



FCSD

Technical Training

INTERACTIVE STUDY GUIDE

FIRTFT 6.0L DIESEL ENGINE TURBOCHARGER BOOST SYSTEM



FCS-13981-DL



Ford Customer Service Division
Technical Training



FIRTFT 6.0L DIESEL ENGINE TURBOCHARGER BOOST SYSTEM
06-OCT-04 **COURSE CODE: 51G05F0**

IMPORTANT SAFETY NOTICE

Appropriate service methods and proper repair procedures are essential for the safe, reliable operation of all motor vehicles, as well as the personal safety of the individual doing the work. This manual provides general directions for accomplishing service and repair work with tested, effective techniques. Following them will help assure reliability.

There are numerous variations in procedures, techniques, tools and parts for servicing vehicles, as well as in the skill of the individual doing the work. This manual cannot possibly anticipate all such variations and provide advice or cautions as to each. Accordingly, anyone who departs from instructions provided in this manual must first establish that he compromises neither his personal safety nor the vehicle integrity by his choice of methods, tools or parts.

As you read through the procedures, you will come across NOTES, CAUTIONS, and WARNINGS. Each one is there for a specific purpose. NOTES give you added information that will help you to complete a particular procedure. CAUTIONS are given to prevent you from making an error that could damage the vehicle. WARNINGS remind you to be especially careful in those areas where carelessness can cause personal injury. The following list contains some general WARNINGS that you should follow when you work on a vehicle.

- Always wear safety glasses for eye protection.
- Use safety stands whenever a procedure requires you to be under the vehicle.
- Be sure that the ignition switch is always in the OFF position, unless otherwise required by the procedure.
- Set the parking brake when working on the vehicle. If you have an automatic transmission, set it in PARK unless instructed otherwise for a specific service operation. If you have a manual transmission it should be in RE-VERSE (engine OFF) or NEUTRAL (engine ON) unless instructed otherwise for a specific service operation.
- Operate the engine only in a well-ventilated area to avoid the danger of carbon monoxide.
- Keep yourself and your clothing away from moving parts when the engine is running, especially the fan and belts.
- To prevent serious burns, avoid contact with hot metal parts such as the radiator, exhaust manifold, tail pipe, catalytic converter and muffler.
- Do not smoke while working on the vehicle.
- To avoid injury, always remove rings, watches, loose hanging jewelry, and loose clothing before beginning to work on a vehicle. Tie long hair securely behind your head.
- Keep hands and other objects clear of the radiator fan blades. Electric cooling fans can start to operate at any time by an increase in underhood temperatures, even though the ignition is in the OFF position. Therefore, care should be taken to ensure that the electric cooling fan is completely disconnected when working under the hood.

The recommendations and suggestions contained in this manual are made to assist the dealer in improving his dealership parts and/or service department operations. These recommendations and suggestions do not supersede or override the provisions of the Warranty and Policy Manual, and in any cases where there may be a conflict, the provisions of the Warranty and Policy Manual shall govern.

The descriptions, testing procedures, and specifications in this handbook were in effect at the time the handbook was approved for printing. Ford Motor Company reserves the right to discontinue models at any time, or change specifications, design, or testing procedures without notice and without incurring obligation. Any reference to brand names in this manual is intended merely as an example of the types of tools, lubricants, materials, etc. recommended for use. Equivalents, if available, may be used. The right is reserved to make changes at any time without notice.

WARNING: MANY BRAKE LININGS CONTAIN ASBESTOS FIBERS. WHEN WORKING ON BRAKE COMPONENTS, AVOID BREATHING THE DUST. BREATHING THE ASBESTOS DUST CAN CAUSE ASBESTOSIS AND CANCER.

Breathing asbestos dust is harmful to your health.

Dust and dirt present on car wheel brake and clutch assemblies may contain asbestos fibers that are hazardous to your health when made airborne by cleaning with compressed air or by dry brushing.

Wheel brake assemblies and clutch facings should be cleaned using a vacuum cleaner recommended for use with asbestos fibers. Dust and dirt should be disposed of in a manner that prevents dust exposure, such as sealed bags. The bag must be labeled per OSHA instructions and the trash hauler notified as to the contents of the bag.

If a vacuum bag suitable for asbestos is not available, cleaning should be done wet. If dust generation is still possible, technicians should wear government approved toxic dust purifying respirators.

OSHA requires areas where asbestos dust generation is possible to be isolated and posted with warning signs. Only technicians concerned with performing brake or clutch service should be present in the area.



CUSTOMER EXPECTATIONS

Customer Expectations: Service

1. Make it convenient to have my vehicle serviced at your dealership.
2. The Service Advisor should demonstrate a genuine concern for my service needs.
3. Fix it right the first time.
4. Complete servicing my vehicle in a timely and professional manner.
5. Provide me with a clear and thorough explanation of the service performed.
6. Call me within a reasonable amount of time after my service visit to ensure that I'm completely satisfied.
7. Be responsive to questions or concerns I bring to your attention.

Expectation 3

“Fix It Right The First Time, on Time.”

