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TNO report

TNO 2018 R11448

IVECO EURO VI LNG PEMS test report

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Contents

1 Introduction

1.1 Purpose

In 2017, 2 Euro VI LNG vehicles were tested. One of these vehicles was an Iveco vehicle. In response to the results, further investigation was conducted.

A series of seven (7) on-road emission tests were performed on a truck with Vehicle Identification Number WJMM1VRH60C356363. This vehicle is an Euro VI LNG vehicle from the category N3, with a mileage of 182.000 km. This vehicle is the same vehicle as was used to perform the testing as described in report TNO 2017 R11336 [1].

The focus of this investigation was on improving emissions in urban operation. The test campaign was started with a new dataset compared to the status of the vehicle in 2017.

The test setup involved the following steps, in chronological order:

- Evaluate the result with the new dataset using 2 different test routes. One of these routes was identical to the route used in 2017. The other route has a slightly different share of urban operation
- Evaluate the effect of driving style
- Evaluate the effect of payload (10 and 100% payload have been evaluated)
- Evaluate the effect of a 2nd new dataset. This dataset was implemented by Iveco Turin.

1.2 Assignor

The emission tests were performed at the request of Rolande B.V.

Rolande B.V.
Postbus 61
4286 ZH Almkerk
The Netherlands

1.3 Method of testing

The emission tests have been performed using a Portable Emission Measurement System (hereinafter ‘PEMS’). The method of testing was according to the procedures described in Regulation EU No. 582/2011 [2] as last amended by EU 136/2014 [3] , yet was not intended to serve as a in-service conformity test.

2 Test Setup

2.1 Description of the test vehicle

The test have been performed on the vehicle as shown in Figure 1.

Figure 1 The test vehicle

2.2 Vehicle specification

2.2.1 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.

Table 1 General information

Model	Iveco Stralis NP400
Vehicle owner	Cornelissen Transport B.V.
License plate no.	28-BHX-4
Date of registration	16-12-2016
Odometer reading at intake vehicle	182363 km
Gross Vehicle Weight (GVW)	19800 kg
Registered mass runningorder	7760 kg
Loading capacity	12040 kg
Axle configuration	4 x 2
VIN (chassis number)	WJMM1VRH60C356363
Wheelbase	3.79 m
Vehicle class	N3
Gearbox make + type	ZF-AS Tronic 12AS1931TD
Number of forward gears	12
Tyre make and type rear axle	Pirelli TR:01
Tyre size	315 / 70 / R22,5
Tyre test pressure	8.5 bar
Fuel tank capacity	2x598 l

Table 2 Engine information

Engine type	F2CFE601E-J002
Fuel injection system	Multi-point port injection
Engine serial number	000137165
Number of cylinders	6
Displacement	8.710 l
Euro Class	Euro VI
Turbo	Yes
Intercooler	Yes
EGR	No

Table 3 Aftertreatment information

Aftertreatment system (downstream)	Three-Way-Catalytic converter (TWC)

2.2.2 Vehicle payload

The vehicle has been tested with payloads of 10, 55 and 100%

The load percentage of 55% results in a mass of the ballast load of 15862 kg. Therefore a combined test mass of 7760 kg (running order mass truck) + 7400 kg (running order mass trailer) + 15862 kg (loading mass) = 31022 kg (total test mass) has been used. The same approach has been used for the 10% payload, resulting in a total mass of 18044 kg. The 100% payload test has been performed with the maximum allowed mass of the total combination of 44000 kg.

The results of the total combination mass measurements can be found in Appendix J.

An artificial payload is used to load the combination to the desired payloads. The load consisted of concrete blocks, a container filled with water, sand bags and the measurement equipment. The payload of 55% is shown in Figure 2.

Figure 2 The vehicle payload of 55%

2.2.3 Fuel specifications

For the performed tests the vehicle was fuelled at Rolande B.V. Veghel with LNG. The specifications of the LNG fuel batch at the time of refuelling were provided by Rolande B.V. as shown in Figure 3.

LNG TRUCK QUALITY & QUANTITY DOCUMENT

LNG loaded at LNG Terminal Zeebrugge:

Date:	19/06/2018 14:33
Shipper:	GDF SUEZ
Truck Company:	GDF SUEZ
Truck Name:	EU-002
Truck Loading Reference:	TRL-EU-002-0160
Truck Appointment Reference:	FOUQI01
Gross Weight After Loading:	43260 kg
Truck has been cooled down:	No

LNG composition (Mol%)

N2	CH4	C2H6	C3H8	i-C4H10	n-C4H10	i-C5H12	n-C5H12	C6H14+
0,1151	93,2210	6,5869	0,0712	0,0028	0,0028	0,0001	0,0001	0,0000

Physical properties

LNG Temperature:	-159,0	°C	UN1972 aardgas, sterk gekoeld, vloeibaar, 2.1(B/D)
LNG Density:	439,3	kg/m³	UN1972 gaz naturel liquide réfrigéré, 2.1(B/D)
Gas Density:	0,7607	kg/m³(n)	UN1972 natural gas, refrigerated liquid, 2.1(B/D)
GHV:	41.821	kJ/m³(n)	UN1972 erdgas,tiefgekült, flussig, 2.1(B/D)
	11,617	kWh/m³(n)	
	54.978	kJ/kg	
	15,272	kWh/kg	
Wobbe:	54.522	kJ/m³(n)	
	15,145	kWh/m³(n)	

Quantities

Energy:	1116,0	GJ
	1057,764	MBtu
	310	MWh
Volume:	46,25	m³
Net Loaded:	20.320	kg
Gas Volume:	26.713	m³(n)

For Fluxys LNG : For GDF SUEZ:

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Figure 3 LNG fuel specifications provided by Rolande B.V.

2.3 Equipment used

2.3.1 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 4. Detailed information about the checks performed for the calibration of the gaseous analysers can be found in Appendix I.

The PEMS analyser installed in the vehicle is shown in Figure 4.

Table 4 OBS-ONE-GS12 specifications

Gaseous component	***Analyser***	***Range***	***Accuracy***
THC	Flame Ionization Detector (FID)	0 – 10000 ppmC	Within ±0.3% of full scale or 2.0% of readings (whichever is larger)
CO	Non-Dispersive Infrared (NIDR)	0 – 10 %	Within ±0.3% of full scale or 2.0% of readings (whichever is larger)
CO_2	Non-Dispersive Infrared (NIDR)	0 – 20 %	Within ±0.3% of full scale or 2.0% of readings (whichever is larger)
NO	Chemi-Luminescence Detection (CLD)	0 – 3000 ppm	Within ±0.3% of full scale or 2.0% of readings (whichever is larger)
NO_x	Chemi-Luminescence Detection (CLD)	0 – 3000 ppm	Within ±0.3% of full scale or 2.0% of readings (whichever is larger)

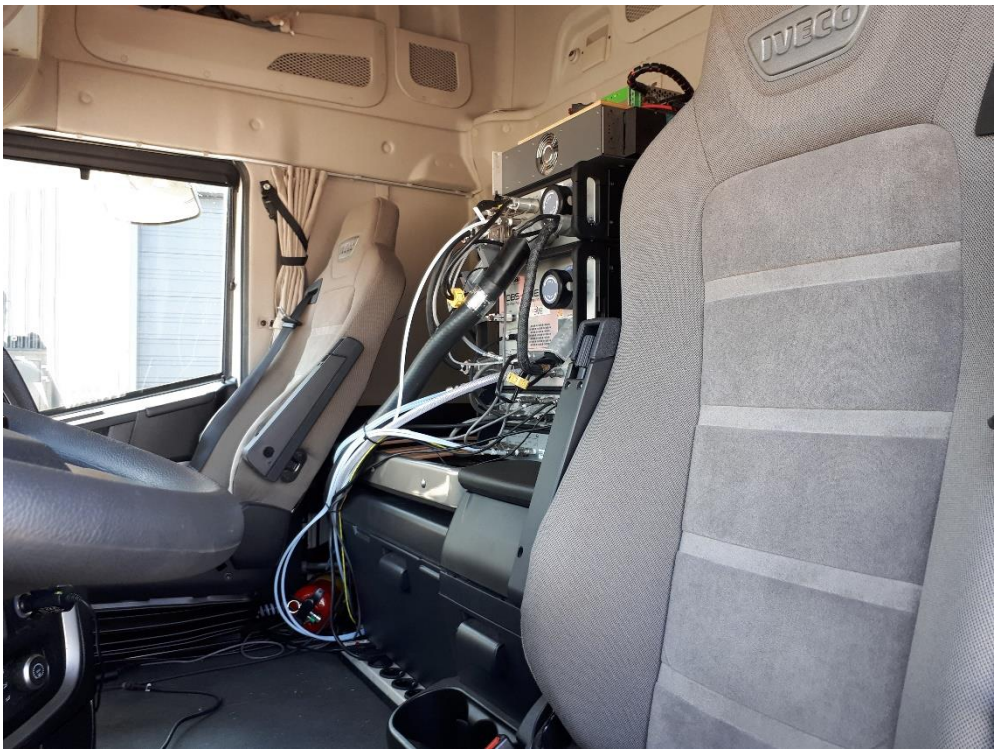


Figure 4 The PEMS analyser mounted in the truck

2.3.2 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 5; for specifications see Table 5. Detailed information about the calibration of the pitot flow module and tube can be found in Appendix A. An additional NO_x sensor was installed by Iveco downstream of the TWC, connected to their Telemaco system.

Table 5 Horiba Pitot Flow Meter specifications

PF serial number	PG7RUL35
Flow tube serial number	170219GH
Flow tube diameter	5 inch (G-tube)
Flow measurement range	0 – 45 m³/min
Flow measurement accuracy	Within ±2.0 % of full scale
Exhaust temperature measurement range	0-800°C
Exhaust temperature accuracy	Within ±0.5 % of full scale or ±2.0 % of readings (whichever is larger)
Exhaust pressure measurement range	70-115 kPa (abs)
Exhaust pressure accuracy	Within ±0.5 % of full scale or ±2.0 % of readings (whichever is larger)
EFM Cable	Exhaust H/L Tube and Thermocouple Cable

Figure 5 The flow tube connected to the exhaust

2.3.3 Other equipment

Table 6 lists the remaining equipment that was used to operate the measurement system.

Table 6 Other equipment

System software	1.2.9
DIAdem software	2.11.1
Power supply	Gen set: 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
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)
Silver Scan-Tool software version	6.22.36.28520
Silverscan CAN interface	Kvaser Leaf Light v2 018504

2.4 Test route

Two different test routes were used in this test campaign:.

Route 1 fulfills the trip composition requirements based on vehicle speed as shown in Table 7.

Table 7 Trip composition as stated in EU 582/2011[2]

Type	Speed range	Time share
Urban	0-50 km/h	20 ±5%
Rural	50-75 km/h	25 ±5%
Motorway	> 75 km/h	55 ±5%

Route 2 corresponds with the N3 route as was used in report TNO 2017 R11336 [1]. Compared to route 1, route 2 has a different urban part and the same rural and motorway part.
Even though this route was used in unchanged form, changes in road and traffic circumstances have led to a different vehicle speed profile such that the trip composition could not be reproduced. As a result of this, the trip composition as specified in Regulation EU No. 582/2011 [2] could not be met during this testing series.

The test sequence is shown in Table 8 and the corresponding routes that were driven are shown in the figures on the next page. The location of the periodic check of the PEMS analysers is pointed out on the map in Figure 6 and Figure 7.

Test 1 has been started with a warm engine. Test 2 to 7 were started with a cold engine. A coolant temperature of > 70°C was used as criterion for a warm engine.

The periodic check of route 1 has been performed while driving, before entering the motorway. For route 2 this has been performed at a standstill with the vehicle idling.

Table 8 Test sequence

Test #	Test start	Route	Payload
1	Warm	1	55%
2	Cold	2	55%
3	Cold	2	55%
4	Cold	2	55%
5	Cold	2	10%
6	Cold	2	100%
7	Cold	2	55%

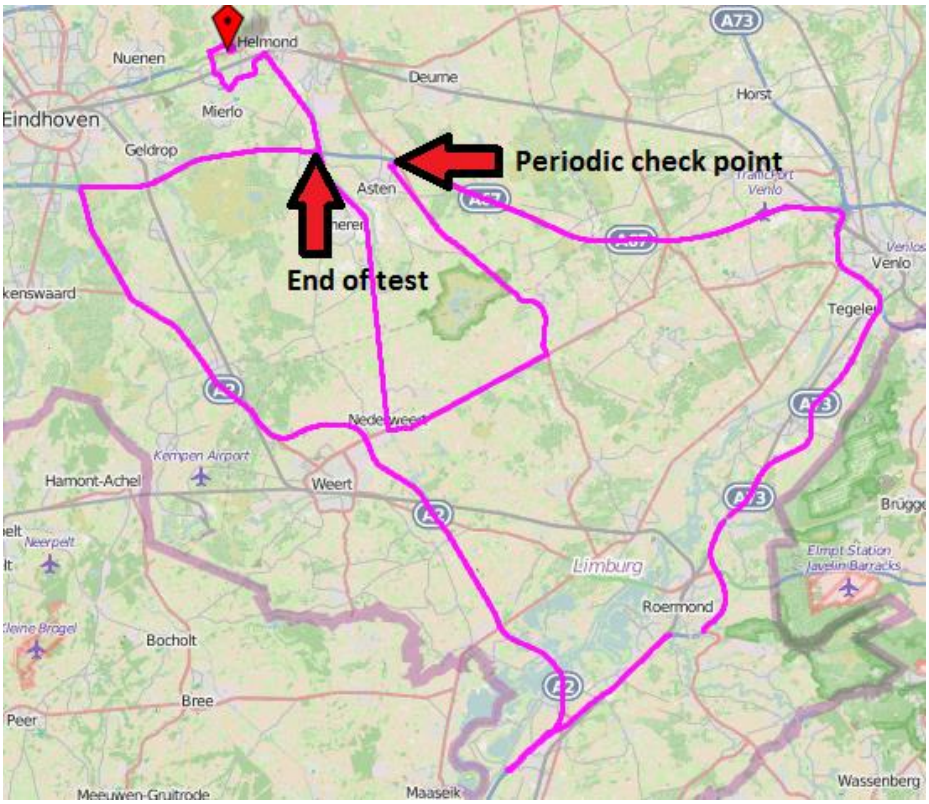


Figure 6 Test route 1

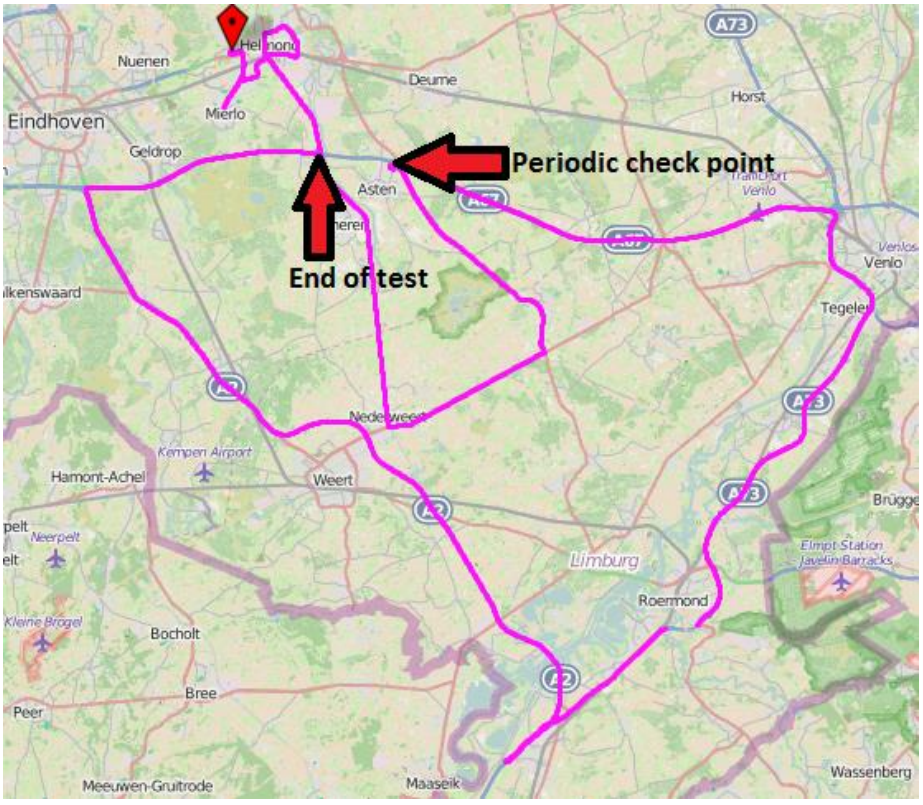


Figure 7 Test route 2

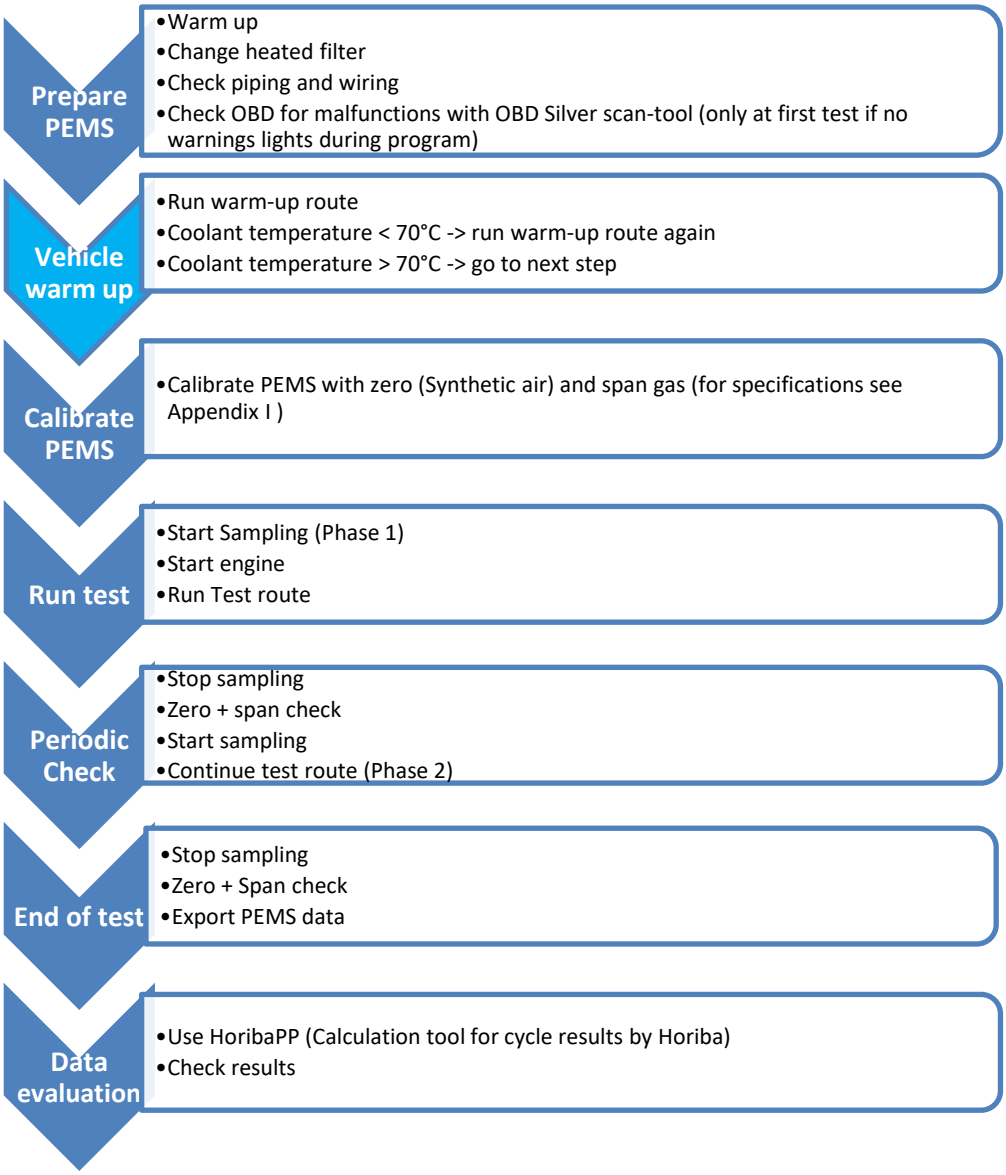
2.5 OBD error check

An OBD error check was performed by TNO prior to start of the first PEMS test. No active error codes were found in the vehicle.

