Short documentation No. LX17549.3/01

via internal emission measurements in the exhaust gas of an internal combustion engine (MTU 12V 396 TC13) when using different fuels for DB Cargo AG in Tilburg (Niederlande)

Operator:

DB Cargo AG
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Short documentation on the performance of emission measurements

Name of the according to § 29b BImSchG notified location:	ZECH Umweltanalytik GmbH
Time limit of the announcement according to § 29b BImSchG:	03.02.2024 for the group I No. 1: G, P, Sp and IV: P
Number short documentation:	LX17549.3/01 Date: 05.05.2023
Client:	DB CargoAG Rheinstraße 2 55116 Mainz
Location:	Motorenprüfstand DSP Niederlande Ledeboerstraat 47 5048 AC Tilburg
Type of measurement:	Measurement to determine emission changes when using different fuels
Date of measurement:	21.03. and 22.03.2023
Order No.:	0014 / VE 2 / 11948687
Order date:	24.02.2023
Scope short documentation:	10 pages

Content

1.) Description

Task

The following components were measured in the exhaust gas of the internal combustion engine using three different fuels (diesel, HVO100 and HVO50) and three load conditions (speed level 15, speed level 9 and speed level 1), each with 6 quarter-hourly mean values (2 per load condition):

- Carbon monoxide (CO)
- Nitrogen oxides (NOX)
- carbon dioxide (CO2)
- total organic carbon (HC)
- total dust

These measurements are intended to determine the change in emission behavior when using three different fuels and three power states.

Combustion engine system

The following table shows the technical data of the combustion engine.

Table 1 Technical data engine

Manufacturer	MTU
Type	12V 396
Engine number	5582577
Year of manufacture	1992
Fuels	Diesel / HVO100 / HVO50

Device for the reduction of emissions

Facilities for mitigating emissions are not present in this test setup.

2.) Measurement method

Table 2 Overview measuring method

Volume flow	Calculation of the volumetric flow rate via the pressure conditions in the exhaust gas duct, the cross-sectional area of the exhaust gas duct and the exhaust gas density; in accordance with DIN EN ISO 16911, Sheet 1
Carbon monoxide (CO)	Determination of the mass concentration of carbon monoxide (CO) - reference measurement method - non-dispersive infrared spectrometry; according to DIN EN 15058
Nitrogen oxides (NOX)	Determination of the mass concentration of nitrogen oxides (NOX) - reference measurement method - chemiluminescence; according to DIN EN 14792
carbon dioxide (CO2)	Determination of the volume concentration of carbon dioxide (CO2) - non-dispersive infrared spectrometry (NDIR)
total organic carbon (HC)	Determination of the mass concentration of total organic carbon (HC) - flame ionization detector; according to
Total dust	Determination of the mass concentration of total dust - gravimetric method; according to VDI guideline 2066, sheet 1 resp. DIN EN 13284

3.) Operating status of the plant during the measurement

The internal combustion engine under consideration can be operated with fifteen speed levels. During the emission measurements, 3 driving stages were examined. In Table 3, the examined driving stages are assigned to the sampling times and generated powers.

Table 3 Operating data when used with diesel and HVO

Date		21.03.2023		
Fuel		Diesel		
Time	[hh:mm]	10:52 - 11:23	11:37 - 12:08	12:16 - 12:47
Driving stage		15	9	1
Power	[kW]	1.185	303	59
Date		21.03.2023		
Fuel		HVO 100		
Time	[hh:mm]	15:44 - 16:15	16:27 - 16:58	17:06 - 17:37
Driving stage		15	9	1
Power	[kW]	1.131	303	59
Date		22.03.2023		
Fuel		HVO 50		
Time	[hh:mm]	09:57 – 10:28	10:46 – 11:17	11:25 – 11:56
Driving stage		15	9	1
Power	[kW]	1.171	303	59

4.) Compilation of the measurement results

The following tables show the results of the measurements. Unless otherwise indicated, all data refer to standard conditions (273 K, 1,013 hPa, dry exhaust gas). All results are given without expanded measurement uncertainty.

Discrepancies between results and calculated values are due to the application of rounding rules and therefore do not constitute an error.

Table 4 Volume flow results

Driving stage		**15**	**9**	**1**
Volume flow (diesel)	[m^3/h]	4.749	1.506	678
Volume flow (HVO 100)	[m^3/h]	4.685	1.574	669
Volume flow (HVO 150)	[m^3/h]	4.686	1.542	687

Table 5 Carbon monoxide (CO) results

Driving stage		**15**	**9**	**1**
Concentration (diesel)	[g/m^3]	0,214	0,180	0,344
Concentration (HVO 100)	[g/m^3]	0,225	0,162	0,180
Concentration (HVO 50)	[g/m^3]	0,221	0,170	0,215
Difference Diesel / HVO 100	[g/m^3]	0,011	-0,018	-0,164
Difference Diesel / HVO 100	[%]	5,1	-10,0	-47,6
Difference Diesel / HVO 50	[g/m^3]	0,007	-0,010	-0,129
Difference Diesel / HVO 50	[%]	3,3	-5,5	-37,6
Spec. mass flow (diesel)	[g/kWh]	0,859	0,895	3,955
Spec. mass flow (HVO 100)	[g/kWh]	0,932	0,842	2,046
Spec. mass flow (HVO 50)	[g/kWh]	0,886	0,866	2,500
Difference diesel / HVO 100	[g/kWh]	0,074	-0,053	-1,909
Difference diesel / HVO 100	[%]	8,6	-5,9	-48,3
Difference diesel / HVO 50	[g/kWh]	0,027	-0,029	-1,455
Difference diesel / HVO 50	[%]	3,2	-3,3	-36,8

