Beilage . 19

Test Report Revision

Project No.:

106 033 0210653

EEffG Test Cycle

This test was run acc. to EEffG Test, June 2015 (based on CEC F-98-08 Issue 7)
We have met the requirements of the CEC Guidelines

Investigation of deposit effects
in a common rail diesel engine

Test performed on behalf of

[redacted]

Dirty-Up and Clean-Up

with test fuel

Haltermann RF 79-07 Batch 8

and additive

[redacted]

Order-no.:

3000434946

Quality Management ISO 9001:2008
Voluntary participation in regular monitoring
DEKRA Certification
DEKRA certified

Table of Contents

1 General Items

Laboratory:	APL Automobil-Prüftechnik Landau GmbH Am Hölzel 11 76829 Landau Germany
Laboratory Contact Person:	Dipl.-Ing. Pascal Junges phone: +49 (0) 6341 / 991-4641 ; email: pascal.junges@apl-landau.de
Customer:	[redacted]
Customers Contact Person:	[redacted]
Order No.:	3000434946
Test Fuel:	[redacted]
Fuel Supplier:	Haltermann GmbH
Date of Receipt:	July 02, 2015
Zinc (Treat rate):	Zn-Neodecanoate (1 mgZn/kgFuel)
Additives (Treat rate):	[redacted]
Oil Code/Batch:	RL 236/3
Test Type:	EEffG Test, June 2015 (based on CEC F-98-08 Issue 7)
Date of last Accreditiation (CEC F-98-08):	August 05, 2014
Injector Type:	CEC Euro V Injectors
Injector Set:	VU - (cleaned)
Test Length:	232 hrs
Project Number:	106 033 0210653
Engine Number:	483569
Engine Model:	WAJ3
Test Bench Number:	21
Start of Test:	July 06, 2015
End of Test:	July 27, 2015
Test Validity:	Valid

Test report contains 11 pages in total.

Test results of this report relate only to the tested items. This report shall not be reproduced except in full without the written approval of APL. It replaces the test report of August 26, 2015.

September 24, 2015

APL GmbH Dipl.-Ing. (FH) Thorsten Kaebernick
Team Manager

Dipl.-Ing. Pascal Junges
Project Engineer

2 Summary of Test Results

Test Type:	EEffG Test, June 2015 (based on CEC F-98-08 Issue 7)
Base Fuel:	[redacted]
Zinc (Treat Rate):	Zn-Neodecanoate (1 mgZn/kgFuel)
Additives (Treat Rate):	[redacted]
Test Length:	232 hrs coking cycles, soak periods and fuel consumption measurements
	- 192 hrs running time in coking cycle with test fuel
	- 40 hrs running time in clean-up cycle with additive
Engine Test hrs at Start of Test:	160 hrs
Injector Type:	CEC Euro V Injectors
Injector Set:	VU - (cleaned)
Injector Set Run Time:	160 hrs
Injector Code Cyl. 1:	0606-04965
Injector Code Cyl. 2:	0606-04952
Injector Code Cyl. 3:	0606-04959
Injector Code Cyl. 4:	0606-04963

Fuel Consumption Result

Method 1 (acc. to EEffG June 2015; page 12, diagram 7)

$\Delta BSFC_{DU} - \Delta BSFC_{CU} \geq 50\% * \Delta BSFC_{DU}$
1,75% ≥ 1,51%   It has been proven that additive [redacted] improves fuel efficiency by a minimum of 50% of 2,6%.

Method 2 (acc. to EEffG June 2015, page 15)

$\Delta BSFC_{DU} - \Delta BSFC_{CU} \geq 50\% * \Delta BSFC_{DU}$
1,82% ≥ 1,51%   It has been proven that additive [redacted] improves fuel efficiency by a minimum of 50% of 2,6%.

Comment (acc. to EEffG June 2015, page 20)

It has been proven that additive [redacted] improves the fuel efficiency by a minimum of 2,6%.

2.1 Method 1 (acc. to EEffG June 2015; page 12, diagram 7)

Dirty-Up Cycle	Start of Test g/kWh	End of Dirty-Up g/kWh	$\Delta BSFC_{DU}$ %
Actual Value	220,1	226,76	3,03%

Clean-Up Cycle	Start of Test g/kWh	End of Clean-Up g/kWh	$\Delta BSFC_{CU}$ %
Actual Value	220,1	222,9	1,27%

$\Delta BSFC_{DU} - \Delta BSFC_{CU} \geq 50\% * \Delta BSFC_{DU}$
1,75% ≥ 1,51%
It has been proven that additive [redacted] improves fuel efficiency by a minimum of 50% of 2,6%.