Both service advisors and technicians are important players when it comes to Expectation #3.

Why

Customers tell us “Fixing It Right The First Time, on Time” is one of the reasons they would decide to return to a dealer to buy a vehicle and get their vehicles serviced.

Technician Training

It is our goal to help the technician acquire all of the skills and knowledge necessary to “Fix It Right The First Time, on Time.” We refer to this as “competency.”

Technician's Role

Acquire the skills and knowledge for competency in your specialty via:

STST

- Self Study
- FordStar Broadcasts
- Ford Multimedia Training (FMT)
- Instructor Led

New Model

- Self Study
- FordStar Broadcasts
- Instructor Led

The Benefits

The successful implementation of expectations means:

- Satisfied customers
- Repeat vehicle sales
- Repeat service sales
- Recognition that Ford and Lincoln/Mercury technicians are “the Best in the Business”

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NOTES



FCSD

Technical Training

The distance learning course you are about to take is intended to give you new knowledge and information about diagnosing and servicing Ford vehicles. We hope you apply this knowledge and information to “Fix It Right The First Time” as part of our effort to satisfy our customers, the owners of Ford Vehicles.

Ground Rules for Successful Completion

This course is “**score based**”. Successful completion of this course requires a passing score of 80% or greater. Achievement of 80% or greater will result in a “PASS” in your STARS training history. A score of less than 80% results in a “FAIL” in your STARS training history. If you logon and participate in the class, but choose NOT to answer any of the questions, you will receive an “AUDIT” in your training history. You may return to complete the test in a future class session, if desired.

INTRODUCTION

LOGGING ON



Your response keypad transmits data and voice between you and the host via telephone lines and satellite. It is your ‘lifeline’, connecting you to the instructor as well as to other participants. Using the keypad, you can become involved fully in the seminar, asking questions and contributing relevant comments. To log on at the beginning of the broadcast session:

1. Enter your I.D. number (in response to the keypad prompt). If you press an incorrect key, press CLEAR and re-enter the numbers.
2. Press ENTER.
3. The system validates your I.D. number by displaying your name on the keypad. If your name does not appear on the keypad, re-enter your I.D. number.
4. If you cannot successfully log on, contact the FORDSTAR Help Desk:
 - a. USA dealers call 1-800-790-HELP (4357).
 - b. Canadian dealers call 1-800-467-8925

KEYPAD OPERATION

CALL Key

- Press the CALL key if you have a question or comment. This places you in the call queue. The system indicates your name and location to the instructor.
- It takes approximately 60 seconds for the instructor to respond. If you change your mind about asking the question, simply press the CALL key again. As long as the instructor has not accepted your call, this takes you out of the call queue.

WAIT and SPEAK Lights

- The red WAIT light illuminates when your call is received and placed in the call queue.
- When the instructor calls on you, the green SPEAK light illuminates and your microphone is activated.
- The microphone is the gray dot between the SPEAK and WAIT lights. Speak in a normal tone of voice from a normal sitting position. The instructor will hear you, as will the other students.

FLAG Key

- Use the FLAG key when requested by the instructor. The FLAG key is usually used to alert the instructor that you have completed a test or exercise.

INTRODUCTION

PURPOSE

This FORDSTAR “Fix it Right the First Time” course is designed to present technicians with the basic information needed to understand the 6.0L diesel engine turbocharger boost system.

AGENDA

The information in this course is arranged in the following order:

- Lesson 1: Overview
- Lesson 2: Theory and Operation
- Lesson 3: Diagnostics

OBJECTIVES

- Introduce the variable geometry turbocharger (VGT).
- Identify the VGT control valve.
- Identify the exhaust backpressure (EBP) sensor.
- Identify the mass airflow (MAF) sensor.
- Identify the charge air cooler (CAC).
- Identify the intake air temperature (IAT1 and IAT2) sensors.

LESSON 1: OVERVIEW

INTRODUCTION

Variable Geometry Turbocharger (VGT)

