Beilage ./12

SGS Drive Technology Center

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| SGS Report No. | 201935 |
| Order No. | 15-21-210975C |
| SGS Test No. | [redacted] |
| Customer Order No. | - |

This report replaces the report no. 201901 of SGS Austria, issued on 19.01.2016.

# Report

## Dirty-Up und Clean-Up Direct Injection, Common Rail Diesel Engine Nozzle Coking Test based on CEC F-98-08 with the PSA DW10B engine, including „Add On FC Measurement" according to method description for EEffG in Austria

01.02.2016

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# Drive Technology Center

[redacted]

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| | |
|---|---|
| **Test no.** | [redacted] |
| **Receipt of Test Fuel** | 04.12.2015 |
| **Start of Test** | 04.12.2015 |
| **End of Test** | 18.12.2015 |
| **Engine no.** | 0431032 (Referenz Nr. 10WAG6) |
| **Engine runtime at Start of Test** | 280 h |
| **Test Fuel Code** | **RF-79-07/8 +[redacted]mg/kg Zn** (Dirty-Up)<br>**RF-79-07/8 +[redacted]mg/kg [redacted]** (Clean-Up)<br>Fuel from Haltermann.<br>The additive and zinc was added by SGS. |
| **Test Fuel ID** | 20155692 (DU), 20155700 (CU) |
| **Test Injectors ID** | 1. Zylinder: 0606-07119 (run time before test: 17 h)<br>2. Zylinder: 0606-07356 (run time before test: 17 h)<br>3. Zylinder: 0606-07361 (run time before test: 17 h)<br>4. Zylinder: 0606-07377 (run time before test: 17 h) |
| **Test Oil Used** | RL 236 / Batch 4 |
| **Test Procedure*** | Test procedure according to EEffG method in Austria* |
| **Comment** | Used, but cleaned injectors were used |
| **Test Validity** | **valid** |
| **Test Result*** | Change of measured fuel consumption<br>in percentage after 32 h: **1,5 %*** |
| | **A change of fuel consumption from 2,9 % to 1,4 % using additive type [redacted] at a treat rate of [redacted]mg/kg was observed.*** |
| **Date of last Accreditation** | 12.11.2014 |

**Schwechat, 01.02.2016**

Dr. Christian Strasser
Lab Manager

DI Thomas Feitzinger
Project Manager

The test results refer to the tested samples only. The partial publication of this reports needs a written acceptance of the testing laboratory. Retain samples are only provided on special request by the customer.

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* = Test Method not accredited: Test is not in accordance with CEC test (CEC F-98-08), because the run time is extended and the additional fuel consumption measurements (Add On FC) are performed.

(1) = Analysis performed in other accredited laboratory
(2) = Analysis performed in other not accredited laboratory

## 1 Test Procedure

Task of the tests is the verification of an additive according to the existing method description, corresponding to the Austrian Energy Efficiency Law for diesel fuels. The overall sequence of the recommended test procedure inclusive handling of the operating materials can be seen in Figure 1 and Figure 2. In Figure 1 the Dirty-Up and in Figure 2 the Clean-Up cycle is described.

