Gas Engine Performance Modifications Job Aid

A Guide to Identifying Failures Related to Performance Modifications

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Introduction

This Job Aid is intended to be used by technicians when servicing vehicles that have suspected aftermarket modifications. If an aftermarket modification can be associated with the need for a repair, that repair may not be warrantable. To make this determination, the technician should refer to the aftermarket modifications flowchart (Chart 1). The following pages supplement the flowchart through pictures and descriptions of common aftermarket modifications and possible associated failures. This document is not exclusive and aftermarket modifications may exist that are not covered here. Note that sections listed as "Universal" are applicable to all engine families. If additional repair assistance is needed, the technician should refer to the Service Repair and Technical Assistance Process document located on the PTS website under the Technical Assistance tab.

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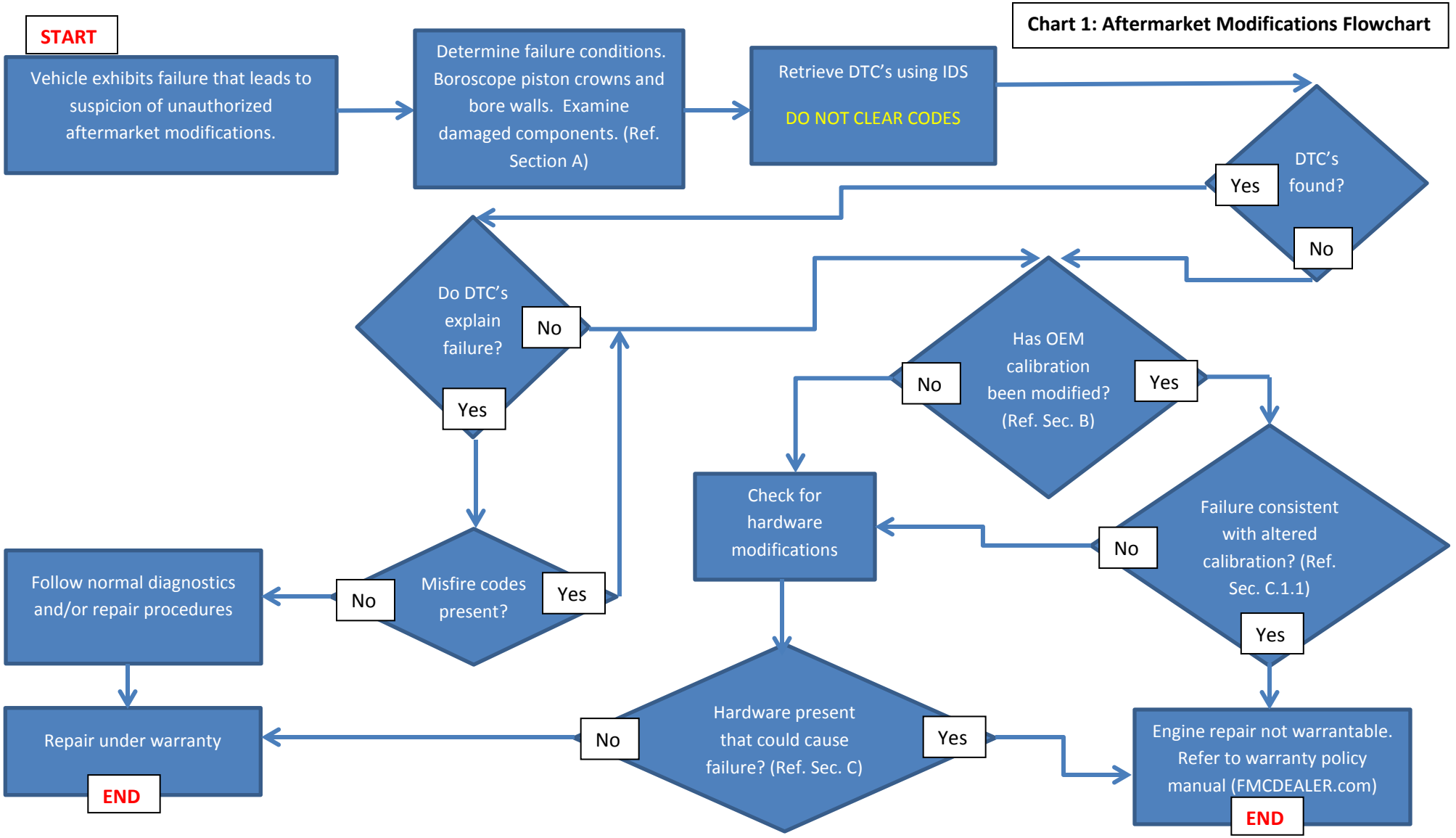
Chart 1: Aftermarket Modifications Flowchart