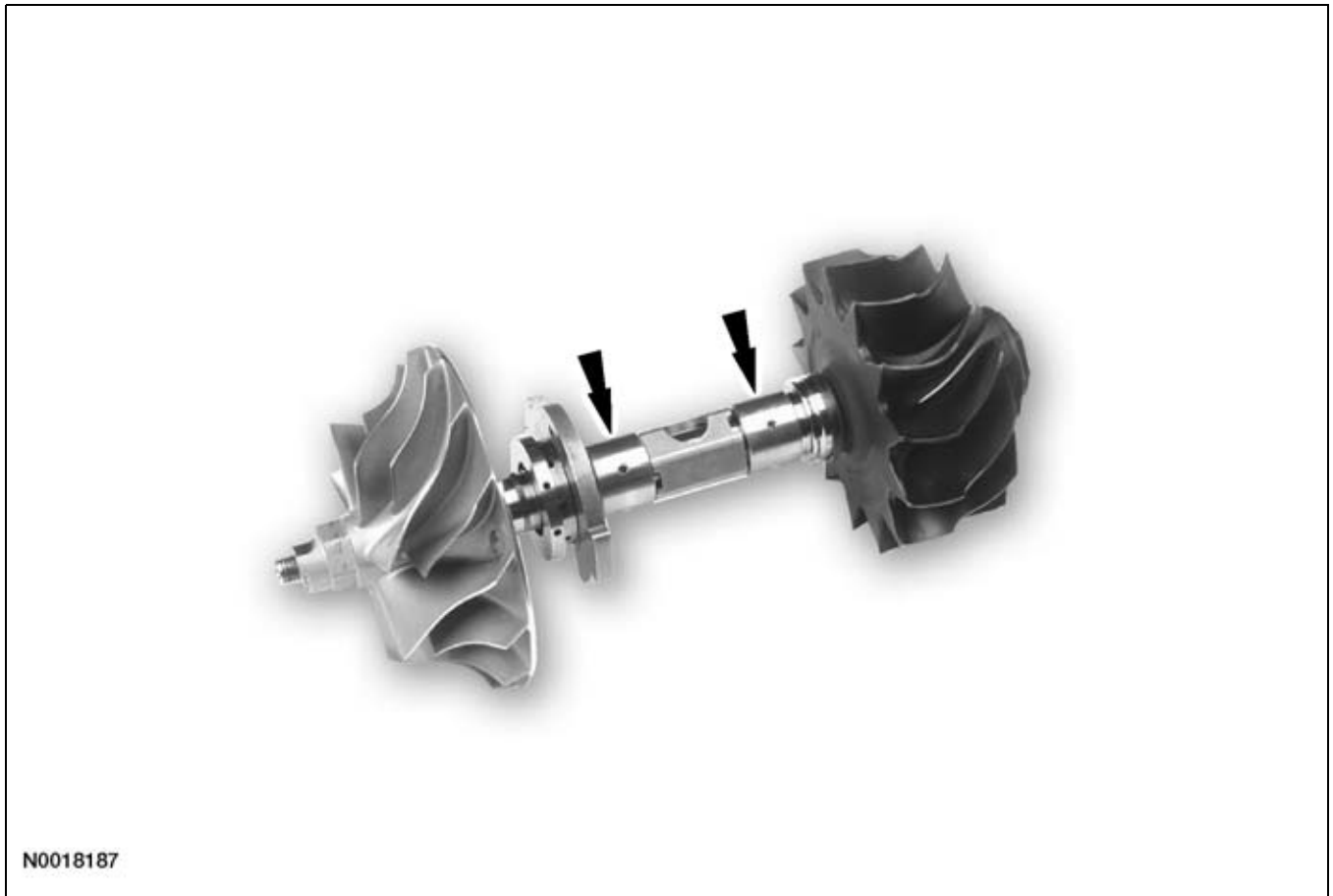


6.0L Diesel Variable Geometry Turbocharger (VGT) with Vanes Closed

The variable geometry turbocharger (VGT) allows the PCM to control boost at low and high speeds for improved response. The vanes inside the turbine side of the turbocharger are electronically controlled and hydraulically actuated to control the level of boost and the amount of exhaust backpressure.

- The variable vane design allows the VGT to operate as efficiently as a small turbocharger at low engine speeds and during engine warmup.
- The design also provides the high boost capability of a large turbocharger at high engine speeds.

NOTE: Some publications refer to the VGT as electronic variable response turbocharger (EVRT).



Turbocharger Floating Bearings

The compressor wheel is connected to the turbine via a common shaft. The shaft is supported by two floating bearings. This design uses an oil film on the inner and outer diameter to create a virtual friction-free bearing.