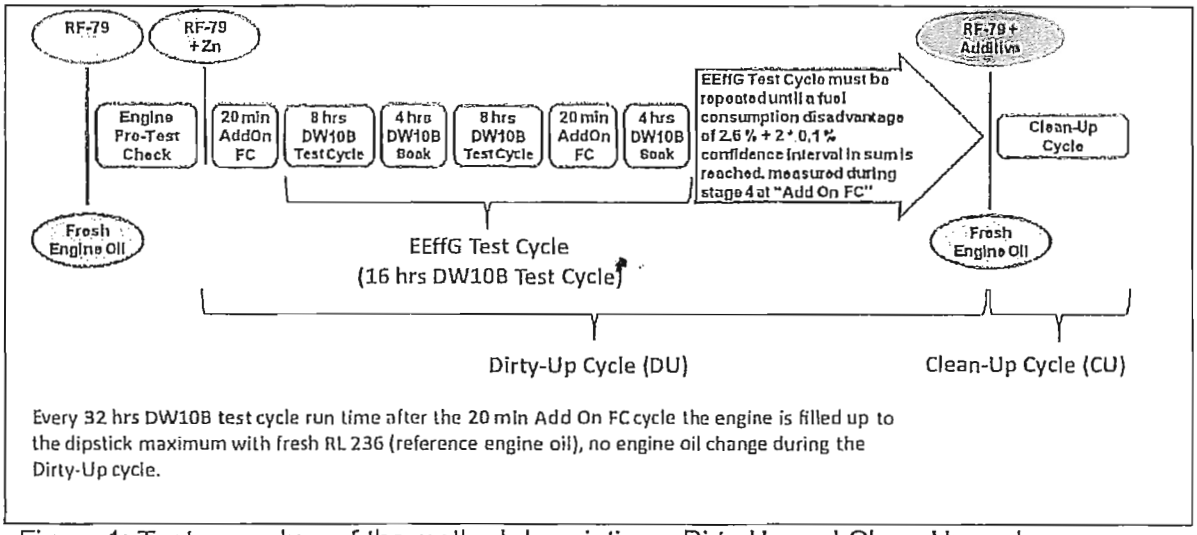



Figure 1: Test procedure of the method description – Dirty-Up and Clean-Up cycle

The duration for the Clean-Up cycle results out of the time which is necessary for reaching more than 50 % of the sum of 2,6 % fuel consumption improvement + 2 * 0,1 % confidence interval. The minimum duration for the Clean-Up cycle is in total at least 32 hours. Figure 2 shows the details during the Clean-Up cycle.

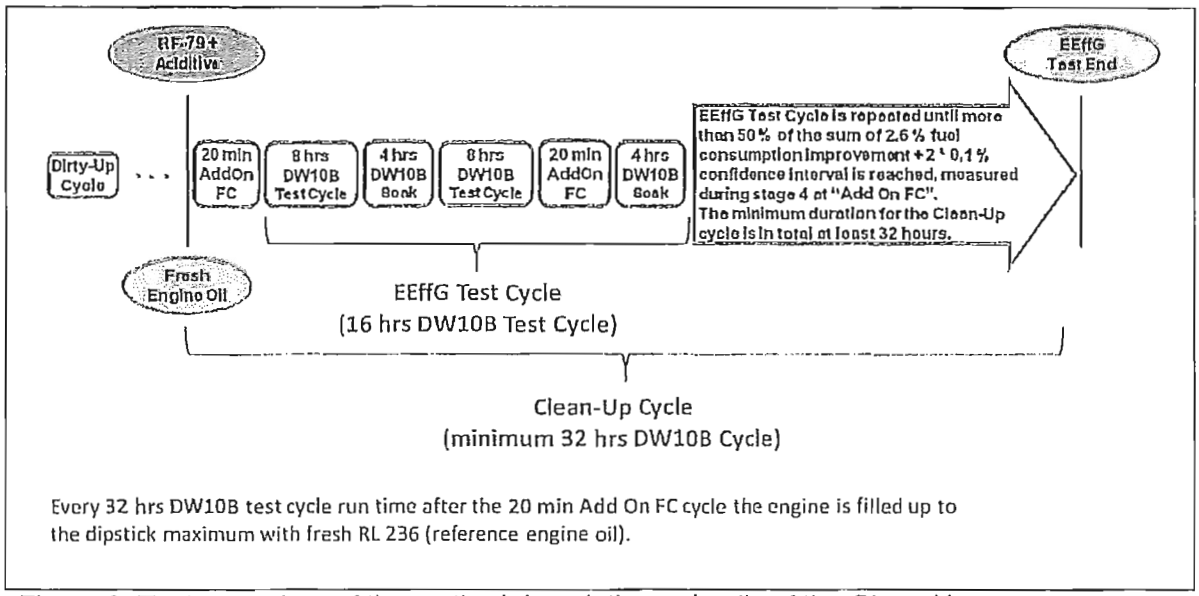



Figure 2: Test procedure of the method description – details of the Clean-Up cycle

Before and during the test cycle reference measurements in terms of a fuel consumption measurement cycle are performed.
These measurements consist of 3 single measurements, which are averaged over 2 minutes. The mean value of these three single measurements results in the detected fuel consumption:

- fuel consumption measurement cycle at stage 4 (20 min):
  - 11 min stabilization
  - 3 x „Add On FC" measurement (single measurements)
    - 2 min measurement
    - 1 min holding time

## 2 Evaluation of Confidence Interval

The evaluation of the confidence interval is described in the document "Methodenempfehlung für EEffG von SGS DTC". A confidence interval of 0,1 % is given for the test.

## 3 Unusual Occurrences

At 142 h test run time (DW10B coking cycle) the thermocouple post intercooler was changed.