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Service Guidelines

- Inform owners that the current factory approved and certified calibrations adjust fuel and spark settings for maximum performance with production hardware, while protecting the engine over a wide range of operating conditions. This includes a knock sensor calibration enabling optimized performance based on fuel grade usage. See Owner's Guide for details. Aftermarket hardware and calibrations risk damage to the engine.

- Unauthorized calibration modifications may or may not be detectable using standard tools, Integrated Diagnostic System (IDS), Portable Diagnostic Software (PDS), NGS+ VCM. Changes can be made to the calibration and flashed to the powertrain control module (PCM) through the on-board diagnostics (OBD) port. Physical modifications to the hardware may or may not be present. If aftermarket power/torque-increasing modifications are suspected, care should be taken to record and store the following items: Permanent diagnostic trouble codes (DTCs), pending DTCs, freeze frame data, mode 6 and mode 9 data. The data should be printed and attached to the repair order for later reference.

- The DTCs, freeze frame data, mode 6 and 9 data can be obtained by using the IDS, PDS or NGS+VCM under tool box selection. The powertrain tab will provide the OBD test modes tab and mode 6 and 9 data selection after the vehicle has been identified.

- Attempting to increase the engine output via recalibrating the PCM may result in poor drivability, DTCs, or component failures.

- Common DTC's associated with aftermarket mods:

    - P0300-P0308 (Engine Misfire)
    - P0605 (ROM Error)
    - P0325, P130D (Engine Knock)
    - P0420, P0430 (Catalyst Temperature)
    - P0171, P0174 (Lean Air-Fuel Ratio)

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- The following aftermarket brands are covered under a separate warranty from Ford Performance:
  - Ford Performance
  - Ford Racing
  - Mountune
    - -If parts from any of these brands appear on the vehicle, please refer to OASIS to confirm installation and for warranty information.

