

SGS Report No. 1820/OGC21/134
SGS Order No. 7187
SGS Test No. DISI-21 024
Customer Order No. VIF/20211115
Customer Test ID. ULG 95 / SBA 1000 ppm (V/V)

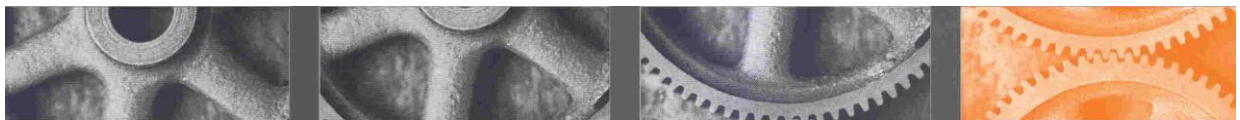
Test Report

SGS DISI Nozzle Coking in-house Test

VW EA111 (CAVE / E injectors) 1,4 litre Gasoline DI Engine

Dirty-up & Clean-up Test

25. 11. 2021



SGS Czech Republic s.r.o.
Engine Test Centre Kolin
Ovcarecka 314
280 13 Kolin, CZ

1 General Information

Test Laboratory:

SGS Czech Republic s.r.o., Engine Test Centre Kolin
Ovcarecka 314, 280 13 Kolin, Czech Republic

Test Identification:

Test Method: SGS-DISI-Test
Test Number: DISI-21 024
Start of Test: 22.11.2021
End of Test: 25.11.2021
Test Duration: 72 hours (DU 48 h + 24 CU h)
Technician: R. Petránek
Test Rating: Valid
Comments: No unexpected occurrences

Customer:

Customer: **VIF s.r.o. / LANG CHEMIE**
Contact: Ing. Boris Božuk / DI Gerhard Stöger
Address_1: Volutová 2523/14
Address_2: 158 00 Praha 13
Address_3: Česká republika

Fuel Data:

Receipt of Test Fuel: 21.11.2021
Dirty-up Fuel ID: **2576**
Dirty-up Fuel: **ULG 95**
Comments: Test fuel by customer
Clean-up Fuel ID: **2579**
Clean-up Fuel: **SBA 1000 ppm (V/V)**
Comments: Test fuel by customer

Engine Data:

Engine Type:	VW EA111 CAVE (1,4L; 132kW)	Engine Hours EOT:	1051,50
Engine ID:	CAVE 000 917	Classification:	MY3
Engine Hours SOT:	746,00	Injector hours_SOT_#1:	328
Injector Type:	03C906036E	Injector hours_SOT_#2:	328
Injector_ID_#1:	00556 I	Injector hours_SOT_#3:	328
Injector_ID_#2:	00461 M	Injector hours_SOT_#4:	328
Injector_ID_#3:	00491 I		
Injector_ID_#4:	00514 I		
Test Type:	Used injectors, cleaned		

Jakub Mistr
Engine Test Centre Manager



Kolin, 25. 11. 2021

Testing laboratory no. 1152.1, accredited by Czech Accreditation Institute in accordance with ČSN EN ISO/IEC 17025:2018 and QMS certified in accordance with ČSN EN ISO 9001:2016.

The test results refer to the tested samples only. The partial publication of this report is a subject to a written acceptance of the testing laboratory. Retain samples are provided upon a special request by the customer only.



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2 Test Results

The SGS DISI test procedure is designed in accordance with the preliminary version of the terms of reference of the proposed CEC/VW gasoline detergency test.

The test engine is the VW EA111 1,4L TSI (CAVE) engine with 132 kW. The twin charged engine is equipped with a supercharger and a turbo charger, including charge air cooler.

The test procedure is performed with used 6-hole injectors, type 03C906036E from Magneti Marelli. The injector clean-up procedure is performed in ultrasonic cleaner for 4 hours.

The test procedure is a steady state test at an engine speed of 2000 rpm and a constant torque of 56 Nm (=5 bar mean effective pressure). The thermostat is in serial condition.

Nozzle coking is measured as change of injection timing. Due to nozzle coking, the hole diameter of the injector holes is reduced, and the injection time adjusted by the Engine Control Unit (ECU) accordingly. The injection time in milliseconds is a direct readout from the ECU via ECU control software.

A linear trend calculation at start of test and end of test defines the nozzle coking during 48 hours of dirty up phase. The total nozzle coking after 48 hours is the reference for the recovery calculation during the 24 hours clean up phase.

DISI Test Results:

Dirty-up Performance:

Initial Injection timing:

Linear Trend calculation of first 5 hours: **1,616 ms** injection time @ 0 hours

End of Dirty-up phase Injection timing:

Linear Trend Calculation of last 5 hours: **2,386 ms** injection time @ 48 hours

Calculated Increase of injection time in Percent: **47,683 %** Nozzle Coking after DU-Phase

Clean-up Performance:

Linear Trend Calculation of last 5 hours: **1,640 ms** injection time @ 72 hours

Calculated decrease of injection time in Percent: **96,889 %** Nozzle Coking after CU-Phase

Minimal injection timing: **1,608 ms** during CU

@ **56,904 hours**

96,889 % Recovery potential calculated

96,889 % Recovery potential corrected

incomplete recovery Classification of Clean up

50% recovery @ **50,10 hours CU test** 2,001 ms

80% recovery @ **54,16 hours CU test** 1,770 ms

100% recovery @ **56,55 hours CU test** 1,616 ms

Measurement of injector nozzle flow test 6 bar / 30 sec.

