U.S. Department
of Transportation
National Highway
Traffic Safety
Administration

Memorandum

Subject: Meeting with Ford Motor Company, EA05-003, 6.0LDiesel Engine Stalling

Date: September 27, 2005

From: Scott Yon

To: File for EA05-003

Ford Motor Company Attendees:
Mr. Ray Nevi, Automotive Safety Office Directo
Mr. Pete Souchock, Automotive Safety Office Manager
Mr. Francis Wickenheiser, Automotive Safety Office Manager
Mr. Kurt Schieding, Quality Engineering
Ms. Mina Shams, Quality Engineering
Mr. Frank Setili, Automotive Safety Office Engineer

NHTSA Attendees:
Ms. Kathy DeMeter, Office Director, ODI
Mr. Jeffrey Quandt, Division Chief, VCD, ODI
Mr. Lloyd Guerci, Attorney, OCC
Mr. Otto Matheke, Attorney, OCC
Mr. Andrew DiMarsico, Attorney, OCC
Mr. Nate Seymour, Investigator, ODI
Mr. Scott Yon, Investigator (EA05-003), ODI

On May 18, 2005, Ford Motor Company (Ford) personnel presented a technical analysis to the Office of Defects Investigation (ODI) and other NHTSA staff regarding Engineering Analysis (EA) 05-003, which is an investigation of complaints of engine stalling on model year (MY) 2003 to 2004 F Super Duty Ford pickups with 6.0L diesel engines. Ford subsequently submitted its presentation to NHTSA under request for confidentiality. This memorandum discusses Ford's presentation while preserving confidentiality. The presentation (85 slides in total) consisted of an introduction, an overview of the 6.0L engine function, an analysis of engine warranty data, and a technical review of ten (10) quality issues identified by Ford as pertinent to engine performance.

Introduction

Ford discussed vehicle operating conditions during an engine stall, the complexities associated with the diagnosis of engine stall complaints and an analysis of ODI's vehicle owner questionnaires (VOQs). Ford discussed that the subject vehicle braking and steering systems use an engine driven hydraulic based power assist system (hydro-boost). When an engine stall occurs while the vehicle is in motion, vehicle momentum can sustain (or 'back-drive') the engine's rotation under certain circumstances. Back-drive permits power assisted braking and steering to remain despite an engine stall. For example, vehicles with manual transmissions will back-drive as long as the vehicle is moving in gear with the clutch engaged. For vehicles with automatic transmissions, back-drive occurs when the vehicle is above a certain speed.[1] Below those speeds, back-drive is

1 ODI notes that vehicles with automatic transmissions must remain in drive for back-drive to occur.

transmission's electronic controller has electrical power, and 2) whether or not the transmission is in tow/haul mode. The approximate speeds, according to Ford, are shown in table one.

	With Electrical Power	Without Electrical Power
Normal Mode	40 MPH	28 MPH
Tow/Haul Mode	18 MPH	28 MPH

Table 1: Approximate speed at which engine back-drive is lost, automatic transmission vehicles

If back-drive is lost or unavailable, Ford maintains that an accumulator (an energy storage device intended to provide backup power) within the hydro-boost system will provide power assisted stopping on a limited basis. If the accumulator is depleted by brake application, the system operates in manual mode (non power assist). The steering system operates in manual mode (non power assist) operation when back-drive ceases (i.e., there is no backup for steering).

Ford discussed complexities associated with the ability to diagnosis and repair 6.0L engine performance complaints. Ford indicated that these complexities include: difficult diagnosis, incorrect part replacement, incorrect repair procedure. Ford stated that the intermittent nature of condition symptoms make it difficult for technicians to duplicate consumer concerns, which results in the misidentification of the root cause, unsuccessful repair attempts, and ambiguous warranty complaints. In its review of the warranty data, Ford encountered difficulty distinguishing between driveability complaints compared to allegations of true engine stall.[2] This caused Ford to identify an extensive list of causal parts, which it asserts resulted from misdiagnosis.

