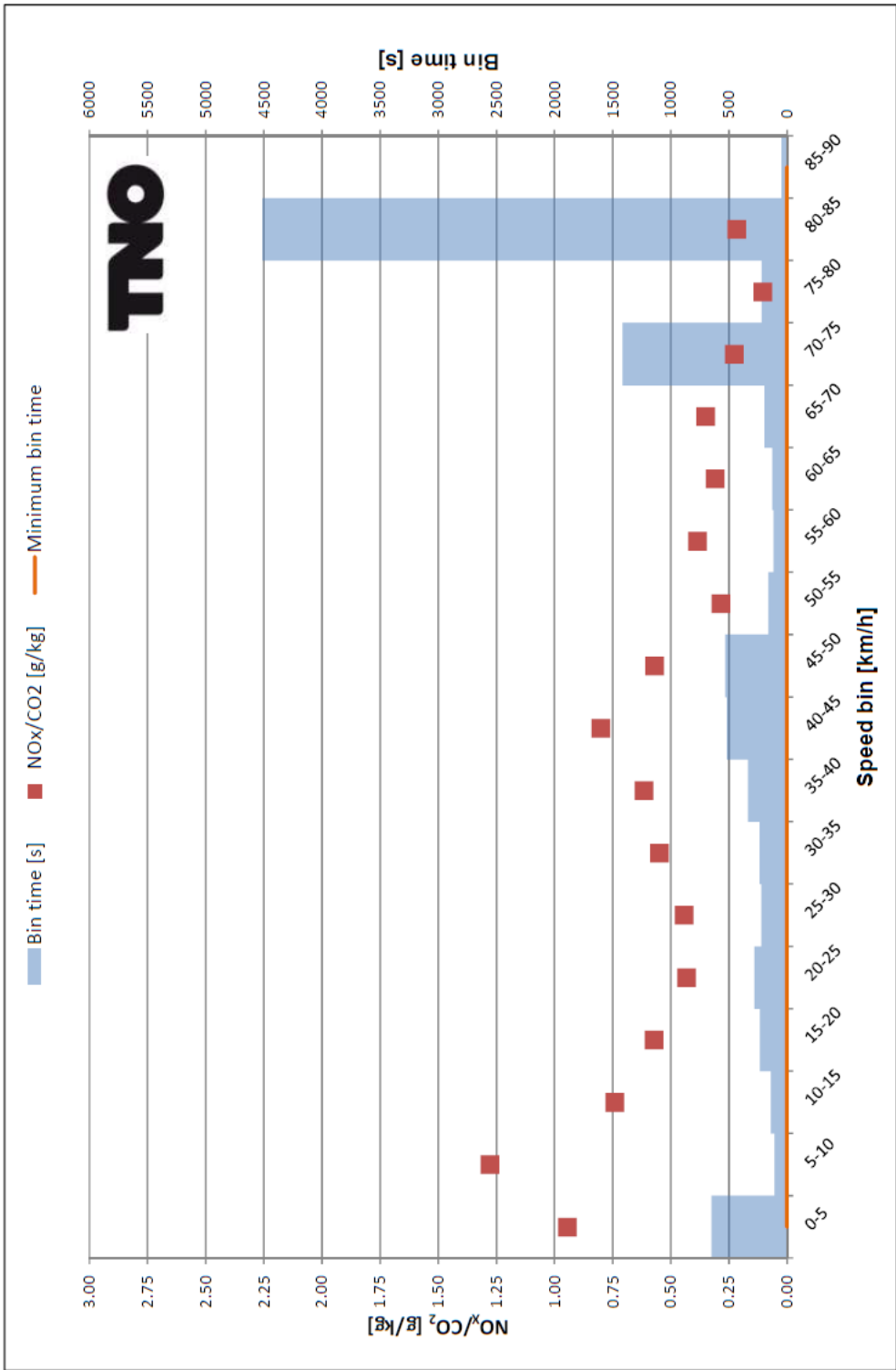
D.9 Ambient pressure validation



D.10 Torque curve correlation



D.11 Binning graph



D.12 Binning results

General		
Filename		L731_11
Test #		3
Trip		N3
Payload	[%]	48

Trip data		
Time	[s]	10027
Distance	[km]	172.29
Average Speed	[km/h]	61.9

Results 1				
Totals	[g/km]	[g/tonkm]	[g/kWh]	g/kgCO2
CO2	644	20.2	519	1000
CO	3.03	0.10	2.44	4.71
NOx	0.22	0.01	0.18	0.34
HC	0.44	0.01	0.35	0.68
NO2	0.14	0.00	0.11	0.21

Results 2	[km/h]	0...<50	>=50...<75	>=75
PEMS bins				
Avg speed in bin	[km/h]	26.8	68.5	82.9
CO2	[g/km]	1291	655	498
CO	[g/km]	6.4	2.3	2.5
NOx	[g/km]	0.81	0.17	0.10
HC	[g/km]	0.8	0.5	0.3
NO2	[g/km]	0.6	0.1	0.0
Time	[s]	3245	2006	4776
Time relative	[%]	32%	20%	48%
NOx/CO2	[g/kg]	0.63	0.27	0.21

General																							
Filename		L731_11																					
Test #		3																					
Trip		N3																					
Payload		48																					
		[%]																					
Bins		[km/h]	Total																				
				0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	75-80	80-85	85-90		
Bin time		[s]	10027	648	108	138	232	280	220	237	334	517	531	160	115	125	192	1414	217	4511	48		
Bin time share		[%]	100%	6%	1%	1%	2%	3%	2%	2%	3%	5%	5%	2%	1%	1%	2%	14%	2%	45%	0%		
Distance		[km]	172.29	0.09	0.23	0.49	1.13	1.76	1.70	2.13	3.51	6.11	7.00	2.30	1.85	2.18	3.61	28.23	4.74	104.09	1.15		
Work		[kWh]	213.81	1.15	1.72	2.93	4.35	6.52	6.62	7.24	8.91	11.12	8.74	4.31	4.50	4.72	6.15	28.28	4.97	101.54	0.04		
Power		[kW]	76.76	6.40	57.46	76.32	67.45	83.87	108.32	110.03	96.05	77.44	59.23	96.88	141.00	135.82	115.28	71.99	82.52	81.03	2.77		
Speed		[km/h]	61.9	0.5	7.6	12.7	17.5	22.6	27.8	32.3	37.8	42.6	47.5	51.8	57.8	62.7	67.8	71.9	78.7	83.1	85.9		
Exhaust temp		[K]	544.0	536.6	539.5	540.1	540.6	542.4	543.4	543.8	545.2	537.7	545.5	539.6	546.0	541.5	541.7	547.7	535.3	545.7	531.0		
Coolant temp		[K]	353.4	354.0	353.9	353.9	353.5	353.2	353.6	353.6	353.6	352.6	353.7	354.0	354.1	354.0	354.1	353.4	353.2	353.3	352.9		
NOx/CO2		[g/kg]	0.34	0.94	1.28	0.74	0.57	0.43	0.44	0.55	0.61	0.80	0.57	0.28	0.38	0.31	0.35	0.23	0.10	0.22	-0.01		
CO2		[g/s]	11.06	1.81	7.52	8.60	11.76	10.56	15.17	15.08	13.82	11.00	9.59	13.26	18.68	18.19	15.25	10.99	11.77	11.56	0.88		
CO		[g/s]	0.05	0.04	0.19	0.14	0.08	0.03	0.04	0.04	0.04	0.03	0.03	0.04	0.05	0.04	0.05	0.04	0.03	0.06	0.02		
NOx		[g/s]	0.00	0.00	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00		
HC		[g/s]	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00		
NO2		[g/s]	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
CO2		[g/km]	644	13106	3566	2430	2422	1679	1962	1678	1315	930	727	922	1164	1045	810	550	539	501	37		
CO		[g/km]	3.03	254.36	91.54	38.78	16.45	5.05	5.19	3.98	3.51	2.94	2.56	2.88	3.21	2.48	2.70	2.18	1.42	2.60	0.91		
NOx		[g/km]	0.22	12.37	4.55	1.80	1.38	0.73	0.87	0.92	0.81	0.74	0.41	0.26	0.45	0.32	0.28	0.12	0.06	0.11	0.00		
HC		[g/km]	0.44	29.00	3.40	1.81	1.42	0.97	0.87	0.68	0.58	0.55	0.53	0.49	0.53	0.35	0.41	0.50	0.30	0.34	0.08		
NO2		[g/km]	0.14	6.46	1.48	0.72	0.81	0.59	0.72	0.79	0.70	0.68	0.37	0.18	0.31	0.21	0.20	0.07	0.02	0.04	0.00		
CO2		[g/kWh]	519	1019	471	405	627	453	504	493	518	511	583	493	477	482	476	549	513	514	1149		
CO		[g/kWh]	2.44	19.78	12.09	6.47	4.26	1.36	1.33	1.17	1.38	1.62	2.05	1.54	1.32	1.14	1.59	2.17	1.35	2.66	28.40		
NOx		[g/kWh]	0.18	0.96	0.60	0.30	0.36	0.20	0.22	0.27	0.32	0.41	0.33	0.14	0.18	0.15	0.17	0.12	0.05	0.11	-0.01		
HC		[g/kWh]	0.35	2.25	0.45	0.30	0.37	0.26	0.22	0.20	0.23	0.30	0.43	0.26	0.22	0.16	0.24	0.50	0.29	0.35	2.58		
NO2		[g/kWh]	0.11	0.50	0.19	0.12	0.21	0.16	0.19	0.23	0.28	0.37	0.29	0.10	0.13	0.10	0.12	0.07	0.02	0.04	-0.03		