Injector ID		00556 I	00461 M	00491 I	00514 I	Ave
Injector flow S.o.T	ml	95,83	96,50	93,83	96,17	95,58
Injector flow E.o.T	ml	95,33	97,67	93,67	96,67	95,83
Flow loss in injector	%	-0,52	1,21	-0,18	0,52	0,26

3 Test Evaluation

The level of injector coking is characterised by the observed increase of injection time during the test. The injection time is an ECU value.

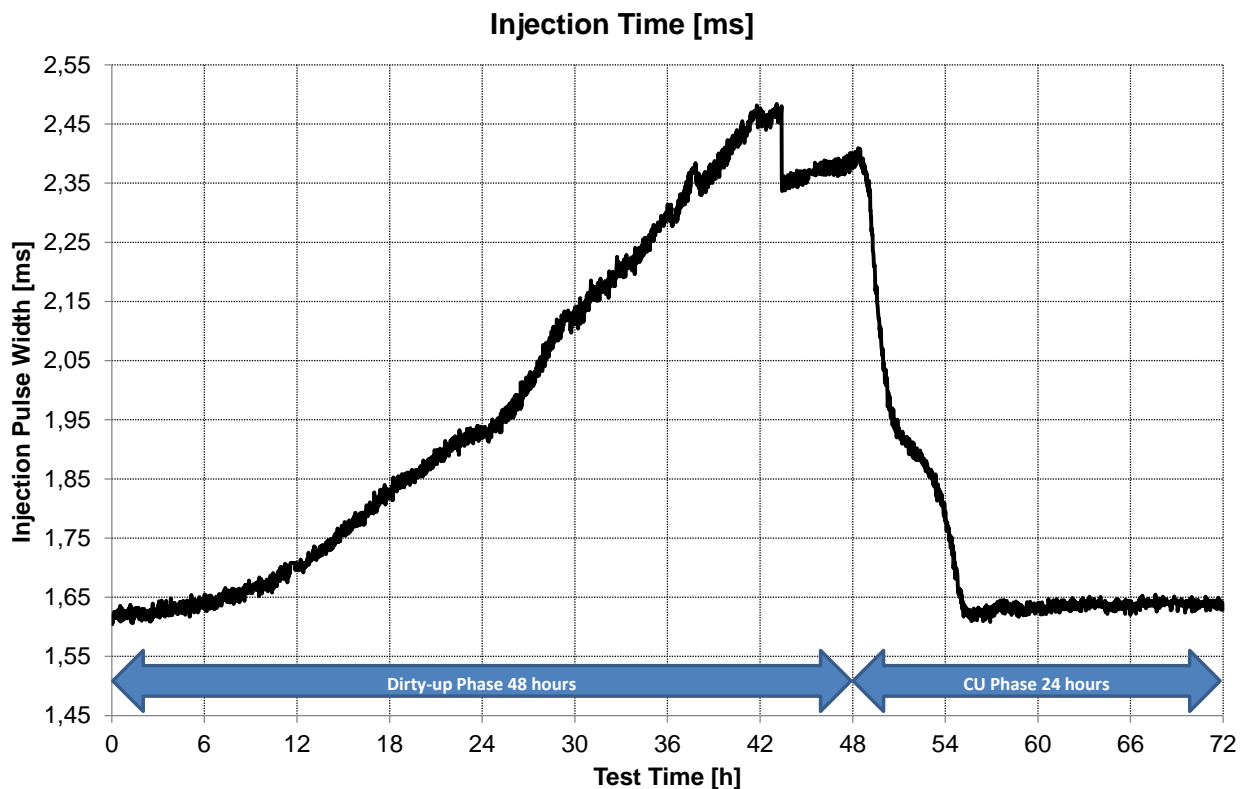
DISI Test Control:

Value:	Units	Target	+/-	Ave	Min	Max
Torque:	[Nm]	56	1,0	55,94	55,38	56,47
Speed:	[rpm]	2000	10,0	1 999,74	1 997,82	2 001,56
Oil temp.	[°C]	105	5,0	94,39	88,03	96,25
Rail press.	[MPa]	7,7	0,2	7,68	7,63	7,76
Lambda	[-]	1,0000	-	0,9980	0,9846	1,1439
T_COOL_OUT	[°C]	92,00	2,00	89,75	89,03	90,26
T_FUEL	[°C]	25,00	5,00	24,89	22,06	26,48
T_AIR_POST_IC	[°C]	35,00	5,00	34,80	27,13	35,76