2.2 Method 2 (acc. to EEffG June 2015, page 15)

Dirty-Up Cycle	Start of Test g/kWh	End of Dirty-Up g/kWh	$\Delta BSFC_{DU}$ %
Actual Value	220,1	226,76	3,03%

Clean-Up Cycle	Start of Test g/kWh	End of Clean-Up g/kWh	$\Delta BSFC_{CU}$ % [abs]
Actual Value	225,61	222,9	1,20%

$\Delta BSFC_{DU} - \Delta BSFC_{CU} \geq 50\% * \Delta BSFC_{DU}$
1,82% ≥ 1,51%
It has been proven that additive [redacted] improves fuel efficiency by a minimum of 50% of 2,6%.

3 Test Description

3.1 Test Purpose

The indirect injection engine has now given way in the market almost entirely to more modern direct injection light duty diesel engines, for reasons of fuel economy, performance and low emissions. These engines are much more sophisticated than the earlier indirect injection types, and must retain all the precision of their calibration in order to maintain their design performance. The injectors, key components in the performance of the engine, are vulnerable to having their operation perturbed by fouling from the deposits resulting from combustion, and this will be even more so the case for vehicles under development for Euro V emission regulations.

This test was developed to demonstrate the propensity of some fuels to provoke fuel injector fouling in these modern engines, and also to demonstrate the ability of detergent fuel additives to prevent or control these deposits.

3.2 Test Hardware

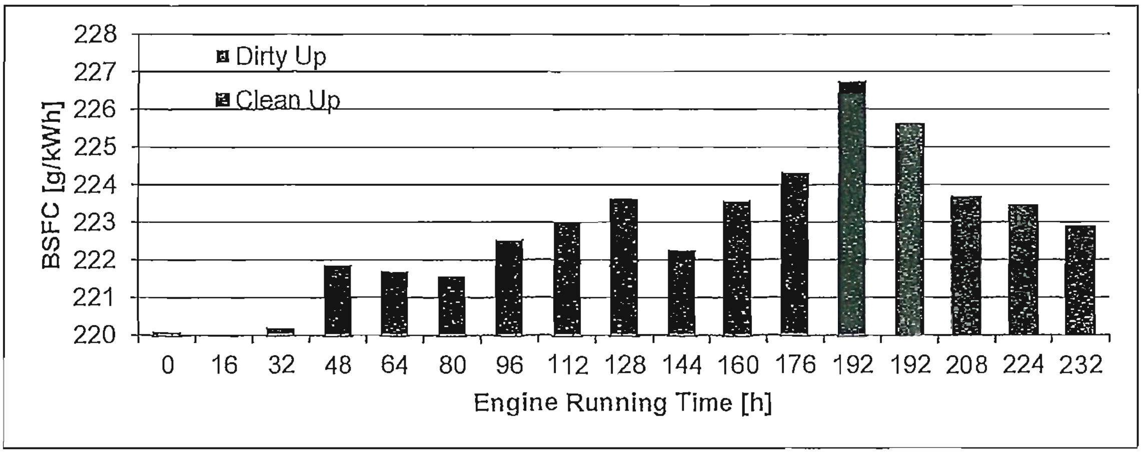
The engine used in this test is the PSA 'DW10B'. Special Euro V type injectors, that are prone to injector fouling, are used for this test.