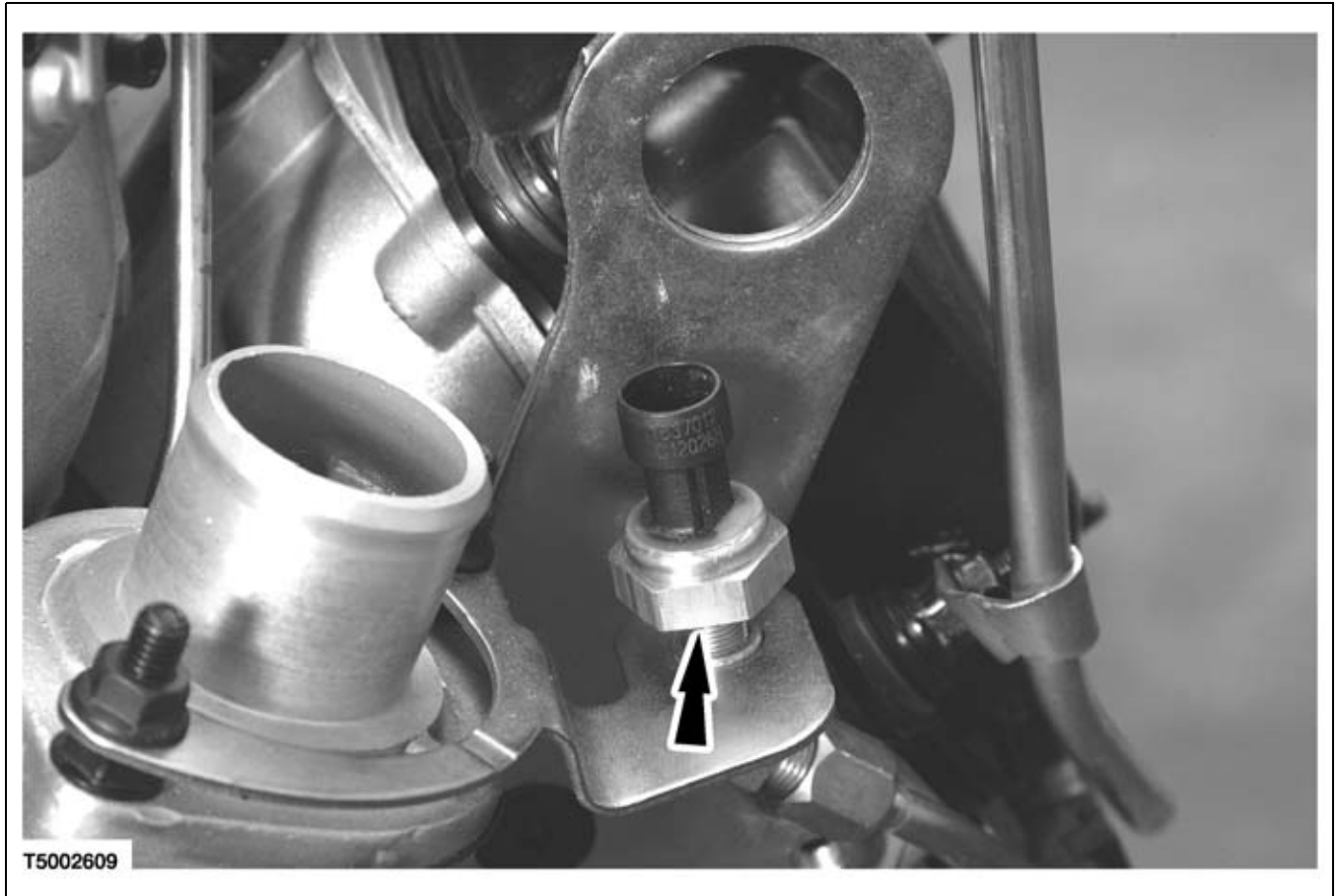
LESSON 1: OVERVIEW



VGT Control Valve

The VGT control valve is controlled by the PCM. The VGT control valve controls the position of the variable vanes in the turbocharger by metering engine oil to either side of the control valve piston.

Exhaust Pressure (EP) Sensor



Exhaust Pressure (EP) Sensor

The PCM uses EP data as one of its inputs to determine what to command the VGT solenoid and EGR valve. The EP sensor is mounted on the front left side of the engine.

NOTE: Some publications refer to this as the exhaust backpressure (EBP) sensor.

LESSON 1: OVERVIEW

Mass Airflow (MAF) Sensor



Mass Airflow (MAF) Sensor

The mass airflow (MAF) sensor measures the amount of air flowing into the engine. The MAF is used for the EGR flow calculations.

The MAF sensor is replaced as an assembly.

Charge Air Cooler (CAC)



Charge Air Cooler (CAC)

The charge air cooler (CAC) is mounted in front of the radiator. Air compressed in the turbocharger becomes hot. The CAC cools the air before it is routed to the intake manifold.

