

Short Documentation No. LX17549.1/01

via internal emission measurements in the exhaust gas of a combustion engine (class 60)
when using different fuels for DB Cargo AG in Nottingham (Great Britain)

Operator:

DB Cargo AG
Rheinstraße 2
55116 Mainz

Editor:



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ZECH Umweltanalytik GmbH • Hessenweg 38 • 49809 Lingen
Tel +49 (0)5 91 - 8 00 16-10 • Fax +49 (0)5 91 - 8 00 16-80 • E-Mail umweltanalytik@zechgmbh.de

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Short Documentation on the implementation of emission measurements

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Client: DB Cargo AG

Rheinstraße 2

55116 Mainz

Location: Plant Nottingham

Toton TMD

Nottingham NG10 5AP

Type of measurement: Measurement to determine changes in emissions when using different fuels

Date of measurement: 15.03. and 16.03.2023

Order no.: 0014 / VE 2 / 11570464

Order date: 21.09.2022 and 11.01.2023

Scope of Short 13 pages

Documentation:

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1.) Description

Task

When using two different fuels (diesel and HVO) and nine load states (speed ranges 1 – 8 and idling), the components listed below were found in the exhaust gas of the combustion engine with two quarter-hour mean values each for speed levels 1, 4 and 8 and with a quarter-hour mean value each for the Speed levels idle, 2, 3, 5, 6, 7 measured:

- carbon monoxide (CO)
- nitrogen oxides (NOX)
- Carbon Dioxide (CO₂)
- total organic carbon (HC)
- total dust

With these measurements, the change in emission behavior when using two different fuels and three power states is to be determined.

Internal combustion engine system

In the Class 60 diesel-electric locomotive, the electrical power required to drive the traction motors is generated by a traction generator driven by the diesel engine..

In the load test, the electrical power generated by the traction generator is not consumed by the traction motors, but by an externally connected braking resistor.

The following table shows the technical data of the internal combustion engine installed in the Class 60 locomotive.

Table 1 technical data engine

Manufacturer	Mirrlees Blackstone
Type	8MB275T
Fuels	Diesel / HVO

Device to reduce emissions

Devices for reducing emissions are not available in this test setup.

2.) Measurement method

Table 2 Overview of measurement methods

Flow rate	Calculation of the volume flow via the pressure conditions in the exhaust gas duct, the cross-sectional area of the exhaust gas duct and the exhaust gas density; according to DIN EN ISO 16911, sheet 1
Carbon monoxide (CO)	Determination of the mass concentration of carbon monoxide (CO) - reference method - non-dispersive infrared spectrometry; according to DIN EN 15058
Nitrogen oxides (NOX)	Determination of the mass concentration of nitrogen oxides (NOX) - reference 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 EN 12619
Total dust	Determination of the mass concentration of total dust - gravimetric method; according to VDI guideline 2066, sheet 1 or EN 13284

3.) Operating status of the system during the measurement

The locomotive under consideration can be operated with eight speed steps. During the emission measurements, 8 driving levels and idling were examined. In Table 3, the checked driving levels are assigned to the sampling times.

Table 3.1 Operating data when used with diesel and HVO

Date	15.02.2023		
Fuel	Diesel		
Time [hh:mm]	11:34 - 12:05	12:17 - 12:32	12:43 - 12:58
Speed level	8	7	6
Date	16.02.2023		
Fuel	HVO		
Time [hh:mm]	09:35 - 10:06	10:19 - 10:34	10:47 - 11:02
Speed level	8	7	6

Table 3.2 Operating data when used with diesel and HVO

Date	15.02.2023		
Fuel	Diesel		
Time [hh:mm]	13:10 - 13:25	13:39 - 14:12	14:22 - 14:37
Speed level	5	4	3
Date	16.02.2023		
Fuel	HVO		
Time [hh:mm]	11:15 - 11:30	11:46 - 12:20	12:33 - 12:48
Speed level	5	4	3

Table 3.3 Operating data when used with diesel and HVO

Date	15.02.2023		
Fuel	Diesel		
Time [hh:mm]	14:49 - 15:04	15:13 - 15:47	15:57 - 16:12
Speed level	2	1	Idle
Date	16.02.2023		
Fuel	HVO		
Time [hh:mm]	12:58 - 13:13	13:25 - 13:57	14:04 - 14:19
Speed level	2	1	Idle

4.) Compilation of the measurement results

The results of the measurements are listed in the following lists. Unless otherwise indicated, all information relates to standard conditions (273 K, 1,013 hPa, dry exhaust gas). All results are given without expanded measurement uncertainty..