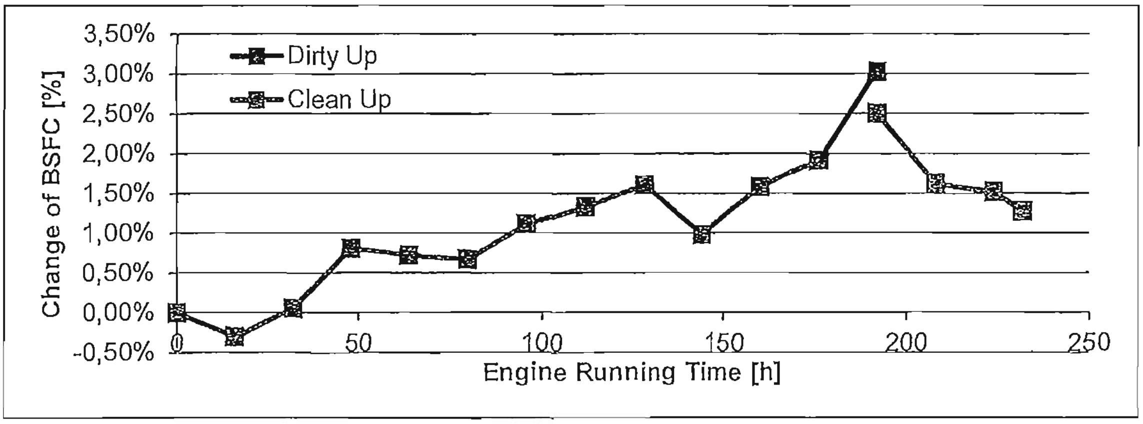
3.3 Test Protocol and Cycles

The test procedure consists of alternating sequences of eight hours of engine operation and four hours of engine stopped. Please refer to Section 7 in the CEC F-098-08 test procedure for details. The Test is separated into dirty-up and clean-up sequences. After every two coking and soaking periods a fuel consumption measuremt is performed. Once fuel consumption has been determined to have increased by 2,6-3,0% the clean-up sequence begins with the test fuel and additve. After 5 additional coking sequences the decrease in fuel consumption is determined.

4 Fuel Consumption Measurements

	Time h	Speed 1/min	Torque Nm	Fuel Cons. mg/strk	Spec. Fuel Cons. g/kWh	Change of BSFC %
Dirty-Up	0	3500	211,97	40,69	220,1	0,00%
	16	3500	212	40,57	219,43	-0,30%
	32	3500	212	40,71	220,2	0,05%
	48	3500	212	41,04	221,87	0,80%
	64	3500	211,93	40,98	221,69	0,72%
	80	3500	212,03	40,97	221,58	0,67%
	96	3500	211,97	41,16	222,55	1,11%
	112	3500	212	41,23	223,03	1,33%
	128	3500	212,03	41,35	223,64	1,61%
	144	3500	212	41,1	222,26	0,98%
	160	3500	211,97	41,34	223,58	1,58%
	176	3500	212	41,47	224,32	1,92%
	192	3500	212	41,92	226,76	3,03%
Clean-Up	192	3500	212	41,72	225,61	2,50%
	208	3500	212	41,35	223,67	1,62%
	224	3500	211,97	41,3	223,45	1,52%
	232	3500	212	41,22	222,9	1,27%





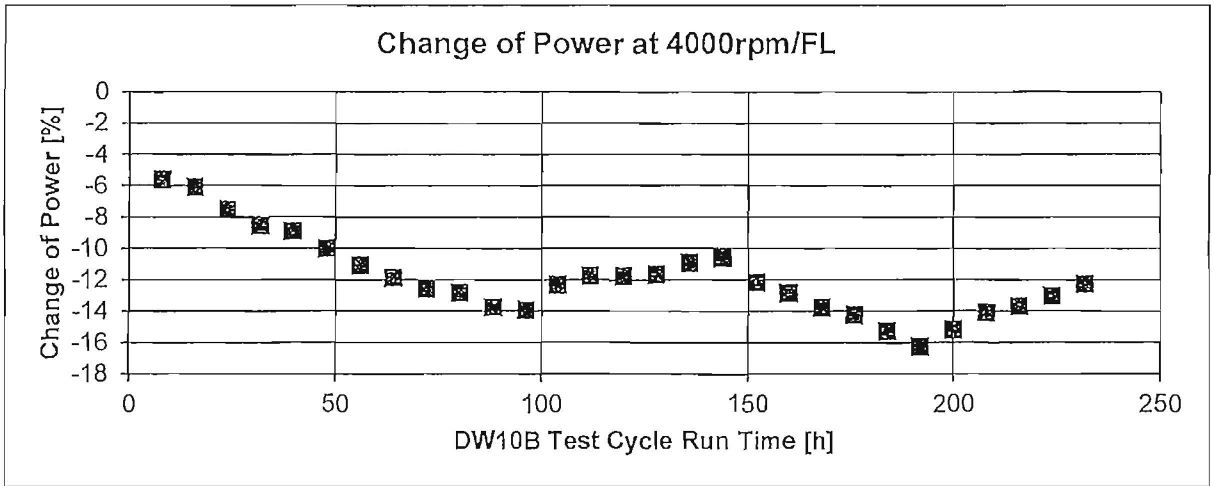
5 Operational Data

5.1 Operational Data Stage 4

Parameter	Unit	Average	Std. Dev.	Min	Max	Target Value
Engine Speed Dyno	rpm	3500,0	0,0	3500,0	3500,0	3500 ± 10
Torque	Nm	212,0	0,1	211,7	212,2	212 ± 6
Coolant Out	°C	97,0	0,0	96,8	97,2	97 ± 2
Fuel Temp Hpp Inlet	°C	32,0	0,1	31,8	32,1	32 ± 2
Intake Air Temp	°C	24,2	1,7	22,5	27,9	23 ± 5
Boost Air after Intercooler	°C	49,8	0,2	49,5	51,2	50 ± 2