LESSON 1: OVERVIEW

Intake Air Temperature Sensors

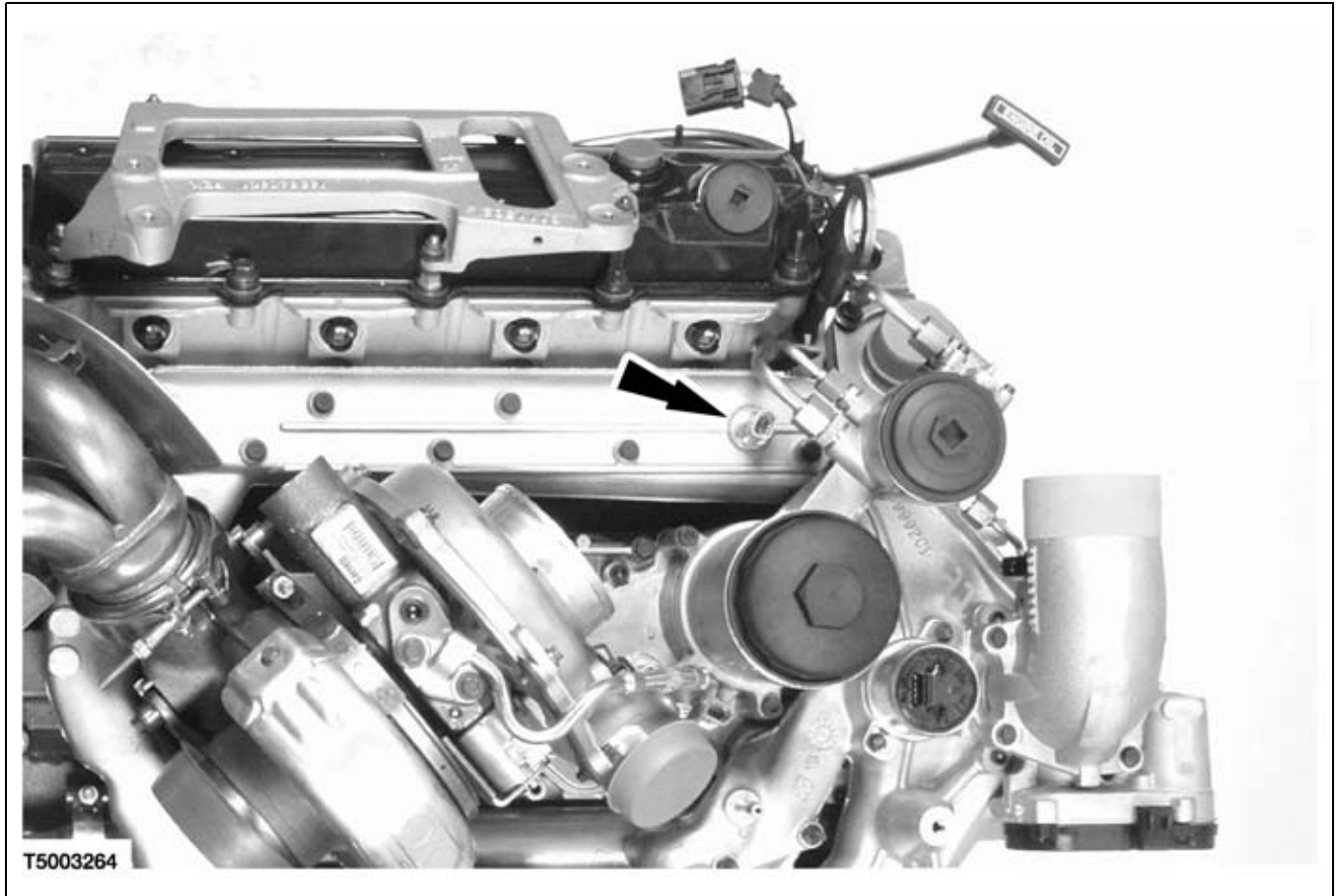


Intake Air Temperature 1 (IAT1) Sensor

The 6.0L engine uses two different intake air temperature sensors.

- Intake air temperature 1 (IAT1) sensor
- Intake air temperature 2 (IAT2) sensor
- The IAT1 sensor monitors ambient air temperature and is integrated into the MAF sensor.

Intake Air Temperature 2 (IAT2) Sensor



Intake Air Temperature 2 (IAT2) Sensor

The intake air temperature 2 (IAT2) sensor performs the same function as the manifold air temperature (MAT) sensor on the 7.3L engine.

- The IAT2 sensor is mounted in the intake manifold on the left side of the engine.

NOTES

OBJECTIVES

- Describe the airflow through the 6.0L diesel engine.
- Describe the theory of operation for the VGT turbocharger and control valve.
- Describe IAT1 and IAT2 sensor theory of operation.
- Describe exhaust backpressure (EBP) sensor operation and electrical circuit.

LESSON 2: THEORY AND OPERATION

TURBOCHARGER BOOST SYSTEM

Variable Geometry Turbocharger (VGT)



6.0L Diesel Variable Geometry Turbocharger (VGT)

In the past, most turbochargers could deliver boost only at higher engine speeds and there was a lag time between pressing the accelerator and turbocharger boost.

The variable geometry turbocharger (VGT), however, allows the PCM to also control boost at low speeds. The VGT improves the response of the 6.0L diesel engine by reducing turbo lag. This is possible because the vanes inside the turbine side of the turbocharger are electronically controlled.

- The variable vane design allows the VGT to operate as efficiently as a small turbocharger at low engine speeds and during engine warmup. It also provides the high boost capability of a large turbocharger at high engine speeds.
- During engine operation at low engine speeds and load, little energy is available from the exhaust to generate boost. To maximize the use of available energy, the vanes are closed. In doing so, the exhaust gas is accelerated between the vanes and across the turbine wheel increasing turbocharger wheel speed and boost. In general, this allows the turbocharger to behave as a smaller turbocharger.

During engine operation at high engine speeds and load, there is a great deal of energy available in the exhaust. Excessive boost under high-speed, high-load conditions can negatively affect component durability. The vanes, therefore, are commanded open to prevent turbocharger overspeed. This, essentially, allows the turbocharger to act as a large turbocharger, not creating excessive backpressure.

- During engine warmup, the vanes in the turbine side are closed. When the vanes of the turbocharger are closed, the engine has a higher exhaust backpressure. This creates more heat and quickly warms the engine to its normal operating temperature.
- During engine operation at moderate engine speeds and load, the vanes are commanded partially open. With the vanes set to this intermediate position, the VGT can supply the correct amount of boost to the engine for optimal combustion as well as provide the necessary backpressure for EGR operation.