E Calibration reports OBS One

E.1 Pitot flow module PG7RUL35

CERTIFICATE OF CALIBRATION		 																					
ISSUED BY: HORIBA UK LIMITED																							
DATE OF ISSUE	25 January 2018	CERTIFICATE NUMBER	C10468																				
HORIBA UK LTD Kyoto Close Moulton Park Northampton NN3 6FL Telephone: 01604 - 542500 Telefax: 01604 - 542699		Page 1 of 4 pages Approved Signatory Name: T. Lowe Signature:  This is an electronically controlled document																					
Customer : TNO PTC Address : Automotiv Campus 25, 5708 JZ Helmond, Netherlands																							
Customer Ref: 4510611024 Site: HORIBA System: HGS PG7RUL35 Software Version: 2.0.6	System Model: PF Channel 1 Serial Number: HUK16080009 Calibration Engineer: A. Cernych Calibration Date: 23 January 2018																						
Method: The K Type Thermocouple Channel was calibrated against a Laboratory Reference Standard which is traceable to national standards. The instrument was calibrated by simulating a temperature to the channel and recording the displayed reading. The Thermocouple calibrator was placed in close proximity to the channel and allowed to acclimatise. Readings were taken at a number of set points across the channels range. The Results are referenced to IEC584-1:2013 The pressure instrument provides a digital indication and an electrical output corresponding to the applied pressure. The instrument was calibrated using the comparison method against a Druck DPI 605 Pressure Calibrator whose calibration is traceable to national standards. The reference device was connected to the system and the pressure was reduced to its lower limit. The pressure was increased to the upper limit and stepped down at regular settings across the instruments range. The displayed instrument readings and reference readings were recorded. The differential pressure instrument provides a digital indication and an electrical output corresponding to the applied vacuum pressure. A set of readings was taken as received and a set of readings was taken as left. The instrument was calibrated using the comparison method against a Furness FCO560 Micro-manometer whose calibration is traceable to national standards. The reference device was placed in close proximity to the instrument. A vacuum pump was used, and the system was depressurised to its lower limit and stepped up at regular settings across the instruments range. The instruments displayed value and the reference readings were recorded.																							
Equipment Used <table border="1"> <thead> <tr> <th>Equipment</th> <th>Serial Number</th> <th>Certificate Number</th> <th>Calibration Date</th> </tr> </thead> <tbody> <tr> <td>Druck DPI 605</td> <td>60504643</td> <td>C10082</td> <td>25 September 2017</td> </tr> <tr> <td>Furness FCO560</td> <td>1504102</td> <td>15206</td> <td>06 October 2017</td> </tr> <tr> <td>Druck Unimat TRX II</td> <td>2662</td> <td>U84963-16</td> <td>06 March 2017</td> </tr> <tr> <td>Temperature & Humidity</td> <td>L2240759</td> <td>U87178-17</td> <td>07 July 2017</td> </tr> </tbody> </table>				Equipment	Serial Number	Certificate Number	Calibration Date	Druck DPI 605	60504643	C10082	25 September 2017	Furness FCO560	1504102	15206	06 October 2017	Druck Unimat TRX II	2662	U84963-16	06 March 2017	Temperature & Humidity	L2240759	U87178-17	07 July 2017
Equipment	Serial Number	Certificate Number	Calibration Date																				
Druck DPI 605	60504643	C10082	25 September 2017																				
Furness FCO560	1504102	15206	06 October 2017																				
Druck Unimat TRX II	2662	U84963-16	06 March 2017																				
Temperature & Humidity	L2240759	U87178-17	07 July 2017																				
Uncertainties The uncertainties associated with the measurement of the applied pressures are:- 0 to 3 kPa (0.3 % + 0.00087 kPa), 3 to 12 kPa (0.3 % + 0.001 kPa), 80 kPa to 120 kPa Absolute (0.05 % + 0.187 kPa) The uncertainty of measurement for Thermocouples are [1.0°C + instrument resolution.] The recorded uncertainty refers to the measurements and is not intended to indicate the specification, or repeatability of the instrument. Standard unit conversions used are: 1 Pa = 0.0002953 inHg @ 0°C, 1 Pa = 0.00750062 mmHg @ 0°C, 1 Pa = 0.00401474 inH ₂ O @ 4°C, 1 Pa = 0.000145038 psi.																							
Condition Of Equipment GOOD Leak Check PASSED The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor $k = 2$, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements.																							
This certificate is issued in accordance with the laboratory accreditation requirements of the United Kingdom Accreditation Service. It provides traceability of measurement to recognised national standards, and to units of measurement realised at the National Physical Laboratory or other recognised national standards laboratories. This certificate may not be produced other than in full, except with the prior written approval of the issuing laboratory.																							

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Environmental Conditions

Barometer kPa	Temperature °C	Humidity %
99.61 ± 0.40	21.7 ± 2.0	28.7 ± 20.0 % rh

Differential DP 1 Pressure					
Make	First Sensor AG	Model	-/+ 0.25KPa 3.3V		
S/N	74-8C-31-EE	Range	0.3 kPa (G)		
Orientation			In Situ		
As Found	Coefficients	A0 -2.1837E-03	A1 1.0025E+00		
A2	7.51120E-03	A3 -1.3347E-02	A4 -3.0792E-02		
Point	Reference	Device	% Error	% Error	
	kPa (G)	kPa (G)	(Rdg)	(F.S)	
1	-0.300	-0.304	1.35	-1.35	
2	0.000	-0.004		-1.38	
3	0.300	0.296	-1.45	-1.45	
Coefficient Adjusted, Stability ± 0.0001 kPa					
As Left	Coefficients	A0 1.9203E-03	A1 1.0034E+00		
A2	5.30982E-03	A3 -1.6781E-02	A4 -5.9688E-03		
Point	Reference	Device	% Error	% Error	
	kPa (G)	kPa (G)	(Rdg)	(F.S)	
1	-0.300	-0.300	0.02	-0.02	
2	-0.250	-0.250	0.00	0.00	
3	-0.200	-0.200	0.06	-0.04	
4	-0.150	-0.150	0.03	-0.02	
5	-0.100	-0.100	-0.04	0.01	
6	-0.050	-0.050	0.00	0.00	
7	0.000	0.000		0.04	
8	0.050	0.050	0.18	0.03	
9	0.100	0.100	-0.02	-0.01	
10	0.150	0.150	-0.06	-0.03	
11	0.200	0.200	0.08	0.05	
12	0.250	0.250	0.06	0.05	
13	0.300	0.300	-0.01	-0.01	

Differential DP 2 Pressure					
Make	First Sensor AG	Model	-/+ 1.25KPA 3.3V		
S/N	35-9B-32-26	Range	1.5 kPa (G)		
Orientation		In Situ			
As Found	Coefficients	A0 1.7305E-03	A1 9.9301E-01		
A2	1.98192E-03	A3 5.0768E-03	A4 -1.3490E-04		
Point	Reference	Device	% Error	% Error	
	kPa (G)	kPa (G)	(Rdg)	(F.S)	
1	-1.250	-1.180	-5.60	4.67	
2	0.000	0.068		4.54	
3	1.500	1.571	4.76	4.76	
Coefficient Adjusted, Stability ± 0.0002 kPa					
As Left	Coefficients	A0 -6.6214E-02	A1 9.9181E-01		
A2	-2.25244E-04	A3 5.4399E-03	A4 1.5451E-04		
Point	Reference	Device	% Error	% Error	
	kPa (G)	kPa (G)	(Rdg)	(F.S)	
1	-1.250	-1.250	-0.02	0.02	
2	-1.000	-1.000	-0.04	0.03	
3	-0.750	-0.750	-0.03	0.01	
4	-0.500	-0.500	-0.04	0.01	
5	-0.300	-0.300	-0.09	0.02	
6	-0.200	-0.200	-0.19	0.03	
7	-0.100	-0.100	-0.38	0.03	
8	0.000	0.000		0.01	
9	0.100	0.101	0.60	0.04	
10	0.200	0.200	0.08	0.01	
11	0.300	0.300	-0.11	-0.02	
12	0.500	0.500	-0.07	-0.02	
13	0.750	0.750	-0.06	-0.03	
14	1.000	1.000	0.00	0.00	
15	1.250	1.250	0.01	0.01	
16	1.500	1.500	-0.01	-0.01	

