FORD MOTOR COMPANY (FORD) RESPONSE TO RQ24-008 Request 14

Request 14

Please provide a detailed summary as to how each of the software updates contribute to resolving the alleged defect for each of the following items:

a) Detection of a pressure drop in the fuel rail
   i. What is the pressure drop threshold for triggering detection?
   ii. How much time elapses between cracking of the subject component and detection?
b) Instrument cluster messaging to the customer to seek service
   i. What parameters must be met to trigger the seek service messaging?
   ii. What visual and auditory messaging does the software activate?
   iii. Does the messaging remain activate until service is performed, or can it be overridden?
c) Disablement of the high-pressure fuel pump
   i. How is the high-pressure fuel pump disabled and what effect does this have on other components within the entire fuel system?
   ii. How does a disabled high-pressure fuel pump affect vehicle performance?
d) Derating engine power output
   i. What parameters must be met to initiate derating of the engine power output?
   ii. What is the amount of reduction in vehicle power (i.e. limitations of speed, RPM, etc.)?
   iii. Does the engine derating occur immediately following the detection of pressure drop or is there a time delay?

Answer

a. Detection of a pressure drop in the fuel rail

i) What is the pressure drop threshold for triggering detection? – Fuel rail pressure is monitored via a pressure sensor on the rail. The software detection algorithm logic has two different detection mechanisms. The first is monitoring for a pressure loss when the direct injection (DI) fuel injector is commanded off by the powertrain control module (PCM). The pressure decay in this mode is used to estimate the volume of fuel which may have leaked from the high-pressure system. One leak of 0.4grams of fuel or three leaks of 0.2grams of fuel will trigger the leak detection. The location of the leak cannot be determined by the control algorithm, meaning, the leak could be external or internal to the engine/fuel system. The second detection mechanism is to monitor for a gross leak. This is when the High-Pressure Fuel Pump is commanded nearly full-on (>95% of HPFP capacity) by the Powertrain Control Module, but the pump is unable to build sufficient pressure (<50% of desired pressure can be achieved). This indicates the system could have a severe leak.

ii) How much time elapses between cracking of the subject component and detection? The time from crack to detection is dependent on the size of the crack and the driving cycle. For smaller leaks, the DI injector must be commanded off with the engine running to then calculate the mass of fuel that left the fuel rail. This can then be used to trigger the detection. DI injectors will be commanded off during Decel Fuel Shut-Off or when the PCM is commanding PFI only injection which is a function of speed/load. For larger leaks, the algorithm will trigger when the HPFP is not capable to build sufficient pressure.

To validate effectiveness of the algorithm in representative conditions, two scenarios were tested. A cracked fuel injector was installed on a test vehicle and the PCM algorithm detected the crack 23seconds after the engine was started from an engine coolant temperature of 48C. This captured how quickly a customer would receive notification of a cracked injector on vehicle startup. In the second scenario tested, PCM software was modified to simulate a cracked injector in a test vehicle. The vehicle was then driven on between a Ford dealership lot and their body shop on a country road in S.E. Michigan. The leak was detected 27sec after it was introduced while driving. This captured how quickly customer would receive notification of a cracked injector while driving and validated the FMEM response.

b. Instrument cluster messaging to the customer to seek service

i) What parameters must be met to trigger the seek service messaging? – Either of the leak detection methods (fuel volume estimation based on pressure drop or gross leak) will immediately trigger the wrench light and the cluster will display the service message pop-up.

ii) What visual and auditory messaging does the software activate? For all vehicles, a wrench light is illuminated concurrent with detection of the unexpected loss of fuel pressure and the application of the fuel pump disablement and torque limitation. A MIL light will also be illuminated on either the first or second trip with the fault present depending on the calibration.

iii) Does the messaging remain activate until service is performed, or can it be overridden? The MIL and wrench will remain illuminated until a service tool commands an OBD code clear (eg. Service Mode $04). The service message will disappear once the user presses “ok”. The service message will re-appear once every consecutive ignition cycles.

c. Disablement of the high-pressure fuel pump

i) How is the high-pressure fuel pump disabled and what effect does this have on other components within the entire fuel system? The high-pressure fuel pump disablement is commanded immediately upon detection of the unexpected loss of fuel pressure. The engine will continue to inject fuel, but at the lower lift pump pressure because the low-pressure fuel pump is still actively controlling flow/pressure. The pressure difference is 250BAR reduced to 6BAR.

ii) How does a disabled high-pressure fuel pump affect vehicle performance? With the high-pressure fuel pump disabled, and the engine in a derated power condition, the vehicle is limited to approximately 40 mph depending on road grade and vehicle loading.

d. Derating engine power output

i) What parameters must be met to initiate derating of the engine power output?

Parameters that will trigger leak detection and initiate derating of the engine power output include one leak of 0.4grams of fuel, or three leaks of 0.2grams of fuel, or a gross leak. Gross leaks are when the High-Pressure Fuel Pump is commanded nearly full-on (>95% of HPFP capacity) by the Powertrain Control Module, but the pump is unable to build sufficient pressure (<50% of desired pressure can be achieved). This indicates the system could have a severe leak.

The derate is commanded immediately upon detection of the unexpected loss of fuel pressure.

ii) What is the amount of reduction in vehicle power (i.e. limitations of speed, RPM, etc.)? The derate is a limit on the manifold pressure target controlled by the PCM. The vehicle is limited to approximately 40mph depending on road grade and vehicle loading.

iii) Does the engine derating occur immediately following the detection of pressure drop or is there a time delay? The engine derating is commanded immediately upon detection of the unexpected loss of fuel pressure.

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