Deviations from the results given to the calculated values are due to the application of the rounding rules and therefore do not represent an error.

Table 4.1 Flow results

Speed level	8	7	6
Flow rate (Diesel) 15.02.2023 [m ³ /h]	15.154	11.076	8.619
Flow rate (HVO) 16.02.2023 [m ³ /h]	13.820	10.248	7.605

Table 4.2 Flow results

Speed level	5	4	3
Flow rate (Diesel) 15.02.2023 [m ³ /h]	5.013	3.339	2.780
Flow rate (HVO) 16.02.2023 [m ³ /h]	5.326	4.119	2.813

Table 4.3 Flow results

Speed level	2	1	Idle
Flow rate (Diesel) 15.02.2023 [m ³ /h]	2.273	1.869	1.839
Flow rate (HVO) 16.02.2023 [m ³ /h]	2.183	1.913	1.852

Table 5.1 Carbon Monoxide (CO) Results

Driving level		8	7	6
Concentration (diesel)	[g/m ³]	0,072	0,097	0,292
Concentration (HVO)	[g/m ³]	0,063	0,077	0,252
Difference	[g/m ³]	-0,009	-0,020	-0,040
Difference	[%]	-13,2	-20,5	-13,8
Mass flow (diesel)	[g/h]	1.092,75	1.074,56	2.516,77
Mass Flow (HVO)	[g/h]	865,50	790,41	1.914,77
Difference	[g/h]	-227,25	-284,15	-602,00
Difference	[%]	-20,8	-26,4	-23,9

Table 5.2 Carbon Monoxide (CO) Results

Driving level		5	4	3
Concentration (diesel)	[g/m ³]	0,645	0,884	1,173
Concentration (HVO)	[g/m ³]	0,618	0,996	1,253
Difference	[g/m ³]	-0,027	+0,112	+0,080
Difference	[%]	-4,2	+12,7	+6,8
Mass flow (diesel)	[g/h]	3.234,18	2.952,61	3.259,88
Mass Flow (HVO)	[g/h]	3.290,68	4.104,13	3.524,12
Difference	[g/h]	+56,50	+1151,51	+264,24
Difference	[%]	+1,7	+39,0	+8,1

Table 5.3 Carbon Monoxide (CO) Results

Driving level		2	1	Idle
Concentration (diesel)	[g/m ³]	0,778	0,223	0,113
Concentration (HVO)	[g/m ³]	0,752	0,179	0,079
Difference	[g/m ³]	-0,026	-0,044	-0,034
Difference	[%]	-3,3	-19,9	-30,5
Mass flow (diesel)	[g/h]	1.768,56	417,57	207,87
Mass Flow (HVO)	[g/h]	1.642,32	342,30	145,58
Difference	[g/h]	-126,24	-75,27	-62,29
Difference	[%]	-7,1	-18,0	-30,0

Table 6.1 Results nitrogen oxides (NOX)

Speed level		8	7	6
Concentration (diesel)	[g/m ³]	3,232	3,826	4,609
Concentration (HVO)	[g/m ³]	2,993	3,544	4,203
Difference	[g/m ³]	-0,239	-0,282	-0,406
Difference	[%]	-7,4	-7,4	-8,8
Mass flow (diesel)	[g/h]	48.980,30	42.373,26	39.725,12
Mass Flow (HVO)	[g/h]	41.362,51	36.314,72	31.959,27
Difference	[g/h]	-7.617,78	-6.058,54	-7.765,86
Difference	[%]	-15,6	-14,3	-19,5

Table 6.2 Results nitrogen oxides (NOX)

Speed level		5	4	3
Concentration (diesel)	[g/m ³]	5,168	5,575	5,606
Concentration (HVO)	[g/m ³]	4,587	4,802	4,896
Difference	[g/m ³]	-0,581	-0,773	-0,711
Difference	[%]	-11,2	-13,9	-12,7
Mass flow (diesel)	[g/h]	25.906,35	18.615,42	15.584,17
Mass Flow (HVO)	[g/h]	24.432,30	19.778,90	13.773,42
Difference	[g/h]	-1.474,06	+1.163,48	-1.810,75
Difference	[%]	-5,7	+6,3	-11,6