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Differential DP 3 Pressure					
Make	First Sensor AG	Model	-/+ 0-5KPA 3.3V		
S/N	55-F6-32-B4	Range	5	kPa (G)	
Orientation					
In Situ					
As Found	Coefficients	A0	-8.6848E-03 <th>A1</th> <td>1.0042E+00</td>	A1	1.0042E+00
A2	1.94517E-04 <th>A3</th> <td>-1.1681E-04<th>A4</th><td>-1.0885E-05</td></td>	A3	-1.1681E-04 <th>A4</th> <td>-1.0885E-05</td>	A4	-1.0885E-05
Point	Reference	Device	% Error	% Error	
	kPa (G)	kPa (G)	(Rdg)	(F.S)	
1	0.000	-0.009		-0.18	
2	2.500	2.493	-0.29	-0.15	
3	5.000	4.994	-0.12	-0.12	
Coefficient Adjusted Stability ± 0.0004 kPa					
As Left	Coefficients	A0	-8.0581E-05 <th>A1</th> <td>1.0027E+00</td>	A1	1.0027E+00
A2	2.46788E-06 <th>A3</th> <td>6.1734E-05<th>A4</th><td>-3.1487E-05</td></td>	A3	6.1734E-05 <th>A4</th> <td>-3.1487E-05</td>	A4	-3.1487E-05
Point	Reference	Device	% Error	% Error	
	kPa (G)	kPa (G)	(Rdg)	(F.S)	
1	0.000	0.001		0.02	
2	0.100	0.101	1.42	0.03	
3	0.200	0.200	0.03	0.00	
4	0.300	0.300	0.10	0.01	
5	0.500	0.501	0.23	0.02	
6	1.000	1.002	0.19	0.04	
7	1.500	1.499	-0.04	-0.01	
8	2.000	2.000	0.02	0.01	
9	2.500	2.499	-0.03	-0.02	
10	3.000	3.001	0.02	0.01	
11	3.500	3.501	0.01	0.01	
12	4.000	4.001	0.01	0.01	
13	4.500	4.498	-0.04	-0.03	
14	5.000	5.001	0.01	0.01	

Differential DP 4 Pressure					
Make	First Sensor AG	Model	-/+ 0-7.5KPa 3.3V		
S/N	70-5C-FF-2F	Range	7.5	kPa (G)	
Orientation					
In Situ					
As Found	Coefficients	A0	7.2174E-03	A1	1.0029E+00
A2	1.29413E-03 <th>A3</th> <td>-6.0782E-04</td> <th>A4</th> <td>4.8089E-05</td>	A3	-6.0782E-04	A4	4.8089E-05
Point	Reference	Device	% Error	% Error	
	kPa (G)	kPa (G)	(Rdg)	(F.S)	
1	0.000	-0.008		-0.10	
2	3.500	3.483	-0.50	-0.23	
3	7.500	7.474	-0.35	-0.35	
Coefficient Adjusted Stability ± 0.001 kPa					
As Left	Coefficients	A0	1.6126E-02	A1	1.0083E+00
A2	-5.02082E-05	A3	-3.5648E-04	A4	3.1927E-05
Point	Reference	Device	% Error	% Error	
	kPa (G)	kPa (G)	(Rdg)	(F.S)	
1	0.000	-0.002		-0.03	
2	0.100	0.099	-1.24	-0.02	
3	0.200	0.200	-0.04	0.00	
4	0.300	0.299	-0.35	-0.01	
5	0.500	0.500	-0.06	0.00	
6	1.000	1.000	0.04	0.01	
7	1.500	1.500	0.00	0.00	
8	2.000	2.000	-0.01	0.00	
9	2.500	2.499	-0.03	-0.01	
10	3.000	2.999	-0.03	-0.01	
11	3.500	3.499	-0.03	-0.01	
12	4.000	4.000	0.00	0.00	
13	4.500	4.500	0.01	0.00	
14	5.000	5.000	0.00	0.00	
15	5.500	5.500	0.00	0.00	
16	6.000	6.001	0.01	0.01	
17	6.500	6.498	-0.03	-0.03	
18	7.000	6.998	-0.03	-0.03	
19	7.500	7.501	0.01	0.01	

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Exhaust Pressure Transducer				
Make	First Sensor AG	Model	800-1100MBAR 3.3V	
S/N	73-FC-3A-AE	Range	110 kPa(A)	
Orientation		In Situ		
As Found	Coefficients	A0 2.3888E+02	A1 -8.6319E+00	
A2	1.45418E-01	A3 -9.7402E-04	A4 2.4421E-06	
Point	Reference	Device	% Error	% Error
	kPa(A)	kPa(A)	(Rdg)	(F.S)
1	90.02	90.03	0.01	0.01
2	100.01	100.00	-0.01	-0.01
3	110.00	110.00	0.01	0.01
No Adjustment. Stability ± 0.04 kPa				
As Left	Coefficients	A0 2.3888E+02	A1 -8.6319E+00	
A2	1.45418E-01	A3 -9.7402E-04	A4 2.4421E-06	
Point	Reference	Device	% Error	% Error
	kPa(A)	kPa(A)	(Rdg)	(F.S)
1	90.01	90.01	0.00	0.00
2	95.00	95.00	0.00	0.00
3	97.50	97.51	0.02	0.02
4	99.99	99.99	0.00	0.00
5	102.48	102.52	0.04	0.03
6	104.98	104.97	-0.01	-0.01
7	109.98	109.98	0.00	0.00

Exhaust Temp Temperature				
Make	HUK	Model	K Type	
S/N	EXT	Range	1400 °C	
Orientation		In Situ		
As Found	Coefficients	A0 -1.6445E+00	A1 1.0129E+00	
A2	3.59721E-05	A3 -1.9436E-07	A4 1.4546E-10	
Point	Reference	Device	% Error	% Error
	°C	°C	(Rdg)	(F.S)
1	0	-1.3	-0.09	-0.09
2	200	198.5	-0.76	-0.11
3	600	599.4	-0.10	-0.04
Coefficient Adjusted. Stability ±0.05°C				
As Left	Coefficients	A0 -4.1702E-01	A1 1.0128E+00	
A2	3.59905E-05	A3 -1.9547E-07	A4 1.4667E-10	
Point	Reference	Device	% Error	% Error
	°C	°C	(Rdg)	(F.S)
1	0.0	0.2	0.01	0.01
2	20.0	19.4	-2.87	-0.04
3	100.0	100.7	0.72	0.05
4	200.0	199.8	-0.08	-0.01
5	400.0	399.4	-0.15	-0.04
6	600.0	600.7	0.12	0.05
7	800.0	799.6	-0.05	-0.03
8	1000.0	1000.1	0.01	0.01

End of UKAS Certificate

SCT 50.0 PF Calibration Certificate v1.1

E.2 Pitot flow tube 150502F

CERTIFICATE OF CALIBRATION			
ISSUED BY	HORIBA UK LIMITED		
DATE OF ISSUE	21 August 2018	CERTIFICATE NUMBER	C11254

HORIBA UK LTD
 Kyoto Close
 Moulton Park
 Northampton
 NN3 6FL
 Telephone: 01604 - 542500
 Telefax: 01604 - 542699

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Approved Signatory
 Name M. Singh

Signature 

Electronically controlled document

Customer : TNO, Department: Powertrains, Attn Jan Willem de Koning,
Address: PTC Building D, Automotive Campus 25, 5708 JZ HELMOND, THE NETHERLAND

Customer Ref: 4510736236
Site: HORIBA Offsite
System: PF Module
System Model: Version 2
Serial Number: HGS GV9FLXS F

Item Calibrated: F Tube
Item Serial Number: 150502F
Item Range: 0 to 30000 l/min
Calibration Date: 13 August 2018
Software Version: 2.0.6

Method:
 The flow tube was acclimatised to the laboratory environment (20 ± 2°C) overnight. The flow tube was connected to a series of Smooth Approach Orifici of traceable calibration history. The flow tube was then calibrated over its given flow range. This data was then recorded and entered into the coefficient calculation software. The new calibration coefficients were entered into the PTFM software. An As Left Accuracy check was carried out and the data recorded. The specified accuracy of the device is ± 2.0 % of point or ± 0.5 % of full scale whichever is the greater. The recorded values were an average of 30 readings, with an interval of 1 Hz.

Equipment Used

Equipment	Serial Number	Certificate Number	Calibration Date
Barometer	4347299	C10045	14 September 2017
Furness FCO510	9411150	15060	04 September 2017
PRT	1501047	C10044	12 September 2017
Temperature & Humidity	10960380	U90432-17	17 January 2018

Pitot Calibration Coefficient

K =	12778.18
A0 =	0.000000E+00
A1 =	1.027608E+00
A2 =	-2.598689E-06
A3 =	1.680517E-10
A4 =	-4.208331E-15

Ambient Conditions

Barometer kPa	Temperature °C	Humidity %
99.35	21.30	50.7

Uncertainties

The uncertainties of calibration is the uncertainty of the applied pressure + 1 digit and instrument readability. The estimated uncertainties associated with the measurement of the applied pressures are: 0 to 2 kPa (0.4 % + 0.9 Pa), 2 to 20 kPa (0.4 % + 6.8 Pa), Absolute Pressure (0.04 % + 187 Pa)

The uncertainty of measurement for temperature is [0.17°C + instrument resolution and instrument readability.]

b. Linearity - Intercept (Xmin(a1-1)+a0) : Within 1.0 % full scale. Slope (a1): 0.98 to 1.02. SEE(Standard Estimated Error) : Within 2.0 % of full scale. r² (Coefficient of determination): 0.990 or more

The recorded uncertainty refers to the measurements and is not intended to indicate the specification, or repeatability of the instrument.

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k = 2, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements.

This certificate is issued in accordance with the laboratory accreditation requirements and certifies that all devices used have traceability of measurement to recognised national standards, and to units of measurement realised at the National Physical Laboratory or other recognised national standards laboratories. This certificate may not be produced other than in full, except with the prior written approval of the issuing laboratory.