Software: Silver Scan-Tool 6.22.36.28250
Adapter: Kvaser Leaf Light v2 73-30130-00685-0

2.6 Test Procedure

The figure below shows the daily test procedure in a flowchart: For test 2 to 7 the step 'Vehicle warm up' was omitted.



3 Test results

3.1 Checks and conditions

Data checks were performed. Chapter 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. The requirements regarding trip composition are shown in section 3.1.5 followed by a full load curve check in section 3.1.6.

3.1.1 Drift check

The analysers were calibrated prior to testing and checked for drift during the periodic check. After the test, the analyser drift was determined. Drift correction was applied for all the test and fulfilled the criteria as stated in EU 582/2011[2]. The results of the drift checks are shown in Appendix A to G, section 4.

3.1.2 Odometer distance check

At the start of the test and after testing, the odometer reading was noted. The travelled distance is compared to GPS data from PEMS in Table 9. Lower GPS mileage can be caused by loss of GPS connection in tunnels, travelled distance during the drift check and odometer accuracy.

Table 9 Odometer distance check against GPS data

Test number	Odometer start	Odometer end	Test distance	GPS data
	km	km	km	km
1	182379	182572	193	187.5
2	182644	182846	202	199.1
3	182858	183060	202	198.8
4	183071	183272	201	198.7
5	183360	183560	200	198.7
6	183586	183788	202	198.7
7	183818	184019	201	198.4

3.1.3 Test conditions

The PEMS cycles with the test-vehicle were measured under the conditions regarding traffic, driving style and weather as shown in Table 10 and Table 11. For test 7 a new dataset was used.

Table 10 Test conditions PEMS tests overview 1/2

Test number	Date	Test start	Route	Payload	Dataset
1	26-06-2018	Warm	1	55%	1
2	27-06-2018	Cold	2	55%	1
3	28-06-2018	Cold	2	55%	1
4	04-07-2018	Cold	2	55%	1
5	16-07-2018	Cold	2	10%	1
6	18-07-2018	Cold	2	100%	1
7	01-08-2018	Cold	2	55%	2

Table 11 Test conditions PEMS test overview 2/2

Test number	Traffic	Driving style	Ambient temperature	Weather
1	Normal	Normal	19 °C	Sunny
2	Busy urban	Normal	26 °C	Sunny
3	Busy urban, hold up at rural, traffic jam at motorway	Normal	19 °C	Sunny
4	Normal	Anticipating	25 °C	Sunny
5	Traffic jam at motorway	Normal	29 °C	Sunny
6	Minor hold up at urban	Normal	25 °C	Sunny
7	Normal	Normal	27 °C	Sunny

3.1.4 Fuel Consistency check

The fuel consistency check was performed by TNO as seen in Figure 8. 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 gas concentrations according to 582/2011[2]. A linear regression was performed for the measured and calculated fuel rate values which resulted in a regression coefficient > 0.9. The fuel consistency check result is valid for all tests and can be found in Appendix A to G, section 3.

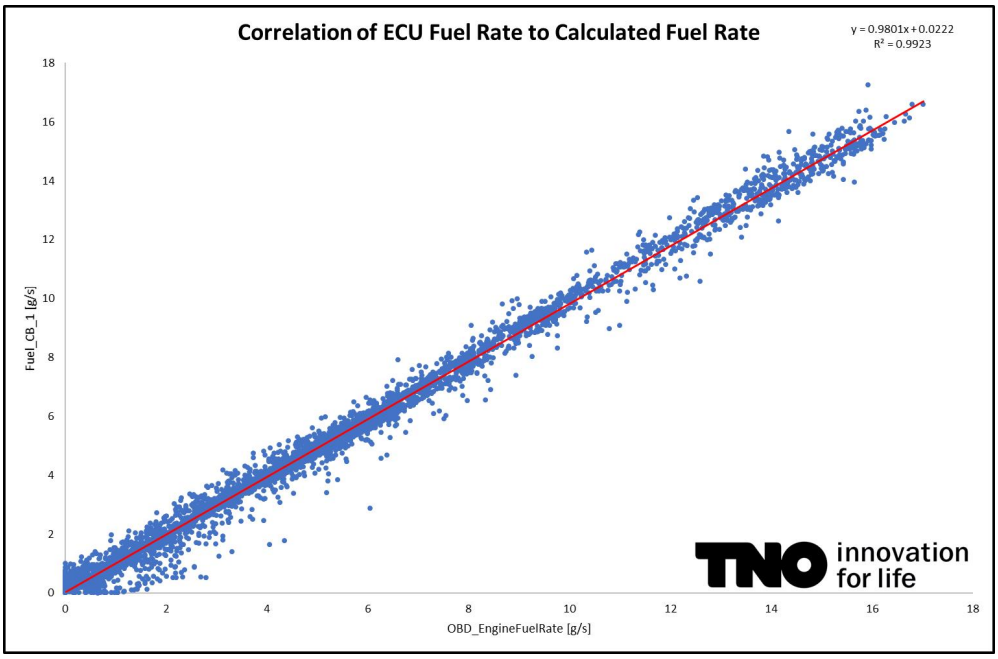


Figure 8 Correlation of ECU Fuel rate to calculated fuel rate test 1

3.1.5 Trip composition

The categories in the tables below are based on the first acceleration by use of first acceleration method[1]:

Urban - Starts at the beginning of the test including cold start if applicable
Rural - Starts after the first acceleration above 55 km/h
Motorway - Starts after the first acceleration above 75 km/h

The trip compositions of the tests are shown in Table 12 to Table 14. The characteristics during the tests expressed as time share can be seen in Table 15.

[1] Which differs from the EU 582/2011 [2] approach

Table 12 Trip composition Urban including cold start if applicable

Test number	Urban		
	Distance [km]	Duration [hours]	Average speed [km/h]
1	9.5	0:18:10	31.4
2	16.8	0:46:32	21.7
3	16.7	0:50:15	19.9
4	16.8	0:44:55	22.4
5	16.8	0:40:42	24.8
6	16.8	0:49:37	20.3
7	16.5	0:40:58	24.2

Table 13 Trip composition Rural

Test number	Rural		
	Distance [km]	Duration [hours]	Average speed [km/h]
1	45.1	0:47:36	56.8
2	49.5	0:54:36	54.4
3	49.3	0:53:49	55.0
4	49.1	0:53:44	54.8
5	48.9	0:51:04	57.5
6	49.3	0:53:48	55.0
7	49.1	0:51:28	57.2

Table 14 Trip composition Motorway

Test number	Motorway		
	Distance [km]	Duration [hours]	Average speed [km/h]
1	132.8	1:38:55	80.6
2	132.8	1:41:05	78.8
3	132.8	1:45:52	75.3
4	132.8	1:40:06	79.6
5	133.0	1:47:08	74.5
6	132.6	1:40:50	78.9
7	132.8	1:40:29	79.3

Table 15 Trip characteristics including cold start

Test number	Accelerating Time share [%]	Decelerating Time share [%]	Cruising Time share [%]	Stop Time share [%]
1	11.7	7.6	78.9	1.8
2	15.3	10.4	68.9	5.4
3	15.0	10.7	66.4	7.9
4	14.5	8.9	71.9	4.7
5	14.3	12.0	68.2	5.6
6	15.3	9.4	68.0	7.2
7	14.4	9.8	71.4	4.5

3.1.6 Full load curve check

The torque data provided by the ECU was compared to the full load curve provided. It was found that the engine load as indicated by the engine ECU matched the full-load curve well for all tests. See Appendix A to G, section 5.

3.2 Emission Results

The results of the emission measurements are described in section 3.2.1 and 3.2.2.

3.2.1 Gaseous emissions

Table 16 shows the total cumulative gaseous emissions divided by the total cycle work excluding the cold start period. A coolant temperature of > 70°C was used as criterion for a warm engine.

Table 16 Test evaluation: Total cycle gaseous emissions excluding cold start

Test number	Date	CO	CO_2	THC	NO_x
		g/kWh	g/kWh	g/kWh	g/kWh
1	26-06-2018	0.951	560.7	0.040	0.320
2	27-06-2018	0.794	566.2	0.033	0.461
3	28-06-2018	0.802	566.8	0.033	0.519
4	04-07-2018	0.679	550.1	0.027	0.321
5	16-07-2018	0.764	577.4	0.033	0.464
6	18-07-2018	1.049	546.8	0.052	0.368
7	01-08-2018	1.161	559.0	0.048	0.133

Table 17 shows the total cumulative gaseous emissions, of the tests performed with a cold start, divided by the total cycle work including the cold start period. Test 1 has been performed with a warm start and is therefore not included in the table.

Table 17 Test evaluation: Total cycle gaseous emissions including cold start

Test number	Date	CO	CO_2	THC	NO_x
		g/kWh	g/kWh	g/kWh	g/kWh
1	26-06-2018	n/a	n/a	n/a	n/a
2	27-06-2018	0.947	571.7	0.087	0.502
3	28-06-2018	0.966	571.7	0.096	0.555
4	04-07-2018	0.821	556.1	0.091	0.376
5	16-07-2018	0.996	583.4	0.114	0.525
6	18-07-2018	1.196	550.7	0.099	0.401
7	01-08-2018	1.312	561.3	0.102	0.134

The NO, NO_2 and NO_x test results were divided in the three trip categories.

The emission results are expressed in grams per kilometre for each test. This has been done for the emission results excluding the cold start period in Table 18 and Figure 9. The emission results including the cold start period can be found in Table 19 and Figure 10.

NO and NO_2 mass - Measured mass on street level
NO mass NO_2 equivalent - Calculated NO_2 mass when all NO is converted to NO_2

Table 18 Test emissions [g/km] excluding cold start including drift correction

Trip category	Test Emissions [g/km]	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7
Urban	NO mass	1.469	2.097	2.166	0.963	1.489	1.182	0.135
	NO mass (NO_2 eq)	2.252	3.215	3.321	1.477	2.283	1.813	0.207
	NO_x mass	2.307	3.233	3.302	1.472	2.283	1.717	0.191
	NO_2 mass	0.055	0.018	0.000	0.000	0.000	0.000	0.000
Rural	NO mass	0.301	0.445	0.587	0.354	0.338	0.602	0.136
	NO mass (NO_2 eq)	0.461	0.682	0.900	0.542	0.518	0.923	0.208
	NO_x mass	0.471	0.685	0.894	0.525	0.523	0.858	0.194
	NO_2 mass	0.009	0.002	0.000	0.000	0.005	0.000	0.000
Motorway	NO mass	0.144	0.161	0.174	0.142	0.154	0.182	0.094
	NO mass (NO_2 eq)	0.221	0.246	0.267	0.217	0.236	0.280	0.144
	NO_x mass	0.222	0.239	0.265	0.209	0.237	0.272	0.143
	NO_2 mass	0.001	0.000	0.000	0.000	0.001	0.000	0.000

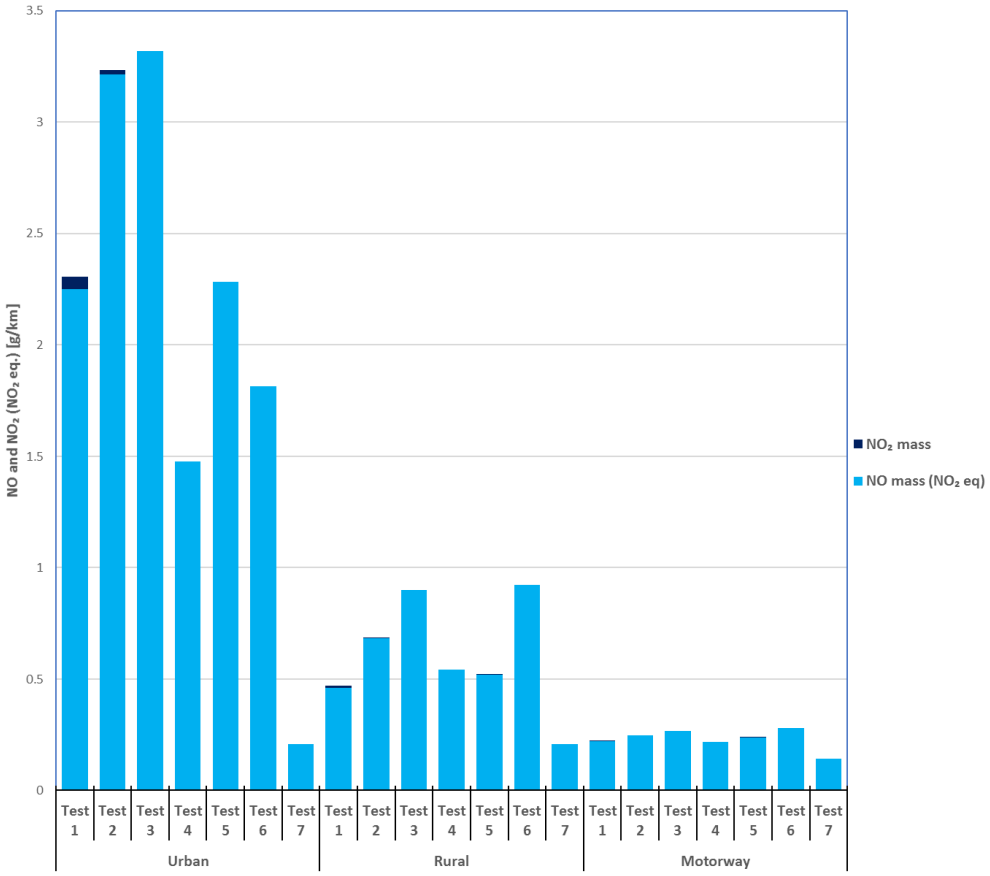


Figure 9 NO_2 and NO (NO_2 eq.) [g/km] excluding cold start

Table 19 Test emissions [g/km] including cold start including drift correction

Trip category	Test Emissions [g/km]	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7
Urban	NO mass	n/a	2.206	2.230	1.341	1.727	1.435	0.153
	NO mass (NO_2 eq)	n/a	3.382	3.420	2.056	2.648	2.200	0.235
	NO_x mass	n/a	3.402	3.415	2.067	2.653	2.139	0.221
	NO_2 mass	n/a	0.020	0.000	0.011	0.005	0.000	0.000
Rural	NO mass	n/a	0.445	0.587	0.354	0.338	0.602	0.136
	NO mass (NO_2 eq)	n/a	0.682	0.900	0.542	0.518	0.923	0.208
	NO_x mass	n/a	0.685	0.894	0.525	0.523	0.858	0.194
	NO_2 mass	n/a	0.002	0.000	0.000	0.005	0.000	0.000
Motorway	NO mass	n/a	0.160	0.174	0.142	0.154	0.182	0.094
	NO mass (NO_2 eq)	n/a	0.246	0.267	0.217	0.236	0.280	0.144
	NO_x mass	n/a	0.239	0.265	0.209	0.237	0.272	0.143
	NO_2 mass	n/a	0.000	0.000	0.000	0.001	0.000	0.000

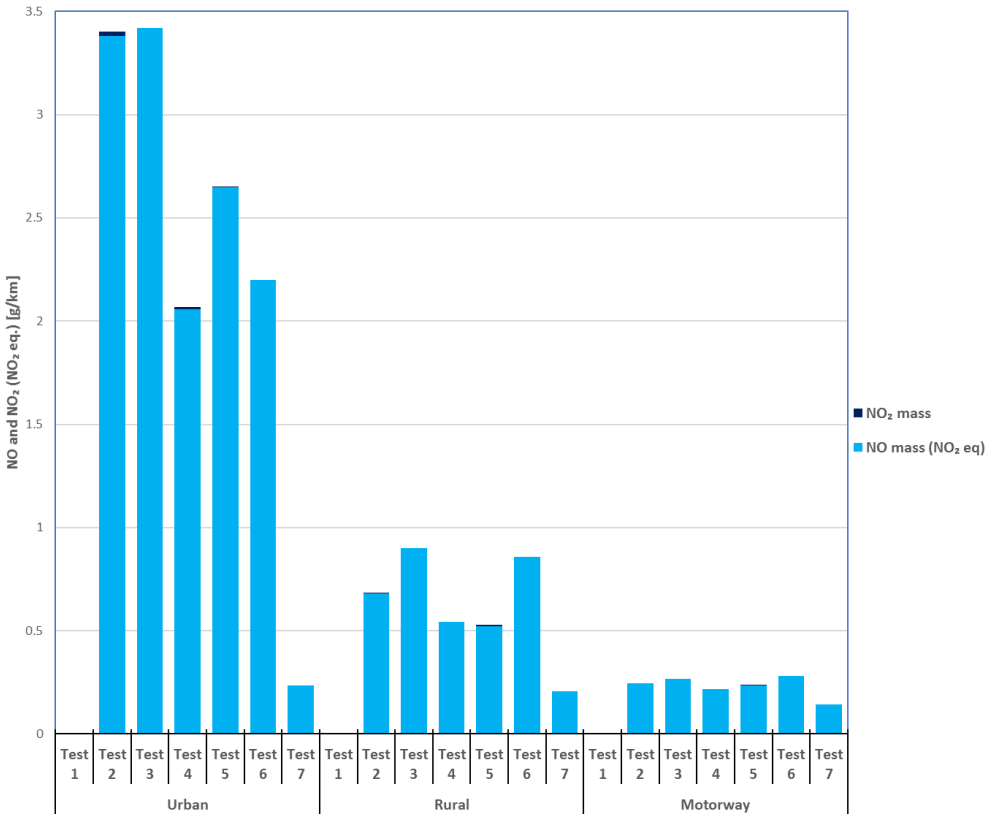


Figure 10 NO_2 and NO (NO_2 eq.) [g/km] including cold start

3.2.2 Calculated conformity factors

The CF (Conformity Factor) results for CO, THC and NO_x emissions, for both work- and CO_2 window based methods are shown in Table 21 and Table 22.
Only test 1 can be considered as valid test because it fulfils the trip composition requirements as stated in EU 582/2011 [2]. The results from test 2 to 7 should be considered as indicative only.

The reference work and CO_2 mass are calculated from the cold and hot WHTC results as reported in the type approval certificate [4], with the respective weighing factors of 14% and 86%:

Reference work - 27.165 kWh
Reference CO_2 mass - 16224 grams

Data was processed according to EU 582/2011 [2], which means that:

- Data evaluation starts after the coolant temperature has reached 70°C or after 20 minutes of testing, whichever condition is met first.

- Windows are marked valid when the average engine power exceeds the minimum power requirement 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 10% 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 as seen in Table 20. No CH_4 analyser was used during testing, therefore the CH_4 limit was used for THC.

Table 20 Euro VI Emission Limits according to EU 582/2011 [2]

	CO	THC	NMHC	CH_4	NO_x
	mg/kWh	mg/kWh	mg/kWh	mg/kWh	mg/kWh
WHTC (PI)	4000		160	500	460

Table 21 Test evaluation: CF Work based window results at 90% according to regulation requirements

Work based window					
Test number	**CO**	**THC**	**NO_x**	**Valid window**	**Threshold**
	CF	**CF**	**CF**	**%**	**%**
1	0.39	0.18	0.93	100	20
2	0.27	0.09	1.21	93.9	20
3	0.28	0.08	1.57	94.4	20
4	0.26	0.07	0.93	95.4	20
5	0.25	0.07	1.02	76.3	20
6	0.42	0.27	1.19	93.8	20
7	0.43	0.16	0.40	94.8	20

Table 22 Test evaluation: CF CO_2 based window results at 90% according to regulation requirements

CO_2 based window					
Test number	**CO**	**THC**	**NO_x**	**Valid window**	**Threshold**
	CF	**CF**	**CF**	**%**	**%**
1	0.41	0.19	1.01	100	20
2	0.28	0.09	1.26	92.9	20
3	0.30	0.09	1.61	93.5	20
4	0.28	0.07	0.97	94.4	20
5	0.27	0.07	1.04	67.3	20
6	0.49	0.31	1.25	93.6	20
7	0.46	0.18	0.43	94.9	20

For more detailed test results see Appendix A to G, section 1 and 2.

4 Summary

Several tests have been performed with different routes, driving styles and traffic conditions. Eventually a new dataset was used for the last test.

The conditions of the tests are summarized in Table 23.