## 4 Instances of operations outside specific limits

none

## 5 Brake Specific Fuel Consumption (BSFC) during "Add On FC"

*BSFC and change of BSFC in percentage during fuel consumption measurement cycle ("Add On FC") of the overall result:*

| | runtime | BSFC | Change of BSFC* |
|---|---|---|---|
| | [h] | [g/kWh] | [%] |
| SoT | 0 | 223,1 | 0,0 |
| EoT - DU | 160 | 229,7 | 2,9 |
| EoT - CU | 192 | 226,4 | 1,4 |
| Real Value = | $\Delta$ BSFC$_{CU}$ - $\Delta$ BSFC$_{DU}$ = | | **1,5** |
| Target > | 50% v. (2,6 % + 2 x confidence interval) = | | **1,4**** |

SoT... Result at Start of Dirty-Up Phase

EoT- DU... Result at End of Dirty-Up Phase

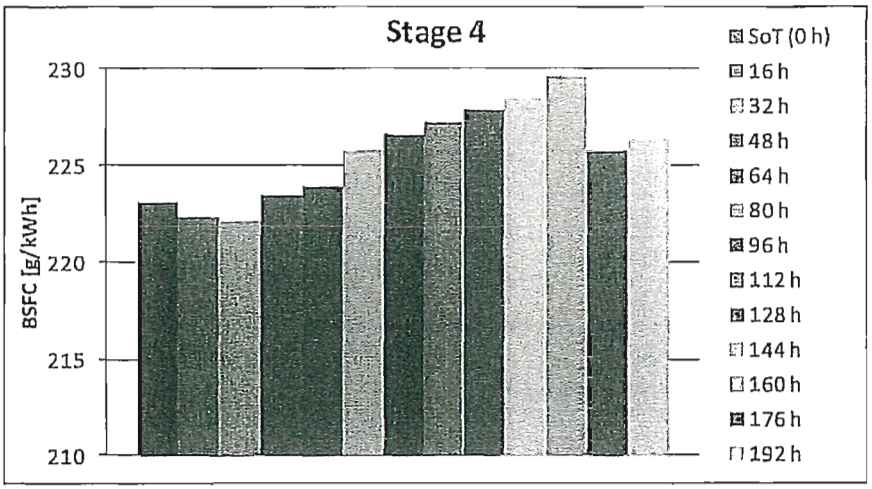
EoT- CU... Result at End of Clean-Up Phase

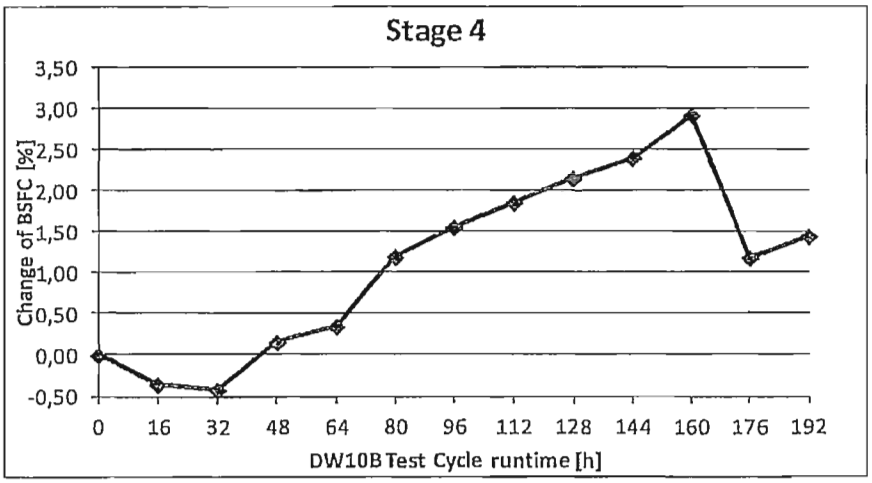
*... Change of brake specific fuel consumption (BSFC) referred to the BSFC at the beginning of the Dirty-Up phase in percentage.