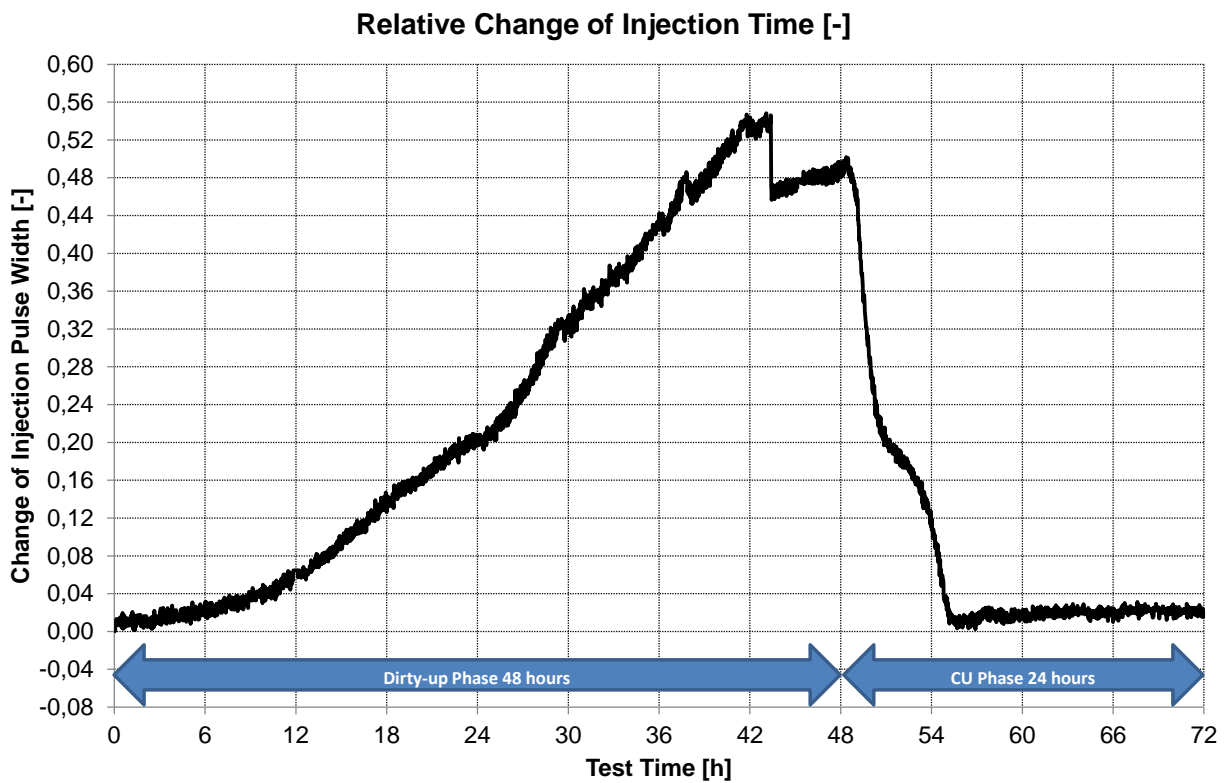
Engine Status at start of test with reference fuel:

Blow By	@ 4000 rpm	54,85 l/min	< 75 l/min
Power	@ 4000 rpm	103,65 kW	> 95 kW
Ignition timing	@ 2000 rpm / 56 Nm	1,616 ms	1,65 ± 0,05 ms *)
Oil consumption per test		3,51 g/h	< 5,0 g/h

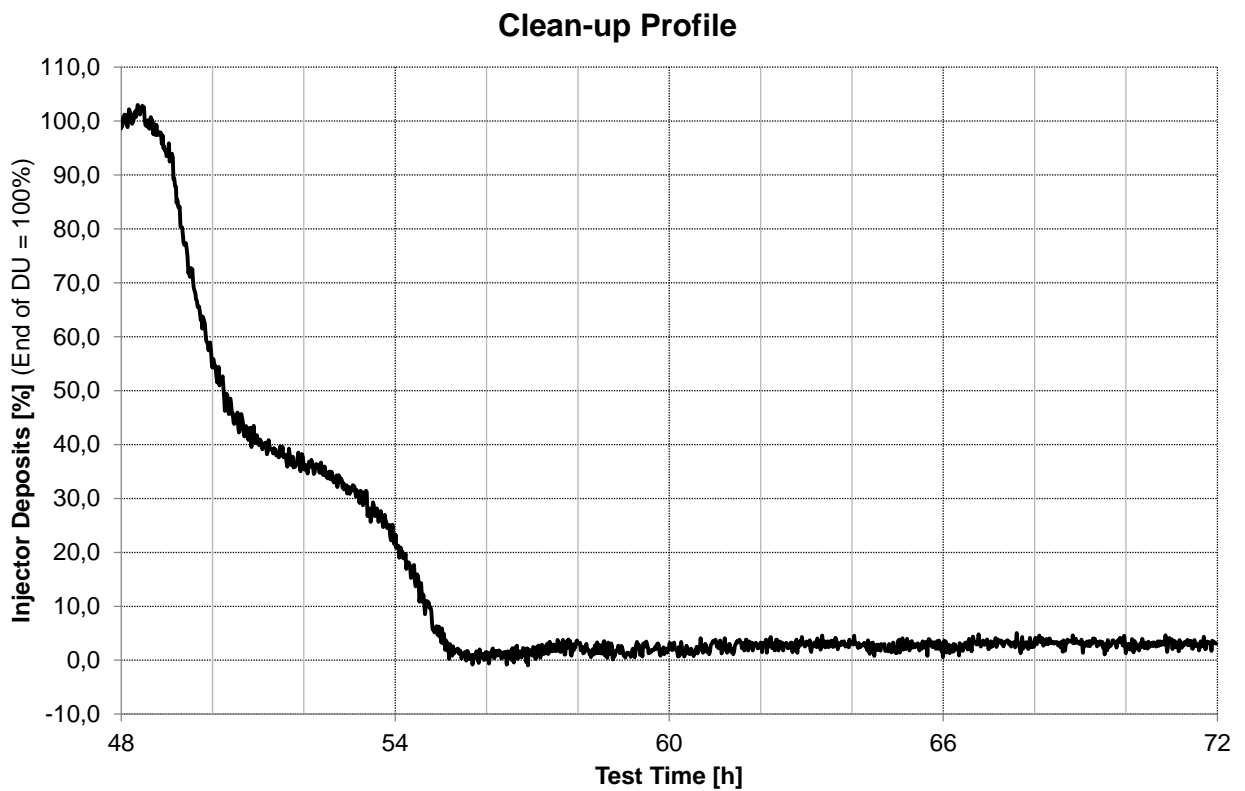
*) in case of reference fuel by Haltermann (RF-83-A-91 or RF-02-03) only.