NOTE: The VGT makes different sounds than the 7.3L turbocharger. If a noise concern is perceived, compare to a known good unit before attempting a repair.

LESSON 2: THEORY AND OPERATION



VGT Control Valve

The VGT control valve is actuated by the PCM, based on engine speed and load. The function of the VGT control valve is to open and close the variable vanes inside the VGT.

- The VGT control valve is a variable-position duty-cycle controlled valve and a proportional hydraulic spool valve.
 - The variable geometry turbocharger control valve (VGTCV) is located on top of the turbocharger and can be serviced separately from the VGT. The control valve allows oil to flow to one side of the piston or the other side of the piston depending on which way the PCM wants the vanes to move.
 - When one side of the piston is pressurized, the opposite side is vented to drain.
 - Spring force moves the spool valve to the center closed position.
 - When ON signal time increases, the exhaust manifold pressure increases.
- Once the desired turbocharger vane position is obtained, the VGTCV goes to a parked position. Both ports of the spool valve are blocked and the VGTCV piston remains in the last position.
- The command can be viewed on WDS as VGTDC# and is described in percent closed. A low percent means the vanes are commanded to an open state. A high percent means the vanes are commanded to a closed state.
 - The WDS view shows zero and allows you to command zero, but it is not zero.
 - The actual range is approximately 15 to 85 percent.

A cam follower at the end allows the valve to return to a neutral position when the PCM is not using the valve to move the vanes.

LESSON 2: THEORY AND OPERATION

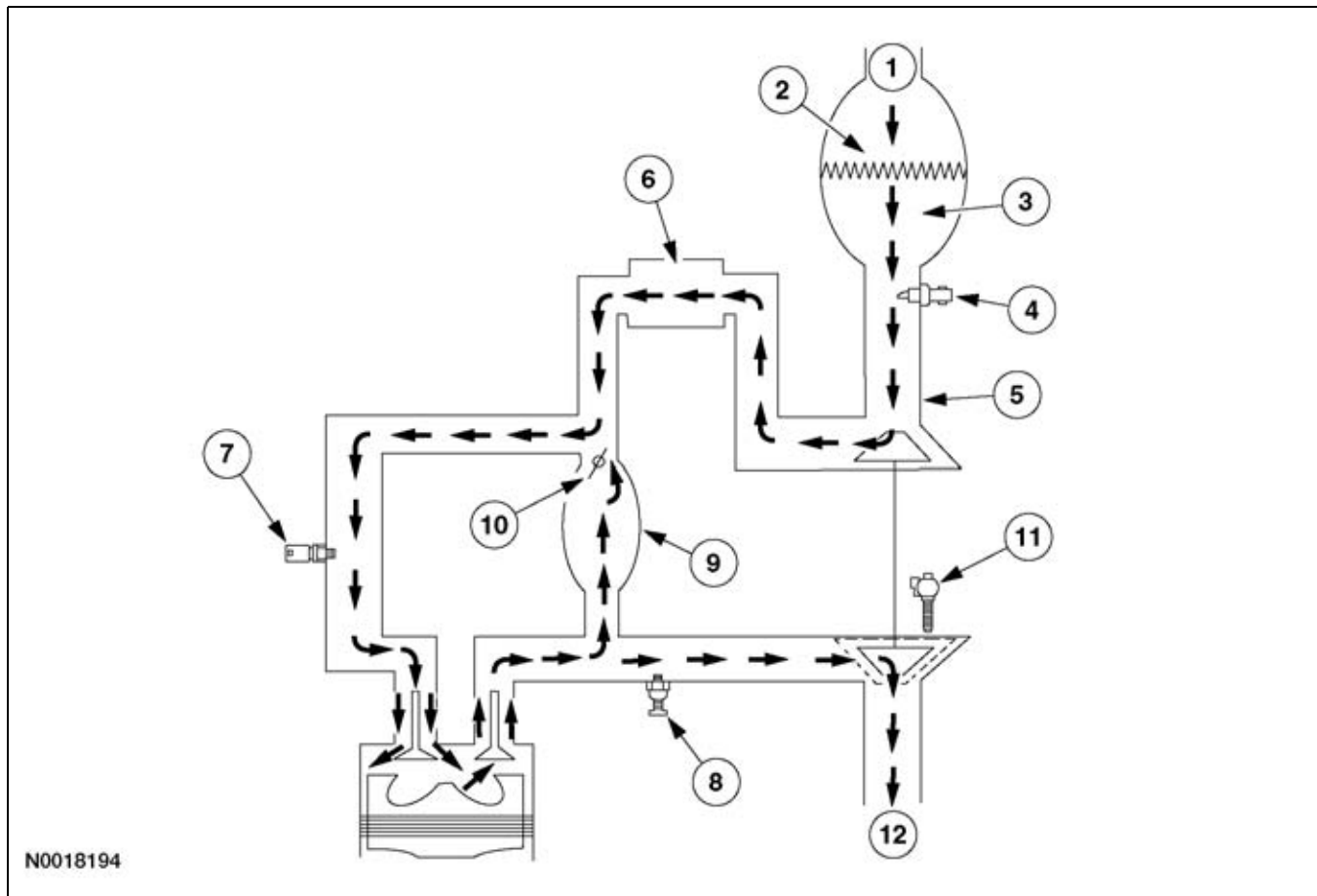
NOTE: The VGT control valve is the only serviceable component of the VGT.