Blowby at SoT: 70 l/min

Oil Consumption for Complete Test Run: 6,21 g/h



5.2 Operations Outside Specified Limits

none

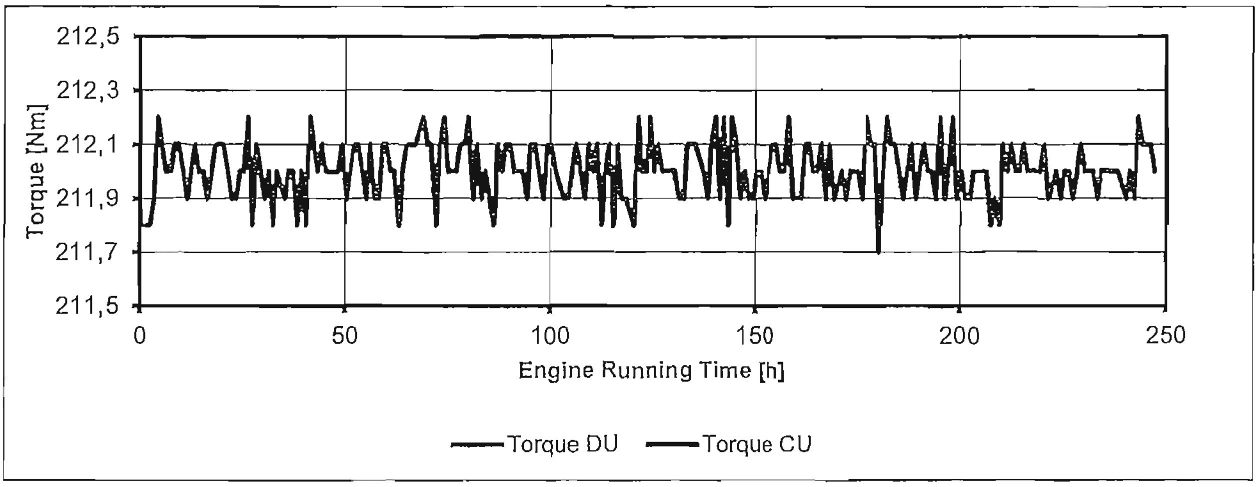