Graph 1: Injection Time in milliseconds during dirty-up and clean-up phase



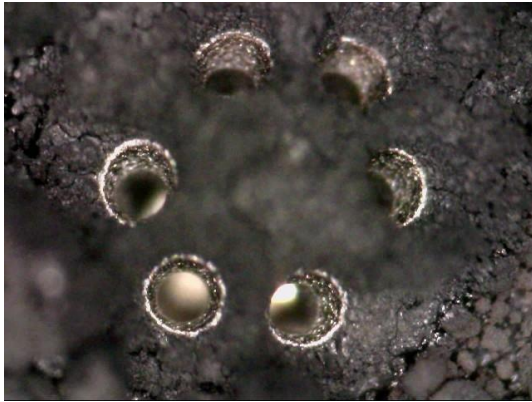
Graph 2: Relative Change of Injection Time during dirty-up and clean-up phase



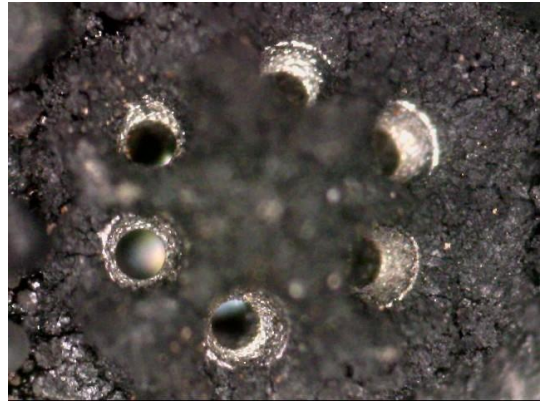
Graph 3: Clean-up performance during clean-up phase (End of dirty-up phase= 100%)

4 Injector Photos

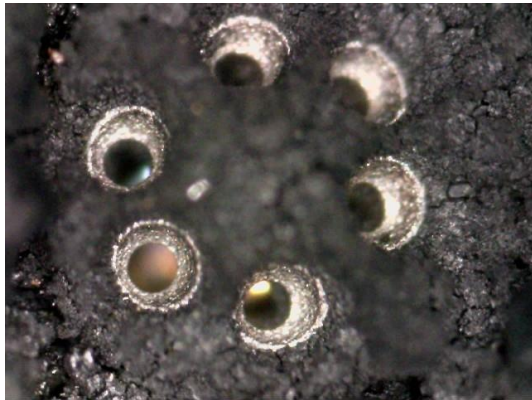
Spray holes at end of test (72 hours):



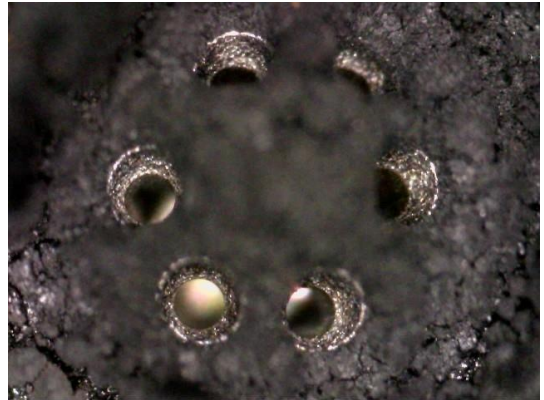
←
Injector #1



→
Injector #2

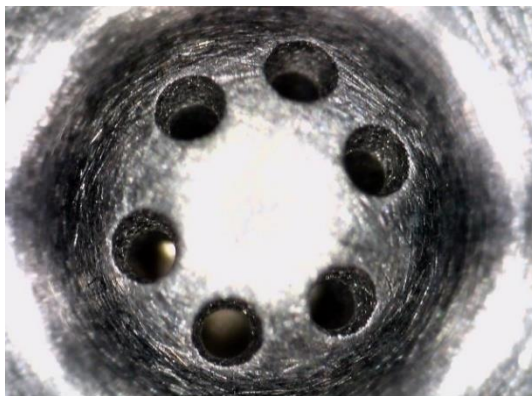


←
Injector #3



→
Injector #4

Spray holes at start of test (after 4 hours injector run-in and clean-up procedure):