NOTE: If it is disconnected, the valve will default to the vanes open position.

The valve position is controlled by switching the current source inside the PCM. If the valve is disconnected, the turbocharger vanes remain in an open state.

LESSON 2: THEORY AND OPERATION

Airflow



Air Intake System Schematic

Item	Description
1	Air inlet
2	Crankcase vent to intake air
3	Filtered air
4	Intake air temperature sensor 1 (IAT1)
5	Turbocharger compressor inlet
6	Charge air cooler (CAC)

Item	Description
7	Intake air temperature sensor 2 (IAT2)
8	Exhaust backpressure sensor (EBP)
9	EGR cooler
10	EGR valve
11	VGT control valve
12	Turbocharger outlet to exhaust

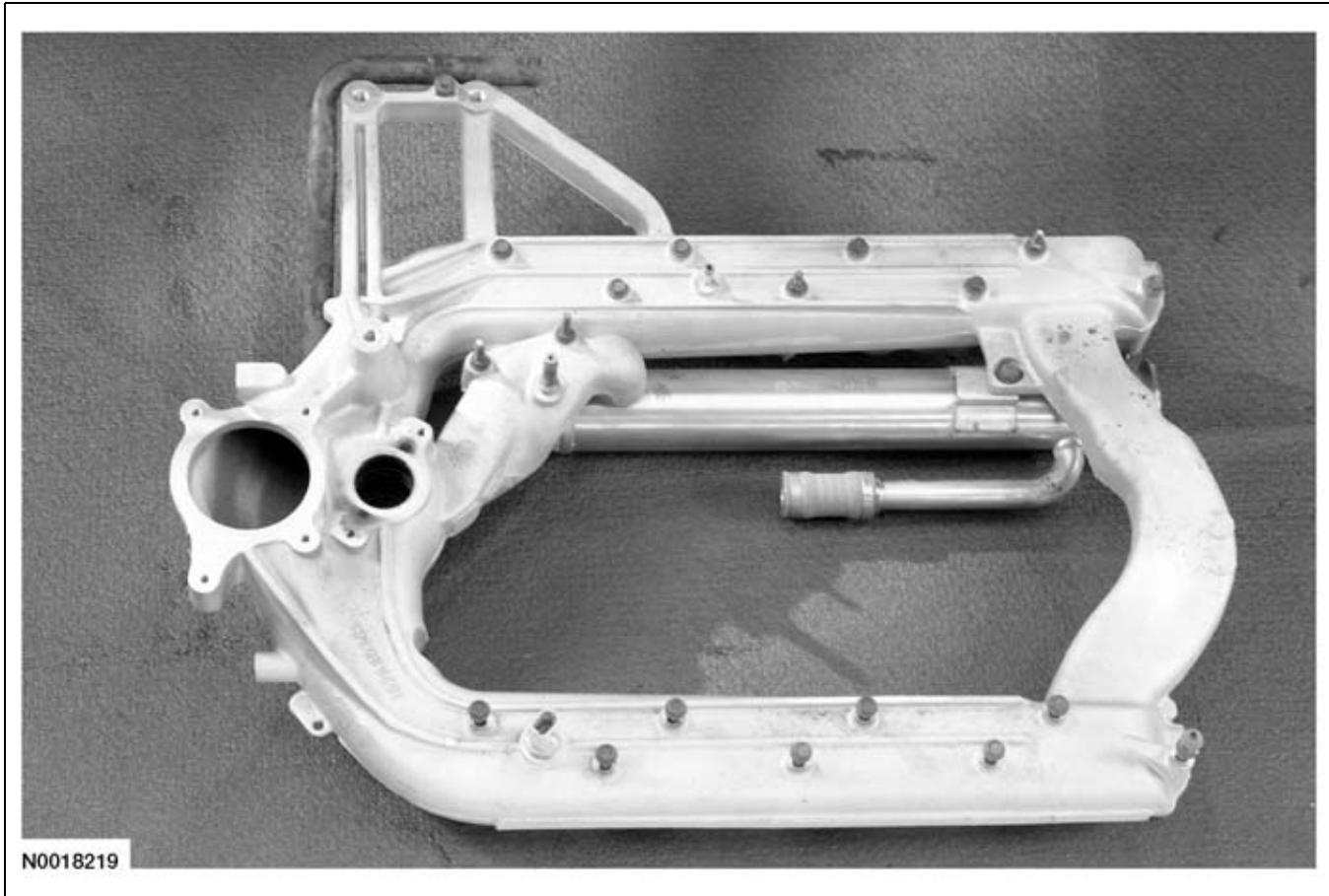
Air flows through the 6.0L engine, starting with the air filter. The filtered air is then directed past the crankcase ventilation system and mixed with crankcase vapors.