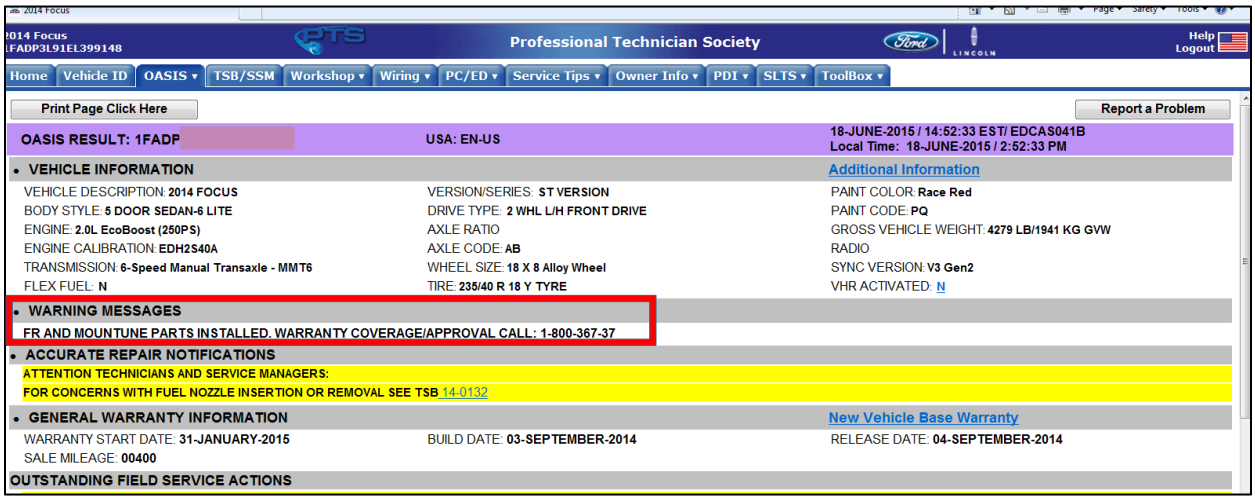

Figure 1: OASIS Warning

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Section A: Common Failure Modes

This section contains common failure conditions that are seen in vehicles with aftermarket modifications. Technicians should compare the failure modes found in the vehicle being serviced to the conditions presented in this section. The aftermarket modifications that may have contributed to these failure conditions can be found in Section C.

A.1 Universal Failure Modes

- Failure modes that may be seen in all engine families are presented here.

A.1.1 Piston Knock Damage

Figure 2: Scored Bore Walls

Figure 3: Light/Heavy Knock Damage

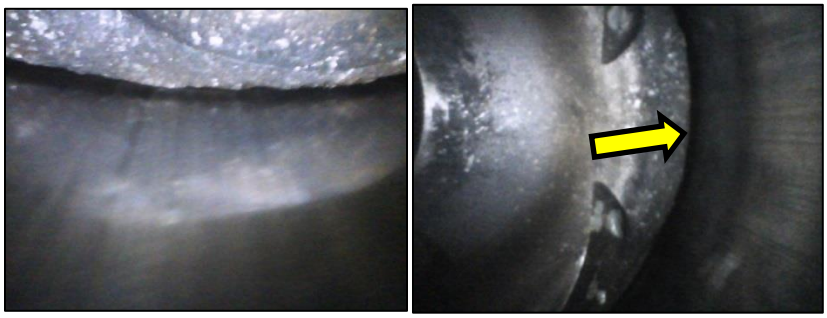

Figure 4A & B: Boroscope View of Piston Damage

Description: Damage to piston profiles can often be attributed to pre-ignition (knock) events. OEM calibrations will protect the engine from pre-ignition damage by retarding spark. Aftermarket calibrations will typically change timing schedules and allow the engine to run closer to damage limits. Pre-ignition along with extreme air-fuel ratios and excessive oil consumption may also damage catalyst material. This material can then be pulled back into the engine, scoring the cylinder bore walls.

Possible Causes:

- Altered calibration (Sec. C.1.1)
- Turbo modifications (Sec. C.2.1)
- Exhaust system modifications (Sec. C.1.5)
- Catalyst Damage
- Low Quality Fuel

A.1.2 Piston Ring Damage

Figure 5: Piston Ring Damage

Figure 6: Ring Land Damage

Description: Damage to the top piston ring may exhibit in the form of delamination or pitting.

Possible Causes:

- Excessive spark advance from altered calibration (Sec. C.1.1)
- Excessive spark advance from changes in induction system (Sec. C.1.2)

A.1.3 Connecting Rod Damage

Figure 7: Bent Connecting Rod from Hydrolock

Description: Hydrolock occurs when a volume of liquid greater than the smallest volume of the combustion chamber enters the cylinder and becomes incompressible as the piston reaches TDC. The result is most commonly a bent or broken connecting rod. Rod damage may also be caused by excessive cylinder pressure (overboost condition) and may not be obvious via visual inspection. Rod twisting can lead to bore scoring and eventual piston failure. Note that rod bends or twists may not be obvious visually, but can still contribute to engine damage or failure.

Possible Causes:

- Leaking Fuel Injectors (Sec. C.1.6)
- Rerouted air induction systems that show evidence of water injestion (Sec. C.1.2)
- Turbocharger modifications (Sec. C.2.1)
- Supercharger modifications (Sec. C.2.2)

A.1.4 Torque Converter Damage (Automatic Transmission)

Figure 8: Left - Normal TC | Right - Overheated TC

Description: Overheated torque converters will exhibit discoloration.