←
Injector #1



→
Injector #2



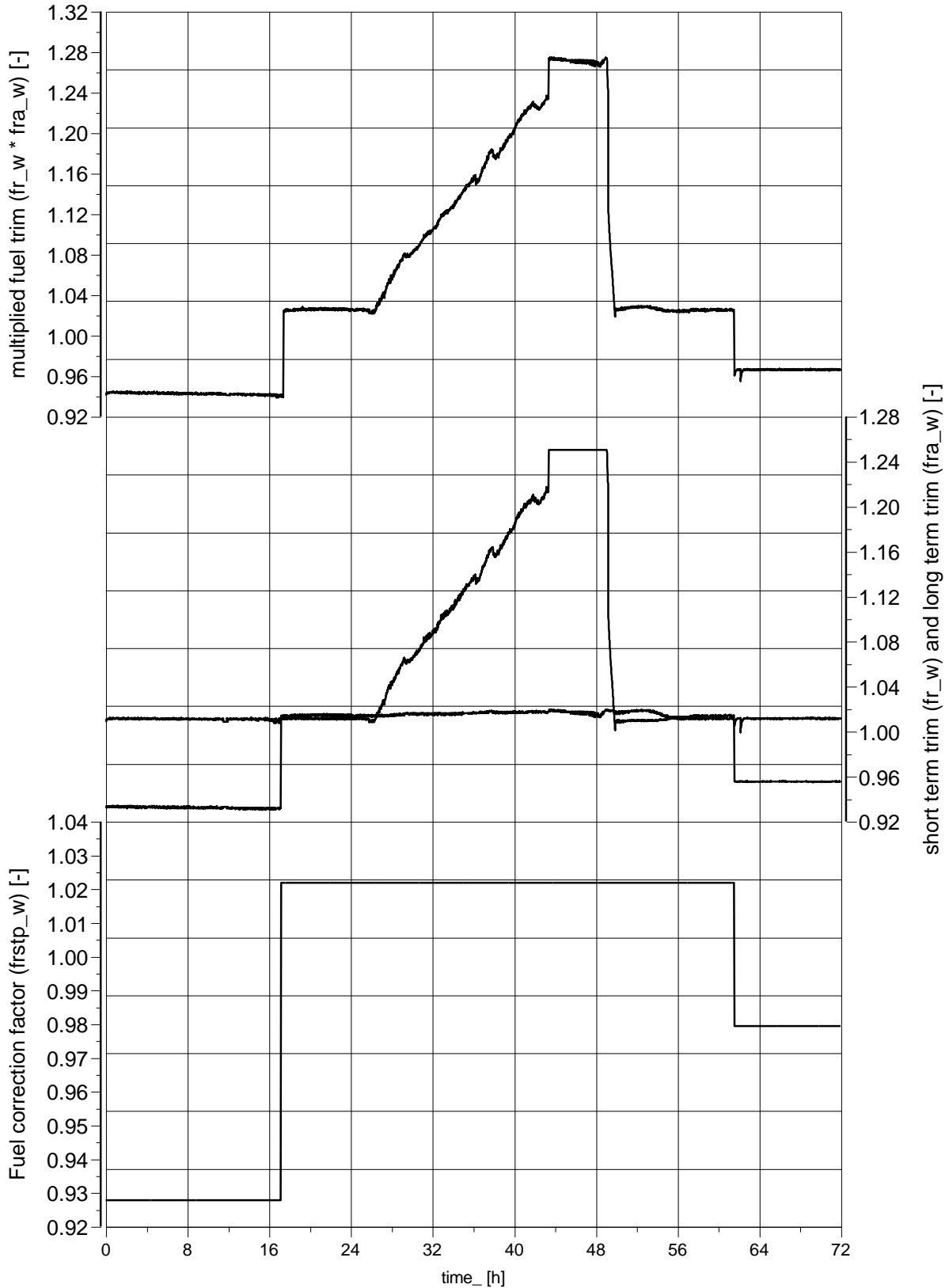
←
Injector #3



→
Injector #4

5 Additional Information

Additional ECU parameters for fuel correction:

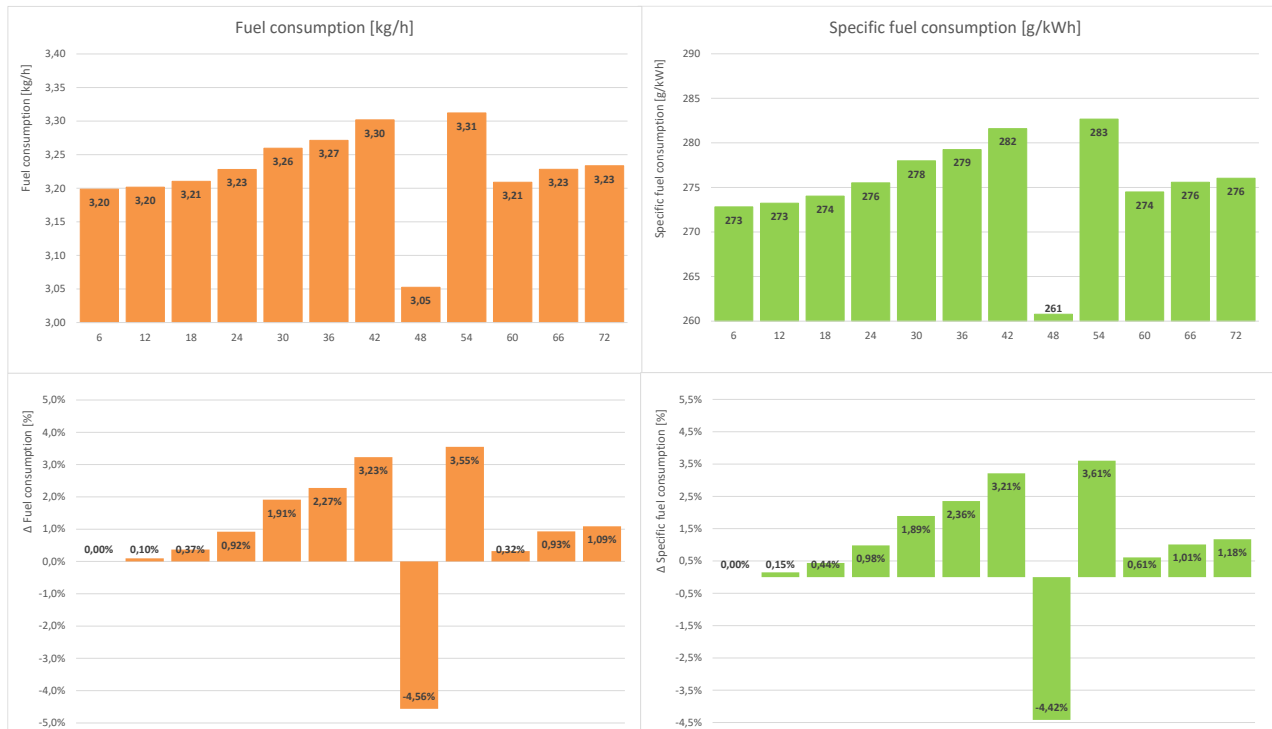


Graph 5: ECU fuel trim and correction factor values

hours	ti_ms	%	
0	1,6156	0,0	Start of DU (trend calculation)
48	2,3859	100,0	End of DU (trend calculation)
49	2,3578	96,3	
50	2,0746	59,6	
51	1,9354	41,5	
52	1,8989	36,8	
53	1,8668	32,6	
54	1,8029	24,3	
55	1,6674	6,7	
56	1,6215	0,8	
57	1,6260	1,4	
58	1,6341	2,4	
59	1,6291	1,8	
60	1,6312	2,0	
61	1,6349	2,5	
62	1,6370	2,8	
63	1,6390	3,0	
64	1,6391	3,1	
65	1,6314	2,1	
66	1,6376	2,9	
67	1,6411	3,3	
68	1,6390	3,0	
69	1,6433	3,6	
70	1,6414	3,4	
71	1,6395	3,1	
72	1,6388	3,0	

Table 1: Injection time during clean-up phase

6 Fuel consumption

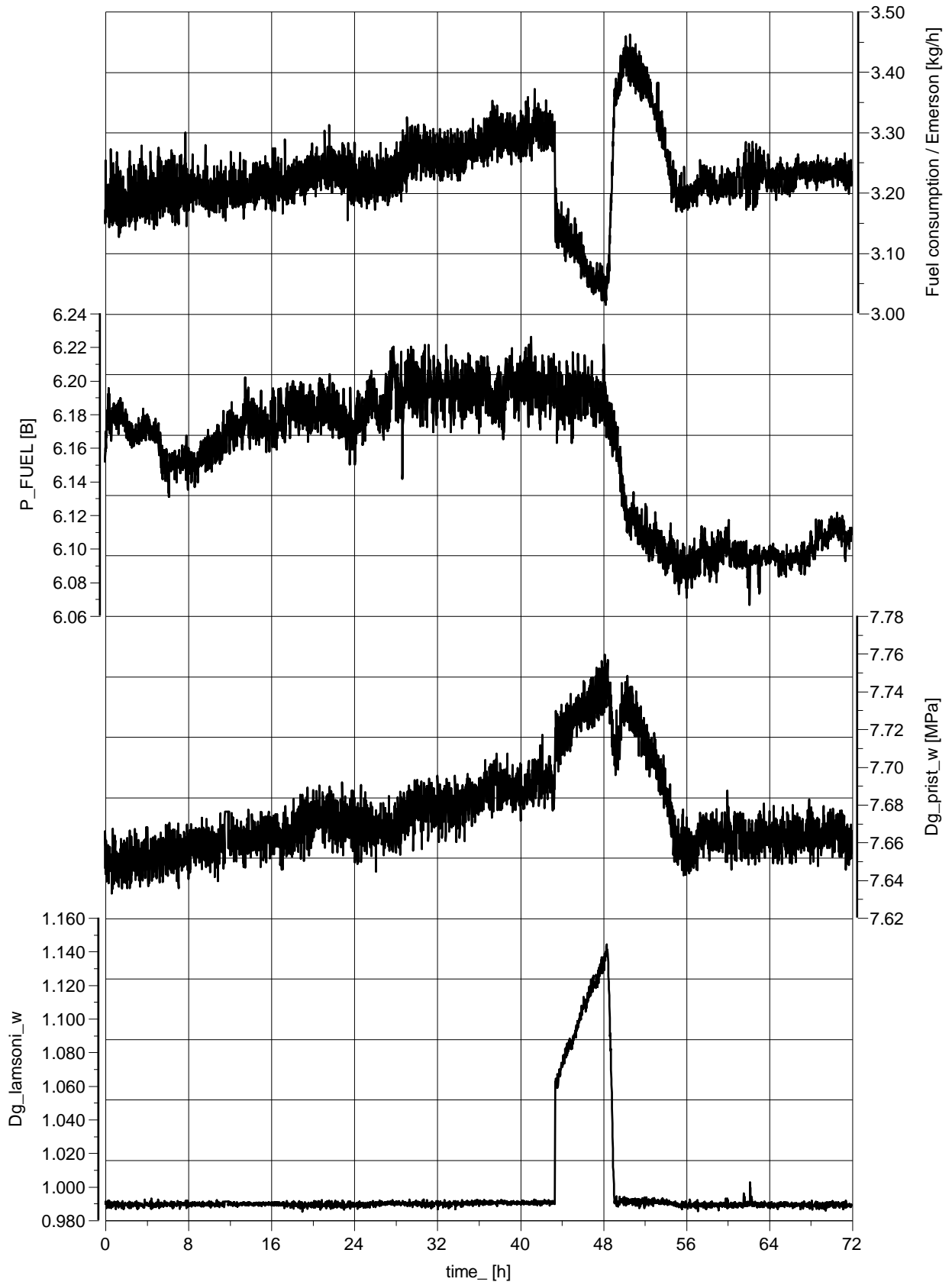


Graph 6: Fuel consumption during DISI test

Hour of test	Fuel consumption [kg/h]	Δ fuel consumption [%]	Specific fuel consumption [g/kWh]	Δ specific fuel consumption [%]	Power [kW]	Δ power [%]
6	3,1985	0,0%	272,8189	0,00%	11,7144	0,0%
12	3,2017	0,10%	273,2302	0,15%	11,7191	0,04%
18	3,2103	0,37%	274,0213	0,44%	11,7158	0,01%
24	3,2280	0,92%	275,5037	0,98%	11,7126	-0,02%
30	3,2597	1,91%	277,9830	1,89%	11,7129	-0,01%
36	3,2713	2,27%	279,2456	2,36%	11,7157	0,01%
42	3,3018	3,23%	281,5858	3,21%	11,7177	0,03%
48	3,0525	-4,56%	260,7649	-4,42%	11,7191	0,04%
54	3,3121	3,55%	282,6568	3,61%	11,7140	0,00%
60	3,2088	0,32%	274,4879	0,61%	11,7127	-0,01%
66	3,2283	0,93%	275,5783	1,01%	11,7144	0,00%
72	3,2334	1,09%	276,0253	1,18%	11,7124	-0,02%