Ford contends that the low number and minor nature of the crashes and injuries reported by consumers allegedly related to engine stalling are indicative of adequate steering and braking control under engine stall conditions.

Ford presented its analysis of the 81 vehicles reported in ODI's opening resume for EA05-003[3]. Seventy-six (76) of the 81 vehicles (94%) had multiple engine related repair claims in Ford's warranty database. The average number of repairs per vehicle was 4.6 with one vehicle having 11 separate claims.[4]

Engine Function Overview

Ford discussed the design and operation of the fuel delivery and intake air management systems of the subject engine. In addition, it explained Ford's design revisions to the engine's electrical wiring harness. Ford stated that because diesel engines are fuel throttled; for an engine stall to occur, either a total loss of air intake or a total loss of fuel delivery, or both, must occur. Since Ford did not identify any failure modes with the air management system that could result in total air loss, it concluded that fuel system and fuel system related electrical system failures were the likely causes of the engine stall in the subject vehicles.

Warranty Data Analysis

Ford's warranty database contains a customer concern code (CCC) field that Ford asserts is an indication of the vehicle conditions leading to a warranty repair. Ford instructs its repair facilities to use the CCC code "D21" when an engine stall is reported.[5] Ford produced a chart showing D21 warranty claim rates for subject vehicles achieving 12 months in service (MIS) versus date of vehicle build (DOB). Based on the rates in this chart, Ford subdivided the subject vehicles into three populations. The first population consisted of vehicles manufactured from start of production (September 2002) through April 2003, which Ford referred to as time period one vehicles (TP1). The second population consisted of vehicles built from May 2003 to September 2003 inclusively. The third population consisted of vehicles built from October 2003 through May 2004, which Ford

---

2 Some consumers use the term 'stall' to describe a condition where the engine does not produce enough power to propel the vehicle forward as anticipated, however, the engine continues to run and does not require a restart.

3 ODI notes that 81 of 101 vehicle owner questionnaires, or VOQs, contained a valid VIN number.

4 Ford developed a 26-bin Pareto chart based on its review of problem descriptions identified by VIN. The chart ranked the problem descriptions from most to least common. Multiple repair visits were the most common concern and dealer inability to duplicate/resolve problem was the second most.

5 The CCC code is determined by the repair facility that submits the warranty claim.

referred to as time period two vehicles (TP2). In comparison to vehicles manufactured from May to September 2003, TP1 and TP2 vehicles displayed higher levels of D21 warranty claim rate[6].

For the subject vehicles, Ford produced a chart showing a 12 MIS warranty claim rate versus DOB for all engine related customer concern codes and superimposed the D21 claim data on it. The chart showed that the D21 claim rate was significantly lower than overall engine related warranty[7].

Ford produced Pareto charts based on engine related warranty claim CCCs for TP1 and TP2 vehicle populations. Each Pareto chart consisted of 10 bins of CCC[8] claims, ranked by number of claims, as shown in figure 2 below. The D21 claims ranked 8th (representing [redacted] of claims) on the TP1 Pareto and 4th (representing [redacted] of claims) on the TP2 Pareto. Ford asserted that the difference in D21 ranking between TP1 and TP2 was an indication that engine stalling was more prevalent in the TP2 as compared to the TP1 vehicle populations. [

[redacted]

]

6 Ford states that the D21 claim rate for subject vehicles built May to September 2003 is similar to predecessor 7.3L diesel engines used in earlier model year vehicles, which did not suffer engine performance concerns and is representative of a typical diesel engine claim rate.

7 ODI estimates that D21 coded stalling claims were [redacted] of total engine warranty claim rate.

8 The other 9 CCCs (non-D21) were for non-stall related engine performance concerns.

Ford also produced charts for the TP1 and TP2 populations showing: 1) D21 coded CCC warranty claims versus date of repair; and 2) D21 coded CCC reliability data. Ford claimed that the charts showed the occurrence of D21 warranty claims is declining and is declining at a faster rate for TP2 vehicles. Ford contends that this indicates that engine performance issues are now understood by Ford and are being resolved through service and production countermeasures.