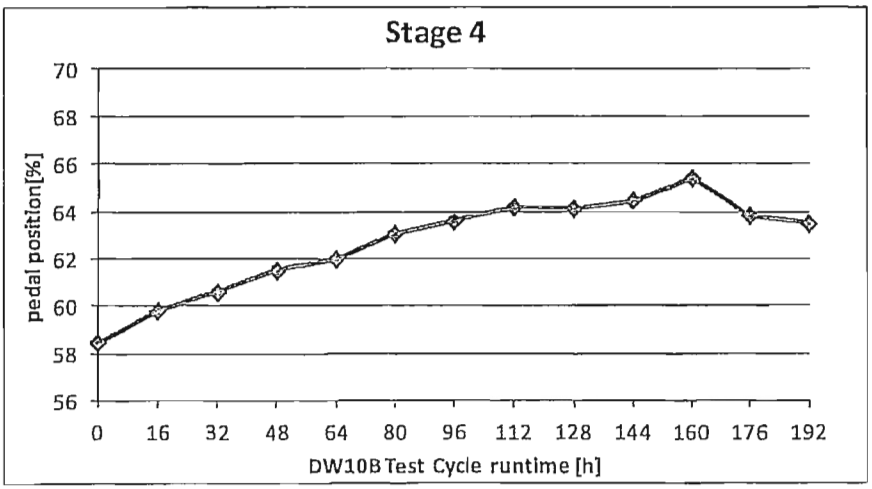
**... As described in detail in the EEffG method description (Umsetzung/Anerkennung der Energieeffizienzmaßnahmen für Dieselkraftstoffe im Rahmen des EEffG mittels Additiven in Österreich, Juni 2015) for Austria, a change of fuel consumption greater than 1,4 % must be achieved by clean up effect within at least 32 h.

A change of fuel consumption from 2,9 % to 1,4 % using additive type [redacted] at a treat rate of [redacted] **mg/kg** was observed.

*BSFC and change of BSFC in percentage during fuel consumption measurement cycle ("Add On FC") and the pedal value during runtime:*



# 6 Operational Data

## 6.1 Operational Data at Pre-Check

| parameter | | | unit | 4000rpm FL | | | 2000rpm FL | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | value | lower limit | upper limit | value | lower limit | upper limit |
| speed | | | 1/min | 4000,0 | 3995 | 4005 | 2000,0 | 1995 | 2005 |
| torque | | | Nm | 236,2 | 227 | 250 | 322,6 | 305 | 335 |
| blowby | | | l/min | N.A. | | | N.A. | | |
| coolant | | | °C | 97,1 | 95 | 99 | 97,0 | 95 | 99 |
| coolant flow | inner circuit | | l/min | 124,7 | 120 | 130 | 60,4 | | |
| coolant flow | EGR circuit | | l/min | 33,3 | 30 | 40 | 14,9 | | |
| boost air | after IC | | °C | 50,0 | 47 | 53 | 50,2 | | |
| exh | pre turbo | | °C | 733,7 | | 780 | 651,7 | | |
| fuel | pre HPP | | °C | 32,0 | 30 | 34 | 31,7 | | |
| oil gallery | engine inlet | | °C | 101,2 | | 136 | 100,2 | | |
| oil pressure | | gauge | bar | 4,2 | 3 | | 2,5 | | |
| intake air | air filter | gauge | mbar | -36,4 | -80 | | -11,3 | | |
| exh | after turbo | gauge | mbar | 416,8 | 410 | 450 | -1015,6 | | |
| boost pressure | after IC | absolute | mbar | 2203,2 | 2100 | 2300 | 2337,4 | | |
| fuel | pre HPP | gauage | mbar | -71,4 | -300 | 0 | -69,4 | | |
| fuel | injector return | gauage | mbar | 1424,0 | 700 | | 928,2 | | |
| fuel | HPP return | gauage | mbar | 587,1 | | 800 | 272,0 | | |
| t_tia | | | °C | 21,0 | 20 | 30 | 20,5 | 20 | 30 |
| t_tco | | | °C | 97,0 | 95 | 99 | 97,0 | 95 | 99 |
| t_mf_tot | | | mg/strk | 50,6 | 50 | 51 | 62,0 | | |
| t_map_sp_mmv | | | hPa | 2198,3 | 2190 | 2210 | 2319,9 | | |
| t_map_mmv | | | hPa | 2194,7 | 2190 | 2210 | 2313,9 | | |
| tmaf_sp_mmv | | | mg/strk | 995,2 | 960 | | 1152,8 | | |
| t_maf_mmv | | | mg/strk | 993,8 | 960 | | 1151,8 | | |
| t_fup | | | MPa | 159,8 | 159 | 161 | 135,1 | | |
| t_fup_dif | | | MPa | 0,1 | -1 | 1 | 0,2 | | |