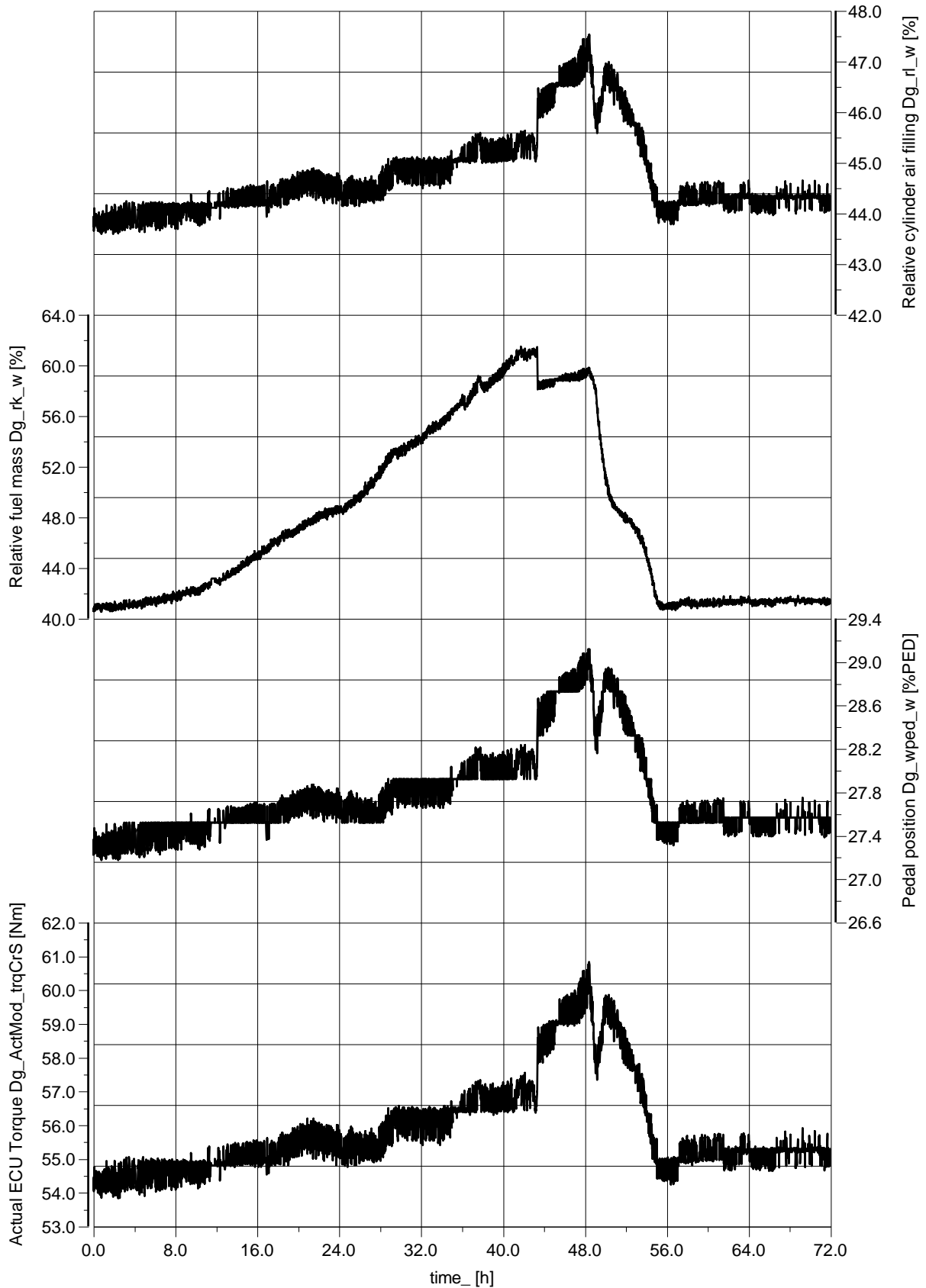
Table 2: Fuel consumption during DISI test

Additional parameters for fuel consumption:

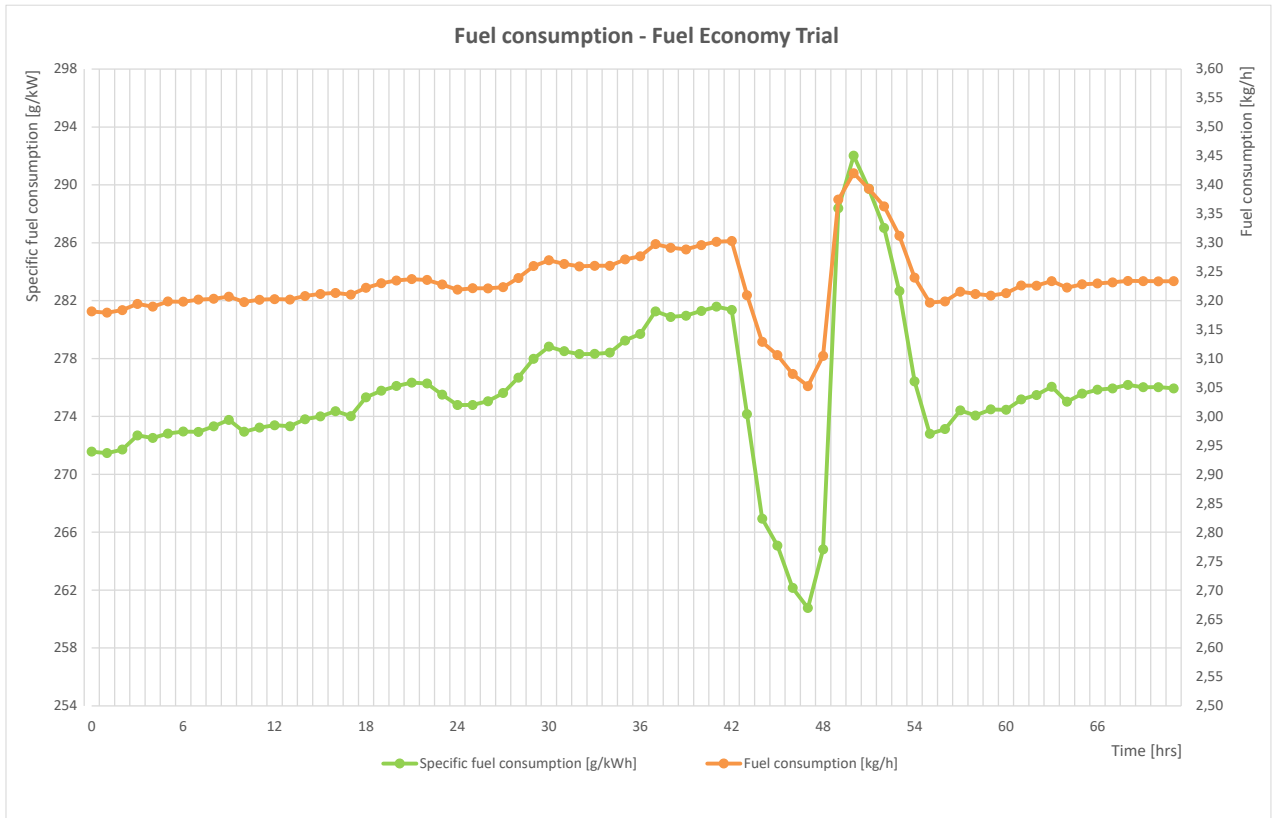


Graph 7: Fuel consumption and pressures, ECU lambda correction

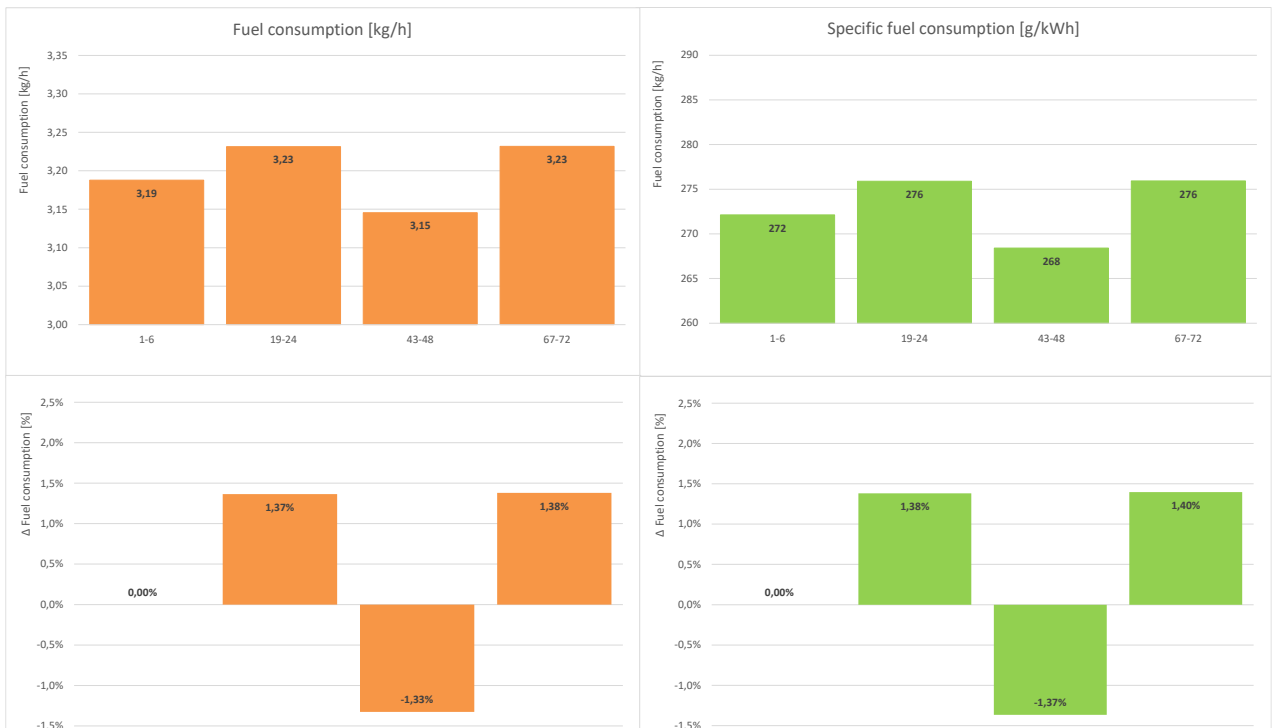
Additional parameters for ECU adjustment:



Graph 8: Parameters for ECU adjustment, relative cylinder filling, actual ECU torque



Graph 9: Fuel consumption during DISI test



Graph 10: Total change in fuel consumption between DU and CU parts of the test