Possible Causes:

- Any aftermarket modification that increases torque or power output may cause the torque converter to overheat.

A.1.5 Clutch Damage

Figure 9: Damaged Clutch Discs

Figure 10: Damaged Separator Plate

Description: Clutch damage can present itself in many forms including discoloration, cracking, and warping of the clutch discs and separator plates.

Possible Causes:

- Any aftermarket modification that increases torque or power output may cause damage to the clutch system.

A.1.6 Driveshaft Damage

Figure 11: Twisted Driveshaft

Figure 12: Twisted Driveshaft

Description: Twisting of the driveshaft is commonly associated with increased torque output.

Possible Causes:

- Any aftermarket modification that increases torque or power output may cause damage to the driveshaft.
- Soft compound race tires (often identified by rubber built up in wheel well) combined with hard launches.

A.2 Forced Induction Failure Modes

- This section contains failures specific to turbocharged engines.

A.2.1 Turbocharger Compressor Damage

Figure 13: Compressor Blade Damage from Overspeed Event

Figure 14: Compressor Blade Damage from Overspeed Event

Description: Turbo compressor damage is commonly identified by broken or deformed turbine blades.

Possible Causes:

- Altered calibration (Sec. C.1.1)
- Wastegate modification (Sec. C.2.1.1)
- Exhaust system modification (Sec. C.1.5)

- Air induction system modification (Sec. C.1.2)
  - Cold air intake
  - Throttle body spacer
- Blow off valve (Sec. C.2.1.2)

Section B: Determining the Existence of an Aftermarket Calibration

This section should be used when the vehicle being serviced currently has or possibly had an aftermarket PCM calibration. Complete all sections (B.1-B.2).

B.1 Abnormalities in Calibration File Name

1. Pull Mode 9 data with IDS

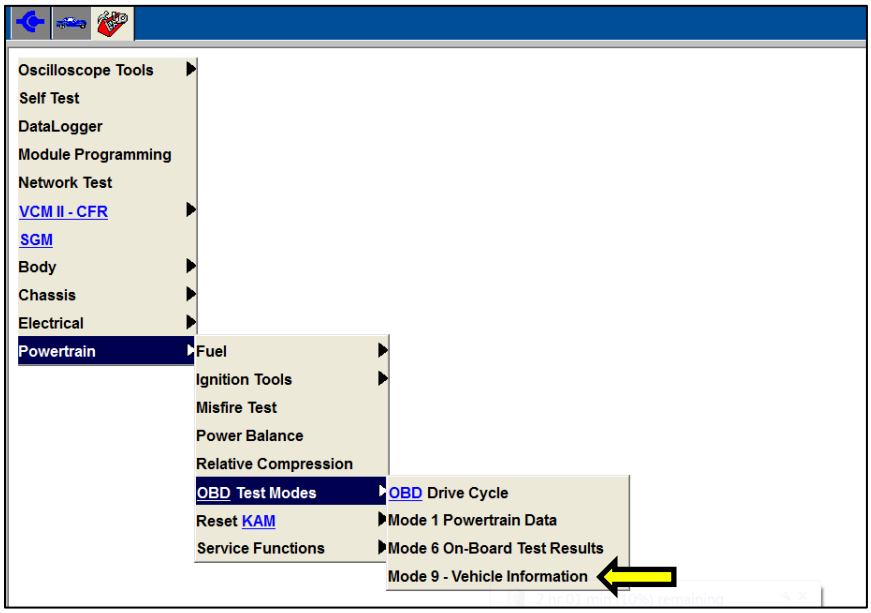

Figure 15: Mode 9 Data

2. View calibration file name in Mode 9 Data.
3. Look for any abnormalities in calibration file name and/or revision level.
4. Refer to the Service Repair and Technical Assistance Process document for help in determining the correct calibration name, if needed.