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a. Performance test

Linearity		SAO flow		Pitot flow		Error		Status
	SAO NO	[m3/min]	[l/min]	[m3/min]	[l/min]	[%RD]	[%FS]	
1	1	0.000	0.000	0.000	0.326		0.00	PASS
2	1	3.038	3038.148	3.040	3039.944	0.06	0.01	PASS
3	1	6.001	6000.575	6.027	6027.088	0.44	0.09	PASS
4	1	9.022	9021.510	9.059	9058.863	0.41	0.12	PASS
5	1	12.082	12081.890	12.073	12073.049	-0.07	-0.03	PASS
6	1	14.876	14876.197	14.936	14935.885	0.40	0.20	PASS
7	1	17.981	17980.646	17.882	17881.536	-0.55	-0.33	PASS
8	1	21.127	21126.894	21.110	21110.056	-0.08	-0.06	PASS
9	1	23.973	23973.208	23.992	23991.535	0.08	0.06	PASS
10	1	27.051	27051.390	26.943	26943.325	-0.40	-0.36	PASS
11	1	30.102	30102.355	29.970	29969.750	-0.44	-0.44	PASS

b. Linearity

[a0](FS%) = 0.13

a1 = 0.9960 SEE (FS%) = 0.24

r² = 1.0000

c. Noise (2.0 % of full scale or less)				STATUS
Component		Test Result		
Exh. Flow	ZERO	0.02	%FS	PASS
	SPAN	0.33	%FS	PASS

d. Repeatability (2.0% of reading scale or less)				STATUS
Component		Test Result		
Exh. Flow	SPAN	1.71	%RS	PASS

Test Data		Average Data		Standard deviation data	
		ZERO	SPAN	ZERO	SPAN
		[m3/min]	[m3/min]	[m3/min]	[m3/min]
1		-0.003	9.784	0.004	0.141
2		-0.004	9.931	0.005	0.125
3		-0.004	9.746	0.004	0.134
4		-0.010	9.890	0.007	0.096
5		-0.006	9.843	0.005	0.107
6		-0.008	9.836	0.007	0.124
7		-0.008	9.758	0.007	0.123
8		-0.007	9.783	0.005	0.093
9		-0.006	9.723	0.006	0.092
10		-0.008	9.760	0.007	0.088

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Calibration Data

[illegible]

SAO Calibration Data

No. 1

S/N	HII017		a0	9.4140252E-01	a3	7.3399193E-18
Throat	3.442	"	a1	6.0983919E-07	a4	-5.9595008E-24
Inlet	1000	"	a2	-3.2375236E-12	a5	0.0000000E+00

E.3 Checks performed on the different analysers

E.3.1 CO Linearize check



Analyzer Linearize Check

HGS No. : 63JNMN52	Start Time : 2018/08/16 15:05:42
Device : GA	End Time : 2018/08/16 15:50:32
Line : Tailpipe	Test Status : Pass

Analyzer	Test Result
Component : CO	Linearize Check : Pass
Range : 10.0 vol%	Drift Check : ---
Check Gas	Top Gas Check : ---
Top Gas Supply Port : Span	Mid Span Check : ---
Top Gas Concentration : 9.48 vol%	
Checker	
Control Type : GDC-ONE	
Curve Setting	Curve Criteria
Poly Order : 4th	Preset Name : Standard
Fitting Type : Weights	Judge Type : Use Larger Limit
Adjust 0% 100% : Active	Criteria 1 : 2.0 % of Point (PT)
	Criteria 2 : 0.3 % of Full Scale (FS)

Measurement Value			
Curve :			
Reference Pressure :	101.4 kPa	Curve Coefficient	
Reference Temperature :	26.13 deg C	A0	-9.874196E+00
Reference Humidity :	51.23 %	A1	1.325990E-01
Ref. Temp. (Humidity) :	26.13 deg C	A2	5.047525E-06
		A3	2.145788E-11
		A4	-1.422080E-16
		Z/S Coefficient	
		A	1.000797E+00
		B	3.737542E+02

Current Data Set				Current Curve		
Point #	Cut [%]	Gen. Conc. [vol%]	Z/S Adj. Counts	Measured Conc. [vol%]	Error [%]	Status
1	100.0	9.480	120573	9.480	0.00(PT)	Pass
2	90.0	8.532	113226	8.558	0.31(PT)	Pass
3	80.0	7.584	105694	7.628	0.58(PT)	Pass
4	70.0	6.636	97826	6.685	0.73(PT)	Pass
5	60.0	5.688	89570	5.736	0.84(PT)	Pass
6	50.0	4.740	80871	4.772	0.68(PT)	Pass
7	40.0	3.792	70992	3.807	0.40(PT)	Pass
8	36.0	3.413	66848	3.423	0.29(PT)	Pass
9	32.0	3.034	62469	3.037	0.12(PT)	Pass
10	30.0	2.844	60219	2.847	0.12(PT)	Pass
11	28.0	2.654	57884	2.656	0.08(PT)	Pass
12	24.0	2.275	52985	2.276	0.06(PT)	Pass
13	20.0	1.896	47632	1.894	-0.11(PT)	Pass
14	18.0	1.706	44755	1.702	-0.23(PT)	Pass
15	16.0	1.517	41727	1.512	-0.32(PT)	Pass
16	14.0	1.327	38508	1.322	-0.06(FS)	Pass

Test No. 176

1 / 2

AIA-03H-X0C64RX2



Analyzer Linearize Check

Current Data Set				Current Curve		
Point #	Cut [%]	Gen. Conc. [vol%]	Z/S Adj. Counts	Measured Conc. [vol%]	Error [%]	Status
17	12.0	1.138	35095	1.134	-0.04(FS)	Pass
18	10.0	0.948	31413	0.947	-0.01(FS)	Pass
19	9.0	0.853	29490	0.856	0.03(FS)	Pass
20	8.0	0.758	27384	0.762	0.03(FS)	Pass
21	7.0	0.664	25141	0.667	0.03(FS)	Pass
22	6.0	0.569	22742	0.572	0.03(FS)	Pass
23	5.0	0.474	20143	0.477	0.03(FS)	Pass
24	4.0	0.379	17271	0.382	0.03(FS)	Pass
25	3.6	0.341	16022	0.343	0.02(FS)	Pass
26	3.2	0.303	14708	0.305	0.01(FS)	Pass
27	3.0	0.284	14022	0.285	0.01(FS)	Pass
28	2.8	0.265	13323	0.266	0.00(FS)	Pass
29	2.4	0.228	11823	0.226	-0.01(FS)	Pass
30	2.0	0.190	10240	0.188	-0.02(FS)	Pass
31	1.8	0.171	9426	0.169	-0.02(FS)	Pass
32	1.6	0.152	8563	0.149	-0.02(FS)	Pass
33	1.4	0.133	7649	0.130	-0.03(FS)	Pass
34	1.2	0.114	6706	0.111	-0.03(FS)	Pass
35	1.0	0.095	5721	0.092	-0.03(FS)	Pass
36	0.8	0.076	4680	0.073	-0.03(FS)	Pass
37	0.6	0.057	3585	0.054	-0.03(FS)	Pass
38	0.4	0.038	2429	0.035	-0.03(FS)	Pass
39	0.2	0.019	1227	0.018	-0.01(FS)	Pass
40	0.0	0.000	-76	0.000	0.00(FS)	Pass

Drift Check (Zero) :

Step	Gas Conc. [vol%]	Measured Conc. [vol%]	Criteria [%]	Error [%]	Status
Zero	---	---	---	---	---

Drift Check (Span) :

Step	Gas Conc. [vol%]	Measured Conc. [vol%]	Criteria [%]	Error [%]	Status
Span	---	---	---	---	---

Comment

E.3.2 CO₂ Linearize check

Analyzer Linearize Check

HGS No. : 63JNMN52	Start Time : 2018/08/16 14:17:09
Device : GA	End Time : 2018/08/16 15:02:05
Line : Tailpipe	Test Status : Pass

Analyzer

Component : CO2
Range : 20.0 vol%

Check Gas

Top Gas Supply Port : Span
Top Gas Concentration : 15.16 vol%

Checker

Control Type : GDC-ONE

Curve Setting

Poly Order : 4th
Fitting Type : Weights
Adjust 0% 100% : Active

Test Result

Linearize Check : Pass
Drift Check : ---
Top Gas Check : ---
Mid Span Check : ---

Curve Criteria

Preset Name : Standard
Judge Type : Use Larger Limit
Criteria 1 : 2.0 % of Point (PT)
Criteria 2 : 0.3 % of Full Scale (FS)

Measurement Value

Curve :	Reference Pressure : 101.4 kPa	Curve Coefficient	Z/S Coefficient
	Reference Temperature : 25.84 deg C	A0 -5.216313E+01	A 1.006618E+00
	Reference Humidity : 52.38 %	A1 2.787561E-01	B 9.380610E+02
	Ref. Temp. (Humidity) : 25.84 deg C	A2 1.631171E-06	
		A3 -1.865571E-12	
		A4 1.714194E-18	

Current Data Set				Current Curve		
Point #	Cut [%]	Gen. Conc. [vol%]	Z/S Adj. Counts	Measured Conc. [vol%]	Error [%]	Status
1	100.0	15.16	252189	15.16	0.00(PT)	Pass
2	90.0	13.64	234674	13.65	0.06(PT)	Pass
3	80.0	12.13	216231	12.13	0.03(PT)	Pass
4	70.0	10.61	197219	10.64	0.23(PT)	Pass
5	60.0	9.096	177081	9.133	0.41(PT)	Pass
6	50.0	7.580	155662	7.628	0.64(PT)	Pass
7	40.0	6.064	132468	6.111	0.77(PT)	Pass
8	36.0	5.458	122663	5.506	0.88(PT)	Pass
9	32.0	4.851	112378	4.895	0.90(PT)	Pass
10	30.0	4.548	107172	4.595	1.04(PT)	Pass
11	28.0	4.245	101768	4.291	1.08(PT)	Pass
12	24.0	3.638	90421	3.675	1.00(PT)	Pass
13	20.0	3.032	78417	3.058	0.86(PT)	Pass
14	18.0	2.729	72082	2.748	0.09(FS)	Pass
15	16.0	2.426	65521	2.437	0.06(FS)	Pass
16	14.0	2.122	58776	2.129	0.03(FS)	Pass

