Intra Company Correspondence

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Subject: **Use of ROAD SPEED FAN for Emissions Testing for the 2014 MY 3.0L Diesel DS**

Conclusion: For the 2014 MY 3.0L DS, using good engineering judgement and supporting test data, VM recommends emissions testing with the hood closed and a variable speed fan for emissions testing.

Discussion: VM would like to exercise the option of using the road speed fan in place of the fixed speed fan for testing because it is more representative of real world driving. The regulation states in section 86.135-90 (b) Dynamometer procedure

> *(b) During dynamometer operation, a **fixed speed cooling fan shall be positioned** so as to direct cooling air to the vehicle in an appropriate manner with the engine compartment cover open. In the case of vehicles with front engine compartments, the fan shall be squarely positioned within 12 inches (30.5 centimeters) of the vehicle. In the case of vehicles with rear engine compartments (or if special designs make the above impractical), the cooling fan shall be placed in a position to provide sufficient air to maintain vehicle cooling. The fan capacity shall normally not exceed 5300 cfm (2.50 m3 /sec). However, **if the manufacturer can show that during field operation the vehicle receives additional cooling, and that such additional cooling is needed to provide a representative test, the fan capacity may be increased, additional fans used, variable speed fan(s) may be used, and/or the engine compartment cover may be closed, if approved in advance by the Administrator.** For example, the hood may be closed to provide adequate air flow to an intercooler through a factory installed hood scoop. Additionally, the Administrator may conduct certification, fuel economy and in-use testing using the additional cooling set-up approved for a specific vehicle.*

It is VM's opinion, based on their extensive testing of DS vehicle with diesel engine, that the hood closed road speed fan is more representative of the engine temperature profiles during normal driving on the road. This is supported by a comparison between steady-state runs in the chassis dynamometer with the hood open using a fixed speed fan and with the hood closed using a variable speed fan on a prototype DS diesel, where:

1) The coolant temperature with the hood up causes the cooling fan to operate, while there is adequate cooling flow with the hood closed not to cause the coolant fan to operate. (See Figure 1.) Driving on the road, at these speeds and ambient temperatures, the coolant fan doesn't operate. With the hood closed, variable speed fan, the coolant remains at 95 degrees °C. With the hood open, fixed speed fan, the coolant temperature remains about 9 degrees °C higher at all vehicle speeds.
2) The inlet air temperature (MAF Air temperature) and charge air temperature (CAC) are elevated with the hood open and fixed speed fan for the same environmental temperature (cell temperature).
3) The ambient temperature (measured by the vehicle sensor) accurately measures the temperature and is constant for the speeds tested with the hood closed, variable speed fan. With the hood open, fixed speed fan, the ambient temperature (measured by the vehicle sensor) increases with increasing vehicle speed, while the cell temperature remains constant.
4) The Oil temperature is elevated with the hood open, fixed speed fan over the hood closed and variable speed fan. The difference increases with increasing vehicle speed.
5) The injected fuel is also changed with the hood open, fixed speed fan. At low speeds, 50 km/h, the injected fuel is the same. As the speed increased, the injected fuel is reduced with

the hood open, fixed speed fan, over the hood closed, variable speed fan. The difference increases with increasing vehicle speed.

The main reason for the different engine operating conditions using the hood open and fixed speed fan is because the engine compartment temperature distribution changes. This is not seen on the road for the same driving situations.

Figure 1 – 3.0L DS Diesel operation on the chassis dynamometer with fixed speed and variable speed cooling fan

CONSTANT SPEED DATA

	Hood Closed, Road Speed Fan			Hood Open, Fixed Speed Fan (8000 cfm - "FTP-type")		
Vehicle speed [km/h]	50	75	100	50	75	100
gear engaged	5	7	8	5	7	8
Engine speed [rpm]	1450	1420	1520	1450	1440	1520
Injected fuel [mg/stroke]	9.6	17	27.5	9.6	16.5	26.5
MAF Air temperature [°C]	30	27	27	30	32.5	35
CAC out Temperature [°C]	28.5	27	27.5	33.5	33.5	39
Ambient Temperature [°C]	23	23	23	24	26	28.5
Cell Temperature [°C]	23.9	23.9	23.9	23.9	23.9	23.9
Coolant temperature [°C]	95	94.5	95	104	104	105
Oil temperature [°C]	97	97	99	105.5	107	110
Fan status	off	off	off	on	on	on

On the bench with road speed fan, radiator fan does not turn on

On the bench with fixed speed fan, radiator fan turn on