Table 6.3 Results nitrogen oxides (NOX)

Speed level		2	1	Idle
Concentration (diesel)	[g/m ³]	4,916	3,082	0,572
Concentration (HVO)	[g/m ³]	4,532	2,666	0,457
Difference	[g/m ³]	-0,383	-0,416	-0,115
Difference	[%]	-7,8	-13,5	-20,1
Mass flow (diesel)	[g/h]	11.175,77	5.761,38	1.051,21
Mass Flow (HVO)	[g/h]	9.895,61	5.100,92	846,39
Difference	[g/h]	-1.280,16	-660,46	-204,82
Difference	[%]	-11,5	-11,5	-19,5

Table 7.1 Carbon dioxide (CO₂) results

Speed level		8	7	6
Concentration (diesel)	[g/m ³]	5,09	5,51	6,34
Concentration (HVO)	[g/m ³]	4,84	5,28	5,92
Difference	[g/m ³]	-0,25	-0,23	-0,42
Difference	[%]	-4,9	-4,2	-6,6
Mass flow (diesel)	[g/h]	1.016.771,69	805.875,70	723.665,35
Mass Flow (HVO)	[g/h]	880.606,93	713.326,55	594.928,97
Difference	[g/h]	-136.164,77	-92.549,15	-128.736,37
Difference	[%]	-13,4	-11,5	-17,8

Table 7.2 Carbon dioxide (CO₂) results

Speed level		5	4	3
Concentration (diesel)	[g/m ³]	7,24	8,06	8,54
Concentration (HVO)	[g/m ³]	6,79	7,58	8,01
Difference	[g/m ³]	-0,44	-0,49	-0,52
Difference	[%]	-6,1	-6,1	-6,1
Mass flow (diesel)	[g/h]	481.905,41	358.780,06	316.661,18
Mass Flow (HVO)	[g/h]	479.752,17	414.855,05	300.162,79
Difference	[g/h]	-2.153,23	+5.6074,99	-16.498,39
Difference	[%]	-0,4	+15,6	-5,2

Table 7.3 Carbon dioxide (CO₂) results

Speed level		2	1	Idle
Concentration (diesel)	[g/m ³]	7,91	5,60	1,29
Concentration (HVO)	[g/m ³]	7,45	5,07	1,25
Difference	[g/m ³]	-0,46	-0,53	-0,05
Difference	[%]	-5,8	-9,5	-3,6
Mass flow (diesel)	[g/h]	239.393,33	138.215,01	30.935,78
Mass Flow (HVO)	[g/h]	216.026,90	127.793,18	30.056,83
Difference	[g/h]	-23.366,43	-10.421,83	-878,95
Difference	[%]	-9,8	-7,5	-2,8

Tabelle 8.1 Total Organic Carbon (HC) Results

Speed level		8	7	6
Concentration (diesel)	[g/m ³]	0,0952	0,1060	0,1053
Concentration (HVO)	[g/m ³]	0,0775	0,0898	0,1016
Difference	[g/m ³]	-0,0177	-0,0162	-0,0037
Difference	[%]	-18,5	-15,2	-3,5
Mass flow (diesel)	[g/h]	1.442,35	1.173,81	907,44
Mass Flow (HVO)	[g/h]	1.071,47	920,47	772,28
Difference	[g/h]	-370,88	-253,34	-135,16
Difference	[%]	-25,7	-21,6	-14,9

Tabelle 8.2 Total Organic Carbon (HC) Results

Fahrstufe Speed level		5	4	3
Concentration (diesel)	[g/m ³]	0,0882	0,0702	0,0670
Concentration (HVO)	[g/m ³]	0,0780	0,0676	0,0726
Difference	[g/m ³]	-0,0101	-0,0026	0,0056
Difference	[%]	-11,5	-3,7	8,3
Mass flow (diesel)	[g/h]	441,89	234,42	186,36
Mass Flow (HVO)	[g/h]	415,65	278,38	204,29
Difference	[g/h]	-26,24	+43,96	+17,92
Difference	[%]	-5,9	+18,8	+9,6