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Analyzer Linearize Check

Current Data Set				Current Curve		
Point #	Cut [%]	Gen. Conc. [vol%]	Z/S Adj. Counts	Measured Conc. [vol%]	Error [%]	Status
17	12.0	1.819	51689	1.819	0.00(FS)	Pass
18	10.0	1.516	44446	1.517	0.00(FS)	Pass
19	9.0	1.364	40594	1.362	-0.01(FS)	Pass
20	8.0	1.213	36805	1.214	0.01(FS)	Pass
21	7.0	1.061	32801	1.062	0.00(FS)	Pass
22	6.0	0.910	28645	0.909	0.00(FS)	Pass
23	5.0	0.758	24537	0.763	0.02(FS)	Pass
24	4.0	0.606	20145	0.612	0.03(FS)	Pass
25	3.6	0.546	18281	0.549	0.02(FS)	Pass
26	3.2	0.485	16490	0.491	0.03(FS)	Pass
27	3.0	0.455	15639	0.463	0.04(FS)	Pass
28	2.8	0.424	14709	0.433	0.04(FS)	Pass
29	2.4	0.364	12796	0.373	0.04(FS)	Pass
30	2.0	0.303	10795	0.310	0.04(FS)	Pass
31	1.8	0.273	9857	0.281	0.04(FS)	Pass
32	1.6	0.243	8841	0.251	0.04(FS)	Pass
33	1.4	0.212	7836	0.220	0.04(FS)	Pass
34	1.2	0.182	6795	0.190	0.04(FS)	Pass
35	1.0	0.152	5685	0.157	0.03(FS)	Pass
36	0.8	0.121	4648	0.127	0.03(FS)	Pass
37	0.6	0.091	3620	0.097	0.03(FS)	Pass
38	0.4	0.061	2556	0.067	0.03(FS)	Pass
39	0.2	0.030	1300	0.032	0.01(FS)	Pass
40	0.0	0.000	147	0.000	0.00(FS)	Pass

Drift Check (Zero) :

Step	Gas Conc. [vol%]	Measured Conc. [vol%]	Criteria [%]	Error [%]	Status
Zero	---	---	---	---	---

Drift Check (Span) :

Step	Gas Conc. [vol%]	Measured Conc. [vol%]	Criteria [%]	Error [%]	Status
Span	---	---	---	---	---

Comment

E.3.3 NO Linearize check



Analyzer Linearize Check

HGS No. : 63JNMN52		Start Time : 2018/08/21 8:05:18	
Device : GA		End Time : 2018/08/21 8:48:57	
Line : Tailpipe		Test Status : Pass	
Analyzer		Test Result	
Component : NO		Linearize Check : Pass	
Range : 3000 ppm		Drift Check : ---	
Check Gas		Top Gas Check : ---	
Top Gas Supply Port : Span		Mid Span Check : ---	
Top Gas Concentration : 2510 ppm			
Checker			
Control Type : GDC-ONE			
Curve Setting		Curve Criteria	
Poly Order : 2nd		Preset Name : Standard	
Fitting Type : Weights		Judge Type : Use Larger Limit	
Adjust 0% 100% : Active		Criteria 1 : 2.0 % of Point (PT)	
		Criteria 2 : 0.3 % of Full Scale (FS)	
Measurement Value			
Curve :			
Reference Pressure : 101.9 kPa		Curve Coefficient	
Reference Temperature : 32.41 deg C		Z/S Coefficient	
Reference Humidity : 57.21 %		A 1.018714E+00	
Ref. Temp. (Humidity) : 25.89 deg C		B -3.696425E+02	
		A0 -1.175100E+00	
		A1 3.507678E-03	
		A2 4.711025E-11	
		A3 0.000000E+00	
		A4 0.000000E+00	

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Analyzer Linearize Check

Current Data Set				Current Curve		
Point #	Cut [%]	Gen. Conc. [ppm]	Z/S Adj. Counts	Measured Conc. [ppm]	Error [%]	Status
17	12.0	301.2	81009	298.5	-0.09(FS)	Pass
18	10.0	251.0	67457	248.2	-0.09(FS)	Pass
19	9.0	225.9	60762	223.3	-0.09(FS)	Pass
20	8.0	200.8	54071	198.5	-0.08(FS)	Pass
21	7.0	175.7	47210	173.0	-0.09(FS)	Pass
22	6.0	150.6	40475	148.1	-0.08(FS)	Pass
23	5.0	125.5	33727	123.3	-0.07(FS)	Pass
24	4.0	100.4	26993	98.34	-0.07(FS)	Pass
25	3.6	90.36	24339	88.49	-0.06(FS)	Pass
26	3.2	80.32	21646	78.58	-0.06(FS)	Pass
27	3.0	75.30	20318	73.73	-0.05(FS)	Pass
28	2.8	70.28	18936	68.61	-0.06(FS)	Pass
29	2.4	60.24	16269	58.75	-0.05(FS)	Pass
30	2.0	50.20	13592	48.91	-0.04(FS)	Pass
31	1.8	45.18	12254	43.97	-0.04(FS)	Pass
32	1.6	40.16	10924	39.05	-0.04(FS)	Pass
33	1.4	35.14	9592	34.10	-0.03(FS)	Pass
34	1.2	30.12	8255	29.19	-0.03(FS)	Pass
35	1.0	25.10	6882	24.13	-0.03(FS)	Pass
36	0.8	20.08	5562	19.26	-0.03(FS)	Pass
37	0.6	15.06	4264	14.47	-0.02(FS)	Pass
38	0.4	10.04	2948	9.616	-0.01(FS)	Pass
39	0.2	5.020	1636	4.791	-0.01(FS)	Pass
40	0.0	0.000	335	0.000	0.00(FS)	Pass

Drift Check (Zero) :

Step	Gas Conc. [ppm]	Measured Conc. [ppm]	Criteria [%]	Error [%]	Status
Zero	---	---	---	---	---

Drift Check (Span) :

Step	Gas Conc. [ppm]	Measured Conc. [ppm]	Criteria [%]	Error [%]	Status
Span	---	---	---	---	---

Comment

E.3.4 NOx Linearize check



Analyzer Linearize Check

HGS No. : 63JNMN52	Start Time : 2018/08/21 8:58:09
Device : GA	End Time : 2018/08/21 10:29:03
Line : Tailpipe	Test Status : Pass

Analyzer	Test Result
Component : NOx	Linearize Check : Pass
Range : 3000 ppm	Drift Check : ---
Check Gas	Top Gas Check : ---
Top Gas Supply Port : Span	Mid Span Check : ---
Top Gas Concentration : 2510 ppm	

Checker
Control Type : GDC-ONE

Curve Setting	Curve Criteria
Poly Order : 2nd	Preset Name : Standard
Fitting Type : Weights	Judge Type : Use Larger Limit
Adjust 0% 100% : Active	Criteria 1 : 2.0 % of Point (PT)
	Criteria 2 : 0.3 % of Full Scale (FS)

Measurement Value

Curve :	Reference Pressure : 102.0 kPa	Curve Coefficient	Z/S Coefficient
	Reference Temperature : 32.96 deg C	A0 3.833296E-01	A 9.786935E-01
	Reference Humidity : 57.28 %	A1 3.505967E-03	B -1.065683E+03
	Ref. Temp. (Humidity) : 25.86 deg C	A2 -4.843976E-11	
		A3 0.000000E+00	
		A4 0.000000E+00	

Current Data Set				Current Curve		
Point #	Cut [%]	Gen. Conc. [ppm]	Z/S Adj. Counts	Measured Conc. [ppm]	Error [%]	Status
1	100.0	2510	676042	2510	0.00(PT)	Pass
2	90.0	2259	609724	2267	0.35(PT)	Pass
3	80.0	2008	542430	2018	0.52(PT)	Pass
4	70.0	1757	475288	1771	0.79(PT)	Pass
5	60.0	1506	407698	1520	0.93(PT)	Pass
6	50.0	1255	339900	1269	1.13(PT)	Pass
7	40.0	1004	271917	1018	1.37(PT)	Pass
8	36.0	903.6	244723	916.4	1.42(PT)	Pass
9	32.0	803.2	217622	814.4	1.40(PT)	Pass
10	30.0	753.0	204222	764.5	1.52(PT)	Pass
11	28.0	702.8	190495	713.1	1.46(PT)	Pass
12	24.0	602.4	163331	611.6	1.53(PT)	Pass
13	20.0	502.0	135732	508.5	1.30(PT)	Pass
14	18.0	451.8	121953	456.8	1.12(PT)	Pass
15	16.0	401.6	108071	405.0	0.11(FS)	Pass
16	14.0	351.4	94121	353.2	0.06(FS)	Pass