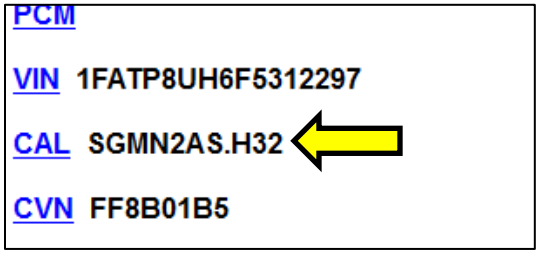

Figure 16: Calibration Name

B.2 Ignition Counter

1. Pull Mode 9 data with IDS.
2. Compare ignition counter (IGNCNTR) value to vehicle service history. If counter value is abnormally low and there is no history of a recent reflash, assume an unauthorized reflash has occurred. Refer to Chart 1.
3. Low ignition counters in conjunction with abnormal calibration naming points to an unauthorized reflash.

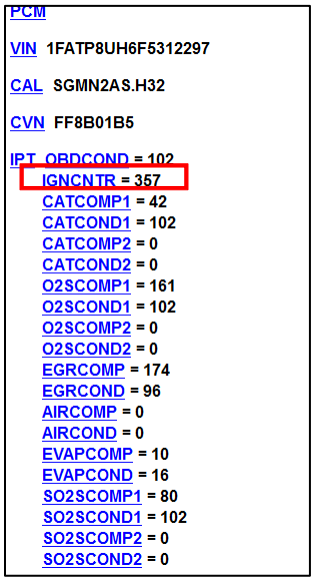

Figure 17: Ignition Counter

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Section C: Typical Aftermarket Modifications

This section contains items that are frequently modified in an effort to increase the engine's torque/power output. Modifying these items may, or may not improve performance, but can lead to drivability issues, DTC's and component failures. This section is divided into two subsections that cover modifications that may occur in all engine familes (C.1) and modifications that are specific to forced induction engines (C.2-C.3).

C.1 Universal Modifications

- Modifications included in this section may be present in any engine family, including forced induction engines.

C.1.1 Aftermarket Calibration

Description: Aftermarket calibrations are used to increase engine performance by altering calibratable parameters such as rev limit, spark advance and air-fuel ratio. Most aftermarket tuners advise the customer to reflash the PCM back to the stock calibration when bringing the car in for any warranty work. Refer to Section B to help determine if an aftermarket calibration is or was present in the vehicle. The following is a list of possible calibration-induced component failures :

Excessive Cylinder Pressure and Temperature:

- Piston damage (Sec. A.1.1-A.1.2)
- Turbocharger damage (Sec. A.2.1)
- Catalyst damage

Knock Sensor Calibration Changes:

- Piston and/or ring damage due to improper knock control. (Sec. A.1.1-A.1.2)

Increased RPM Limit/Overspeed:

- Piston damage (Sec. A.1.1 – A.1.2)
- Connecting rod damage (Sec. A.1.3)
- Oil pump damage
- Catalyst damage
- Clutch damage (Sec. A.1.5)

Over-Temperature/Melting:

- Transmission, PTU & torque converter damage. (Sec. A.1.4)

C.1.2 Air Intake Modification

Figure 18: Aftermarket Air Intake

Description: Modifications to the air intake system may include aftermarket air boxes, filters and low/high pressure air ducts. The system may be particularly susceptible to flexible air ducts between the air filter and the compressors. Restrictions on either side of the compressor can result in over-speeding the turbo in forced induction engines. Aftermarket air induction systems may cause lean air-fuel ratio DTC's (P0171 & P0174).