5.3 Unusual Occurrences

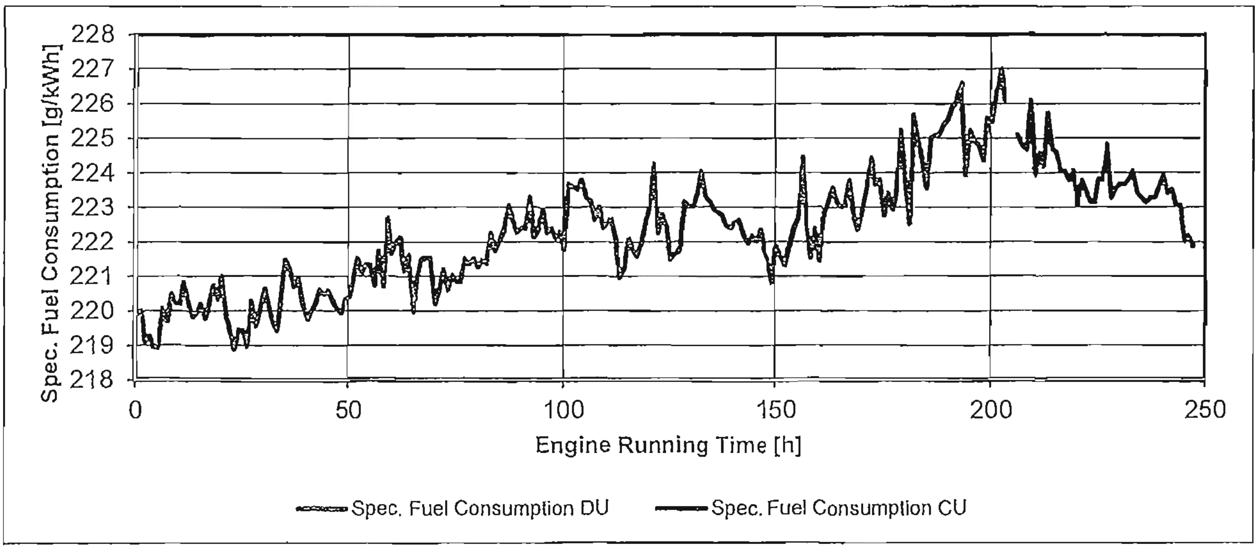
none

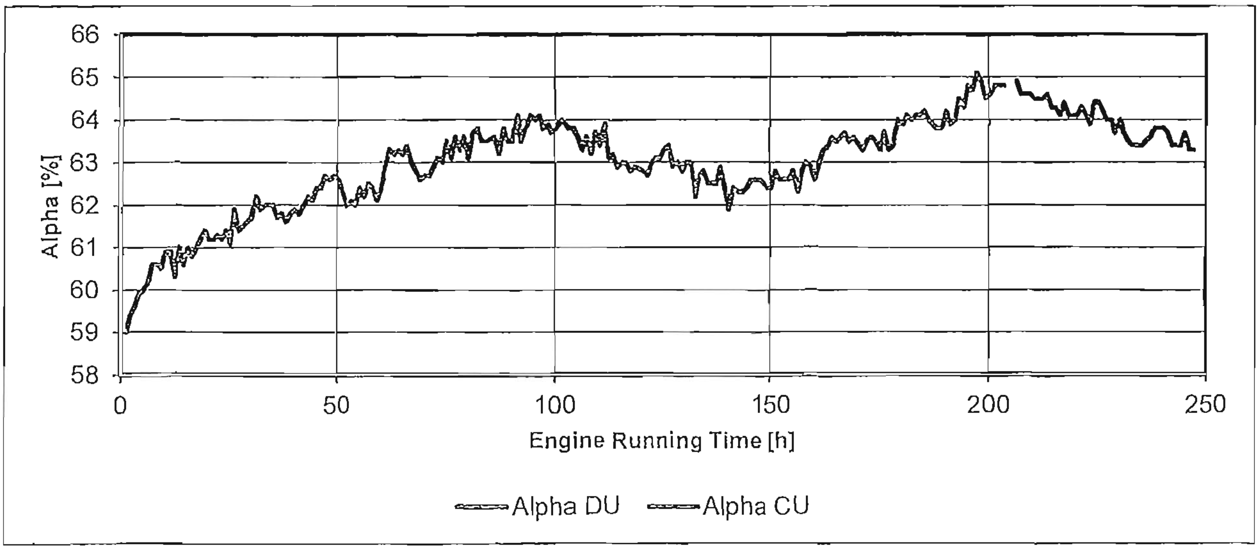
5.4 Measures taken during testing and Comments