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Analyzer Linearize Check

Current Data Set				Current Curve		
Point #	Cut [%]	Gen. Conc. [ppm]	Z/S Adj. Counts	Measured Conc. [ppm]	Error [%]	Status
17	12.0	301.2	80392	302.0	0.03(FS)	Pass
18	10.0	251.0	66887	251.3	0.01(FS)	Pass
19	9.0	225.9	60272	226.3	0.01(FS)	Pass
20	8.0	200.8	53494	200.8	0.00(FS)	Pass
21	7.0	175.7	46744	175.5	-0.01(FS)	Pass
22	6.0	150.6	39976	150.2	-0.01(FS)	Pass
23	5.0	125.5	33257	125.0	-0.02(FS)	Pass
24	4.0	100.4	26542	99.76	-0.02(FS)	Pass
25	3.6	90.36	23852	89.76	-0.02(FS)	Pass
26	3.2	80.32	21165	79.72	-0.02(FS)	Pass
27	3.0	75.30	19816	74.69	-0.02(FS)	Pass
28	2.8	70.28	18476	69.74	-0.02(FS)	Pass
29	2.4	60.24	15821	59.78	-0.02(FS)	Pass
30	2.0	50.20	13143	49.69	-0.02(FS)	Pass
31	1.8	45.18	11806	44.62	-0.02(FS)	Pass
32	1.6	40.16	10471	39.63	-0.02(FS)	Pass
33	1.4	35.14	9147	34.64	-0.02(FS)	Pass
34	1.2	30.12	7815	29.67	-0.01(FS)	Pass
35	1.0	25.10	6446	24.55	-0.02(FS)	Pass
36	0.8	20.08	5118	19.58	-0.02(FS)	Pass
37	0.6	15.06	3818	14.71	-0.01(FS)	Pass
38	0.4	10.04	2527	9.872	-0.01(FS)	Pass
39	0.2	5.020	1201	4.904	0.00(FS)	Pass
40	0.0	0.000	-107	0.000	0.00(FS)	Pass

Drift Check (Zero) :

Step	Gas Conc. [ppm]	Measured Conc. [ppm]	Criteria [%]	Error [%]	Status
Zero	---	---	---	---	---

Drift Check (Span) :

Step	Gas Conc. [ppm]	Measured Conc. [ppm]	Criteria [%]	Error [%]	Status
Span	---	---	---	---	---

Comment

E.3.5 NO_x Converter efficiency checkNO_x Converter Efficiency Check

HGS No. : 63JNMN52	Start Time : 2018/08/21 10:43:10
Device : GA	End Time : 2018/08/21 11:10:51
Line : Tailpipe	Test Status : Pass

Analyzer	Checker
Component : NO _x	Control Type : GDC-ONE
Range : 3000 ppm	Ozone Initial Counts : 240
Check Gas	Ozone Step Counts : 20
Gas Supply Port : Span	Ozone Final Counts : 240
Concentration : 190 ppm	

Sequence
Condition in 'a' & 'b' : (a) Approx. 90%, 10% < (b) < 20%
Data Collecting Time : 10 s

Measurement Value	
Zero Cal. Concentration :	0 ppm
Span Cal. Concentration :	190 ppm
Number of Retry Step-3(b) :	0

Step	Time [s]	O2 Flow	OGU	Mode	Target Conc. [ppm]	Measured Conc. [ppm]
Step-1(A)	90	OFF	OFF	NO		138.9
Step-2(a)	90	ON	OFF	NO	Approx. 123	135.3
Step-3(b)	300	ON	ON	NO	14 < Conc. < 27	19.56
Step-4(c)	300	ON	ON	NO _x		132.7
Step-5(d)	90	ON	OFF	NO _x		135.7
Step-6(B)	90	OFF	OFF	NO _x		137.0

Test Result				
Item	Criteria [%]	Result [%]	Status	
NOx Converter Efficiency = $\left(1 - \frac{NO(d) - NO(c)}{NO(a) - NO(b)}\right) \times 100$	95.0 - 100.0	97.44	Pass	
Percent NO2 in NO = $\frac{NO(B) - NO(A)}{NO(A)} \times 100$	-1.0 - 5.0	0.09	Pass	

Comment

E.3.6 THC Linearize check



Analyzer Linearize Check

HGS No. : 63JNMN52	Start Time : 2018/08/16 15:55:56
Device : GA	End Time : 2018/08/16 16:20:28
Line : Tailpipe	Test Status : Pass

Analyzer	Test Result
Component : THC	Linearize Check : Pass
Range : 10000 ppmC	Drift Check : ---
Check Gas	Top Gas Check : ---
Top Gas Supply Port : Span	Mid Span Check : ---
Top Gas Concentration : 938 ppmC	

Checker
Control Type : GDC-ONE

Curve Setting	Curve Criteria
Poly Order : 2nd	Preset Name : Standard
Fitting Type : Weights	Judge Type : Use Larger Limit
Adjust 0% 100% : Active	Criteria 1 : 2.0 % of Point (PT)
	Criteria 2 : 0.3 % of Full Scale (FS)

Measurement Value

Curve :	Reference Pressure : 101.3 kPa	Curve Coefficient	Z/S Coefficient
	Reference Temperature : 26.15 deg C	A0 -7.852548E-01	A 1.098253E+00
	Reference Humidity : 51.25 %	A1 1.071870E-02	B 3.648264E+01
	Ref. Temp. (Humidity) : 26.15 deg C	A2 4.981597E-10	
		A3 0.000000E+00	
		A4 0.000000E+00	

Current Data Set				Current Curve		
Point #	Cut [%]	Gen. Conc. [ppmC]	Z/S Adj. Counts	Measured Conc. [ppmC]	Error [%]	Status
1	100.0	938.0	88565	938.0	0.00(FS)	Pass
2	90.0	844.2	79676	843.4	-0.01(FS)	Pass
3	80.0	750.4	70957	750.7	0.00(FS)	Pass
4	70.0	656.6	62344	659.2	0.03(FS)	Pass
5	60.0	562.8	53632	566.8	0.04(FS)	Pass
6	50.0	469.0	44839	473.5	0.05(FS)	Pass
7	45.0	422.1	40326	425.7	0.04(FS)	Pass
8	40.0	375.2	36009	380.0	0.05(FS)	Pass
9	35.0	328.3	31536	332.6	0.04(FS)	Pass
10	30.0	281.4	27059	285.2	0.04(FS)	Pass
11	25.0	234.5	22682	238.9	0.04(FS)	Pass
12	20.0	187.6	18189	191.4	0.04(FS)	Pass
13	15.0	140.7	13607	142.9	0.02(FS)	Pass
14	10.0	93.80	9073	95.00	0.01(FS)	Pass
15	5.0	46.90	4558	47.30	0.00(FS)	Pass
16	0.0	0.000	79	0.000	0.00(FS)	Pass

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FIA-01HDSV-RMYLEWK4



Analyzer Linearize Check

Drift Check (Zero) :

Step	Gas Conc. [ppmC]	Measured Conc. [ppmC]	Criteria [%]	Error [%]	Status
Zero	---	---	---	---	---

Drift Check (Span) :

Step	Gas Conc. [ppmC]	Measured Conc. [ppmC]	Criteria [%]	Error [%]	Status
Span	---	---	---	---	---

Comment

E.3.7 THC Hang-up check



Hang-up Check

HGS No. : 63JNMN52	Start Time : 2018/08/22 10:00:53
Device : GA	End Time : 2018/08/22 10:07:15
Line : Tailpipe	Test Status : Pass

Analyzer

Component : THC
Range : 10000 ppmC

Check Gas

Gas Supply Port : Leak Checker

Sequence

Zero/Span Calibration : Active
Purge Time : 30 s
Data Collecting Time : 10 s

Measurement Value

Zero CAL Concentration :	0 ppmC	Span CAL Concentration :	938 ppmC
Step	Time	Measured Conc.	
Overflow Zero	60 s	0.00 ppmC	

Test Result

Item	Criteria	Result	Status
Hang-up	$\leq$ 2.0 ppmC	0.00 ppmC	Pass

E.3.8 V-leak check (Span Gas)



VLeak Check (Span Gas)

HGS No. : 63JNMN52	Start Time : 2018/10/10 22:42:00
Device : GA	End Time : 2018/10/10 22:50:59
Line : Tailpipe	Test Status : Pass

Analyzer

	Hot Sample	Cold Sample
Component : CO2	---	---
Range :	20.0 vol%	---
Concentration :	15.94 vol%	---

Check Gas

Gas Supply Port : Leak Checker

Sequence

Zero/Span Calibration : Active		
	Hot Sample	Cold Sample
Overflow Zero Time :	60 s	---
Overflow Span Time :	60 s	---
Data Collecting Time :	10 s	
Overflow Purge Time :	60 s	
Purge Time :	30 s	

Measurement Value

	Hot Sample	Cold Sample
Zero Cal. Concentration :	0.00 vol%	---
Span Cal. Concentration :	15.94 vol%	---
Hang-up Concentration :	---	---

Step	Time	Measured Conc.
Overflow Span (Hot)	60 s	15.87 vol%
Overflow Span (Cold)	---	---

Test Result

Item	Criteria	Result	Status
$VLeak = \frac{Span - (Overflow\ Span - Hang\ -up)}{Span} \times 100$	$ VLeak\ (Hot) \leq 1.0\ %$ $ VLeak\ (Cold) \leq ---$	0.43 % ---	Pass ---

E.4 Checks performed on PN analyser

TRE00544A(1/3)

TEST REPORT

Customer : HE Stock
 Model : On-board Emissions Measurement System
 Type : OBS-ONE-PN
 WBS No. : S2100508840000090
 HGS No. : P8UC6BRA

HORIBA, Ltd.

