TECHNICAL BULLETIN APTB-06/08

6.0L Fuel Interruption/Air in Fuel Discussion and Recommendations

Explanation of terms

- Fuel interruption – Fuel is pressurized, but lacks enough volume to completely fill the injector pumping chamber during the charging cycle; usually a result of restricted fuel filter(s) or fuel line(s)
- Air in fuel – Typically the result of suction side leaks in the fuel system, or compression gases leaking into the fuel system

Fuel Interruption/Air in fuel failure analysis

6.0L injectors exhibit a unique failure pattern when subjected to fuel interruption/air in fuel. Our analysis has shown that either fuel interruption or air in fuel is likely to cause a failure beginning with one of the following two parts:

- Check plate – 6.0L injectors contain a valve, in the form of a rectangular plate with an orifice in its center, that isn't described in Ford or International literature. Operating in a similar manner as a snubber valve in a fuel injection pump, it attenuates the flow of fuel from the nozzle to the return circuit during nozzle valve closure. During the pumping event, the check plate is pushed off its seat, and fuel flows unimpeded past the plate; at the end of the pumping event, the plate is seated and fuel flowing from the nozzle area is forced to flow through the check plate's orifice.
- Plunger spring retainer – The plunger spring retainer connects the pumping plunger to the plunger return spring; following the pumping event, spring force, exerted directly on the amplifier piston and via the plunger spring retainer on the pumping plunger, moves the amplifier piston and the pumping plunger to their upper positions.

Injectors can operate at close to normal output for a short while after the failure of either of these two parts, however, if the engine isn't shutdown, debris from the failed parts will soon cause the amplifier piston or pumping plunger to seize, or plug the nozzle, which will lead to a dead miss.

Separated stator housing failure ("broken injector")

Virtually every time we've seen a separated stator housing and injector body failure, the amplifier piston has been seized or stuck in the down position, creating a dead miss in the engine. The loss of the cylinder(s) will cause the vehicle driver to increase throttle, which leads to increased injection control pressure (ICP). When the amplifier piston is inoperable, there is no force to exhaust oil between pumping events, and the high pressure oil pumping chamber stays completely filled. Because the pumping chamber is completely filled, full oil rail pressure is exerted on the two stator housing-to-body retaining screws during each pumping event (when the amplifier piston is operating normally, pressure in the pumping chamber varies as the piston moves downward, and the pumping chamber never has time to reach full rail pressure because pressure is throttled past the spool valve). The increased hydraulic pressure resulting from the forces described above causes cyclic loading on the screws during each pumping event, which leads to failure.
The conclusion is that separated stator housing failures are a secondary effect of another failure.

Durability test rig analysis

After testing on an engine durability rig, our engineering consultants determined that interruption of fuel supply (or air in fuel) to any injector during operation resulted in the failure of the check plate and/or the plunger spring retainer in less than 15 minutes at rated speed and load. The stator housing to body screws failed (separated housing failure) within 20 minutes at the same conditions.

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Fuel interruption sources

Fuel supply interruption in the field is most likely to occur from a plugged or partially plugged fuel filter (e.g., from fuel contamination or winter gelling) that allows enough fuel flow to keep the engine running, but not enough to keep all injectors full of fuel. The amount of restriction determines how many injectors will not fill with fuel.

Checking for fuel interruption

- Check for correct fuel pressure
  - Key on / engine off (KOEO) pressure should be 45 psi minimum (this checks the pressure regulator)
  - During 0-50mph acceleration run at WOT, minimum pressure should be 45 psi (this check must be done at WOT under load, or the results won't be accurate)
- Check for vacuum
  - Ford advises that vacuum before the horizontal fuel conditioning module (HFCM) should not exceed 6" hg, but we advise using <5" hg as a standard

Air in fuel sources

As we know all too well, sources of air in fuel in any engine are likely to be found anywhere in the suction side of the fuel system. Compression gases in the fuel system are the secondary result of another mechanical defect, such as running with a loose injector or a leak path across the injector to injector sleeve sealing surface.

Checking for air in fuel

Install a clear line in the return circuit between the HFCM and the fuel tank; there should be no bubbles visible in the clear line during engine operation. You will then need to determine if air is entering from a suction side leak or compression gases. For diagnostic procedures to determine if compression gases are entering the fuel system, refer to the detailed descriptions of the "balloon test," and the latest test, the "compression bubble test" at http://www.forddoctorsdts.com/articles/article-08-03.php. Once the general origin of air is determined, use standard diagnostic techniques to pinpoint the exact source.

Recommendations

- Advise your 6.0L customers to change both pre-filter and final (primary and secondary) fuel filters regularly (at a minimum with every other lube oil change)
  - Somewhat off topic, but you will do your 6.0L and 7.3L Power Stroke customers a favor to remind them to adhere religiously to Ford's minimum recommended lube oil and filter change intervals (7,500 miles normal duty; 5,000 miles severe duty)
- If you find multiple no-fire injector failures in the same engine, fuel interruption/air in fuel is the likely suspect; you should track down the source of the air (refer to "Fuel interruption sources," "Air in fuel sources," and "Checking for air in fuel," above) before installing replacement injectors (even before you receive injector failure analysis from Alliant Power)
- With any injector failure, but especially with suspected fuel interruption/air in fuel failures, you may contact Alliant Power warranty staff (866-283-1785) and ask to have warranty analysis expedited

Warranty considerations

Alliant Power will continue to provide warranty coverage for injectors that are diagnosed to have failed due to fuel interruption/air in fuel the first time they're submitted from any vehicle on a policy basis (not due to workmanship or material failure), and we'll provide failure analysis to the submitting DSD/CD. However, Alliant Power reserves the right to deny warranty for subsequent fuel interruption/air in fuel claims submitted for injectors from the same vehicle.

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