Table 23 Test conditions

Test number	Route	Payload	Traffic	Driving style	Dataset
1	1	55%	Normal	Normal	1
2	2	55%	Busy urban	Normal	1
3	2	55%	Busy Urban & Hold up at rural & traffic jam at motorway	Normal	1
4	2	55%	Normal	Anticipating	1
5	2	10%	Traffic jam at motorway	Normal	1
6	2	100%	Minor hold up at urban	Normal	1
7	2	55%	Normal	Normal	2

Findings

Repeating the test cycle as was used in TNO 2017 R11336 [1] resulted in similar NO_x emissions as were reported in TNO 2017 R11336 [1].
Variation of traffic conditions and driving style and changing to a new dataset has shown that the NO_x emissions, as seen in Figure 9, are affected by traffic conditions, driving style and used dataset. The effects described below were mainly observed in the urban part of the tests.

- Test 2 and 4 used the same routes. Test 4 was performed with a more conservative driving style in less dense traffic conditions. This resulted in an approximate reduction of 50% in NO_x emissions, compared to the initial results.
- Test 4 was performed using a more conservative driving style compared to test 1, but has comparable traffic conditions. The comparison of the results for these two tests indicates that a conservative driving style has a reducing effect on NO_x emissions.
- Test 7 was performed with a normal driving style but a new dataset by Iveco. A significant reduction of NO_x emissions was observed, specifically for the urban part, of approximately 90% compared to the initial results of this test campaign.

General

- The share of NO_2 on street level in the NO_x emissions is very low for all tests.
- Test were performed with respective payloads of 10, 55 and 100%. No clear effect of the payload on the NO_x emissions are observed. This finding is based on tests with dataset 1 only.
- Including or excluding the cold-start phase was found to have a limited effect on the NO_x emissions in urban operation.

- The driver gave positive feedback after driving with dataset number two (test 7). He observed a smoother behavior during deceleration (down shifting).

- Result specific for dataset 2:
  - Reduction of NO_x emissions was observed for urban and rural operation in test 7. The observed reduction is highest over this test when driving is more dynamical, as occurs in typical urban driving/traffic. For urban, rural and motorway operation, respectively 93%, 66% and 5% reduction was found compared to the 2017 results reported in report TNO 2017 R11336 [1].
  - For NOx, the conformity factor for a single PEMS test with dataset 2 is 0.4, which is below the applicable limit of 1.5.

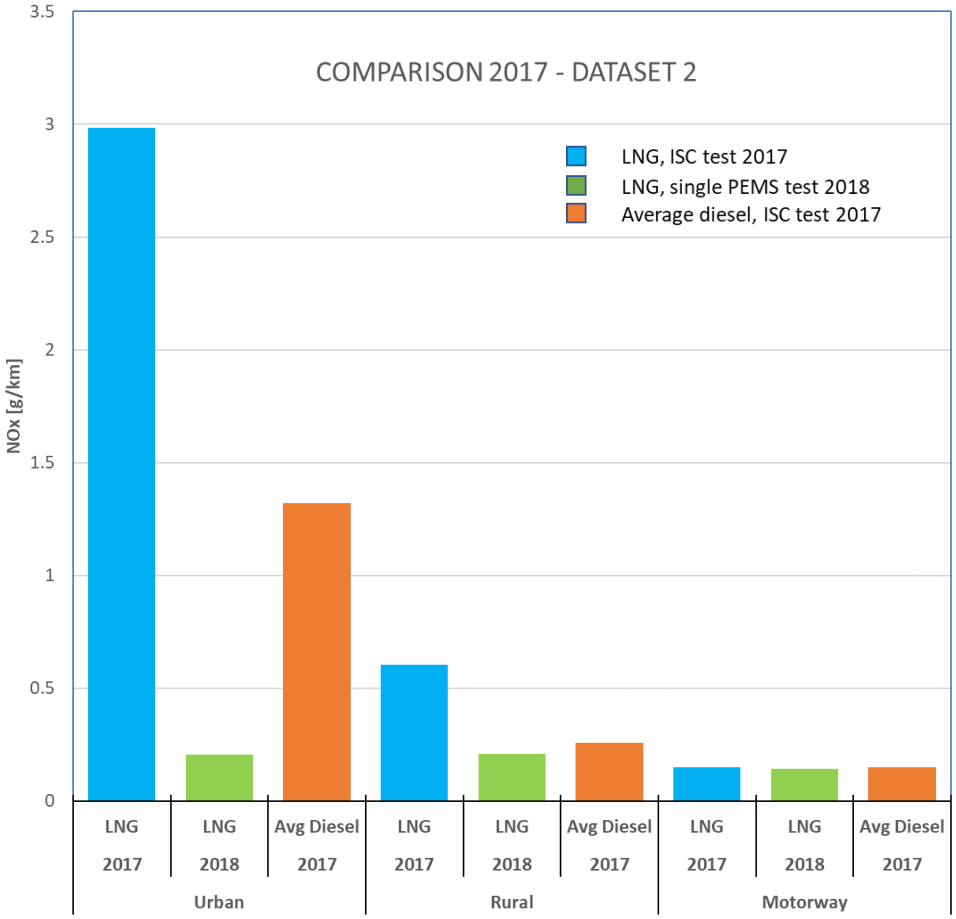


Figure 11, Comparison on NO_x, ISC testing 2017 vs dataset 2

- Comparison with diesel trucks:

When comparing the dataset 2 (test 7) results to the average EURO VI diesel vehicles from the testing programme as mentioned in rapport TNO 2017 R11336 [1] it is observed that the NOx emissions in [g/km] are lower than those of the average diesel.

For urban, rural and motorway operation, respectively 84%, 20% and 4% reduction was found compared to the 2017 average EURO VI diesel results reported in report TNO 2017 R11336 [1].

The results presented for dataset 2 (Test 7) show lower NOx emissions. It should be noted that these conclusions and findings are based on a single PEMS test with this updated dataset. Iveco has informed TNO that a homologation procedure has been started. This, after homologation, opens up the possibility to adapt already running vehicles to the new calibration.

5 References

[1] Emissions testing of two Euro VI LNG heavy-duty vehicle in the Netherlands: tank-to-wheel emissions, TNO 2017 R11336

[2] 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.

[3] Commission Regulation (EU) No 136/2014, of 11 February 2014 amending Directive 2007/46/EC of the European Parliament and of the Council, Commission Regulation (EC) No 692/2008 as regards emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and Commission Regulation (EU) No 582/2011 as regards emissions from heavy duty vehicles (Euro VI).

[4] Certificato di omologazione CE, of 30 November 2015 motor e3_595_2009_67_2014C_1024_00

6 Signature

Helmond, 30-11-2018

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I.A. of Ir. M.D. (Martijn) Stamm
Head of department

TNO

Ing. J.W.H. (Jeroen) van Schaijk
Author

A Test 1

A.1 CO_2-based report

HORIBA
Automotive Test Systems

Window (HDV CO2-based) Report

Test

Test ID	:	109
Test Date	:	2018/06/26
Test Start	:	10:15:40
Test End	:	13:17:28
Driver	:	Ricardo
Comment	:	first test

Vehicle

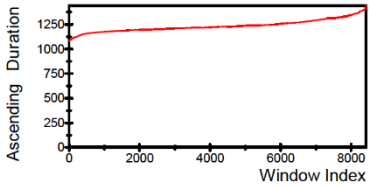
Vehicle Name	:	Iveco 28-BH
Vehicle Type	:	N3
Fuel Type	:	CNG
Description	:	Iveco Curso

Device

Cell Name	:	OBS-ONE
Cell Description	:	

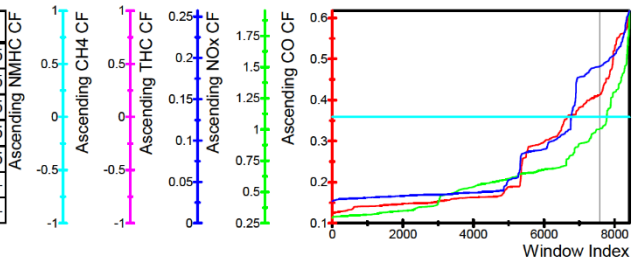
Test Normality

	Threshold		Valid Window	Criteria	Unit
Duration	≦ 20		100.0	50	%



CF Result

		90%	CF Criteria
CO		0.41	1.5
THC		0.19	1.5
NMHC	-	---	1.5
CH4	-	---	1.5
NOx		1.01	1.5
PM	-	---	---
PN	-	---	---



Window Info.

	Value	Unit
All Window Number	8425	#
Valid window Number	8425	#

OBS-ONE Post Processing v2.11.1

Template ID : WindowHDVCO2_ENG.TDR
Report ID : 20180723093527_A

A.2 Work-based report

HORIBA
Automotive Test Systems

Window (HDV work-based) Report

Test

Test ID	:	109
Test Date	:	2018/06/26
Test Start	:	10:15:40
Test End	:	13:17:28
Driver	:	Ricardo
Comment	:	first test

Vehicle

Vehicle Name	:	Iveco 28-BH
Vehicle Type	:	N3
Fuel Type	:	CNG
Description	:	Iveco Curso

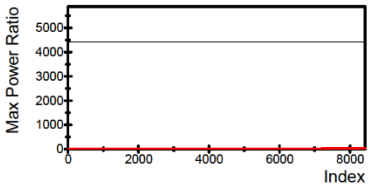
Device

Cell Name	:	OBS-ONE
Cell Description	:	

Test Normality

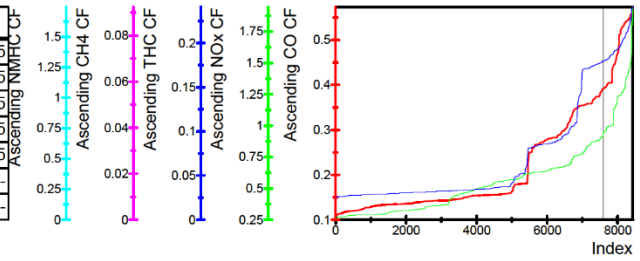
	Threshold		Valid Window	Criteria	Unit
Power	20 <		100.0	50	%

Valid Urban Window	---



CF Result

		90%	CF Criteria
CO		0.39	1.5
THC		0.18	1.5
NMHC	-	---	1.5
CH4	-	---	1.5
NOx		0.93	1.5
PM	-	---	---
PN	-	---	---



Window Info.

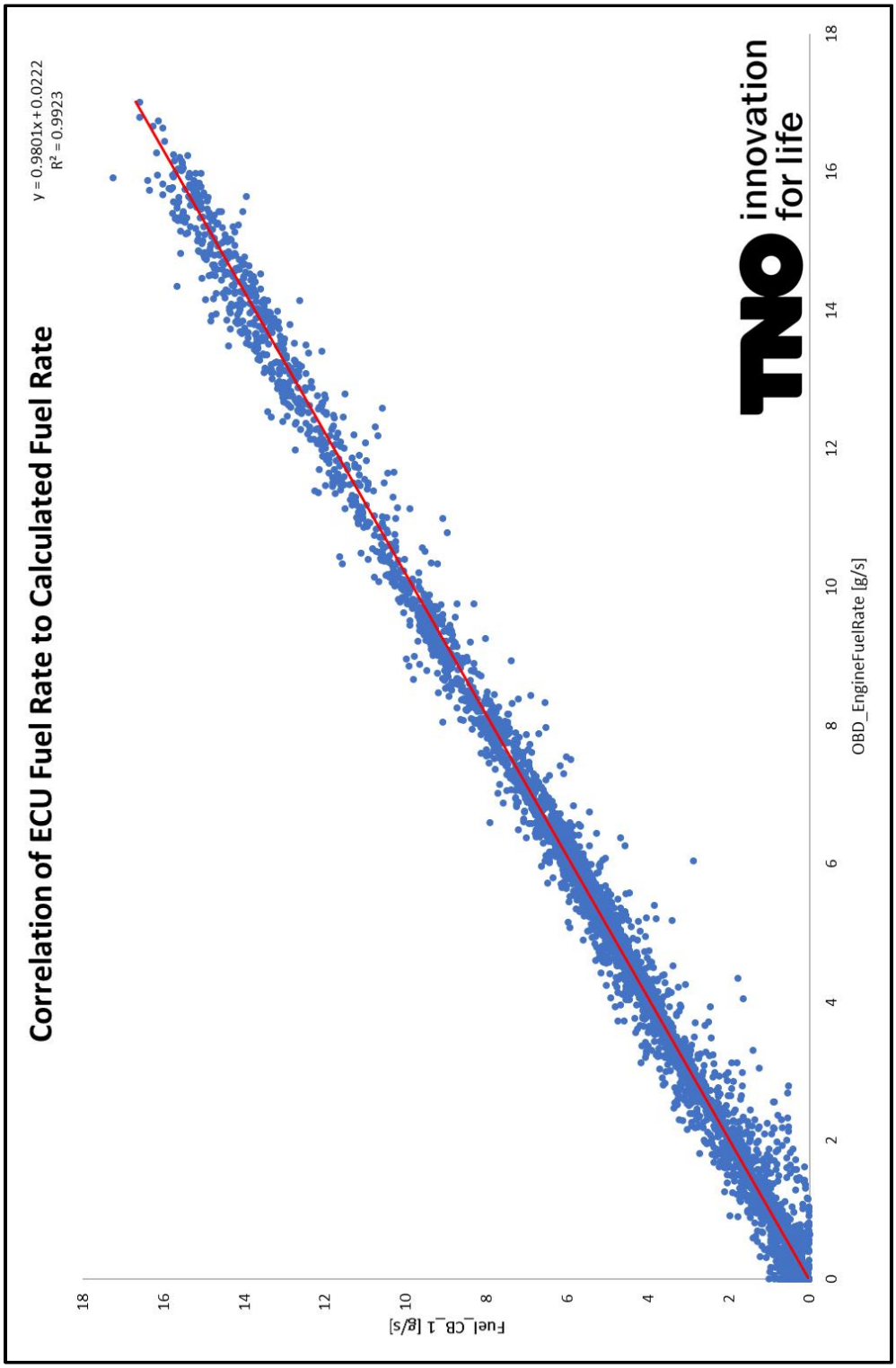
	Value	Unit
All Window Number	8433	#
Valid window Number	8433	#

OBS-ONE Post Processing v2.11.1

Template ID : WindowHDVWork_ENG.TDR

Report ID : 20180723094025_A

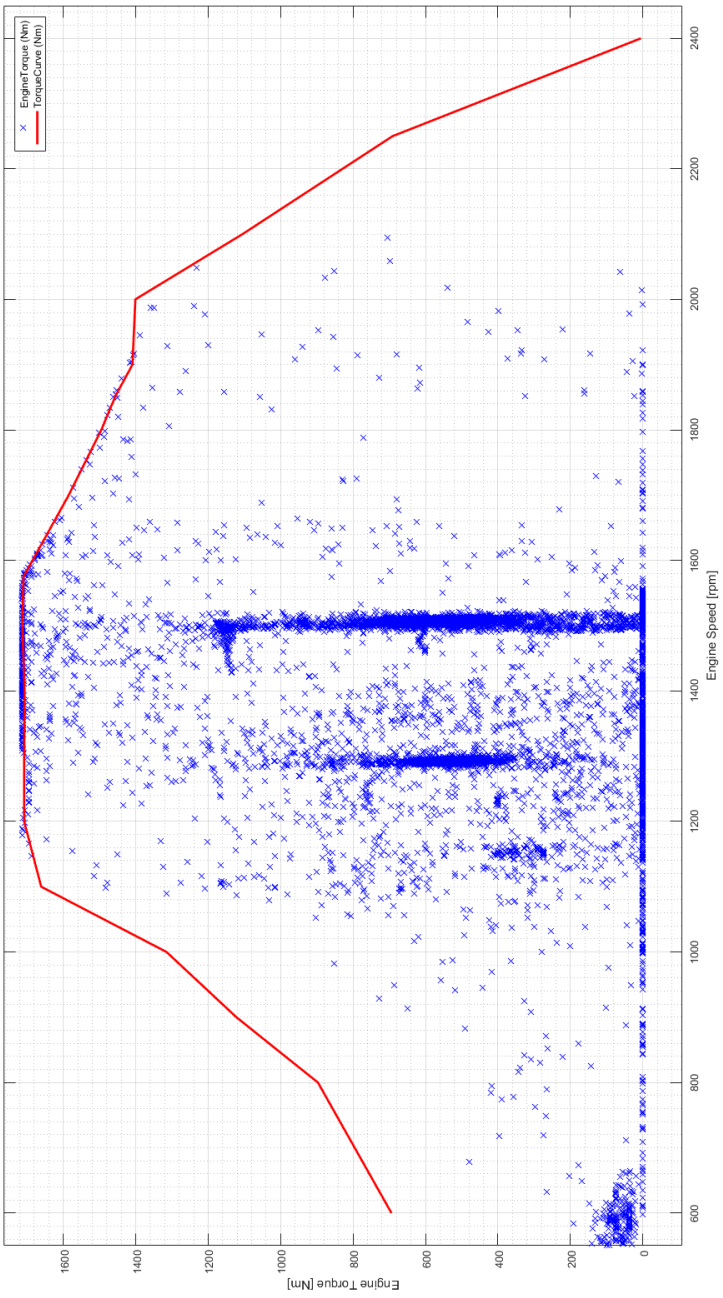
A.3 Fuel rate correlation



A.4 Drift check results

		Zero			Span		
	Channel	Pre	Post	Drift [%FS]	Pre	Post	Drift [%FS]
CO [vol%]	MeasData_1Hz/GA_COConc	-0.002340	-0.000464	0.018760	3.008795	3.038691	0.298960
CO2 [vol%]	MeasData_1Hz/GA_CO2Conc	-0.001780	0.003210	0.024950	16.044600	16.185980	0.706900
NO [ppm]	MeasData_1Hz/GA_NOConc	0.420000	0.240000	-0.006000	2488.110000	2537.750000	1.654667
NOx [ppm]	MeasData_1Hz/GA_NOxConc	0.850000	0.840000	-0.000333	2502.030000	2522.520000	0.683000
THC [ppmC]	MeasData_1Hz/GA_THCConc	0.000000	0.040000	0.000400	990.600000	966.280000	-0.243200

A.5 Full load curve



B Test 2

B.1 CO_2-based report

HORIBA
Automotive Test Systems

Window (HDV CO2-based) Report

Test

Test ID	:	110
Test Date	:	2018/06/27
Test Start	:	11:11:04
Test End	:	14:49:28
Driver	:	Ricardo
Comment	:	cold start old N3 ro

Vehicle

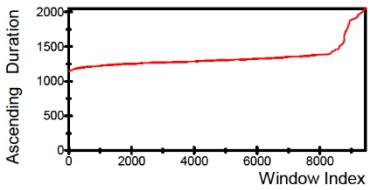
Vehicle Name	:	Iveco 28-BH
Vehicle Type	:	N3
Fuel Type	:	CNG
Description	:	Iveco Curso

Device

Cell Name	:	OBS-ONE
Cell Description	:	

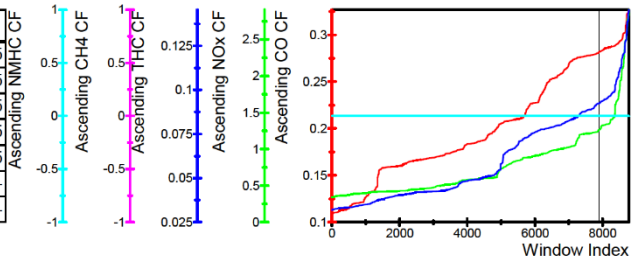
Test Normality

	Threshold		Valid Window	Criteria	Unit
Duration	≦ 20		92.8	50	%



CF Result

		90%	CF Criteria
CO		0.28	1.5
THC		0.09	1.5
NMHC	-	---	1.5
CH4	-	---	1.5
NOx		1.26	1.5
PM	-	---	---
PN	-	---	---



Window Info.