Possible Failure Modes:

- Turbocharger Compressor Damage (Sec. A.2.1)
- Catalyst Damage
- Piston Damage from Detonation (Sec. A.1.1)

C.1.3 PCV System Modification

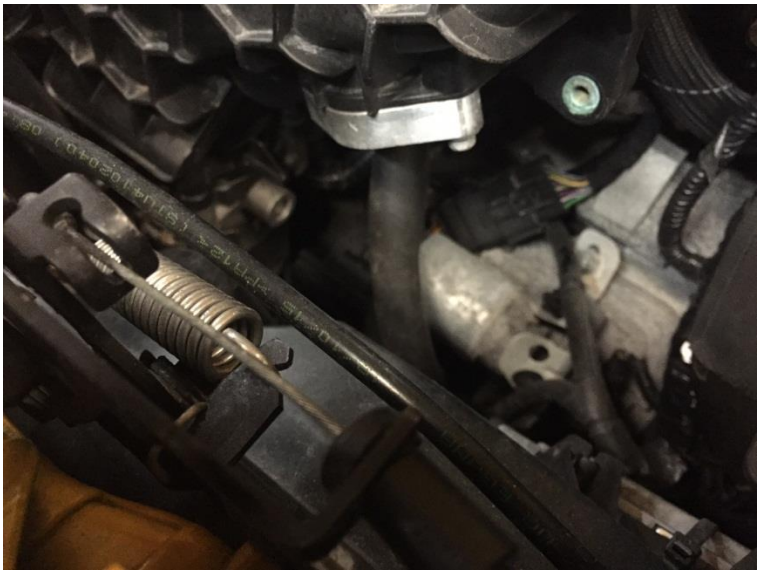

Figure 19: PCV Block off Plate

Description: PCV systems that are modified (vented to atmosphere being the most common modification) can result in a condition where oil gets past the turbine seal even on an undamaged, fully functional turbocharger. Oil in the exhaust system may not be sufficient evidence to identify a failed turbo if the PCV system has been compromised. Modified PCV systems, however, are often good indicators that other engine modifications may be present.

Possible Failure Modes:

- Unlikely to be direct cause of failure
- Emission compliance issue
- Oil in exhaust system (smoke from tailpipe)

C.1.4 Overdrive Crankshaft Pulley/Damper

Figure 20: Aftermarket Crankshaft Pulley

Description: Overdrive pulleys are intended to spin faster than OEM pulleys. On forced induction engines they may increase boost pressure which can lead to an overboost condition and subsequent engine damage. Most aftermarket pulleys are machine finished, where OEM pulleys are painted a dull black. Examine the stock pulley bolt for signs of tampering.

Possible Failure Modes:

- Piston damage (Sec. A.1.1-A.1.2)
- Driveshaft damage (Sec. A.1.6)
- Clutch damage (Sec. A.1.5)
- Oil Pump damage

C.1.5 Aftermarket Exhaust

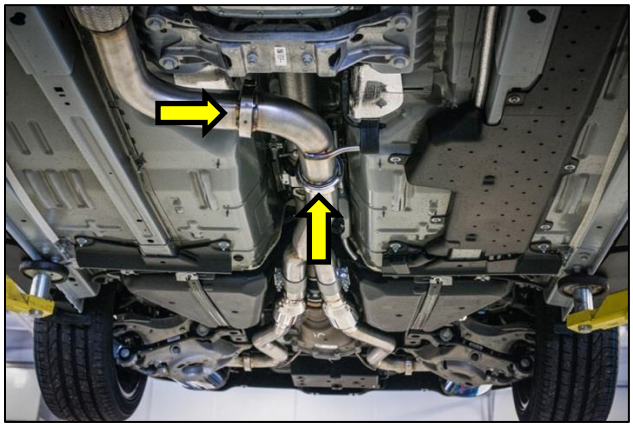

Figure 21: Aftermarket Exhaust

Figure 22: Long Tube Headers - Catalyst Delete and "X" pipe

Description: Common modifications include the removal of catalysts, mufflers and resonators. In turbocharged applications modifications to the exhaust system can reduce backpressure and may result in over-speeding the turbo(s). In some cases a good indicator of an aftermarket exhaust is the presence of additional clamps (Figure 21). Visually compare installed exhaust to pictures of OEM exhaust, if necessary.

Possible Failure Modes:

- Turbocharger compressor damage (Sec. A.2.1)
- Exhaust smoke due to change in system backpressure
- Piston damage (Sec. A.1.1-A.1.2)

C.1.6 Fuel Injection Devices

Description: The high pressure fuel system used for the EcoBoost engine will not support additional fuel flow beyond what the factory calibration requests. Inspect the engine for an additional aftermarket injector(s) located somewhere in the induction system to provide increased fuel flow.

