

**Short Documentation No. LX17549.2/01**

via internal emission measurements in the exhaust gas of a combustion engine (TEM 2)  
when using different fuels for DB Cargo AG in Rybnik (Poland)

---

Operator:

DB Cargo AG  
Rheinstraße 2  
55116 Mainz

Editor:



Date of document:

16.03.2023



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](mailto:umweltanalytik@zechgmbh.de)

**ANALYTIK**

**LUFTINHALTSSTOFFE**

**STAUB**

[www.zechgmbh.de](http://www.zechgmbh.de)

## Short documentation on the implementation of emission measurements

Name of the according to § 29b BImSchG

notified body: ZECH Umweltanalytik GmbH

Time Limitation of Notice

according to § 29b BImSchG: 02/03/2024 for group I No. 1: G, P, Sp and IV: P

Number short documentation: LX17549.2/01 Date: 16.03.2023

Client: DB Cargo AG

Rheinstraße 2

55116 Mainz

Location: Plant Rybnik  
ul. Kłokocińska 51  
Rybnik 44-251

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

Date of measurement: 21.03. and 22.03.2023

Order no.: 0014 / VE 2 / 11772433

Order date: 14.12.2022

Scope of Short 9 pages

Documentation:

---

**Contents**

	<u>Page</u>
1.) Description .....	4
2.) Measurement method .....	5
3.) Operating status of the system during the measurement .....	6
4.) Compilation of the measurement results .....	7

## 1.) Description

### Task

When using two different fuels (diesel and HVO) and three load conditions (drive level 8, drive level 4 and drive level 1), the components listed below were measured in the exhaust gas of the combustion engine with 6 quarter-hour mean values each (2 per load condition):

- carbon monoxide (CO)
- nitrogen oxides (NOX)
- Carbon Dioxide (CO<sub>2</sub>)
- 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 TEM2 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 rheostat.

The following table shows the technical data of the internal combustion engine installed in the TEM2 locomotive.

**Tabelle 1** technical data engine

Manufacturer	Pensa
Type	PD1M
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 (CO <sub>2</sub> )	Determination of the volume concentration of carbon dioxide (CO <sub>2</sub> ) - 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, 3 driving levels were examined. In Table 3, the checked driving levels are assigned to the sampling times.

**Table 3** Operating data when used with diesel and HVO

Date	21.02.2023	22.02.2023	
Fuel	Diesel	Diesel	
Time [hh:mm]	15:01 - 15:34	09:39 - 10:10	08:45 - 09:16
Speed level	8	4	1
Date	22.02.2023		
Fuel	HVO		
Time [hh:mm]	13:26 - 13:57	12:40 - 13:11	11:53 - 12:24
Speed level	8	4	1

#### **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

<b>Speed level</b>	<b>8</b>	<b>4</b>	<b>1</b>
Flow rate (diesel) [m <sup>3</sup> /h]	3.303	1.019	675
Flow rate (HVO) [m <sup>3</sup> /h]	2.653	1.133	742

**Table 5** Carbon Monoxide (CO) Results

<b>Speed level</b>	<b>8</b>	<b>4</b>	<b>1</b>
Concentration (diesel) [g/m <sup>3</sup> ]	0,170	0,111	0,952
Concentration (HVO) [g/m <sup>3</sup> ]	0,137	0,084	0,135
Difference [g/m <sup>3</sup> ]	-0,033	-0,027	-0,816
Difference [%]	-19,3	-24,4	-85,8
Mass flow (diesel) [g/h]	562,41	113,06	642,61
Mass Flow (HVO) [g/h]	364,58	95,07	100,37
Difference [g/h]	-197,84	-17,99	-542,24
Difference [%]	-35,2	-15,9	-84,4