Technical Reviews

Ford identified ten engine related quality issues and discussed the technical root cause for each and its impact on vehicle operation. As part of its technical reviews, Ford presented warranty CCC Paretos, Reliability charts, and discussed countermeasure actions for each issue.

Injector scuffing: The 6.0L engine employs a fuel injection system that requires an engine driven oil pump to pressurize the engine lubricating oil from the engine crankcase. The high pressure oil actuates an electronically controlled injector plunger that forces fuel into the combustion chamber at high pressure (up to 4,000 PSI). The fuel plunger of the injector may wear with age and result in fuel leakage into the engine crankcase. As the oil in the crankcase becomes diluted by fuel, a loss of oil viscosity will occur. This causes the oil pressure that actuates the injectors to diminish and reduces injected fuel volume. Engine performance decreases and an engine stall may occur[9]. D21 coded claims were 8th (representing [redacted] of claims) on Ford's 10 bin CCC Pareto for fuel injector related warranty claims, and based on this, Ford stated that fuel injectors were not a significant cause of engine stall. A production countermeasure was implemented in May 2003. Ford notes that fuel injectors are covered by a 10 year, 100,000 miles powertrain warranty.

ICP Sensor: The injector control pressure (ICP) sensor produces a signal proportional to the high pressure oil used for fuel injection. Starting from job one engine production, Ford discovered that a distorted o-ring seal within the sensor assembly obscured a portion of the pressure sensing element, which resulted in an erroneous signal output. An erroneous signal could result in poor engine performance including stall. D21 coded warranty claims ranked 8th (representing [redacted] of claims) on the CCC Pareto of ICP warranty. A new sensor with an improved o-ring material was introduced in vehicle production in February 2003. An owner notification program was commenced by Ford in April 2003 and has resulted in the replacement of a high percentage [redacted%] of the effected sensors.

Pilot Injection Calibration: Depending on engine speed, the fuel injection system may operate in 'pilot' or 'single' shot modes[10]. Subject engines manufactured from job one were intended to operate in pilot mode at idle speeds. As the fuel injectors age, variability within the quantity of fuel delivered while in pilot mode from one injection to the next increases. This so called 'shot to shot' variability can result in poor idle quality, including an engine roll speed of approximately 50 RPMs. D21 coded claims ranked 6th (representing [redacted] of claims) on the CCC Pareto for related warranty claims. Ford developed a new engine calibration[11] that eliminated pilot mode operation (the engine now operates in single shot mode at all times). Ford conducted a service campaign in October 2003 to recalibrate or "re-flash" the effected vehicles (including unsold vehicles in dealer stock) and introduced the new calibration in production in December 2003.

FICM Wire Chaffing: Ford implemented design changes to the fuel injection control module (FICM) wiring harness in October and December 2003. Variability in engine-to-engine assembly caused some harnesses to be placed in close proximity to rocker cover and/or intake manifold bolt heads resulting in the FICM harness chaffing. The chaffing caused wiring shorts. Various failure modes can occur depending on which electrical circuit shorts. This could include FICM reset and/or a loss of crank/cam position signals, resulting in sudden engine stall. D21 coded claims ranked 1st (representing [redacted] of claims) on the CCC Pareto for FICM harness related warranty. A revised harness connector with a 90 degree bend was introduced in April 2004, and additional exterior harness protection (convolute tubing) was introduced in September 2004. Service documentation (TSB 04-18-6) was issued to dealer technicians in September 2004.