Possible Failure Modes:

- Ruptured fuel lines
- Hydrolock induced failures if injectors are leaking:
  - Bent or broken connecting rods (Sec. A.1.3)
  - Fractured crankshaft
  - Crankcase damage
  - Damaged bearings

C.1.7 Nitrous Oxide Systems

Description: Nitrous oxide is often used in drag racing to increase an engine's rate of fuel consumption and thus power output. Nitrous oxide systems can most easily be identified by reservoir bottles (usually mounted in the trunk) and trigger buttons in the cockpit. There may also be holes drilled in the trunk for the bottle bracket, along with extra wiring and lines running to the engine compartment.

Possible Failure Modes:

- Piston Damage (Sec. A.1.1-A.1.2)
- Connecting Rod Damage (Sec. A.1.3)
- Intake Manifold Damage
- Cylinder Head Damage
- Crankshaft Damage

C.1.8 Aftermarket Part Badges/Decals

Figure 23: Aftermarket Badge

- Indicator of possible aftermarket modifications present
    - Inquire with customer as to existence of said aftermarket parts

C.2 Forced Induction Engine Modifications

- Modifications presented in this section are specific to turbocharged and supercharged applications.

C.2.1 Turbocharged Engine Modifications

The following engines are applicable to Section C.2.1:

- 2.0L I4 GTDI
- 2.3L I4 GTDI
- 3.5L V6 GTDI

C.2.1.1 Wastegate Modification

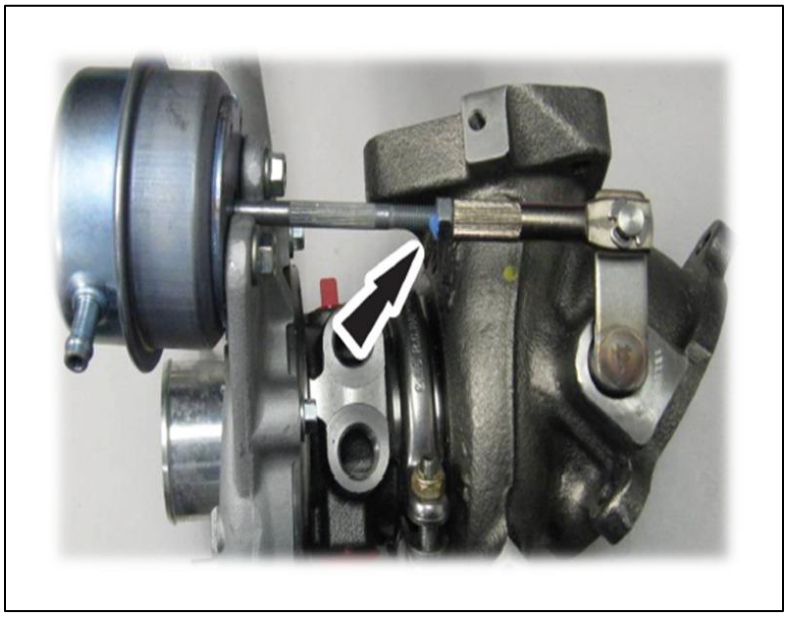

Figure 24: Wastegate Adjuster Modification

Description: The full load output of some turbocharged engines will increase if the wastegate spring pre-tension is increased. This is not the case with the EcoBoost engine. Adjusting the wastegate pre-tension out of the specified range can result in DTCs. A tamper evident paint dot has been applied to the wastegate actuator adjustment mechanism to make modifications more apparent.

Possible Failure Modes:

- Piston damage (Sec. A.1.1-A.1.2)
- Turbocharger damage (Sec. A.2.1)

C.2.1.2 Compressor Bypass Valve (Blowoff Valve)

Figure 25: Typical Blowoff Valve

Description: Blowoff valves relieve intake manifold pressure to prevent turbo compressor surge. When the pressure is released a distinct hissing sound can be heard. Blowoff valves are often tuned for their auditory effect. In doing so, the amount of pressure relieved from the system can change leading to compressor surge.