	Value	Unit
All Window Number	9456	#
Valid window Number	8779	#

OBS-ONE Post Processing v2.11.1

Template ID : WindowHDVCO2_ENG.TDR
Report ID : 20180723094841_A

B.2 Work-based report

HORIBA
Automotive Test Systems

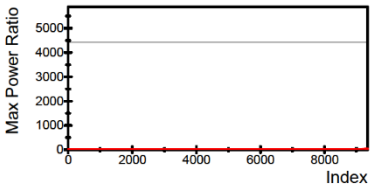
Window (HDV work-based) Report

Test			Vehicle			Device		
Test ID	:	110	Vehicle Name	:	Iveco 28-BH	Cell Name	:	OBS-ONE
Test Date	:	2018/06/27	Vehicle Type	:	N3	Cell Description	:	
Test Start	:	11:11:04	Fuel Type	:	CNG			
Test End	:	14:49:28	Description	:	Iveco Curso			
Driver	:	Ricardo						
Comment	:	cold start old N3 ro						

Test Normality

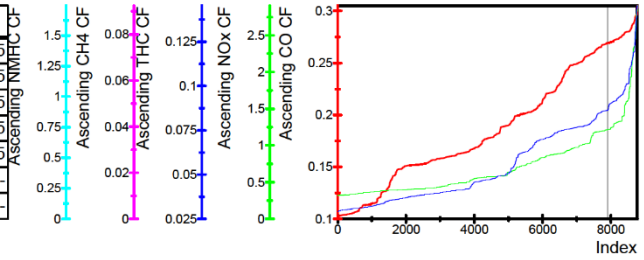
	Threshold		Valid Window	Criteria	Unit
Power	20 <		93.9	50	%

Valid Urban Window	---



CF Result

		90%	CF Criteria
CO		0.27	1.5
THC		0.09	1.5
NMHC	-	---	1.5
CH4	-	---	1.5
NOx		1.21	1.5
PM	-	---	---
PN	-	---	---



Window Info.

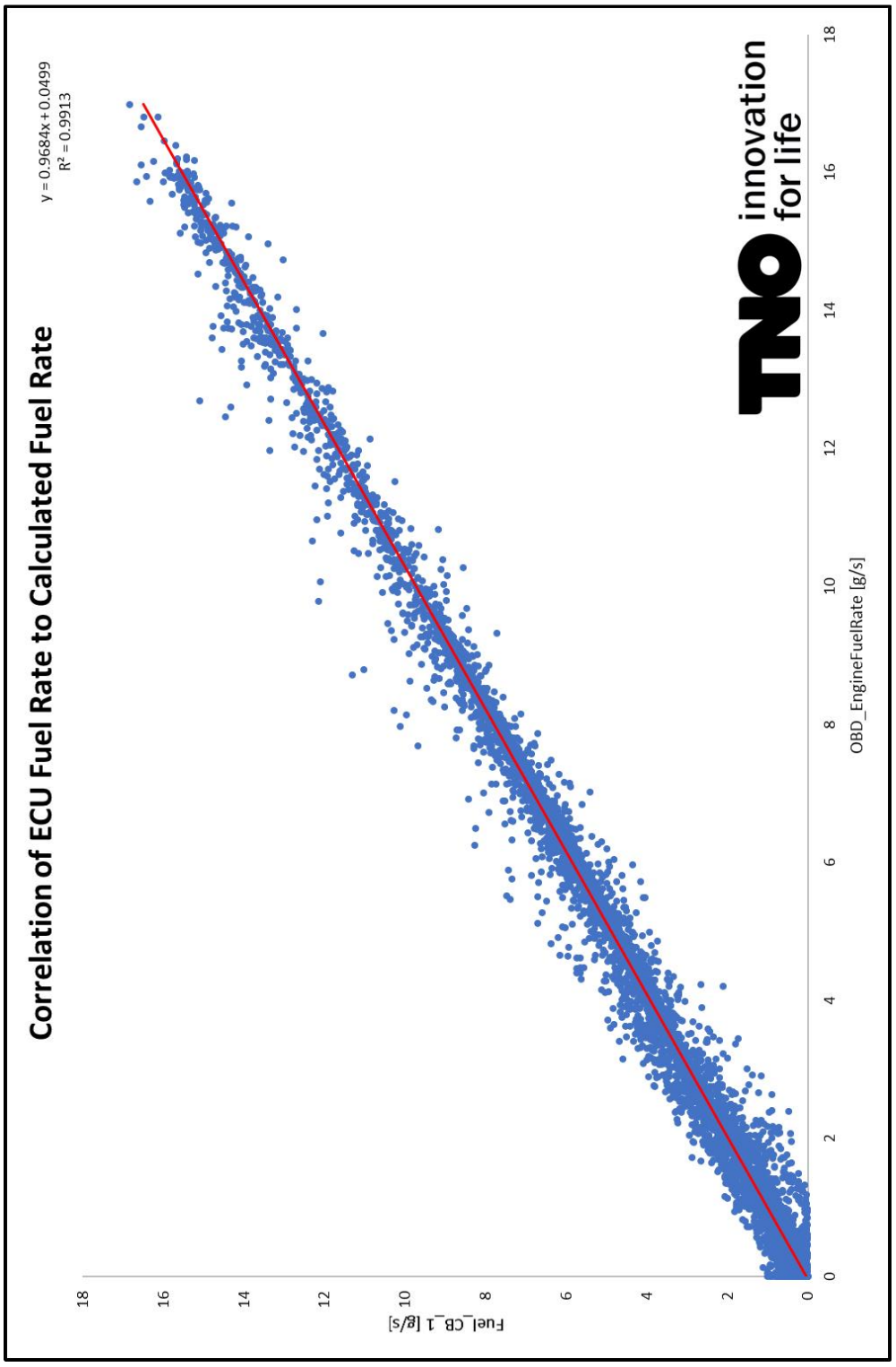
	Value	Unit
All Window Number	9349	#
Valid window Number	8775	#

OBS-ONE Post Processing v2.11.1

Template ID : WindowHDVWork_ENG.TDR

Report ID : 20180723094948_A

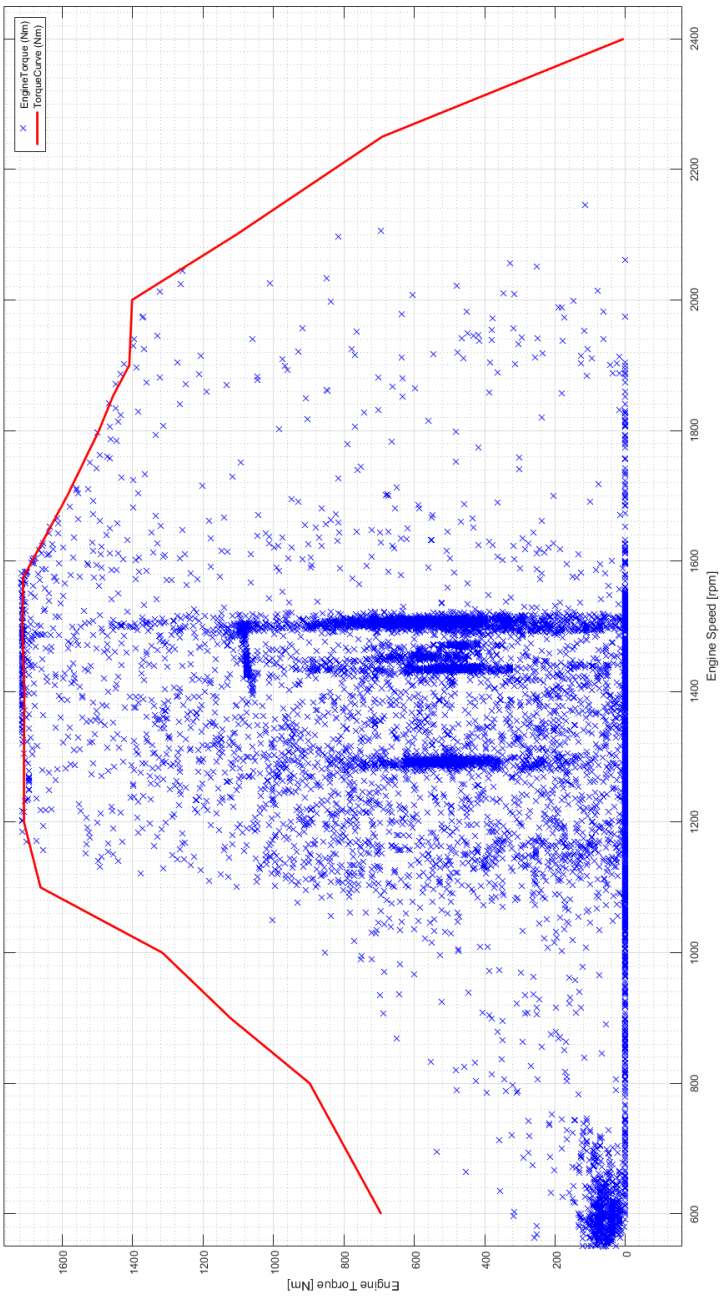
B.3 Fuel rate correlation



B.4 Drift check results

		Zero			Span		
	Channel	Pre	Post	Drift [%FS]	Pre	Post	Drift [%FS]
CO [vol%]	MeasData_1Hz/GA_COConc	-0.000144	0.001516	0.016600	3.008424	3.040175	0.317510
CO2 [vol%]	MeasData_1Hz/GA_CO2Conc	0.002511	0.013635	0.055620	16.016840	16.103150	0.431550
NO [ppm]	MeasData_1Hz/GA_NOConc	0.190000	-0.070000	-0.008667	2508.830000	2475.150000	-1.122667
NOx [ppm]	MeasData_1Hz/GA_NOxConc	0.850000	0.720000	-0.004333	2505.490000	2473.480000	-1.067000
THC [ppmC]	MeasData_1Hz/GA_THCConc	-0.080000	-0.140000	-0.000600	990.660000	995.580000	0.049200

B.5 Full load curve



C Test 3

C.1 CO_2-based report

HORIBA
Automotive Test Systems

Window (HDV CO2-based) Report

Test

Test ID	:	112
Test Date	:	2018/06/28
Test Start	:	08:35:38
Test End	:	12:21:59
Driver	:	Ricardo
Comment	:	cold start old N3 ro

Vehicle

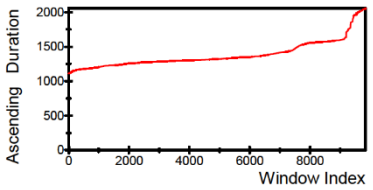
Vehicle Name	:	Iveco 28-BH
Vehicle Type	:	N3
Fuel Type	:	CNG
Description	:	Iveco Curso

Device

Cell Name	:	OBS-ONE
Cell Description	:	

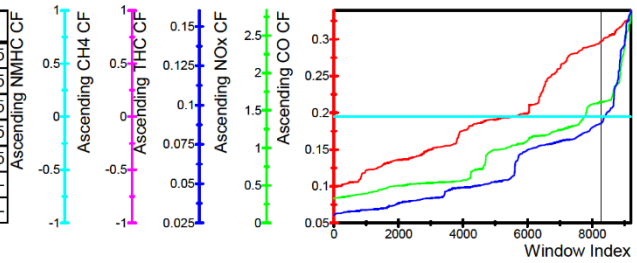
Test Normality

	Threshold		Valid Window	Criteria	Unit
Duration	≦ 20		93.5	50	%



CF Result

		90%	CF Criteria
CO		0.30	1.5
THC		0.09	1.5
NMHC	-	---	1.5
CH4	-	---	1.5
NOx	*	1.61	1.5
PM	-	---	---
PN	-	---	---



Window Info.

	Value	Unit
All Window Number	9840	#
Valid window Number	9203	#

OBS-ONE Post Processing v2.11.1

Template ID : WindowHDVCO2_ENG.TDR
Report ID : 20180723100634_A

C.2 Work-based report

HORIBA
Automotive Test Systems

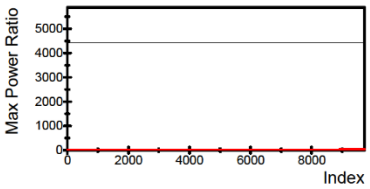
Window (HDV work-based) Report

Test			Vehicle			Device		
Test ID	:	112	Vehicle Name	:	Iveco 28-BH	Cell Name	:	OBS-ONE
Test Date	:	2018/06/28	Vehicle Type	:	N3	Cell Description	:	
Test Start	:	08:35:38	Fuel Type	:	CNG			
Test End	:	12:21:59	Description	:	Iveco Curso			
Driver	:	Ricardo						
Comment	:	cold start old N3 ro						

Test Normality

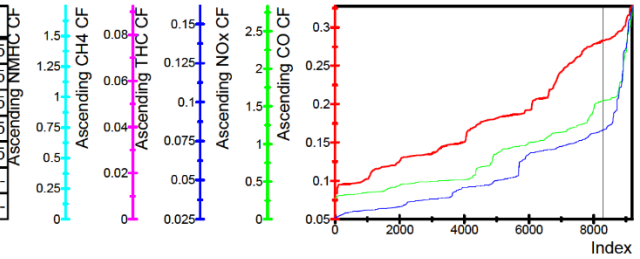
	Threshold		Valid Window	Criteria	Unit
Power	20 <		94.4	50	%

Valid Urban Window	---



CF Result

		90%	CF Criteria
CO		0.28	1.5
THC		0.08	1.5
NMHC	-	---	1.5
CH4	-	---	1.5
NOx	*	1.57	1.5
PM	-	---	---
PN	-	---	---



Window Info.

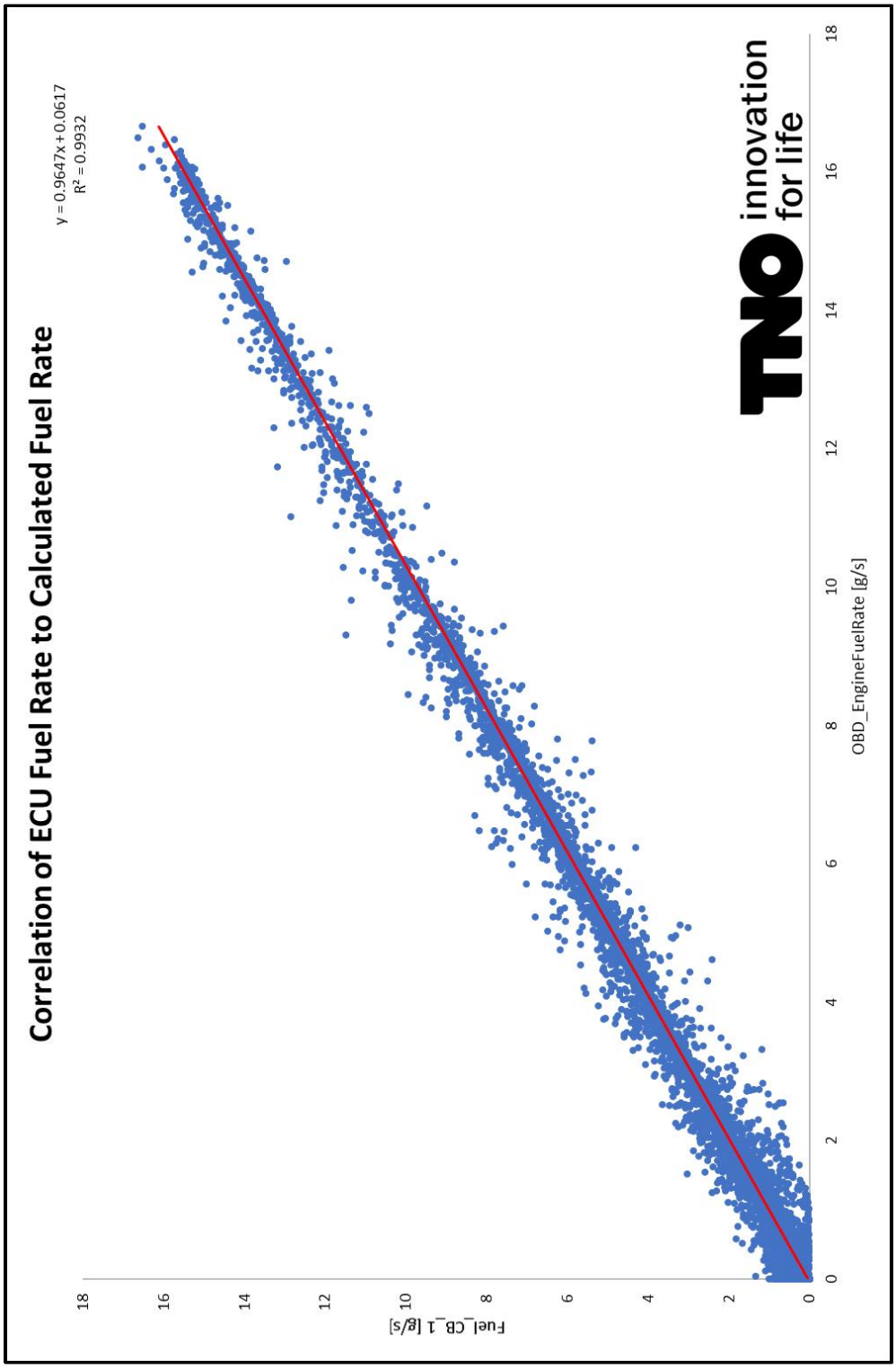
	Value	Unit
All Window Number	9740	#
Valid window Number	9195	#

OBS-ONE Post Processing v2.11.1

Template ID : WindowHDVWork_ENG.TDR

Report ID : 20180723100726_A

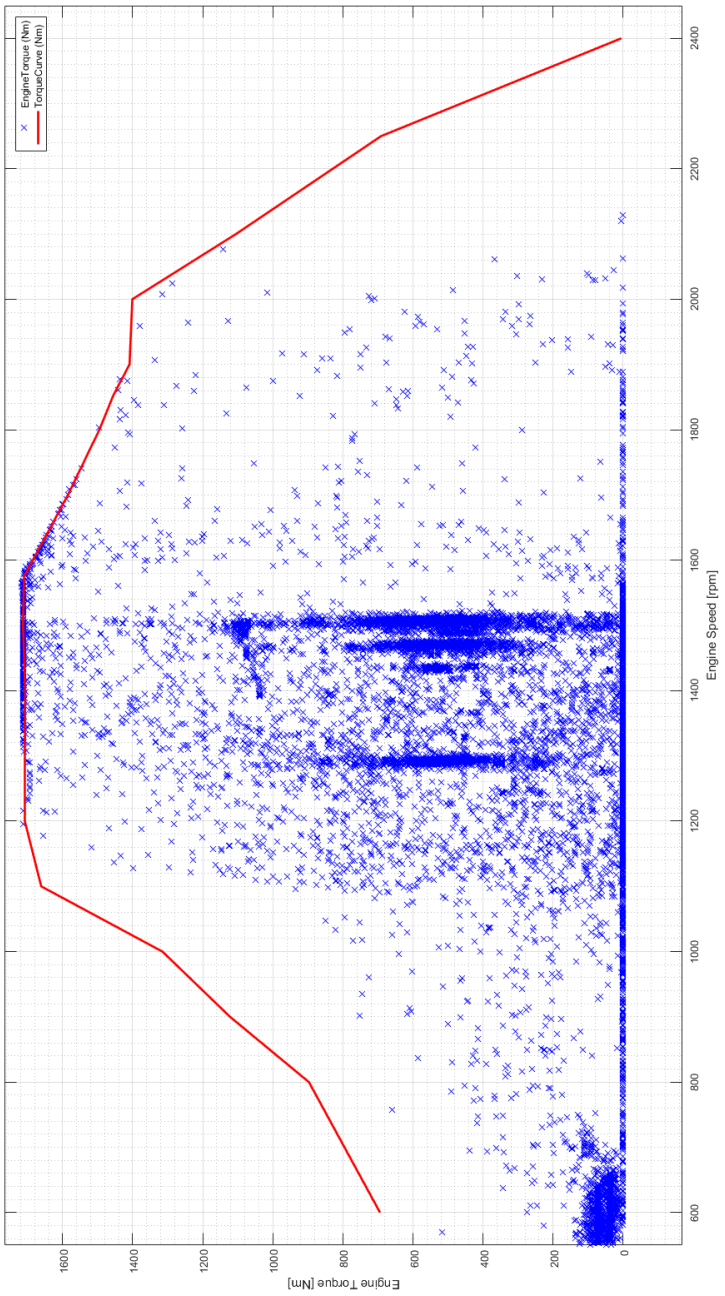
C.3 Fuel rate correlation



C.4 Drift check results

	Channel	Zero			Span		
		Pre	Post	Drift [%FS]	Pre	Post	Drift [%FS]
CO [vol%]	MeasData_1Hz/GA_COConc	-0.000404	0.001071	0.014750	3.008835	3.035095	0.262600
CO2 [vol%]	MeasData_1Hz/GA_CO2Conc	0.003006	0.016033	0.065135	16.010750	16.120780	0.550150
NO [ppm]	MeasData_1Hz/GA_NOConc	0.170000	0.350000	0.006000	2500.710000	2540.300000	1.319667
NOx [ppm]	MeasData_1Hz/GA_NOxConc	0.750000	0.880000	0.004333	2502.050000	2506.640000	0.153000
THC [ppmC]	MeasData_1Hz/GA_THCConc	-0.040000	-0.070000	-0.000300	990.570000	996.060000	0.054900

C.5 Full load curve



D Test 4

D.1 CO_2-based report

HORIBA
Automotive Test Systems

Window (HDV CO2-based) Report

Test

Test ID	:	113
Test Date	:	2018/07/04
Test Start	:	09:04:04
Test End	:	12:39:44
Driver	:	Ricardo
Comment	:	cold start old N3 ro

Vehicle

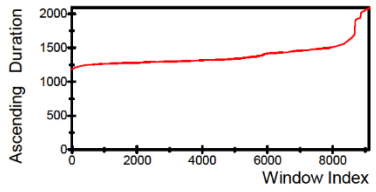
Vehicle Name	:	Iveco 28-BH
Vehicle Type	:	N3
Fuel Type	:	CNG
Description	:	Iveco Curso

Device

Cell Name	:	OBS-ONE
Cell Description	:	

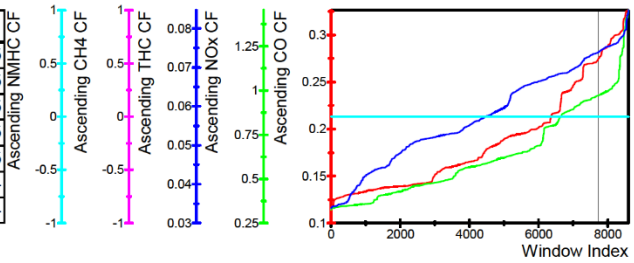
Test Normality

	Threshold		Valid Window	Criteria	Unit
Duration	≦ 20		94.4	50	%



CF Result

		90%	CF Criteria
CO		0.28	1.5
THC		0.07	1.5
NMHC	-	---	1.5
CH4	-	---	1.5
NOx		0.97	1.5
PM	-	---	---
PN	-	---	---



Window Info.