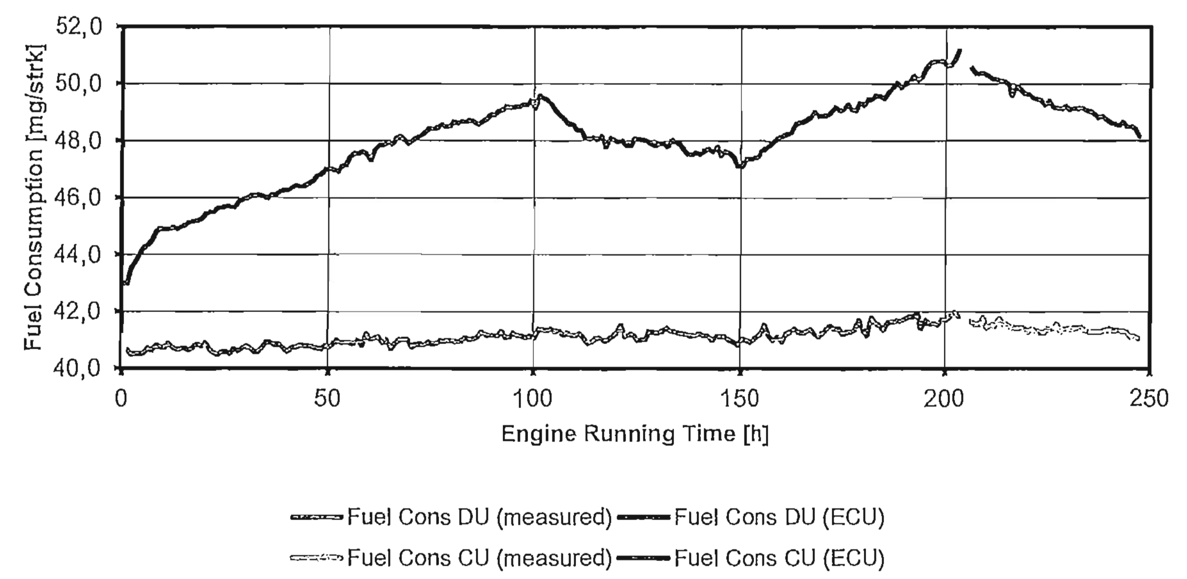
none

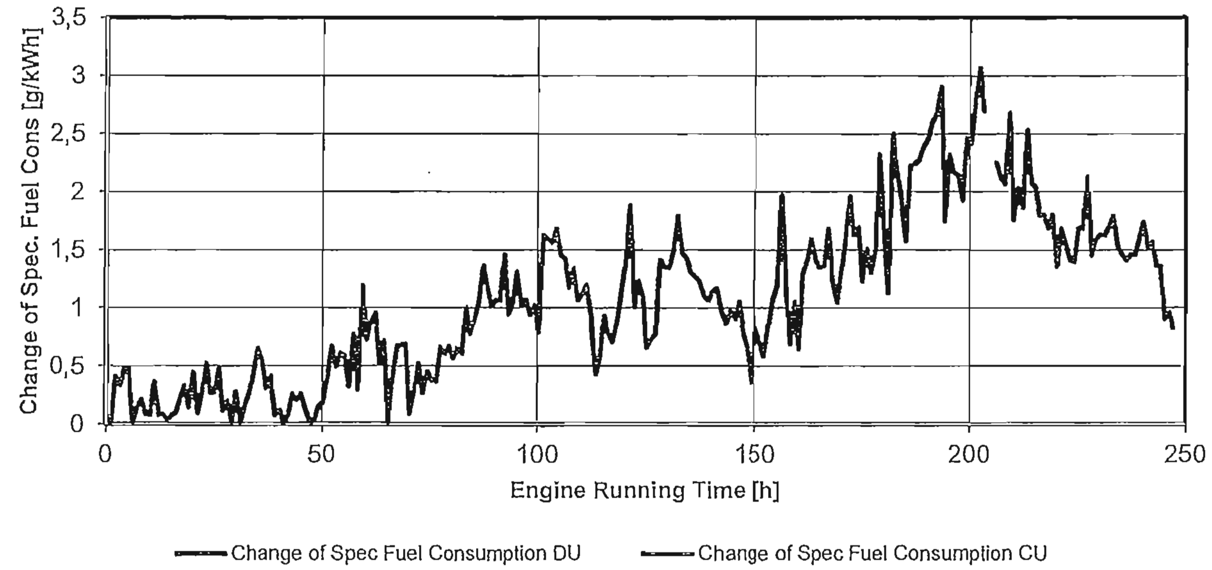
6 Diagrams (Stage 4; 3500min^{-1}, 212Nm)








52,0
50,0
48,0
46,0
44,0
42,0
40,0
Fuel Consumption [mg/strk]
0
50
100
150
200
250
Engine Running Time [h]
Fuel Cons DU (measured)
Fuel Cons DU (ECU)
Fuel Cons CU (measured)
Fuel Cons CU (ECU)


3,5
3
2,5
2
1,5
1
0,5
0
Change of Spec. Fuel Cons [g/kWh]
0
50
100
150
200
250
Engine Running Time [h]
Change of Spec Fuel Consumption DU
Change of Spec Fuel Consumption CU

7 Fuel Analysis

ASTM D7111	Zn mg/kg	Cu mg/kg
IBC 1 DU	1,09	<0,05
IBC 2 DU	1,04	<0,05
IBC 3 DU	1,07	<0,05
IBC 4 DU	1,01	<0,05
Start of DU	1,03	<0,05
End of DU	0,86	<0,05
IBC CU	<0,05	<0,05
Start of CU	0,2	<0,05
End of CU	<0,05	<0,05

Analysis carried out by:

APL Chemical & Physical Laboratory
Am Hölzel 11, D-76829 Landau
DAkkS registration-no: D-PL-11082-01-00