ICP/EBP Sensor Connector: The subject engines utilize exhaust gas recirculation (EGR) for emissions

---

9 The stall can result from reduced fuel delivery or from hydro-locking due to excessive crankcase fluid.

10 The 'pilot' shot (or injection) mode was a feature of the 6.0L engine implemented to reduce engine noise at idle.

11 The term 'engine calibration' refers to engine control software which can be upgraded to a newer design or software level via a service replacement process often referred to as a "re-flash.".

control purposes. The exhaust back pressure (EBP) sensor provides a signal needed for proper EGR system operation. Beginning with December 2003 production, the ICP and the EBP signals could become erratic because the electrical terminals affixed to the wiring for these sensors were insufficiently crimped. While loss of ICP signal may result in engine stall, Ford testing showed that EBP signal loss does not cause engine stall (see ECR Valve Coking below). D21 coded warranty ranked 1st (representing [ ]% of claims) on the CCC Pareto for ICP related warranty; D21 coded claims ranked 7th (representing [ ] of claims) on the EBP related Pareto. The wire harness supplier for the ICP/EBP connector modified their manufacturing process in April 2004 to correct this issue, and a service kit with a replacement ICP connector was released in April 2005.

EGR Valve Coking: The EGR valve controls the flow of exhaust gas for recirculation into the engine. Ford determined that unburned hydrocarbons in the exhaust gas can collect on the EGR control valve and cause the valve to stick in a fixed position. Ford testing showed that the EGR valve does not cause an engine stall regardless whether the valve is stuck in the fully closed or fully open positions and whether the engine is at idle, accelerating, or decelerating, etc.[12] D21 coded claims ranked 5th (representing [ ]% of claims) on the CCC Pareto for EGR valve related warranty. Ford has implemented a new EGR valve design and control strategy to reduce the occurrence of valve sticking.

Cruise Control Calibration: When a subject vehicle enters an extended (more than 3 minutes) downhill run while the cruise control is engaged, the cruise control system will attempt to lower vehicle speed by reducing fuel supply. In some circumstances, sufficient fuel may not be available when the throttle is reapplied and an engine stall may occur. D21 coded claims ranked 2nd (representing [ ]% of claims) on the CCC Pareto for warranty claims related to this issue. Ford developed an improved engine calibration to address this issue and implemented it in both service and production in April 2004.

CAC Tube Separation: The charge air cooler (CAC) reduces the temperature of air pressurized by the turbocharger before it enters the engine. This function improves engine performance and efficiency. Ford replaced a metal air tube (duct) with a rubber tube during MY 2004 production. Insufficient clamping of the rubber tube ends can result in some instances where the tube becomes disconnected. Ford asserted that this condition does not cause an engine stall. D21 coded claims ranked 10th (representing [ ]% of claims) on the CCC Pareto for CAC tube warranty. Ford implemented a new clamp design in April 2004.

EBP Sensor Gold Corrosion: The sensing element of the EBP sensor deteriorates with vehicle use. As discussed above, Ford's testing showed that EGR system failure does not cause engine stall, only driveability related symptoms. D21 coded claims ranked 6th (representing [ ]% of claims) on the CCC Pareto for EBP sensor warranty. A new sensor was implemented in production in January 2005.

Injector Stiction: The spool valve controls flow of the high pressure oil supply needed to inject fuel. As the injector ages, the spool valve can stick in the closed position during cold start-up due to hydraulic surface tension between the spool valve and injector body. The valve frees itself after a short period[13]. Fuel will not be injected when the valve is stuck and a misfire will occur at startup. If several valves stick, a stall can occur. D21 coded claims ranked 6th (representing [ ]% of claims) on the CCC Pareto for stiction and cold start related warranty. A new engine calibration was implemented to service and production in April 2005 that will preheat the injectors prior to engine start-up; a [ ]% reduction in injector stiction was claimed.

Summary

Ford provided a timeline showing the various vehicle populations and 10 technical issues overlaid against date of production. Ford acknowledged that the 6.0L diesel engine performance has resulted in a significant customer dissatisfaction issue. Ford maintained that many of the reported stalling incidents either occurred at start-up or the consumer had a driveability related warning, and that vehicle control would be maintained by the driver should an engine stall occur while moving.

---

12 Exhaust smoke and power loss may occur if the valve sticks open while the engine is producing power.

13 Ford testing of certain high mileage field return parts indicated that a [ ] second period occurred for worst case injector stiction. If poor idle or stalling occur, the condition will clear-up within a short period.