	Value	Unit
All Window Number	9116	#
Valid window Number	8601	#

OBS-ONE Post Processing v2.11.1

Template ID : WindowHDVCO2_ENG.TDR
Report ID : 20180723105331_A

D.2 Work-based report

HORIBA
Automotive Test Systems

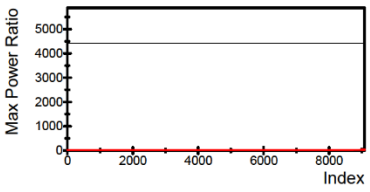
Window (HDV work-based) Report

Test			Vehicle			Device		
Test ID	:	113	Vehicle Name	:	Iveco 28-BH	Cell Name	:	OBS-ONE
Test Date	:	2018/07/04	Vehicle Type	:	N3	Cell Description	:	
Test Start	:	09:04:04	Fuel Type	:	CNG			
Test End	:	12:39:44	Description	:	Iveco Curso			
Driver	:	Ricardo						
Comment	:	cold start old N3 ro						

Test Normality

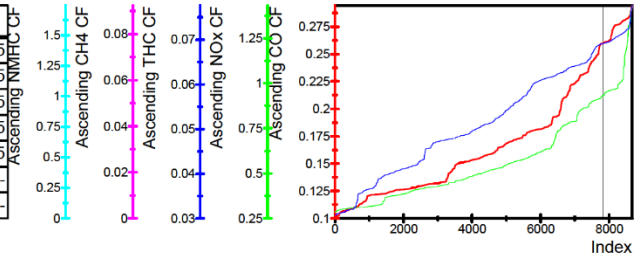
	Threshold		Valid Window	Criteria	Unit
Power	20 <		95.4	50	%

Valid Urban Window	---



CF Result

		90%	CF Criteria
CO		0.26	1.5
THC		0.07	1.5
NMHC	-	---	1.5
CH4	-	---	1.5
NOx		0.93	1.5
PM	-	---	---
PN	-	---	---



Window Info.

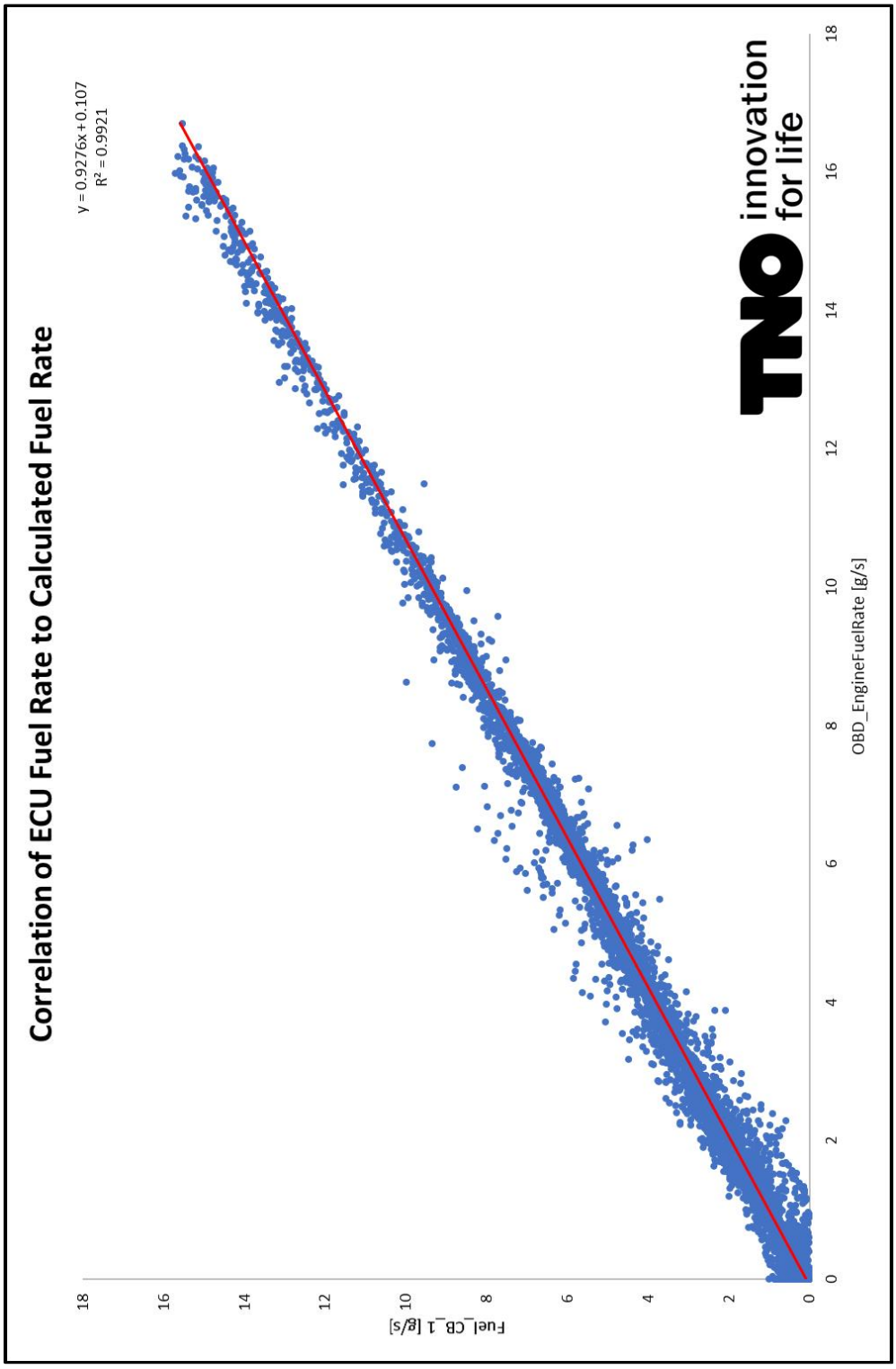
	Value	Unit
All Window Number	9089	#
Valid window Number	8673	#

OBS-ONE Post Processing v2.11.1

Template ID : WindowHDVWork_ENG.TDR

Report ID : 20180723105436_A

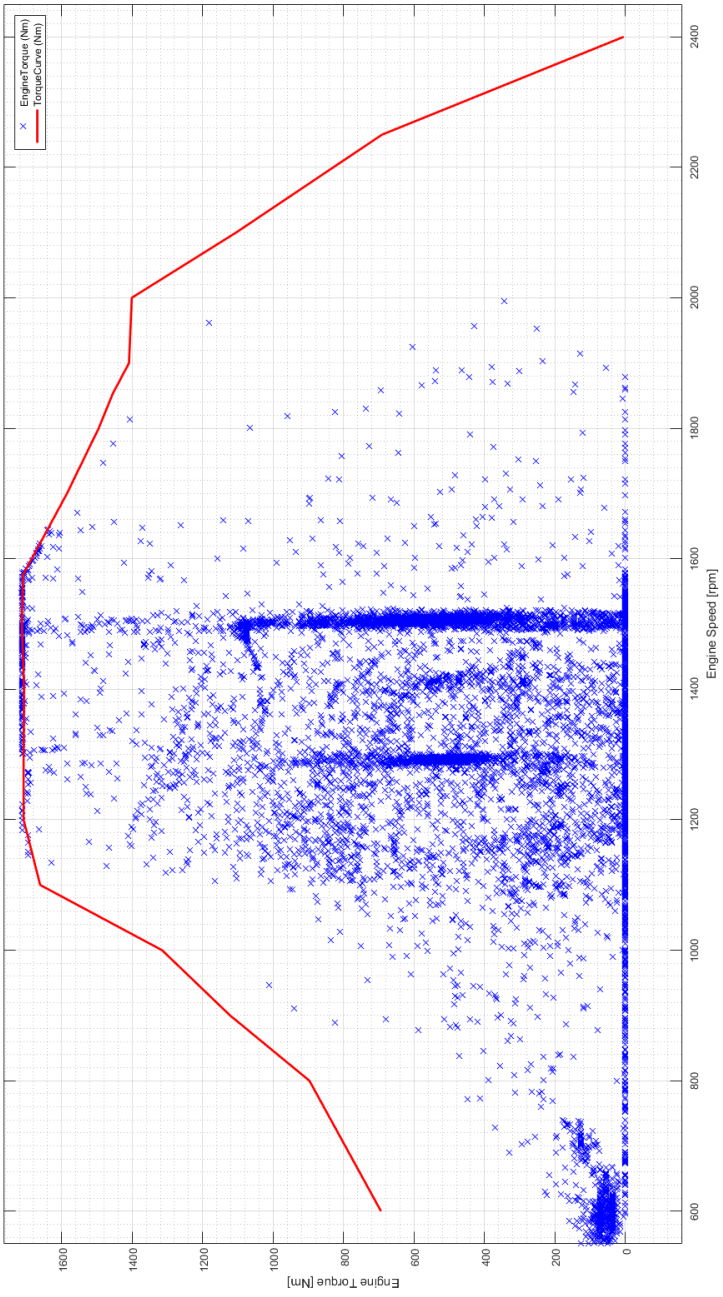
D.3 Fuel rate correlation



D.4 Drift check results

		Zero			Span		
	Channel	Pre	Post	Drift [%FS]	Pre	Post	Drift [%FS]
CO [vol%]	MeasData_1Hz/GA_COConc	-0.000458	-0.000389	0.000690	3.007590	3.018297	0.107070
CO2 [vol%]	MeasData_1Hz/GA_CO2Conc	-0.005037	0.003674	0.043555	15.994920	16.032000	0.185400
NO [ppm]	MeasData_1Hz/GA_NOConc	0.150000	0.020000	-0.004333	2502.290000	2618.860000	3.885667
NOx [ppm]	MeasData_1Hz/GA_NOxConc	0.690000	0.340000	-0.011667	2503.890000	2516.340000	0.415000
THC [ppmC]	MeasData_1Hz/GA_THCConc	-0.250000	-0.660000	-0.004100	990.640000	994.890000	0.042500

D.5 Full load curve



E Test 5

E.1 CO_2-based report

HORIBA
Automotive Test Systems

Window (HDV CO2-based) Report

Test

Test ID	:	114
Test Date	:	2018/07/16
Test Start	:	09:51:49
Test End	:	13:27:23
Driver	:	Ricardo
Comment	:	cold start old N3 ro

Vehicle

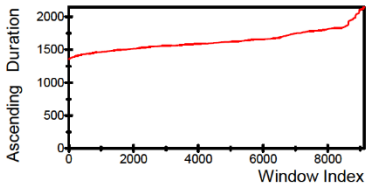
Vehicle Name	:	Iveco 28-BH
Vehicle Type	:	N3
Fuel Type	:	CNG
Description	:	Iveco Curso

Device

Cell Name	:	OBS-ONE
Cell Description	:	

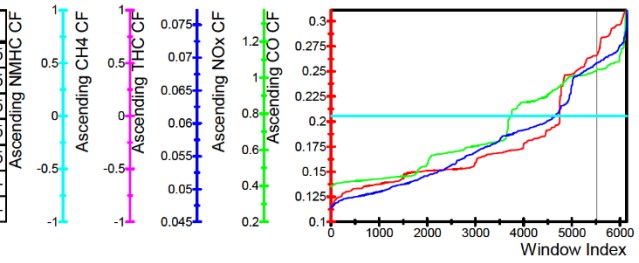
Test Normality

	Threshold		Valid Window	Criteria	Unit
Duration	≦ 20		67.3	50	%



CF Result

		90%	CF Criteria
CO		0.27	1.5
THC		0.07	1.5
NMHC	-	---	1.5
CH4	-	---	1.5
NOx		1.04	1.5
PM	-	---	---
PN	-	---	---



Window Info.

	Value	Unit
All Window Number	9126	#
Valid window Number	6140	#

OBS-ONE Post Processing v2.11.1

Template ID : WindowHDVCO2_ENG.TDR
Report ID : 20180723110220_A

E.2 Work-based report

HORIBA
Automotive Test Systems

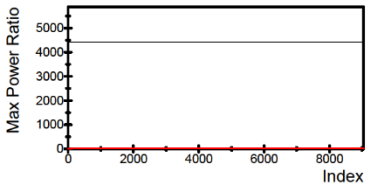
Window (HDV work-based) Report

Test			Vehicle			Device		
Test ID	:	114	Vehicle Name	:	Iveco 28-BH	Cell Name	:	OBS-ONE
Test Date	:	2018/07/16	Vehicle Type	:	N3	Cell Description	:	
Test Start	:	09:51:49	Fuel Type	:	CNG			
Test End	:	13:27:23	Description	:	Iveco Curso			
Driver	:	Ricardo						
Comment	:	cold start old N3 ro						

Test Normality

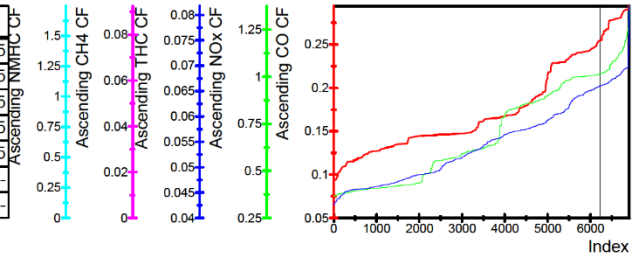
	Threshold		Valid Window	Criteria	Unit
Power	20 <		76.3	50	%

Valid Urban Window	---



CF Result

		90%	CF Criteria
CO		0.25	1.5
THC		0.07	1.5
NMHC	-	---	1.5
CH4	-	---	1.5
NOx		1.02	1.5
PM	-	---	---
PN	-	---	---



Window Info.

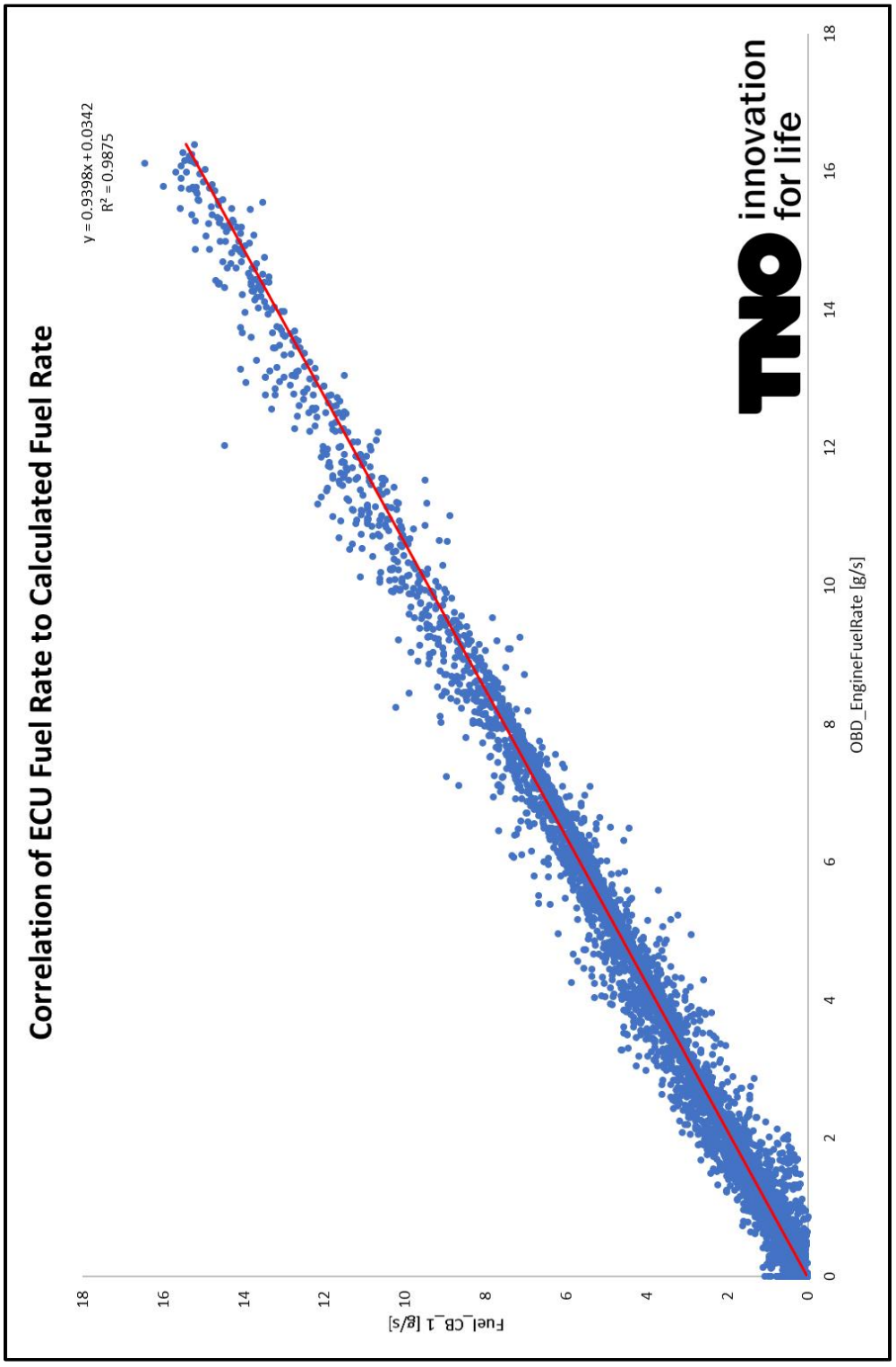
	Value	Unit
All Window Number	9049	#
Valid window Number	6908	#