**Table 6** Results nitrogen oxides (NOX)

Speed level		8	4	1
Concentration (diesel)	[g/m <sup>3</sup> ]	1,502	2,921	0,893
Concentration (HVO)	[g/m <sup>3</sup> ]	1,341	2,439	1,041
Difference	[g/m <sup>3</sup> ]	-0,161	-0,481	0,148
Difference	[%]	-10,7	-16,5	16,5
Mass flow (diesel)	[g/h]	4.962,43	2.976,22	603,11
Mass Flow (HVO)	[g/h]	3.558,42	2.764,64	772,20
Difference	[g/h]	-1404,01	-211,58	169,09
Difference	[%]	-28,3	-7,1	28,0

**Table 7** Carbon dioxide (CO<sub>2</sub>) results

Speed level		8	4	1
Concentration (diesel)	[Vol.-%]	5,35	4,35	2,13
Concentration (HVO)	[Vol.-%]	4,96	4,04	1,76
Difference	[Vol.-%]	-0,39	-0,31	-0,37
Difference	[%]	-7,3	-7,1	-17,4
Mass flow (diesel)	[g/h]	233.169,87	58.204,09	18.708,10
Mass Flow (HVO)	[g/h]	173.252,42	60.088,92	16.958,62
Difference	[g/h]	-59917,45	1884,83	-1749,48
Difference	[%]	-25,7	3,2	-9,4

**Table 8** Total Organic Carbon (HC) Results

Speed level		8	4	1
Concentration (diesel)	[g/m <sup>3</sup> ]	0,1182	0,0457	0,0963
Concentration (HVO)	[g/m <sup>3</sup> ]	0,0872	0,0214	0,0242
Difference	[g/m <sup>3</sup> ]	-0,031	-0,024	-0,072
Difference	[%]	-26,3	-53,2	-74,9
Mass flow (diesel)	[g/h]	390,50	46,54	65,04
Mass Flow (HVO)	[g/h]	231,28	24,24	17,96
Difference	[g/h]	-159,22	-22,29	-47,08
Difference	[%]	-40,8	-47,9	-72,4



**Table 9** Total Dust Results

Speed level		8	4	1
Concentration (diesel)	[g/m <sup>3</sup> ]	0,0256	0,0111	0,0264
Concentration (HVO)	[g/m <sup>3</sup> ]	0,0183	0,0169	0,0092
Difference	[g/m <sup>3</sup> ]	-0,007	0,006	-0,017
Difference	[%]	-28,4	53,0	-65,0
Mass flow (diesel)	[g/h]	84,43	11,26	17,83
Mass Flow (HVO)	[g/h]	48,58	19,16	6,86
Difference	[g/h]	-35,85	7,91	-10,98
Difference	[%]	-42,5	70,2	-61,6

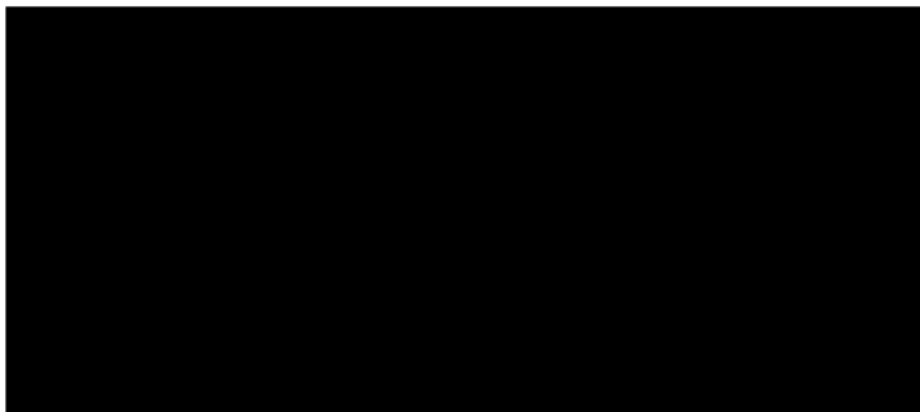
The above Short Documentation was created to the best of our knowledge and belief with the greatest care. It consists of 9 pages.

Lingen, the 16.03.2023 PF/IH

ZECH Umweltanalytik GmbH

checked by

created by:



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