Date tested : 28, Nov.,2017

Date of Calibration: 2017/11/13

1. Specification
 - 1) Power Source
Main unit : DC24V
2. Test Data
 - 1) Appearance, Dimensions and Construction Check Good
 - 2) Leak Test Good
 - 3) Performance Tests
 - a. CPC Calibration Coefficients Good

Parameters	Calibration Coefficients
C1	1.0814
C2	-0.0215
C3	0.0015

CPC S/N: OBS ONE PN 174102

- b. CPC Linearity Check Good

Reference Conc. (#/cm ³)	CPC Conc. (#/cm ³)	Error (±10.0%RS)
0.0	0.0	0.0%
1471.1	1380.8	-6.1%
3001.4	2846.6	-5.2%
4473.2	4251.2	-5.0%
7300.1	6898.8	-5.5%
10672.6	10026.5	-6.1%
16764.1	15893.3	-5.2%
27163.0	25712.0	-5.3%
a1(0.90~1.10)	0.95	
lxmin(a1-1)+a0l(≤5.0%FS)	0.3	
R ² (≥0.970)	1.000	
SEE(≤10.0%FS)	3.09	

- c. Particle Concentration Correction Factor (200nm monodisperse soot) Good

Reference Conc. (#/cm ³)	CPC Conc. (#/cm ³)	Ratio (Reference / CPC)
6901.9	5849.1	1.18
18918.3	16931.5	1.12
26388.5	23017.8	1.15
C0		1.1382

※Sample line length:6.0m

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OBS-ONE-PN
 S2100508840000090

TRE00544A(2/3)

d. System Efficiency (Monodisperse soot) Good

Particle Size (nm)	Reference Conc. (#/cm ³)	CPC Conc. (#/cm ³)	Criteria	Efficiency (%)
15	5886.5	422.4	<10%	7.2
23	5481.5	2294.2	20-60%	41.9
30	6354.9	4037.6	30-100%	63.5
50	5414.7	4741.1	60-110%	87.6
70	5425.4	5321.1	70-110%	98.1
100	6541.9	6297.6	90-110%	96.3
200	6941.1	7266.9	90-110%	104.7

※Sample line length:6.0m

e. Volatile Particle Removal Efficiency Check (Removal Efficiency: >99%) Good

Diam.	>100nm nebulizer Emery oil	
Inlet (#/cm ³)	Outlet (#/cm ³)	Removal Efficiency (%)
512619.8	3241.9	99.4

f. Warm-up (30minutes after power on) Good

Item	Temp. Range
Saturator	30.0°C±0.2°C
Condenser	21.0°C±0.2°C
Optics	20.8°C~29.0°C
Catalytic Stripper	350°C±10°C
Heated Line	≥20°C

g. Noise check (≤1000#/cm³ / 120sec) Good

h. System Zero Check Good

Item	Value	Unit	Criteria
System Zero	0.0	#/cm ³	≤100

※Sample line length:6.0m

i. Warm-up and ZERO Drift Check (CPC Conc.: ≤100#/cm³) Good

Line	HEPA air at Sample Inlet	Unit
After 0.5(h)	0.0	#/cm ³
After 4(h)	0.0	#/cm ³

j. Flowrate accuracy check Good

Item	Reference	Value	Unit	Criteria	Error
CPC					
Sample flowrate	0.102	0.100	L/min	±5.0%	-2.3%
Bypass flowrate	0.597	0.596	L/min	±16.0%	-0.1%
1st Diluter					
Dilution flowrate	6.317	6.299	L/min	±3.0%	-0.3%
2nd Diluter					
Sample flowrate	0.072	0.071	L/min	±20.0%	-0.4%

TRE00544A(3/3)

k. Dilution Factors check Good

Item	Target	Value	Unit	Criteria	Difference
1st Dilution Factor	10.0	10.0	-	± 1	0.0
2nd Dilution Factor	9.0	9.6	-	± 1	0.6

4) Accessories Check (Quality, quantity and appearance) Good3. Overall Inspection Pass

Each of the above results must meet with the standards by HORIBA, Ltd.

Inspected by: T. Tachibana Approved by: R. Proyas
HORIBA, Ltd.

TRE00544A(1/2)

TEST REPORT

Customer : HE Stock
 Type : On-board Emissions Measurement System
 Model : OBS-ONE-PN
 WBS No. : S2100508840000090
 HGS No. : P8UC6BRA

1. Specification

Power source : 24VDC

2. Test results

1) Appearance, dimension and construction Good

2) Function Good

3) Performance of sensors Good

a. Accuracy of pressure sensor for ambient air
 Within ± 0.2 kPa

b. Linearity of pressure sensor for ambient air
 Intercept($|X_{\min}(a_1-1)+a_0|$) : Within 1.0% of full scale
 Slope(a_1) : 0.99 to 1.01
 SEE(Standard Estimated Error) : Within 1.0% of full scale
 r^2 (Coefficient of determination) : 0.998 or more

c. Accuracy of temperature sensor for ambient air
 Within ± 0.5 degC

d. Linearity of temperature sensor for ambient air
 Intercept($|X_{\min}(a_1-1)+a_0|$) : Within 1.0% of full scale
 Slope(a_1) : 0.99 to 1.01
 SEE(Standard Estimated Error) : Within 1.0% of full scale
 r^2 (Coefficient of determination) : 0.998 or more

e. Accuracy of humidity sensor for ambient air
 Within ± 1.5 % as relative humidity

f. Accuracy of power input voltage
 Within ± 1.0 % of reading scale

3. Overall inspection Passed

Date: 28 Nov.2017

Inspector:

T. Tachiri

Approver:

R. Moizan

1/2

OBS-ONE-PN
 S2100508840000090

TRE00544A(2/2)

Detail of test results

3) Performance of sensors

a. Accuracy of pressure sensor for ambient air

Range: 70~115kPa

Component	Reference value	Actual value	Error	Max Error
115 kPa	115.00 kPa	114.90 kPa	-0.10 kPa	-0.10 kPa
110 kPa	110.00 kPa	110.00 kPa	0.00 kPa	
105 kPa	105.00 kPa	105.00 kPa	0.00 kPa	
100 kPa	100.00 kPa	100.00 kPa	0.00 kPa	
95 kPa	95.00 kPa	95.00 kPa	0.00 kPa	
90 kPa	90.00 kPa	90.00 kPa	0.00 kPa	
85 kPa	85.00 kPa	85.00 kPa	0.00 kPa	
80 kPa	80.00 kPa	80.00 kPa	0.00 kPa	
75 kPa	75.00 kPa	75.00 kPa	0.00 kPa	
70 kPa	70.00 kPa	70.00 kPa	0.00 kPa	

b. Linearity of pressure sensor for ambient air

Intercept($(X_{min}(a_1-1)+a_0)$)	0.0 %FS
Slope(a_1)	1.00
SEE(Standard Estimated Error)	0.0 %FS
r^2 (Coefficient of determination)	1.000

c. Accuracy of temperature sensor for ambient air

Range: -40~60degC

Reference value	Actual value	Error	Max Error
0.00 degC	0.00 degC	0.00 degC	0.00 degC
5.00 degC	5.00 degC	0.00 degC	
10.00 degC	10.00 degC	0.00 degC	
15.00 degC	15.00 degC	0.00 degC	
20.00 degC	20.00 degC	0.00 degC	
25.00 degC	25.00 degC	0.00 degC	
30.00 degC	30.00 degC	0.00 degC	
35.00 degC	35.00 degC	0.00 degC	
40.00 degC	40.00 degC	0.00 degC	
45.00 degC	45.00 degC	0.00 degC	
50.00 degC	50.00 degC	0.00 degC	

d. Linearity of temperature sensor for ambient air

Intercept($(X_{min}(a_1-1)+a_0)$)	0.0 %FS
Slope(a_1)	1.00
SEE(Standard Estimated Error)	0.0 %FS
r^2 (Coefficient of determination)	1.000

e. Accuracy of humidity sensor for ambient air

Range: 0~100%RH

Component	0 %RH	20 %RH	40 %RH	60 %RH	80 %RH	100 %RH	Max Error
Sensor	0.0 %RH	20.0 %RH	40.0 %RH	60.0 %RH	80.0 %RH	100.0 %RH	0.0 %RH

f. Accuracy of power input voltage

Component	24.50 V	Test Result
Voltage	24.5 V	0.00 %RS

F Details of the gases used

F.1 Span gas

THE LINDE GROUP **PanGas**

Kalibrierzertifikat / Certificat d'étalonnage

PanGas AG Spezialgase-Füllwerk Industriepark 10 CH-6252 Dagmersellen Tel.0844 800 300 Fax 0844 800
 Von der Schweizerischen Akkreditierungsstelle akkreditierte Kalibrierstelle
 Laboratoire d'étalonnage accrédité par le Service d'Accréditation Suisse
 The Swiss Calibration Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Zertifikat Nr. 2017014687
N° du certificat
Auftraggeber Linde Gas Benelux B.V.
Client Kanaalweg 4e
 6951 KJ Dieren

Probenahme Aus Behälter, nach Abfüllung
Prélèvement Dans le récipient, après remplissage de celui-ci **Nr.** 75631110726305