OBS-ONE Post Processing v2.11.1

Template ID : WindowHDVWork_ENG.TDR

Report ID : 20180723110332_A

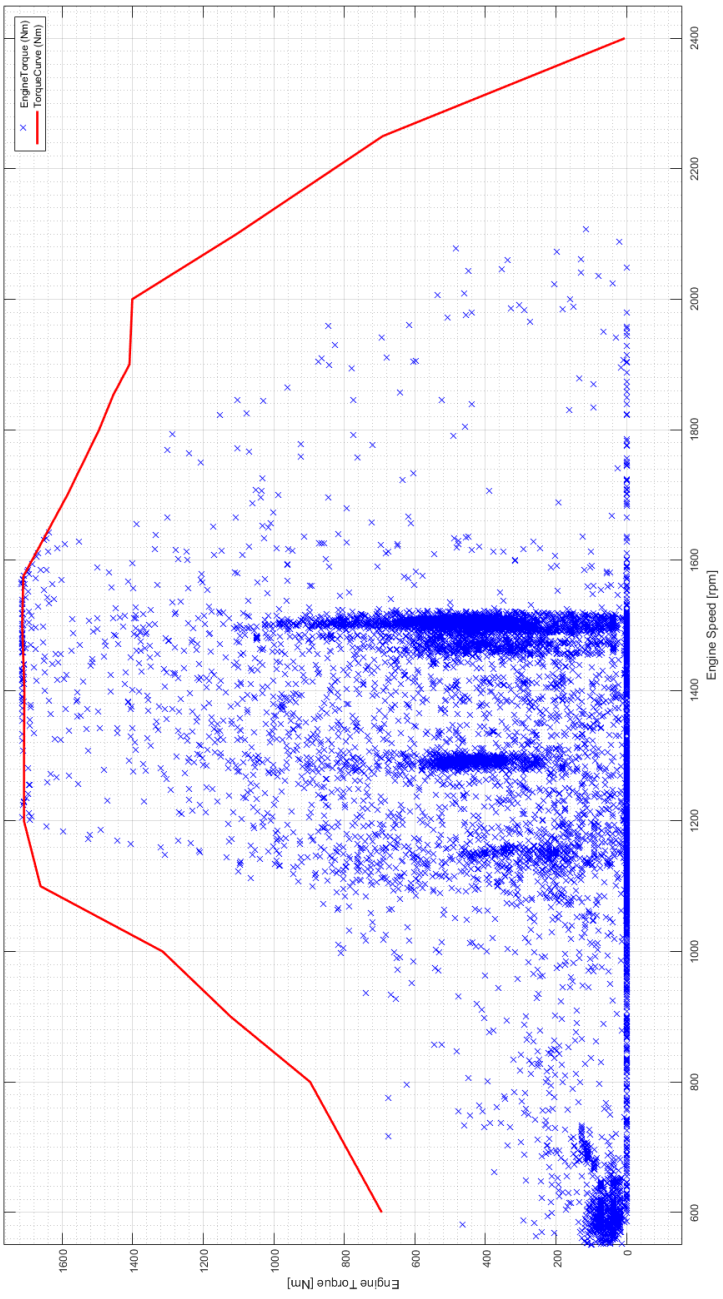
E.3 Fuel rate correlation



E.4 Drift check results

		Zero			Span		
	Channel	Pre	Post	Drift [%FS]	Pre	Post	Drift [%FS]
CO [vol%]	MeasData_1Hz/GA_COConc	-0.000836	0.000590	0.014260	3.006754	3.039491	0.327370
CO2 [vol%]	MeasData_1Hz/GA_CO2Conc	0.003253	0.010942	0.038445	16.035580	16.124360	0.443900
NO [ppm]	MeasData_1Hz/GA_NOConc	0.340000	0.290000	-0.001667	2501.360000	2492.130000	-0.307667
NOx [ppm]	MeasData_1Hz/GA_NOxConc	0.980000	0.530000	-0.015000	2503.100000	2509.150000	0.201667
THC [ppmC]	MeasData_1Hz/GA_THCConc	-0.140000	-0.730000	-0.005900	990.520000	994.120000	0.036000

E.5 Full load curve



F Test 6

F.1 CO_2-based report

HORIBA
Automotive Test Systems

Window (HDV CO2-based) Report

Test

Test ID	:	115
Test Date	:	2018/07/18
Test Start	:	09:16:17
Test End	:	12:57:20
Driver	:	Ricardo
Comment	:	cold start old N3 ro

Vehicle

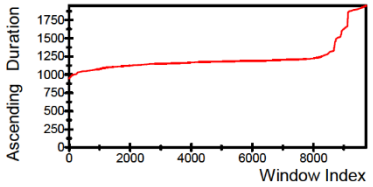
Vehicle Name	:	Iveco 28-BH
Vehicle Type	:	N3
Fuel Type	:	CNG
Description	:	Iveco Curso

Device

Cell Name	:	OBS-ONE
Cell Description	:	

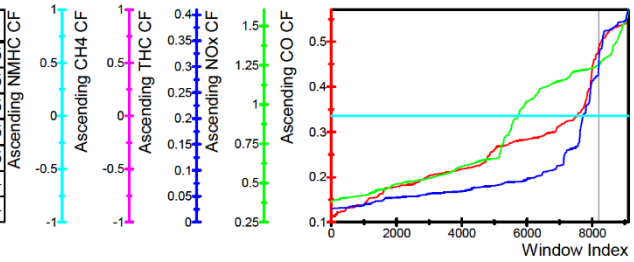
Test Normality

	Threshold		Valid Window	Criteria	Unit
Duration	≦ 20		93.6	50	%



CF Result

		90%	CF Criteria
CO		0.49	1.5
THC		0.31	1.5
NMHC	-	---	1.5
CH4	-	---	1.5
NOx		1.25	1.5
PM	-	---	---
PN	-	---	---



Window Info.

	Value	Unit
All Window Number	9731	#
Valid window Number	9113	#

OBS-ONE Post Processing v2.11.1

Template ID : WindowHDVCO2_ENG.TDR
Report ID : 20180723110916_A

F.2 Work-based report

HORIBA
Automotive Test Systems

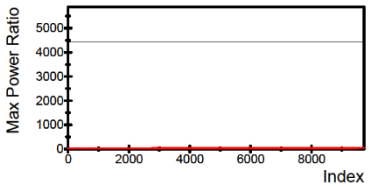
Window (HDV work-based) Report

Test			Vehicle			Device		
Test ID	:	115	Vehicle Name	:	Iveco 28-BH	Cell Name	:	OBS-ONE
Test Date	:	2018/07/18	Vehicle Type	:	N3	Cell Description	:	
Test Start	:	09:16:17	Fuel Type	:	CNG			
Test End	:	12:57:20	Description	:	Iveco Curso			
Driver	:	Ricardo						
Comment	:	cold start old N3 ro						

Test Normality

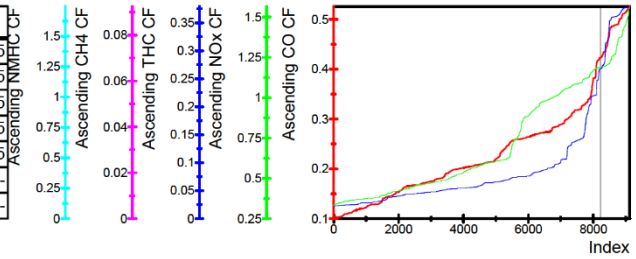
	Threshold		Valid Window	Criteria	Unit
Power	20 <		93.8	50	%

Valid Urban Window	---



CF Result

		90%	CF Criteria
CO		0.42	1.5
THC		0.27	1.5
NMHC	-	---	1.5
CH4	-	---	1.5
NOx		1.19	1.5
PM	-	---	---
PN	-	---	---



Window Info.

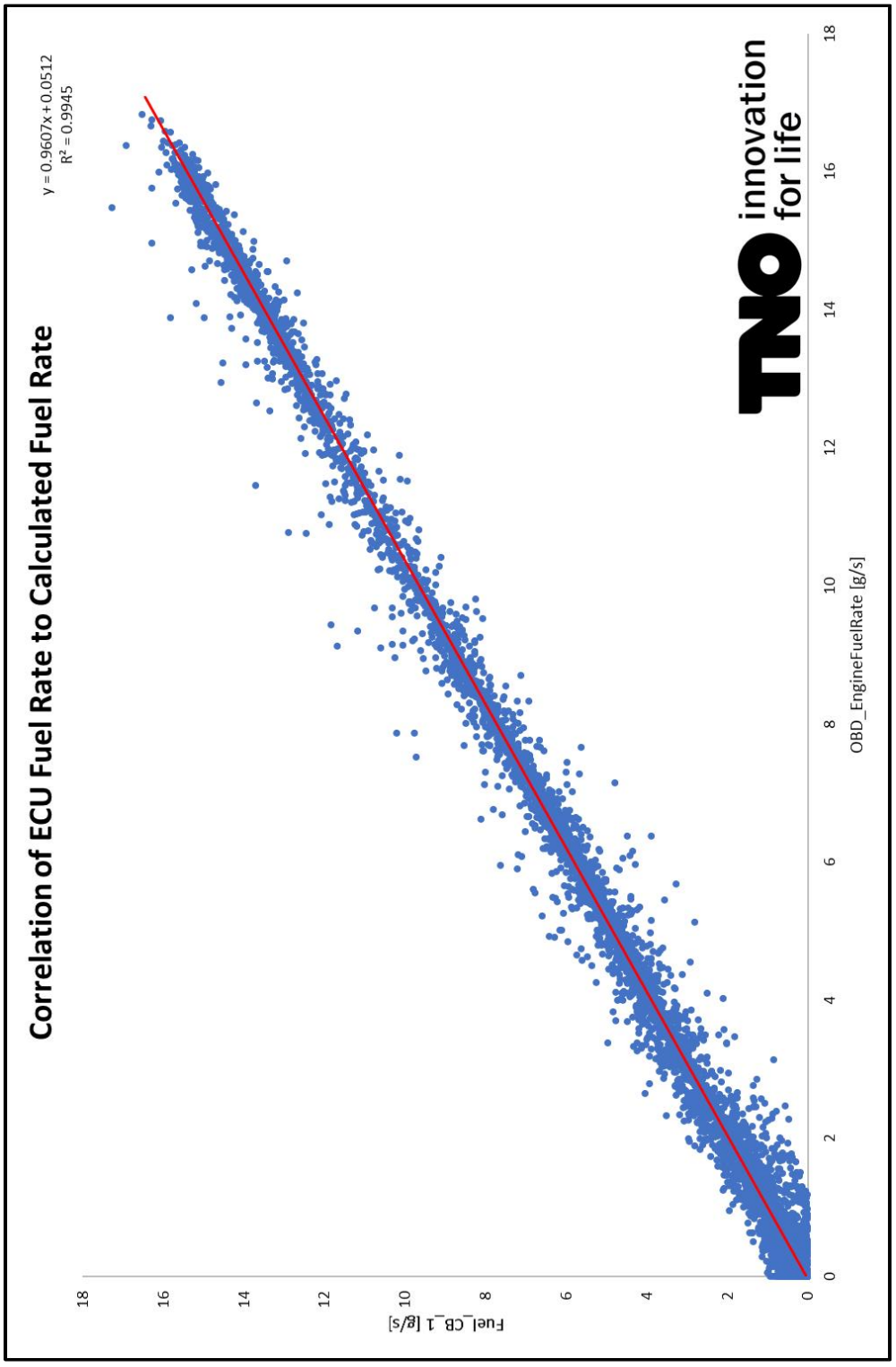
	Value	Unit
All Window Number	9732	#
Valid window Number	9129	#

OBS-ONE Post Processing v2.11.1

Template ID : WindowHDVWork_ENG.TDR

Report ID : 20180723111020_A

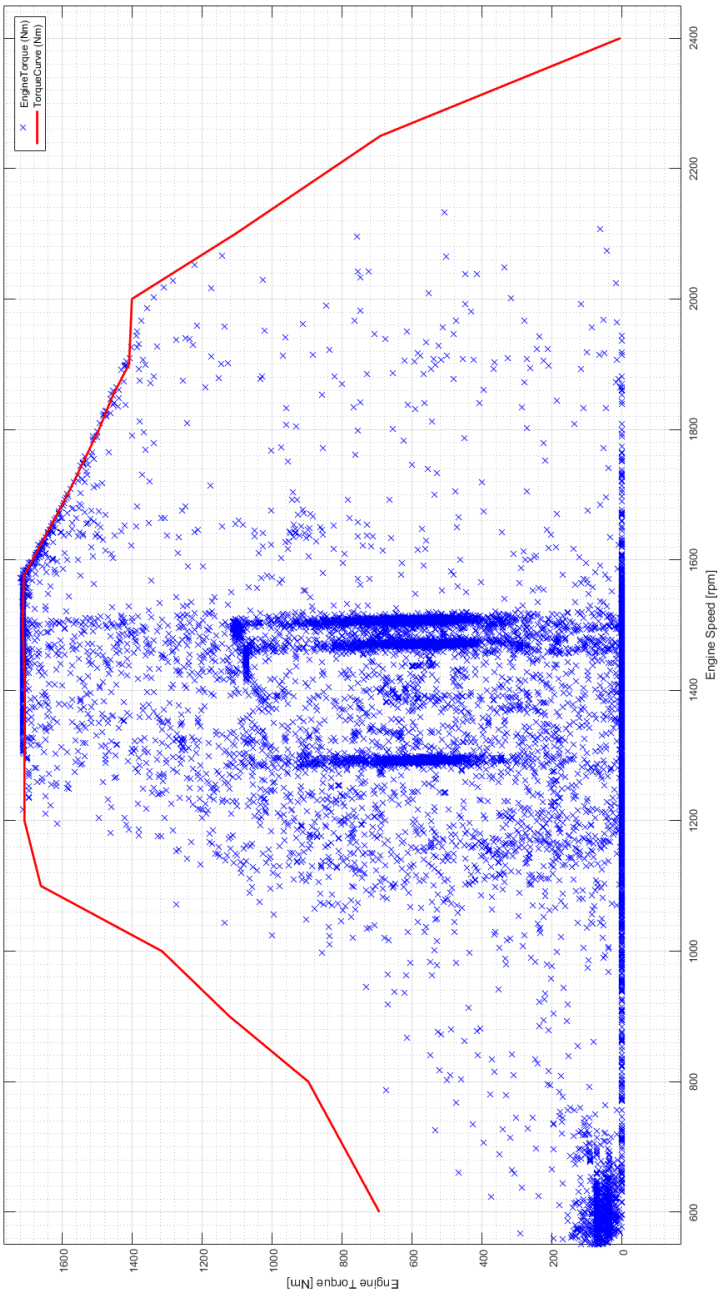
F.3 Fuel rate correlation



F.4 Drift check results

		Zero			Span		
	Channel	Pre	Post	Drift [%FS]	Pre	Post	Drift [%FS]
CO [vol%]	MeasData_1Hz/GA_COConc	-0.001145	0.000051	0.011960	3.008902	3.029144	0.202420
CO2 [vol%]	MeasData_1Hz/GA_CO2Conc	0.003553	0.011737	0.040920	15.966400	16.039930	0.367650
NO [ppm]	MeasData_1Hz/GA_NOConc	0.250000	0.000000	-0.008333	2496.210000	2618.550000	4.078000
NOx [ppm]	MeasData_1Hz/GA_NOxConc	0.540000	-0.070000	-0.020333	2504.540000	2519.150000	0.487000
THC [ppmC]	MeasData_1Hz/GA_THCConc	-0.810000	-2.150000	-0.013400	990.350000	986.830000	-0.035200

F.5 Full load curve



G Test 7

G.1 CO_2-based report

HORIBA
Automotive Test Systems

Window (HDV CO2-based) Report

Test

Test ID	:	117
Test Date	:	2018/08/01
Test Start	:	09:40:04
Test End	:	13:18:39
Driver	:	Ricardo
Comment	:	cold start old N3 ro

Vehicle

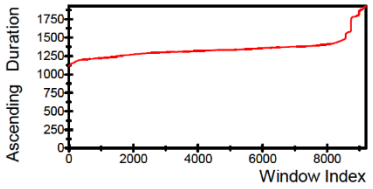
Vehicle Name	:	Iveco 28-BH
Vehicle Type	:	N3
Fuel Type	:	CNG
Description	:	Iveco Curso

Device

Cell Name	:	OBS-ONE
Cell Description	:	

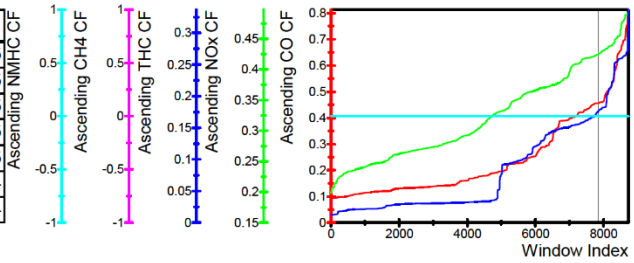
Test Normality

	Threshold		Valid Window	Criteria	Unit
Duration	≦ 20		94.9	50	%



CF Result

		90%	CF Criteria
CO		0.46	1.5
THC		0.18	1.5
NMHC	-	---	1.5
CH4	-	---	1.5
NOx		0.43	1.5
PM	-	---	---
PN	-	---	---



Window Info.

	Value	Unit
All Window Number	9206	#
Valid window Number	8734	#

OBS-ONE Post Processing v2.11.1

Template ID : WindowHDVCO2_ENG.TDR
Report ID : 20180801133445_A

G.2 Work-based report

HORIBA
Automotive Test Systems

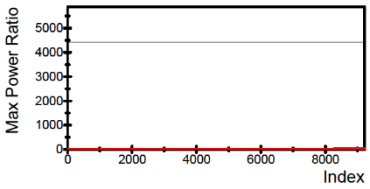
Window (HDV work-based) Report

Test			Vehicle			Device		
Test ID	:	117	Vehicle Name	:	Iveco 28-BH	Cell Name	:	OBS-ONE
Test Date	:	2018/08/01	Vehicle Type	:	N3	Cell Description	:	
Test Start	:	09:40:04	Fuel Type	:	CNG			
Test End	:	13:18:39	Description	:	Iveco Curso			
Driver	:	Ricardo						
Comment	:	cold start old N3 ro						

Test Normality

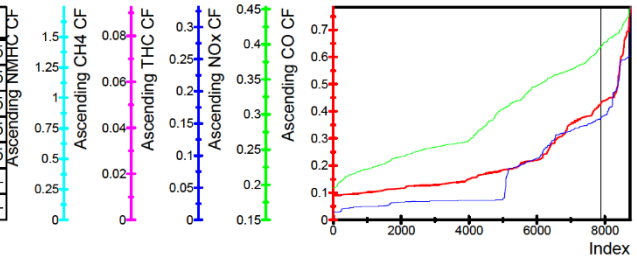
	Threshold		Valid Window	Criteria	Unit
Power	20 <		94.8	50	%

Valid Urban Window	---



CF Result

		90%	CF Criteria
CO		0.43	1.5
THC		0.16	1.5
NMHC	-	---	1.5
CH4	-	---	1.5
NOx		0.40	1.5
PM	-	---	---
PN	-	---	---



Window Info.