Possible Failure Modes:

- Turbocharger Compressor Damage (Sec. A.2.1)

C.2.1.3 Turbocharger Down Pipe

Figure 26: Down Pipe

Description: A downpipe is an unrestricted section of exhaust directly downstream of the turbo. By unrestricting the flow, the turbo may be able to spool up faster, reducing turbo lag. However, unrestricting the flow of exhaust can change the backpressure in the system which can lead to over-speeding the turbo.

Possible Failure Modes:

- Turbocharger Compressor Damage (Sec. A.2.1)
- Piston damage (Section A.1.1 – A.1.2)
- Exhaust smoke from turbocharger seal leakage

C.2.2 Supercharged Engine Modifications

Modifications presented here are specific to the following engines:

- Mustang Shelby GT500 5.4L
- Mustang Shelby GT500 5.8L

C.2.2.1 Drive Pulley Modification

Figure 27: OEM Drive Pulley | Left: Untampered | Right: Tampered With

Description: Customers may modify or replace supercharger drive pulleys to increase supercharger speed and associated boost pressure. Customers may reinstall the OEM drive pulley before bringing the vehicle in for repair. Figure 27 shows both untampered and tampered with pulleys. On the left side of Figure 27, note the white anti-tamper compound and smooth face of the blower shaft. The black plastic cover is an X-mas tree style and can be removed by unscrewing it from the blower shaft. On the right side of Figure 27, note the white anti-tamper compound is almost all removed and is misaligned (12 o'clock on shaft and 3 o'clock on pulley). Gall marks on the face of the blower shaft and scuff marks on the face of the pulley indicate use of a puller to remove the pulley and a press tool to reinstall the pulley. The most common change is a smaller diameter drive pulley to increase boost by spinning the blower at higher RPMs. This modification also requires a PCM aftermarket tune. The OEM pulley is 2.6 inches in diameter. Most aftermarket pulleys are 2.4 inches in diameter.

Possible Failure Modes:

- Piston Damage (Sec. A.1.1-A.1.2)
- Clutch Damage (Sec. A.1.5)
- Driveshaft Damage (Sec. A.1.6)

C.2.2.3 Induction System

Figure 28: GT500 Aftermarket Air Filter, Inlet Tube, Throttle Body & Supercharger

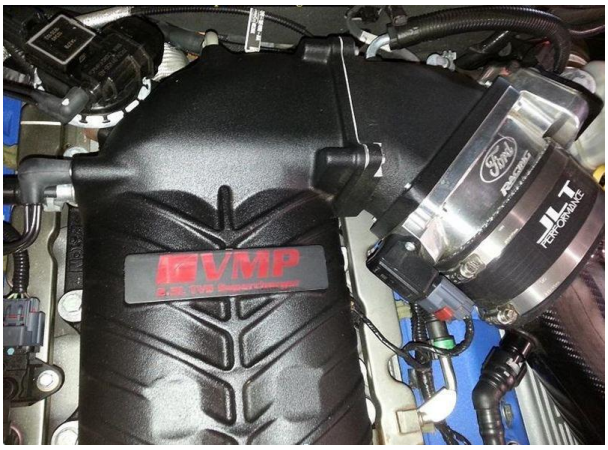

Figure 29: GT500 Aftermarket Supercharger & Throttle Body

Description: Adding aftermarket superchargers can stress the engine beyond design limits through increased torque and power outputs and cause numerous failures. Changes in the induction system such as aftermarket throttle bodies and inlet tubes can cause changes in air-fuel ratio that leads to piston damage. These modifications should be easily visible. Most aftermarket superchargers will have a custom surface finish (polished or wrinkle black).

Possible Failure Modes:

- Piston damage (Sec. A.1.1-A.1.2)
- Clutch Damage (Sec. A.1.5)
- Driveshaft damage (Sec. A.1.6)