Tabelle 8.3 Total Organic Carbon (HC) Results

Speed level		2	1	Idle
Concentration (diesel)	[g/m ³]	0,0626	0,0442	0,0580
Concentration (HVO)	[g/m ³]	0,0599	0,0329	0,0331
Difference	[g/m ³]	-0,0026	-0,0113	-0,0249
Difference	[%]	-4,2	-25,5	-42,9
Mass flow (diesel)	[g/h]	142,21	82,54	106,56
Mass Flow (HVO)	[g/h]	130,79	62,91	61,32
Difference	[g/h]	-11,42	-19,63	-45,24
Difference	[%]	-8,0	-23,8	-42,5

Tabelle 9.1 Total dust results

Speed level		8	7	6
Concentration (diesel)	[g/m ³]	0,0141	0,0098	0,0032
Concentration (HVO)	[g/m ³]	0,0077	0,0057	0,0120
Difference	[g/m ³]	-0,0064	-0,0040	+0,0088
Difference	[%]	-45,1	-41,2	+276,3
Mass flow (diesel)	[g/h]	213,36	108,10	27,58
Mass Flow (HVO)	[g/h]	106,83	58,82	91,56
Difference	[g/h]	-106,53	-49,28	+63,98
Difference	[%]	-49,9	-45,6	+232,0

Tabelle 9.2 Total dust results

Speed level		5	4	3
Concentration (diesel)	[g/m ³]	0,0434	0,0462	0,0524
Concentration (HVO)	[g/m ³]	0,0188	0,0394	0,0492
Difference	[g/m ³]	-0,0246	-0,0068	-0,0032
Difference	[%]	-56,6	-14,7	-6,0
Mass flow (diesel)	[g/h]	217,45	154,36	145,52
Mass Flow (HVO)	[g/h]	100,24	162,42	138,39
Difference	[g/h]	-117,21	+8,06	-7,13
Difference	[%]	-53,9	+5,2	-4,9

Tabelle 9.3 Total dust results

Speed level		2	1	Idle
Concentration (diesel)	[g/m ³]	0,0513	0,0330	0,0134
Concentration (HVO)	[g/m ³]	0,0560	0,0514	0,0143
Difference	[g/m ³]	+0,0047	+0,0184	+0,0009
Difference	[%]	+9,2	+55,8	+7,0
Mass flow (diesel)	[g/h]	116,63	61,71	24,62
Mass Flow (HVO)	[g/h]	122,33	98,42	26,54
Difference	[g/h]	+5,70	+36,71	+1,92
Difference	[%]	+4,9	+59,5	+7,8

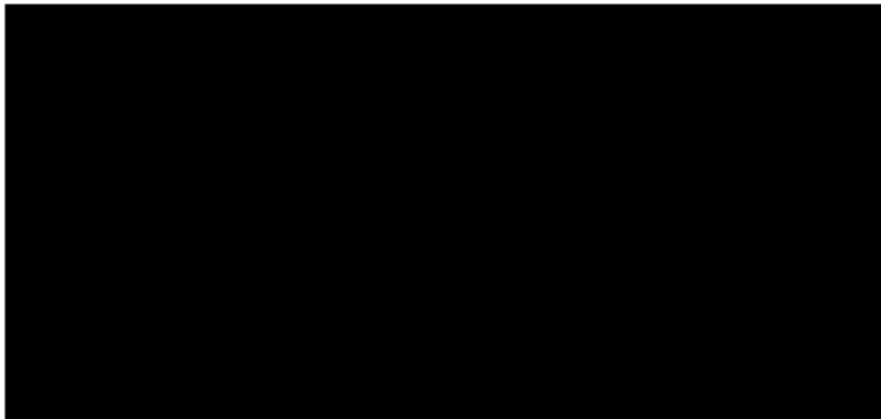
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Lingen, the 16.03.2023 PF/IH

ZECH Umweltanalytik GmbH

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Messstelle nach § 29b BImSchG für
Luftinhaltsstoffe
(Gruppen I(G, P, Sp) und IV(P))

ZECH Umweltanalytik GmbH
Luftschadstoffe · Staub
Hessenweg 38 · 49809 Lingen (Ems)
Tel. 05 91 - 80 01 610 · Fax 05 91 - 8 00 16 80