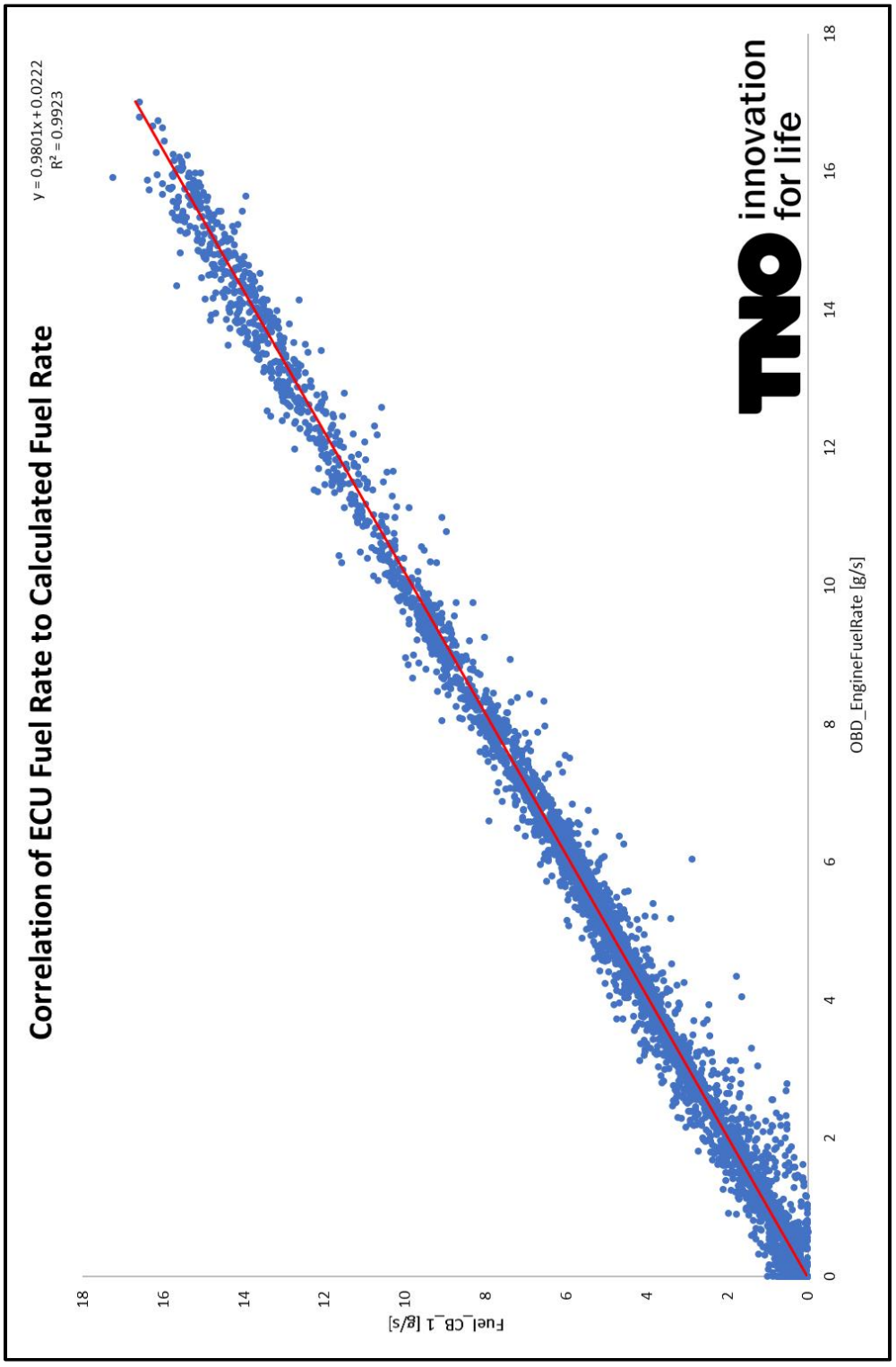
	Value	Unit
All Window Number	9222	#
Valid window Number	8747	#

OBS-ONE Post Processing v2.11.1

Template ID : WindowHDVWork_ENG.TDR

Report ID : 20180801133548_A

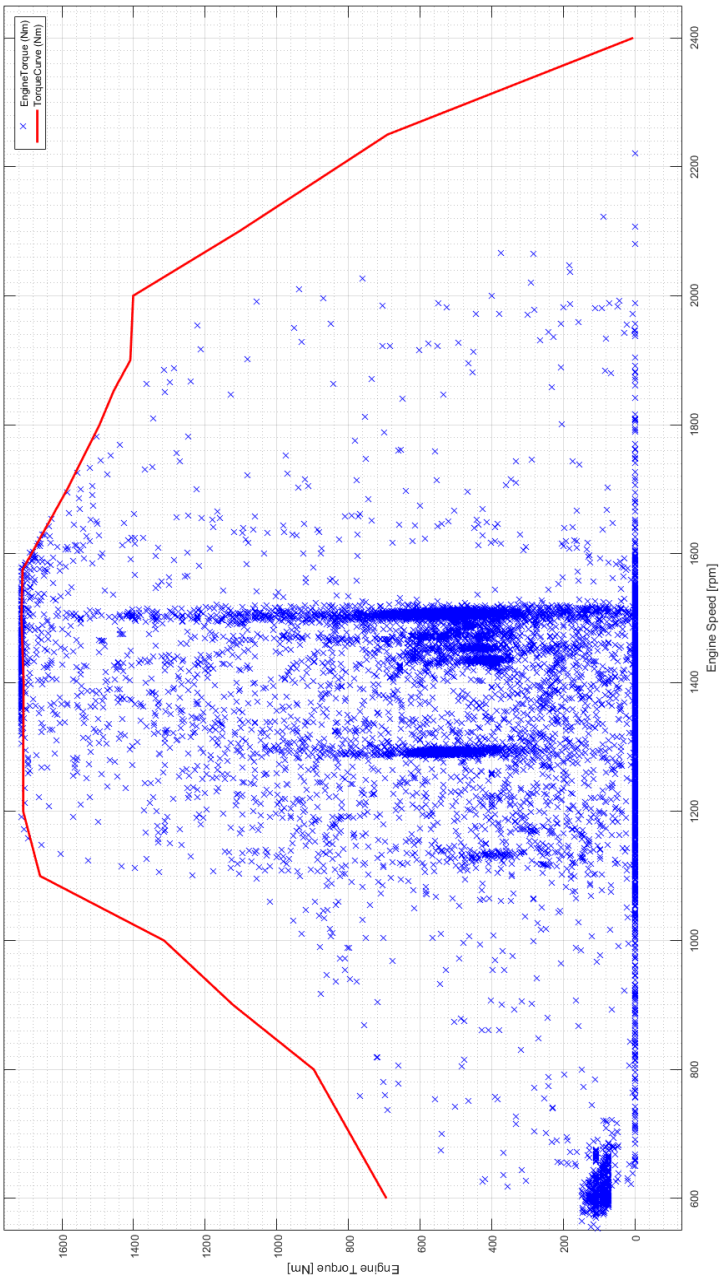
G.3 Fuel rate correlation



G.4 Drift check results

	Channel	Zero			Span		
		Pre	Post	Drift [%FS]	Pre	Post	Drift [%FS]
CO [vol%]	MeasData_1Hz/GA_COConc	-0.000475	0.000730	0.012050	3.005260	3.032402	0.271420
CO2 [vol%]	MeasData_1Hz/GA_CO2Conc	-0.002486	0.006624	0.045550	15.997670	16.053180	0.277550
NO [ppm]	MeasData_1Hz/GA_NOConc	0.030000	-0.440000	-0.015667	2503.220000	2446.950000	-1.875667
NOx [ppm]	MeasData_1Hz/GA_NOxConc	0.320000	-0.440000	-0.025333	2504.090000	2466.520000	-1.252333
THC [ppmC]	MeasData_1Hz/GA_THCConc	-0.760000	-5.660000	-0.049000	990.240000	974.290000	-0.159500

G.5 Full load curve



H Calibration reports OBS One

H.1 Pitot flow module PG7RUL35

CERTIFICATE OF CALIBRATION

ISSUED BY HORIBA UK LIMITED

DATE OF ISSUE 25 January 2018 CERTIFICATE NUMBER C10468

0767

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	**System Model:**	PF Channel 1
Site:	HORIBA	**Serial Number:**	HUK16080009
System:	HGS PG7RUL35	**Calibration Engineer:**	A.Cernych
Software Version:	2.0.6	**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

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 inH2O @ 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.

SCT 50.0 PF Calibration Certificate v1.1

CERTIFICATE OF CALIBRATION

UKAS Accredited Calibration Laboratory No. 0767

Certificate Number C10468

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 kPa (G)	Device kPa (G)	% Error (Rdg)	% Error (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 kPa (G)	Device kPa (G)	% Error (Rdg)	% Error (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 kPa (G)	Device kPa (G)	% Error (Rdg)	% Error (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 kPa (G)	Device kPa (G)	% Error (Rdg)	% Error (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	A1 1.0042E+00	
A2 1.94517E-04		A3 -1.1681E-04	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	A1 1.0027E+00	
A2 2.46788E-06		A3 6.1734E-05	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		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

SCT 50.0 PF Calibration Certificate v1.1

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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

Exaust 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
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
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

H.2 Pitot flow tube 170219GH

CERTIFICATE OF CALIBRATION

ISSUED BY HORIBA UK LIMITED

DATE OF ISSUE 09 March 2018 CERTIFICATE NUMBER C10550

HORIBA

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

Electronically controlled document

Customer :	**HORIBA Europe GmbH**		
Address:	Hans-Mess-Strasse 6, D-61440 OBERURSEL		
Customer Ref:	4510630666	**Item Calibrated:**	G Tube
Site:	HORIBA Offsite	**Item Serial Number:**	170219GH
System:	OBS ONE	**Item Range:**	0 to 45000 l/min
System Model:	Module V2	**Calibration Date:**	09 March 2018
Serial Number:	HUK17060032	**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 Orifi 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 which ever 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	1504102	C10016	24 August 2017
Furness FC560	1504102	15206	06 October 2017
PRT	1504105	C9356	28 March 2017
Temperature & Humidity	L2240759	U87178-17	07 July 2017

Pitot Calibration Coefficient	**K =**	**20760.194**
	A0 =	**0.000000E+00**
	A1 =	**1.040989E+00**
	A2 =	**-1.888184E-06**
	A3 =	**2.384487E-11**
	A4 =	**-6.523823E-16**

Ambient Conditions

Barometer kPa	Temperature °C	Humidity %
98.96	21.67	25.9

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. r^2 (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.

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a. Performance test results AS FOUND

Linearity		SAO flow		Pitot flow				Status
	SAO					Error		
	NO	[m3/min]	[l/min]	[m3/min]	[l/min]	[%RD]	[%FS]	
1	1	0.000	0.000	0.002	1.992		0.00	PASS
2	1	2.975	2974.670	2.794	2794.150	-6.07	-0.40	PASS
3	1	6.001	6001.391	5.915	5914.609	-1.45	-0.19	PASS
4	1	9.001	9001.259	8.787	8786.681	-2.38	-0.48	PASS
5	1	11.987	11986.851	11.695	11694.504	-2.44	-0.65	FAIL
6	1	15.004	15004.000	14.892	14891.763	-0.75	-0.25	PASS
7	1	17.727	17726.650	17.455	17455.160	-1.53	-0.60	PASS
8	1	21.181	21181.058	21.184	21184.371	0.02	0.01	PASS
9	1	24.103	24103.149	24.158	24158.459	0.23	0.12	PASS
10	1	27.122	27122.282	27.305	27304.992	0.67	0.41	PASS
11	1	29.940	29940.383	30.406	30406.378	1.56	1.04	PASS

AS FOUND

Pitot Calibration Coefficient

K = 20808.350
A0 = 0.000000E+00
A1 = 1.000000E+00
A2 = 0.000000E+00
A3 = 0.000000E+00
A4 = 0.000000E+00

b. Linearity

[a0](FS%) = 0.56 a1 = 1.0141 SEE (FS%) = 0.53 r^2 = 0.9997

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a. Performance test results AS LEFT

Linearity	SAO	SAO flow		Pitot flow		Error		Status
	NO	[m3/min]	[l/min]	[m3/min]	[l/min]	[%RD]	[%FS]	
1	1	0.000	0.000	0.002	1.883		0.00	PASS
2	1	3.303	3303.156	3.144	3144.013		-0.35	PASS
3	1	5.911	5911.340	5.942	5941.848	0.52	0.07	PASS
4	1	8.949	8949.016	8.871	8871.150	-0.87	-0.17	PASS
5	1	11.978	11978.424	11.923	11922.649	-0.47	-0.12	PASS
6	1	14.927	14926.970	14.764	14764.067	-1.09	-0.36	PASS
7	1	17.994	17993.549	17.919	17918.924	-0.41	-0.17	PASS
8	1	20.956	20955.606	20.854	20853.878	-0.49	-0.23	PASS
9	1	23.932	23931.679	23.731	23730.552	-0.84	-0.45	PASS
10	1	26.920	26919.506	26.660	26659.996	-0.96		PASS
11	1	30.076	30075.847	29.801	29800.662	-0.91		PASS

b. Linearity

[a0](FS%) = 0.01 a1 = 0.9922 SEE (FS%) = 0.38 r^2 = 1.0000

c. Noise (2.0 % of full scale or less)				STATUS
Component		Test Result		
Exh. Flow	ZERO	0.05	%FS	PASS
	SPAN	0.22	%FS	PASS

d. Repeatability (2.0% of reading scale or less)				STATUS
Component		Test Result		
Exh. Flow	SPAN	1.38	%RS	PASS

Test Data		Average Data		Standard deviation data	
		ZERO	SPAN	ZERO	SPAN
		[m3/min]	[m3/min]	[m3/min]	[m3/min]
1		-0.0104	10.1076	0.0080	0.2106
2		-0.0230	10.0531	0.0142	0.2508
3		-0.0318	9.9693	0.0146	0.1119
4		-0.0328	10.1193	0.0128	0.2098
5		-0.0234	10.1521	0.0141	0.1965
6		-0.0259	10.0886	0.0239	0.1244
7		-0.0140	10.1287	0.0112	0.2154
8		-0.0101	10.0330	0.0068	0.1360
9		-0.0190	10.0617	0.0114	0.2586
10		-0.0210	10.1296	0.0138	0.2282

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Calibration Data

SAO Flow		Pitot dP	Pitot T	Pitot P	Pitot Flow		
[m3/min]	[l/min]	[kPa]	[degC]	[kPa]	[m3/min]	[l/min]	[K=1000]
0.0000	0.0	0.000	19.81	98.89	0.0000	0.0	0.00000
2.9747	2974.7	0.022	19.86	98.88	2.7906	2790.6	0.13442
5.9014	6001.4	0.100	19.95	98.85	5.9127	5912.7	0.28481
9.0013	9001.3	0.220	20.20	98.83	8.7747	8774.7	0.42267
11.9869	11986.9	0.390	20.37	98.77	11.6787	11678.7	0.56255
15.0040	15004.0	0.631	20.46	98.72	14.8506	14850.6	0.71534
17.7267	17726.7	0.869	20.78	98.62	17.4051	17405.1	0.83839
21.1811	21181.1	1.282	20.91	98.58	21.1325	21132.5	1.01793
24.1031	24103.1	1.673	21.17	98.48	24.1213	24121.3	1.16190
27.1223	27122.3	2.136	21.17	98.32	27.2347	27234.7	1.31187
29.9404	29940.4	2.650	20.87	98.23	30.3369	30336.9	1.46130

SAO Calibration Data

No. 1

S/N	HII017		a0	9.4140252E-01	a3	7.3399193E-18
Throat	3.442	"	a1	6.0983919E-07	a4	-5.9595088E-24
Inlet	1000	"	a2	-3.2375236E-12	a5	0.0000000E+00

H.3 Checks performed on the different analysers

H.3.1 CO Linearize check

HORIBA
Automotive Test Systems

Analyzer Linearize Check

HGS No. : 63JNMN52	Start Time : 2018/06/25 10:42:50
Device : GA	End Time : 2018/06/25 11:27:25
Line : Tailpipe	Test Status : Pass

Analyzer

Component : CO	
Range : 10.0 vol%	

Check Gas

Top Gas Supply Port : Span	
Top Gas Concentration : 9.47 vol%	

Checker

Control Type : GDC-ONE	

Test Result

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

Curve Setting

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

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 : 102.4 kPa	
Reference Temperature : 25.90 deg C	
Reference Humidity : 46.63 %	
Ref. Temp. (Humidity) : 25.90 deg C	

Curve Coefficient

A0	-9.874196E+00
A1	1.325990E-01
A2	5.047525E-06
A3	2.145788E-11
A4	-1.422080E-16

Z/S Coefficient

A	9.942434E-01
B	2.230692E+02

Current Data Set				Current Curve		
Point #	Cut [%]	Gen. Conc. [vol%]	Z/S Adj. Counts	Measured Conc. [vol%]	Error [%]	Status
1	100.0	9.470	121518	9.470	0.00(PT)	Pass
2	90.0	8.523	114387	8.586	0.74(PT)	Pass
3	80.0	7.576	106789	7.658	1.08(PT)	Pass
4	70.0	6.629	98875	6.717	1.33(PT)	Pass
5	60.0	5.682	90501	5.762	1.41(PT)	Pass
6	50.0	4.735	81550	4.800	1.36(PT)	Pass
7	40.0	3.788	71764	3.829	1.08(PT)	Pass
8	36.0	3.409	67580	3.443	1.00(PT)	Pass
9	32.0	3.030	63188	3.058	0.92(PT)	Pass
10	30.0	2.841	60875	2.864	0.81(PT)	Pass
11	28.0	2.652	58493	2.670	0.70(PT)	Pass
12	24.0	2.273	53546	2.288	0.68(PT)	Pass
13	20.0	1.894	48122	1.902	0.45(PT)	Pass
14	18.0	1.705	45229	1.711	0.37(PT)	Pass
15	16.0	1.515	42163	1.519	0.25(PT)	Pass
16	14.0	1.326	38919	1.328	0.02(FS)	Pass

Test No. 168 1 / 2 AIA-03H-X0C64RX2

HORIBA
Automotive Test Systems

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	1.136	35451	1.138	0.02(FS)	Pass
18	10.0	0.947	31697	0.949	0.02(FS)	Pass
19	9.0	0.852	29777	0.859	0.06(FS)	Pass
20	8.0	0.758	27654	0.764	0.06(FS)	Pass
21	7.0	0.663	25365	0.668	0.05(FS)	Pass
22	6.0	0.568	22946	0.573	0.05(FS)	Pass
23	5.0	0.474	20293	0.477	0.04(FS)	Pass
24	4.0	0.379	17395	0.382	0.03(FS)	Pass
25	3.6	0.341	16128	0.343	0.02(FS)	Pass
26	3.2	0.303	14794	0.304	0.01(FS)	Pass
27	3.0	0.284	14094	0.284	0.00(FS)	Pass
28	2.8	0.265	13393	0.265	0.00(FS)	Pass
29	2.4	0.227	11893	0.226	-0.01(FS)	Pass
30	2.0	0.189	10276	0.187	-0.02(FS)	Pass
31	1.8	0.170	9425	0.168	-0.03(FS)	Pass
32	1.6	0.152	8536	0.148	-0.03(FS)	Pass
33	1.4	0.133	7635	0.129	-0.03(FS)	Pass
34	1.2	0.114	6652	0.109	-0.04(FS)	Pass
35	1.0	0.095	5626	0.090	-0.05(FS)	Pass
36	0.8	0.076	4612	0.072	-0.04(FS)	Pass
37	0.6	0.057	3516	0.053	-0.04(FS)	Pass
38	0.4	0.038	2340	0.035	-0.03(FS)	Pass
39	0.2	0.019	1080	0.017	-0.02(FS)	Pass
40	0.0	0.000	-170	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

Test No. 168 2 / 2 AIA-03H-X0C64RX2

H.3.2 CO2 Linearize check

HORIBA
Automotive Test Systems

Analyzer Linearize Check

HGS No. : 63JNMN52	Start Time : 2018/06/25 9:42:44
Device : GA	End Time : 2018/06/25 10:33:59
Line : Tailpipe	Test Status : Pass

Analyzer

Component : CO2	
Range : 20.0 vol%	

Test Result

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

Check Gas

Top Gas Supply Port : Span	
Top Gas Concentration : 15.18 vol%	

Checker

Control Type : GDC-ONE

Curve Setting

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

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 : 102.4 kPa	
Reference Temperature : 25.89 deg C	
Reference Humidity : 46.70 %	
Ref. Temp. (Humidity) : 25.89 deg C	

Curve Coefficient

A0	-5.216313E+01
A1	2.787561E-01
A2	1.631171E-06
A3	-1.665571E-12
A4	1.714194E-18

Z/S Coefficient

A	9.992769E-01
B	-1.139555E+02

Current Data Set				Current Curve		
Point #	Cut [%]	Gen. Conc. [vol%]	Z/S Adj. Counts	Measured Conc. [vol%]	Error [%]	Status
1	100.0	15.18	254860	15.18	0.01(PT)	Pass
2	90.0	13.66	237300	13.68	0.14(PT)	Pass
3	80.0	12.14	218857	12.17	0.23(PT)	Pass
4	70.0	10.63	199522	10.66	0.35(PT)	Pass
5	60.0	9.108	179279	9.164	0.62(PT)	Pass
6	50.0	7.590	157556	7.650	0.79(PT)	Pass
7	40.0	6.072	134190	6.134	1.01(PT)	Pass
8	36.0	5.465	124291	5.527	1.15(PT)	Pass
9	32.0	4.858	113917	4.916	1.20(PT)	Pass
10	30.0	4.554	108580	4.611	1.26(PT)	Pass
11	28.0	4.250	102979	4.298	1.13(PT)	Pass
12	24.0	3.643	91724	3.693	1.36(PT)	Pass
13	20.0	3.036	79570	3.073	1.23(PT)	Pass
14	18.0	2.732	73098	2.759	0.13(FS)	Pass
15	16.0	2.429	66394	2.444	0.08(FS)	Pass
16	14.0	2.125	59548	2.135	0.05(FS)	Pass