Table 6 Results Nitrogen oxides (NOX)

Driving stage		**15**	**9**	**1**
Concentration (diesel)	[g/m³]	2,964	3,278	2,033
Concentration (HVO 100)	[g/m³]	2,567	2,729	1,664
Concentration (HVO 50)	[g/m³]	2,783	2,939	1,765
Difference Diesel / HVO 100	[g/m³]	-0,397	-0,549	-0,369
Difference Diesel / HVO 100	[%]	-13,4	-16,7	-18,2
Difference Diesel / HVO 50	[g/m³]	-0,181	-0,339	-0,268
Difference Diesel / HVO 50	[%]	-6,1	-10,4	-13,2
Spec. mass flow (diesel)	[g/kWh]	11,878	16,292	23,363
Spec. mass flow (HVO 100)	[g/kWh]	10,635	14,173	18,862
Spec. mass flow (HVO 50)	[g/kWh]	11,137	14,951	20,548
Difference diesel / HVO 100	[g/kWh]	-1,243	-2,119	-4,501
Difference diesel / HVO 100	[%]	-10,5	-13,0	-19,3
Difference diesel / HVO 50	[g/kWh]	-0,741	-1,341	-2,815
Difference diesel / HVO 50	[%]	-6,2	-8,2	-12,0

Tabelle 7 Carbon dioxide (CO2) results

Driving stage		**15**	**9**	**1**
Concentration (diesel)	[Vol.-%]	9,30	7,52	3,96
Concentration (HVO 100)	[Vol.-%]	8,88	7,22	3,81
Concentration (HVO 50)	[Vol.-%]	9,17	7,47	3,91
Difference Diesel / HVO 100	[Vol.-%]	-0,42	-0,30	-0,14
Difference Diesel / HVO 100	[%]	-4,5	-4,0	-3,7
Difference Diesel / HVO 50	[Vol.-%]	-0,13	-0,05	-0,05
Difference Diesel / HVO 50	[%]	-1,4	-0,6	-1,3
Spec. mass flow (Diesel)	[g/kWh]	498,77	496,95	597,30
Spec. mass flow (HVO 100)	[g/kWh]	491,34	497,69	567,21
Spec. mass flow (HVO 50)	[g/kWh]	490,75	505,31	597,13
Difference Diesel / HVO 100	[g/kWh]	-7,43	0,73	-30,08
Difference Diesel / HVO 100	[%]	-1,5	0,1	-5,0
Difference Diesel / HVO 50	[g/kWh]	-8,02	8,36	-0,16
Difference Diesel / HVO 50	[%]	-1,6	1,7	< -0,1

Table 8 Results total organic carbon (HC)

Driving stage		**15**	**9**	**1**
Concentration (Diesel)	[g/m³]	0,0458	0,0817	0,1061
Concentration (HVO 100)	[g/m³]	0,0250	0,0658	0,0563
Concentration (HVO 50)	[g/m³]	0,0301	0,0697	0,0681
Difference Diesel / HVO 100	[g/m³]	-0,0207	-0,0159	-0,0498
Difference Diesel / HVO 100	[%]	-45,3	-19,5	-46,9
Difference Diesel / HVO 50	[g/m³]	-0,0156	-0,0120	-0,0379
Difference Diesel / HVO 50	[%]	-34,2	-14,7	-35,8
Spec. mass flow (Diesel)	[g/kWh]	0,183	0,406	1,219
Spec. mass flow (HVO 100)	[g/kWh]	0,104	0,342	0,638
Spec. mass flow (HVO 50)	[g/kWh]	0,121	0,354	0,793
Difference Diesel / HVO 100	[g/kWh]	-0,080	-0,064	-0,581
Difference Diesel / HVO 100	[%]	-43,4	-15,8	-47,6
Difference Diesel / HVO 50	[g/kWh]	-0,063	-0,052	-0,426
Difference Diesel / HVO 50	[%]	-34,3	-12,7	-34,9

Tabelle 9 Total dust results

Driving stage		**15**	**9**	**1**
Concentration (Diesel)	[g/m³]	0,0184	0,0150	0,0177
Concentration (HVO 100)	[g/m³]	0,0167	0,0187	0,0054
Concentration (HVO 50)	[g/m³]	0,0202	0,0232	0,0137
Difference Diesel / HVO 100	[g/m³]	-0,0017	0,0037	-0,0123
Difference Diesel / HVO 100	[%]	-9,4	24,4	-69,7
Difference Diesel / HVO 50	[g/m³]	0,0018	0,0082	-0,0040
Difference Diesel / HVO 50	[%]	10,0	54,6	-22,4
Spec. mass flow (Diesel)	[g/kWh]	0,074	0,075	0,203
Spec. mass flow (HVO 100)	[g/kWh]	0,069	0,097	0,061
Spec. mass flow (HVO 50)	[g/kWh]	0,081	0,118	0,160
Difference Diesel / HVO 100	[g/kWh]	-0,005	0,022	-0,143
Difference Diesel / HVO 100	[%]	-6,4	30,0	-70,1
Difference Diesel / HVO 50	[g/kWh]	0,007	0,043	-0,044
Difference Diesel / HVO 50	[%]	9,8	58,2	-21,4

The above brief documentation was prepared to the best of our knowledge and belief with the greatest care. The brief documentation consists of 10 pages.

Lingen, 05.05.2023 PF/IH

ZECH Umweltanalytik GmbH

audited by:

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Messstelle nach § 29b BImSchG für
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