Produkt / Produit Gasgemisch zertifiziert SCS / Mélange de gaz certifié SCS
Material Nummer / numéro d'article 800002451

Prüfspezifikation; Resultat / Spécification d'essai; Résultat

	Anforderung Exigences	Prüfresultat Résultats d'analyse	Messunsicherheit Incertitude de mesure
C3H8	330.0 ppm mol	330.1 ppm mol	1.00 % rel
NO	2500.0 ppm mol	2503.4 ppm mol	1.00 % rel
CO	3.000 % mol	3.009 % mol	1.00 % rel
CO2	16.000 % mol	16.006 % mol	1.00 % rel
N2	Rest / Reste	Rest / Reste	

Dieses Kalibrierzertifikat dokumentiert die Rückverfolgbarkeit auf nationale Normale zur Darstellung der physikalischen Einheiten (SI)
 Ce certificat d'étalonnage confirme le raccordement aux étalons nationaux qui matérialisent les grandeurs physiques (SI)

Die angegebene erweiterte Messunsicherheit ist die Standardunsicherheit der Messung multipliziert mit einem Erweiterungsfaktor k=2, was bei einer Normalverteilung einem Vertrauensniveau von etwa 95% entspricht.
 L'incertitude de mesure élargie donnée est l'incertitude-type sur le résultat de la mesure multipliée par le facteur d'élargissement k=2 ce qui, pour une distribution gaussienne, correspond à un niveau de confiance d'environ 95 %

Stabilitäts-Garantie / Garantie de stabilité 24 Monate / Mois

min. Lagertemperatur: - 10° min. Verwendungsdruck: 5 bar empf. Verwendungstemp.: 10 - 30°C
 Température de stockage min.: Pression d'utilisation min.: Température d'utilisation conseillée:

Für die Messung / pour la mesure: DHUBER **Datum / Date:** 04.12.2017
Freigabe / Autorisation: MPALLY

Der Inhalt dieses Zertifikates darf nur in vollständiger Form veröffentlicht oder weitergegeben werden.
 Le contenu du présent certificat ne doit être publié ou communiqué que dans son intégralité.

(Elektronisches Dokument ohne Unterschrift) (Document électronique sans signature)

INPUT		CONVERSION	
Temperature	15 C	Temperature	15 C
Pressure	760 TORR	Pressure	760 TORR
Total	KG	Amount	5 KG
MOLE FRACTION		RELATIVE GAS VOLUME FRACTION	Auto
prop	330.100 PPM	Propane	324.618 PPM
NO	2503.4 PPM	Nitric oxide	2503.908 PPM
CO	3.009 %	Carbon monoxide	3.011 %
CO2	16.006 %	Carbon dioxide	15.935 %
N2	80.70165 %	Nitrogen	80.771 %

Satz 1 von 1

F.2 Hydrogen/helium

THE LINDE GROUP



Ordernummer:
Cilindernummer:
Cilindereigenaar:
cilinderinhoud [l]:

Pagina: 1 van 1
D0030634/3
574426
Linde Cilinder
10

Analyse Certificaat
ISO 6141

Componenten	Analyse
Waterstof	40 vol %
C ₂ H ₂	<1 vpm
Helium	Rest

Vuldruk [15°C]:
Gasvolume:
Stabiliteit:
Aansluiting
Materiaalcode:

ca. 150 bar
1500 l
36 maanden
LU1
3260110

Min. opslag temperatuur:
Min. restdruk:
Aanbevolen gebruikstemperatuur:

Niet van toepassing
5 bar
10°C - 30°C

Analysedatum: 20-10-2016

Analist: Theo van Dick

Linde Gas Benelux B.V. - Kanaalweg 4e - 6951KJ Dieren
Telefoon: +31 (0)313 490 440 Fax: +31 (0)313 450 069 E-mail: hiq.lg.nl@linde.com



F.3 Synthetic air

Produkt Datenblatt

Synthetische Luft KW-frei 20 % Sauerstoff, Rest Stickst



Zusammensetzung: Sauerstoff (O₂) 20 %
Stickstoff (N₂) Rest

Nebenbestandteile, ppm:

H ₂ O	≤ 2
CO ₂	≤ 1
CO	≤ 1
KW	≤ 0,1
NO _x	≤ 0,1

Angaben sind als ideale Volumenanteile (= Molanteile) zu verstehen

**Herstell-
toleranz
(relativ)** **Analyse-
genauigkeit
(relativ)** **Stabilität
genauigkeit (Monate)**

Konformitätserklärung Zu diesem Produkt ist eine Konformitätserklärung in unserem Kundenportal unter www.linde-gas.de/direkt online verfügbar.

Lieferanten:

Stahlflasche

Rauminhalt, [Liter]	Füllmenge, ca. [m ³]	Fülldruck, ca. [bar]	Gesamtgewicht, mit Füllung ca. [kg]	Aussen-Ø, ca. [mm]	Gesamtlänge ca. [mm]
10	1,94	200	20	140	975
50	9,7	200	80	229	1655

Flaschenbündel

Rauminhalt, [Liter]	Füllmenge, ca. [m ³]	Fülldruck, ca. [bar]	Anzahl Flaschen im Bündel	Gesamtgewicht, mit Füllung ca. [kg]	Maße ca. (H x L x B) [mm]
600	116,4	200	12	1200	1900 x 980 x 770

Weitere Lieferdaten auf Anfrage

Sicherheit: EG-Sicherheitsdatenblatt unter www.linde-gas.de/direkt

Kennzeichnung: Fläschenschulterfarbe/
Umlaufender Farbstreifen bei Bündeln
Aufkleber:
Ventilanschluss:

Leuchtendes Grün RAL 6018
mit Angaben zur Zusammensetzung
G 3/4 (DIN 477 Nr. 9), Messing M 19 x 1,5 LH (DIN 477 Nr. 14), Messing

Linde AG
Linde Gases Division, Seithorstr. 70, D-82049 Pullach
Telefon: 018 03.850 00-0*, Telefax: 018 03.850 00-1*, www.linde-gas.de
* 0,09 Euro pro Minute aus dem dt. Festnetz | Mobilfunk bis 0,42 Euro pro Minute. Zur Sicherstellung eines hohen Niveaus der Kundenbetreuung werden Daten unserer Kunden wie z.B. Telefonnummern elektronisch gespeichert und verarbeitet.
Änderungen vorbehalten
Stand 15.10.2012

Synthetische Luft, KW-frei, 20 % Sauerstoff, Rest Stickstoff		Zusatz
Eigenschaften:	verdichtetes Gasgemisch	
	Chemisches Zeichen:	O ₂ in N ₂
Anwendungen:	Betriebsgas für GC-Detektoren; Spül- und Nullgas für Probenahmeeinrichtungen und Meßgeräte	
Ebenfalls verfügbar:	EURO 6 Synthetische Luft KW-frei Prüfgas 1 % Sauerstoff, Rest Stickstoff Prüfgas 10 % Sauerstoff, Rest Stickstoff Prüfgas 18 % Sauerstoff, Rest Stickstoff Prüfgas 2 % Sauerstoff, Rest Stickstoff Prüfgas 2,5 % Sauerstoff, Rest Stickstoff Prüfgas 20,9 % Sauerstoff, Rest Stickstoff Prüfgas 4 % Sauerstoff, Rest Stickstoff Prüfgas 5 % Sauerstoff, Rest Stickstoff Prüfgas 8 % Sauerstoff, Rest Stickstoff Prüfgas 9 % Sauerstoff, Rest Stickstoff Prüfgas in HiQ® MINICAN 1 % Sauerstoff, Rest Stickstoff Synthetische Luft 20 % Sauerstoff, Rest Stickstoff	
	Gasgemische und Prüfgase in kundenspezifischer Zusammensetzung auch in weiteren Gebindegrößen.	
Haftungsausschluss:	Alle Angaben des Produktdatenblattes entsprechen dem gegenwärtigen Wissensstand. Die Linde AG prüft und aktualisiert die Informationen ständig und behält sich das Recht vor, Änderungen oder Ergänzungen der bereitgestellten Informationen vorzunehmen. Trotz aller Sorgfalt können sich Daten inzwischen verändert haben. Eine Haftung oder Garantie für die Aktualität, Richtigkeit und Vollständigkeit der zur Verfügung gestellten Informationen kann daher nicht übernommen werden. Jeder Anwender trägt selbst die Verantwortung dafür, dass alle relevanten gesetzlichen Bestimmungen eingehalten werden und dass die hier beschriebenen Produkte für seine Einsatzzwecke geeignet sind. Die Angaben auf diesem Produktdatenblatt sind keine vertraglichen Zusicherungen von Produkteigenschaften. Die Vervielfältigung von Informationen, Texten, Bildern oder Daten bedarf der vorherigen Zustimmung der Linde AG.	



Linde AG
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 Änderungen vorbehalten
 Stand 15.10.2012

G Vehicle mass receipt

Gebr. van Busse
Herselseweg 36
5715 PJ Lierop
Tel: 0492-332110

Bonnr: 12919

Datum: 12.10.2018

Voertuig: TESTVOERTUIG
Testvoertuig

Klant: 28020
TNO
Postbus 96829
2509 JE DEN HAAG

Transp.: 28020
TNO
Postbus 96829
2509 JE DEN HAAG

Produkt :

Weging1 : 31.920 kg 14:22 17869
Weging2 : 31.920 kg 14:22 17869

Netto: 0 kg

*** Pfister Weegtechniek ***