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HORIBA
Automotive Test Systems

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	1.822	52504	1.829	0.04(FS)	Pass
18	10.0	1.518	44990	1.519	0.00(FS)	Pass
19	9.0	1.366	41245	1.369	0.02(FS)	Pass
20	8.0	1.214	37285	1.216	0.01(FS)	Pass
21	7.0	1.063	33338	1.068	0.03(FS)	Pass
22	6.0	0.911	29162	0.915	0.02(FS)	Pass
23	5.0	0.759	24849	0.764	0.02(FS)	Pass
24	4.0	0.607	20386	0.612	0.02(FS)	Pass
25	3.6	0.546	18641	0.555	0.04(FS)	Pass
26	3.2	0.486	16715	0.492	0.03(FS)	Pass
27	3.0	0.455	15882	0.465	0.05(FS)	Pass
28	2.8	0.425	14917	0.435	0.05(FS)	Pass
29	2.4	0.364	12975	0.374	0.05(FS)	Pass
30	2.0	0.304	11020	0.314	0.05(FS)	Pass
31	1.8	0.273	9949	0.281	0.04(FS)	Pass
32	1.6	0.243	8849	0.248	0.03(FS)	Pass
33	1.4	0.213	7937	0.221	0.04(FS)	Pass
34	1.2	0.182	6919	0.191	0.05(FS)	Pass
35	1.0	0.152	5828	0.160	0.04(FS)	Pass
36	0.8	0.121	4718	0.128	0.03(FS)	Pass
37	0.6	0.091	3604	0.096	0.03(FS)	Pass
38	0.4	0.061	2597	0.068	0.04(FS)	Pass
39	0.2	0.030	1337	0.033	0.01(FS)	Pass
40	0.0	0.000	130	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

Test No. 167 2 / 2 AIA-03H-X0C64RX2

H.3.3 NO Linearize check

HORIBA
Automotive Test Systems

Analyzer Linearize Check

HGS No. : 63JNMN52	Start Time : 2018/06/25 12:17:48
Device : GA	End Time : 2018/06/25 13:02:12
Line : Tailpipe	Test Status : Pass

Analyzer

Component : NO	
Range : 3000 ppm	

Test Result

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

Check Gas

Top Gas Supply Port : Span	
Top Gas Concentration : 2510 ppm	

Checker

Control Type : GDC-ONE

Curve Setting

Poly Order : 2nd	
Fitting Type : Weights	
Adjust 0% 100% : Active	

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 : 102.4 kPa	
Reference Temperature : 32.56 deg C	
Reference Humidity : 46.79 %	
Ref. Temp. (Humidity) : 25.78 deg C	

Curve Coefficient

A0	-1.175100E+00
A1	3.507678E-03
A2	4.711025E-11
A3	0.000000E+00
A4	0.000000E+00

Z/S Coefficient

A	9.798796E-01
B	-4.169539E+02

Current Data Set				Current Curve		
Point #	Cut [%]	Gen. Conc. [ppm]	Z/S Adj. Counts	Measured Conc. [ppm]	Error [%]	Status
1	100.0	2510	694874	2510	0.00(PT)	Pass
2	90.0	2259	629413	2271	0.55(PT)	Pass
3	80.0	2008	561266	2024	0.77(PT)	Pass
4	70.0	1757	492771	1774	0.96(PT)	Pass
5	60.0	1506	424030	1525	1.27(PT)	Pass
6	50.0	1255	353945	1271	1.31(PT)	Pass
7	40.0	1004	283827	1018	1.40(PT)	Pass
8	36.0	903.6	255455	915.8	1.35(PT)	Pass
9	32.0	803.2	227232	814.3	1.38(PT)	Pass
10	30.0	753.0	213052	763.1	1.35(PT)	Pass
11	28.0	702.8	198776	711.8	1.28(PT)	Pass
12	24.0	602.4	170576	610.6	1.36(PT)	Pass
13	20.0	502.0	141907	507.9	1.17(PT)	Pass
14	18.0	451.8	127567	456.3	1.00(PT)	Pass
15	16.0	401.6	113300	405.2	0.12(FS)	Pass
16	14.0	351.4	98950	353.5	0.07(FS)	Pass

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HORIBA
Automotive Test Systems

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	84622	302.1	0.03(FS)	Pass
18	10.0	251.0	70464	251.3	0.01(FS)	Pass
19	9.0	225.9	63657	226.9	0.03(FS)	Pass
20	8.0	200.8	56548	201.5	0.02(FS)	Pass
21	7.0	175.7	49456	176.0	0.01(FS)	Pass
22	6.0	150.6	42348	150.4	-0.01(FS)	Pass
23	5.0	125.5	35301	125.2	-0.01(FS)	Pass
24	4.0	100.4	28233	99.87	-0.02(FS)	Pass
25	3.6	90.36	25418	89.76	-0.02(FS)	Pass
26	3.2	80.32	22582	79.60	-0.02(FS)	Pass
27	3.0	75.30	21189	74.62	-0.02(FS)	Pass
28	2.8	70.28	19778	69.55	-0.02(FS)	Pass
29	2.4	60.24	16968	59.53	-0.02(FS)	Pass
30	2.0	50.20	14158	49.47	-0.02(FS)	Pass
31	1.8	45.18	12766	44.51	-0.02(FS)	Pass
32	1.6	40.16	11382	39.57	-0.02(FS)	Pass
33	1.4	35.14	9967	34.50	-0.02(FS)	Pass
34	1.2	30.12	8574	29.51	-0.02(FS)	Pass
35	1.0	25.10	7151	24.42	-0.02(FS)	Pass
36	0.8	20.08	5800	19.58	-0.02(FS)	Pass
37	0.6	15.06	4409	14.59	-0.02(FS)	Pass
38	0.4	10.04	3033	9.667	-0.01(FS)	Pass
39	0.2	5.020	1666	4.767	-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

Test No. 170 2 / 2 CLA-02HSV-XOC64RX2

H.3.4 NO_x Linearize check

HORIBA
Automotive Test Systems

Analyzer Linearize Check

HGS No. : 63JNMN52	Start Time : 2018/06/25 13:02:47
Device : GA	End Time : 2018/06/25 14:34:17
Line : Tailpipe	Test Status : Pass

Analyzer

Component : NOx
Range : 3000 ppm

Test Result

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

Check Gas

Top Gas Supply Port : Span
Top Gas Concentration : 2510 ppm

Checker

Control Type : GDC-ONE

Curve Setting

Poly Order : 2nd
Fitting Type : Weights
Adjust 0% 100% : Active

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 : 102.4 kPa
Reference Temperature : 32.55 deg C
Reference Humidity : 45.58 %
Ref. Temp. (Humidity) : 25.80 deg C

Curve Coefficient

A0	3.833296E-01
A1	3.595957E-03
A2	-4.843976E-11
A3	0.000000E+00
A4	0.000000E+00

Z/S Coefficient

A	9.876330E-01
B	-9.818909E+02

Current Data Set				Current Curve		
Point #	Cut [%]	Gen. Conc. [ppm]	Z/S Adj. Counts	Measured Conc. [ppm]	Error [%]	Status
1	100.0	2510	691215	2510	0.00(PT)	Pass
2	90.0	2259	623707	2270	0.48(PT)	Pass
3	80.0	2008	554862	2020	0.62(PT)	Pass
4	70.0	1757	485957	1770	0.72(PT)	Pass
5	60.0	1506	417045	1520	0.92(PT)	Pass
6	50.0	1255	347733	1268	1.02(PT)	Pass
7	40.0	1004	278410	1016	1.21(PT)	Pass
8	36.0	903.6	250406	913.9	1.14(PT)	Pass
9	32.0	803.2	222425	812.3	1.13(PT)	Pass
10	30.0	753.0	208462	762.5	1.26(PT)	Pass
11	28.0	702.8	194550	712.0	1.31(PT)	Pass
12	24.0	602.4	166804	610.1	1.28(PT)	Pass
13	20.0	502.0	138714	507.3	1.06(PT)	Pass
14	18.0	451.8	124672	455.8	0.89(PT)	Pass
15	16.0	401.6	110597	404.4	0.09(FS)	Pass
16	14.0	351.4	96501	353.3	0.06(FS)	Pass

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HORIBA
Automotive Test Systems

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	82445	302.0	0.03(FS)	Pass
18	10.0	251.0	68559	251.3	0.01(FS)	Pass
19	9.0	225.9	61898	227.0	0.04(FS)	Pass
20	8.0	200.8	54930	201.4	0.02(FS)	Pass
21	7.0	175.7	47976	175.8	0.00(FS)	Pass
22	6.0	150.6	41077	150.4	-0.01(FS)	Pass
23	5.0	125.5	34160	125.2	-0.01(FS)	Pass
24	4.0	100.4	27253	99.95	-0.02(FS)	Pass
25	3.6	90.36	24499	89.92	-0.01(FS)	Pass
26	3.2	80.32	21777	80.03	-0.01(FS)	Pass
27	3.0	75.30	20383	74.99	-0.01(FS)	Pass
28	2.8	70.28	19007	69.93	-0.01(FS)	Pass
29	2.4	60.24	16262	59.85	-0.01(FS)	Pass
30	2.0	50.20	13537	49.85	-0.01(FS)	Pass
31	1.8	45.18	12176	44.83	-0.01(FS)	Pass
32	1.6	40.16	10795	39.78	-0.01(FS)	Pass
33	1.4	35.14	9432	34.81	-0.01(FS)	Pass
34	1.2	30.12	8062	29.80	-0.01(FS)	Pass
35	1.0	25.10	6680	24.76	-0.01(FS)	Pass
36	0.8	20.08	5333	19.84	-0.01(FS)	Pass
37	0.6	15.06	3978	14.88	-0.01(FS)	Pass
38	0.4	10.04	2616	9.918	0.00(FS)	Pass
39	0.2	5.020	1246	4.925	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

Test No. 171 2 / 2 CLA-02HSV-XOC64RX2

H.3.5 NO_x Converter efficiency check

HORIBA
Automotive Test Systems

NOx Converter Efficiency Check

HGS No. : 63JNMN52	Start Time : 2018/06/25 15:04:02
Device : GA	End Time : 2018/06/25 15:30:28
Line : Tailpipe	Test Status : Pass

Analyzer

Component : NOx	
Range : 3000 ppm	

Checker

Control Type : GDC-ONE	
Ozone Initial Counts :	240
Ozone Step Counts :	20
Ozone Final Counts :	240

Check Gas

Gas Supply Port : Span	
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		187.5
Step-2(a)	90	ON	OFF	NO	Approx. 169	171.8
Step-3(b)	300	ON	ON	NO	19 < Conc. < 37	21.35
Step-4(c)	300	ON	ON	NOx		173.3
Step-5(d)	90	ON	OFF	NOx		176.1
Step-6(B)	90	OFF	OFF	NOx		191.3

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	98.09	Pass
Percent NO2 in NO $= \frac{NO(B)-NO(A)}{NO(A)}\times 100$	-1.0 - 5.0	2.04	Pass

Comment

Test No. 172 1 / 1 CLA-02HSV-XOC64RX2

H.3.6 THC Linearize check

HORIBA
Automotive Test Systems

Analyzer Linearize Check

HGS No. : 63JNMN52	Start Time : 2018/06/25 11:33:14
Device : GA	End Time : 2018/06/25 11:55:02
Line : Tailpipe	Test Status : Pass

Analyzer

Component : THC	
Range : 10000 ppmC	

Test Result

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

Check Gas

Top Gas Supply Port : Span	
Top Gas Concentration : 938 ppmC	

Checker

Control Type : GDC-ONE

Curve Setting

Poly Order : 2nd	
Fitting Type : Weights	
Adjust 0% 100% : Active	

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 : 102.4 kPa	
Reference Temperature : 25.85 deg C	
Reference Humidity : 47.30 %	
Ref. Temp. (Humidity) : 25.85 deg C	

Curve Coefficient

A0	-7.852548E-01
A1	1.071870E-02
A2	4.981597E-10
A3	0.000000E+00
A4	0.000000E+00

Z/S Coefficient

A	1.035095E+00
B	2.919386E+01

Current Data Set				Current Curve		
Point #	Cut [%]	Gen. Conc. [ppmC]	Z/S Adj. Counts	Measured Conc. [ppmC]	Error [%]	Status
1	100.0	938.0	90661	938.0	0.00(FS)	Pass
2	90.0	844.2	81538	842.7	-0.01(FS)	Pass
3	80.0	750.4	72554	749.9	-0.01(FS)	Pass
4	70.0	656.6	63619	657.1	0.01(FS)	Pass
5	60.0	562.8	54769	565.4	0.03(FS)	Pass
6	50.0	469.0	45649	470.9	0.02(FS)	Pass
7	45.0	422.1	41116	423.9	0.02(FS)	Pass
8	40.0	375.2	36698	378.2	0.03(FS)	Pass
9	35.0	328.3	32191	331.6	0.03(FS)	Pass
10	30.0	281.4	27650	284.6	0.03(FS)	Pass
11	25.0	234.5	23064	237.2	0.03(FS)	Pass
12	20.0	187.6	18473	189.8	0.02(FS)	Pass
13	15.0	140.7	13829	141.8	0.01(FS)	Pass
14	10.0	93.80	9226	94.29	0.00(FS)	Pass
15	5.0	46.90	4648	47.04	0.00(FS)	Pass
16	0.0	0.000	88	0.000	0.00(FS)	Pass

Test No. 169 1 / 2 FIA-01HDSV-RMYLEWK4

HORIBA
Automotive Test Systems

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

Test No. 169 2 / 2 FIA-01HDSV-RMYLEWK4

H.3.7 THC Hang-up check

HORIBA
Automotive Test Systems

Hang-up Check

HGS No. : 63JNMN52	Start Time : 2018/06/25 15:50:22
Device : GA	End Time : 2018/06/25 15:56:41
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	0.33 ppmC

Test Result

Item		Criteria	Result	Status
Hang-up	≦	2.0 ppmC	0.33 ppmC	Pass

ID : 6 1 / 1

H.3.8 V-leak check (Span Gas)

HORIBA
Automotive Test Systems

VLeak Check (Span Gas)

HGS No. :	63JNMN52	Start Time :	2018/06/25 15:37:19
Device :	GA	End Time :	2018/06/25 15:45:55
Line :	Tailpipe	Test Status :	Pass

Analyzer

	Hot Sample	Cold Sample
Component :	CO	---
Range :	10.0 vol%	---
Concentration :	9.47 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 :	9.48 vol%	---
Hang-up Concentration :	---	---

Step	Time	Measured Conc.
Overflow Span (Hot)	60 s	9.46 vol%
Overflow Span (Cold)	---	---

Test Result

Item		Criteria	Result	Status
VLeak = $\frac{Span-(Overflow\ Span-Hang-up)}{Span}\times 100$	|VLeak (Hot)| ≦	0.5 %	0.18 %	Pass
	|VLeak (Cold)| ≦	---	---	---

ID : 12 1 / 1

I Details of the gases used

I.1 Span gas

Cilinder n° 223524

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. / *N° du certificat*	**2017014687**
Auftraggeber / Client	**Linde Gas Benelux B.V.** **Kanaalweg 4e** **6951 KJ Dieren**
Probenahme / *Prélèvement*	Aus Behälter, nach Abfüllung / *Dans le récipient, après remplissage de celui-ci* — N° **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*	Prüfergebnis / *Résultats d'analyse*	Messunsicherheit / *Incertitude de mesure*
C3H8	330.0 ppm mol	330.1 ppm mol	1.00 % rel
NO	2'500.0 ppm mol	2'503.4 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 multipiziert 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 / *Température de stockage min.:* - 10°
min. Verwendungsdruck / *Pression d'utilisation min.:* 5 bar
empf. Verwendungstemp. / *Temperature d'utilisation conseillée:* 10 - 30°C

Datum / *Date:* **04.12.2017**

Für die Messung /*pour la mesure:* **DHUBER**
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)*

209818 / Rev.I.:1
Erstellt/geändert 27.11.2009
Ersetzt: 209818/SU/06.2008

Seite 1 von 1

I.2 Hydrogen/helium

THE LINDE GROUP

Linde

Pagina: 1 van 1

Ordernummer:	78700/7
Cilindernummer:	361332
Cilindereigenaar:	Linde Cilinder
Cilinderinhoud [l]:	10

Analyse Certificaat
ISO 6141

Componenten	Analyse
Waterstof	40 vol %
C_xH_y	<1 vpm
Helium	Rest

Vuldruk [15°C]:	ca. 150 bar	Min. opslag temperatuur:	Niet van toepassing
Gasvolume:	1500 l	Min. restdruk:	5 bar
Stabiliteit:	36 maanden	Aanbevolen gebruikstemperatuur:	10°C - 30°C
Aansluiting	LU1		
Materiaalcode:	3260110		

Analysedatum: 17-11-2017 Analist: Jeffry Brugman

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

I.3 Synthetic air

› Produktdatenblatt

Synthetische Luft KW-frei 20 % Sauerstoff, Rest Stickst

Zusammensetzung:

Sauerstoff (O_2)	20 %
Stickstoff (N_2)	Rest

Nebenbestandteile, ppm:

H_2O	≤2
CO_2	≤1
CO	≤1
KW	≤0,1
NO_x	≤0,1

Angaben sind als ideale Volumenanteile (= Molanteile) zu verstehen

Herstell-toleranz (relativ) | Analysen-genauigkeit (relativ) | Stabilität (Monate)

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

Lieferarten:

Stahlflasche

Rauminhalt, [Liter]	Füllmenge, ca. [m³]	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. [m³]	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 Gebinde auf Anfrage

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

Kennzeichnung:

Flaschenschulterfarbe/ Umlaufender Farbstreifen bei Bündeln	Leuchtendes Grün RAL 6018
Aufkleber:	mit Angaben zur Zusammensetzung
Ventilanschluss:	G 3/4 (DIN 477 Nr. 9), Messing M 19 x 1,5 LH (DIN 477 Nr. 14), Messing

Linde AG
Linde Gases Division, Seitnerstr. 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 2 von 2

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.

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Änderungen vorbehalten
Stand 15.10.2012

J Vehicle mass receipt

J.1 55% payload

Test 1 to 4

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

Bonnr: 12486

Datum: 27.06.2018

Voertuig: TESTVOERTUIG
Testvoertuig

Klant: 28020
TNO
POSTBUS 96829
2509JE DEN HAAG

Transp.: 28020
TNO
POSTBUS 96829
2509JE DEN HAAG

Produkt :

Weging1 : 30.860 kg 14:57 17260
Weging2 : 30.860 kg 14:57 17260

Netto: 0 kg

*** Pfister Weegtechniek ***

J.2 10% payload

Test 5

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

Bonnr: 12554

Datum: 13.07.2018

Voertuig: TESTVOERTUIG
Testvoertuig

Klant: 28020
TNO
POSTBUS 96829
2509JE DEN HAAG

Transp.: 28020
TNO
POSTBUS 96829
2509JE DEN HAAG

Produkt :

Weging1 : 18.060 kg 14:14 17342
Weging2 : 18.060 kg 14:14 17342

Netto: 0 kg

*** Pfister Weegtechniek ***

J.3 100% payload

Test 6

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

Bonnr: 12566

Datum: 18.07.2018

Voertuig: TESTVOERTUIG
Testvoertuig

Klant: 28020
TNO
POSTBUS 96829
2509JE DEN HAAG

Transp.: 28020
TNO
POSTBUS 96829
2509JE DEN HAAG

Produkt :

Weging1 : 43.920 kg 13:05 17359
Weging2 : 43.920 kg 13:05 17359

Netto: 0 kg

*** Pfister Weegtechniek ***

J.4 55% payload

Test 7

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

Bonnr: 12620

Datum: 01.08.2018

Voertuig: TESTVOERTUIG
Testvoertuig

Klant: 28020
TNO
POSTBUS 96829
2509JE DEN HAAG

Transp.: 28020
TNO
POSTBUS 96829
2509JE DEN HAAG

Produkt :

Weging1 : 30.660 kg 13:28 17430
Weging2 : 30.660 kg 13:28 17430

Netto: 0 kg

*** Pfister Weegtechniek ***