## 6.2 Operational Data during Stage 12

| Dirty-Up | average | standard deviation | minimum | maximum | *limits* |
|---|---|---|---|---|---|
| Coolant temperature, engine outlet [°C] | 97,0 | 0,1 | 96,7 | 97,3 | *97±2* |
| Lubricant temperature [°C] | 102,1 | 0,7 | 99,0 | 103,1 | *max.136* |
| Fuel temperature at HP pump inlet [°C] | 32,0 | 0,1 | 31,7 | 32,3 | *32±2* |
| Air temperature, Intercooler outlet [°C] | 50,0 | 0,1 | 49,7 | 51,1 | *50±3* |
| Intake air temperature [°C] | 23,1 | 0,3 | 22,1 | 23,7 | *23±5* |
| Fuel pressure at HPP inlet [mbar] | -80,0 | 0,5 | -81,2 | -78,8 | *-150±150* |
| Fuel pressure at HPP injector return [mbar] | 1432,3 | 13,6 | 1385,2 | 1456,3 | *min. 700* |
| Fuel rail pressure (ECU) [MPa] | 159,8 | 0,1 | 159,5 | 160,1 | *160±2* |
| Boost pressure after IC (absolute) [mbar] | 2198,1 | 0,3 | 2196,9 | 2198,7 | *2200±15* |
| Total fuel flow set point from ECU [mg/Strk] | 50,5 | 0,0 | 50,5 | 50,6 | *50±0,5* |
| Pilot injection [µs] | 0,0 | 0,0 | 0,0 | 0,0 | *0,0* |

| Clean-Up | average | standard deviation | minimum | maximum | *limits* |
|---|---|---|---|---|---|
| Coolant temperature, engine outlet [°C] | 97,1 | 0,1 | 96,8 | 97,2 | *97±2* |
| Lubricant temperature [°C] | 100,9 | 0,1 | 100,4 | 101,2 | *max.136* |
| Fuel temperature at HP pump inlet [°C] | 32,0 | 0,2 | 31,7 | 32,3 | *32±2* |
| Air temperature, Intercooler outlet [°C] | 50,0 | 0,1 | 49,7 | 50,2 | *50±3* |
| Intake air temperature [°C] | 22,9 | 0,3 | 22,3 | 23,5 | *23±5* |
| Fuel pressure at HPP inlet [mbar] | -80,2 | 0,5 | -81,1 | -79,1 | *-150±150* |
| Fuel pressure at HPP injector return [mbar] | 1418,6 | 16,7 | 1381,3 | 1441,6 | *min. 700* |
| Fuel rail pressure (ECU) [MPa] | 159,8 | 0,1 | 159,6 | 159,9 | *160±2* |
| Boost pressure after IC (absolute) [mbar] | 2198,1 | 0,5 | 2197,2 | 2199,0 | *2200±15* |
| Total fuel flow set point from ECU [mg/Strk] | 50,5 | 0,0 | 50,5 | 50,6 | *50±0,5* |
| Pilot injection [µs] | 0,0 | 0,0 | 0,0 | 0,0 | *0,0* |

## 6.3 Operational Data during Stage 4

| Dirty-Up | average | standard deviation | minimum | maximum | *limits* |
|---|---|---|---|---|---|
| Coolant temperature, engine outlet [°C] | 97,0 | 0,0 | 96,8 | 97,2 | *97±2* |
| Fuel temperature at HP pump inlet [°C] | 32,0 | 0,1 | 31,6 | 32,2 | *32±2* |
| Air temperature, Intercooler outlet [°C] | 50,0 | 0,1 | 49,8 | 50,2 | *50±3* |
| Intake air temperature [°C] | 23,0 | 0,2 | 22,3 | 23,5 | *23±5* |
| Engine speed [1/min] | 3500,0 | 0,1 | 3499,8 | 3500,1 | *3500±10* |
| Engine torque [Nm] | 212,0 | 0,3 | 211,2 | 212,8 | *212±6* |

| Clean-Up | average | standard deviation | minimum | maximum | *limits* |
|---|---|---|---|---|---|
| Coolant temperature, engine outlet [°C] | 97,0 | 0,0 | 97,0 | 97,1 | *97±2* |
| Fuel temperature at HP pump inlet [°C] | 31,9 | 0,1 | 31,7 | 32,2 | *32±2* |
| Air temperature, Intercooler outlet [°C] | 50,0 | 0,1 | 49,8 | 50,2 | *50±3* |
| Intake air temperature [°C] | 22,9 | 0,3 | 22,3 | 23,2 | *23±5* |
| Engine speed [1/min] | 3500,0 | 0,1 | 3499,9 | 3500,1 | *3500±10* |
| Engine torque [Nm] | 212,0 | 0,3 | 211,4 | 212,7 | *212±6* |