Intra Company Correspondence

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R. W. Shaw Certification--Powertrain RWS12

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

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

Discussion: VM would like to exercise the option of using the road speed fan in place of the fixed speed fan for the DF 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 WK 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 WK diesel, where 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.) Notice that the inlet air temperature (MAF Air temperature) and the charge air temperature (CAC) are elevated with the hood open and fixed speed fan at low speeds for the same ambient temperature. Both conditions become equivalent as the speed approaches 60 mph. Also notice that, at low speeds (31 miles/hour), both the coolant and oil temperatures are elevated by 10 and 9 degrees C respectively with the hood open and fixed speed fan over the hood closed and variable speed fan. This temperature offset is reduced as vehicle speed is increased. As you can see from Figure 1, using the hood open and fixed speed fan causes the fuelling to be increased for the 31 mph condition as shown by injected fuel [mg/stroke] increase on Figure 1. Also, based on the limited road testing with representative vehicles and high ambient temperatures, the vehicle coolant radiator fan doesn't engage.

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 because, with the hood open and fixed speed fan, there is a "recirculation/swirl" of air which goes directly to the intake ducts of the engine. This is not seen on the road for the same driving situations.

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

CONSTANT VEHICLE SPEED DATA

	Hood Closed, Road Speed Fan			Hood Open, Fixed Speed Fan (8000 cfm - "FTP-type")		
Vehicle speed [m/h]	31	47	62	31	47	62
gear engaged	5	7	8	5	7	8
Engine speed [rpm]	1400	1350	1415	1380	1350	1425
Injected fuel [mg/stroke]	9.3	22	27	9.8	21	26
MAF Air temperature [°C]	31	31	32	38	34	32
CAC Temperature [°C]	29	29	30	35	30	29
Ambient temperature [°C]	26	25	27	25	25	25
Coolant temperature [°C]	87	87	87	97	86	87
Oil temperature [°C]	91	90	91	100	94	94

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

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