- Starting at the number 1 callout position, air flows into the air induction system inlet.
- At the number 2 callout position, filtered air is then directed past the crankcase vent and mixed with crankcase vapors.
- Callout 3 shows the air flow past the air filter.

- Callout 4 shows the air flowing past intake air temperature sensor 1.
- Callout 5 shows the air flow into the turbocharger compressor inlet. The compressed air heats up.
- Callout 6 shows the air flow through the charge air cooler where the heated air is cooled.
- Callout 7 shows the air flow past intake air temperature sensor 2.
- The air flows into the combustion chamber and when it comes out on the other side, it splits and can travel out the exhaust or go through the EGR cooler.
- Callout 8 shows the air flow past the EBP sensor toward the exhaust outlet.
- Callout 9 shows the air flow through the EGR cooler.
- Callout 10 is where the air flow goes through the EGR valve.
- Callout 11 shows the VGT control valve.
- Callout 12 shows the air flow through the turbocharger outlet to the exhaust pipe.

LESSON 2: THEORY AND OPERATION

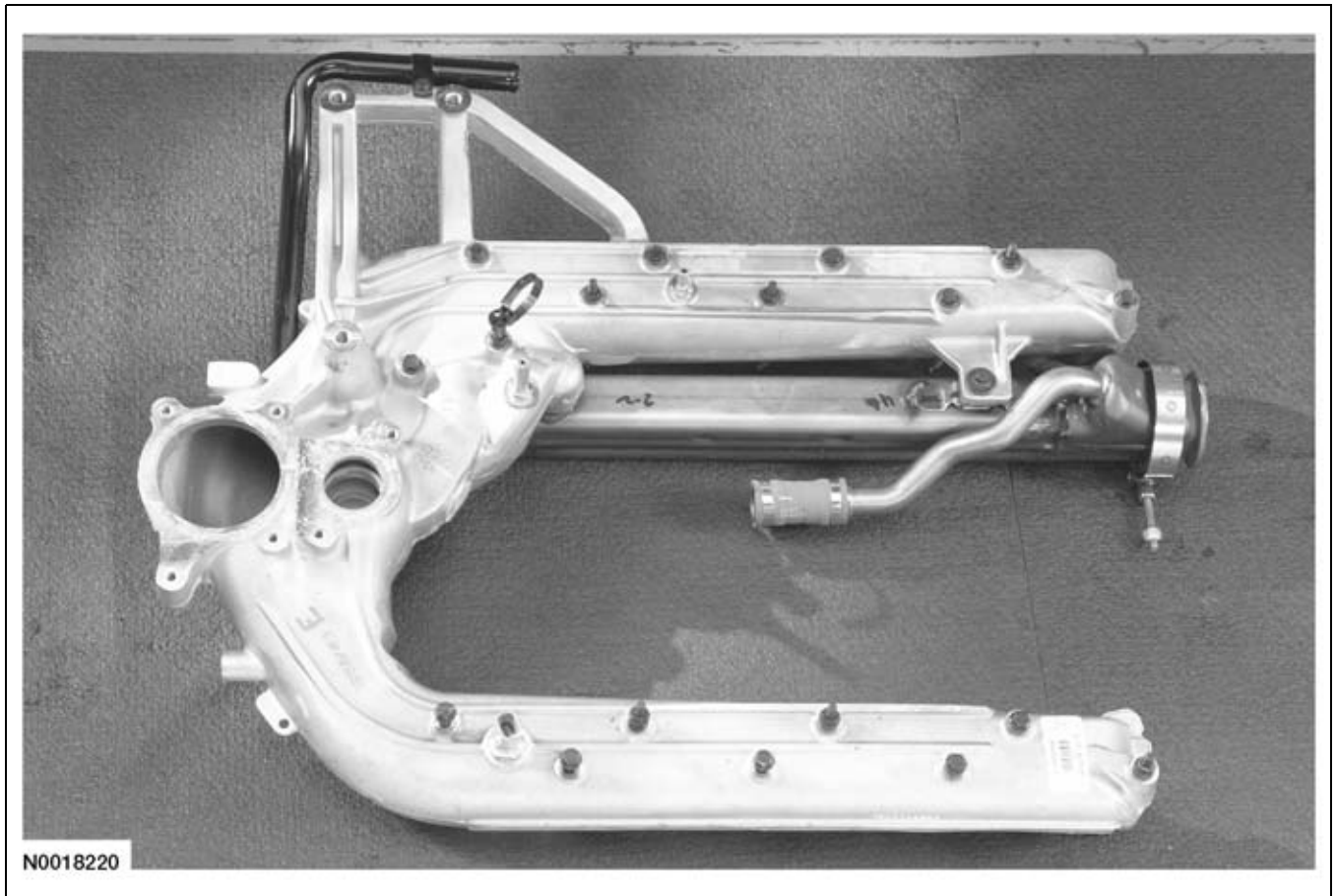
Intake Manifold



2003.25 Intake Manifold

The 6.0L diesel engine is equipped with an aluminum intake manifold that acts as a passage for coolant as well as air.

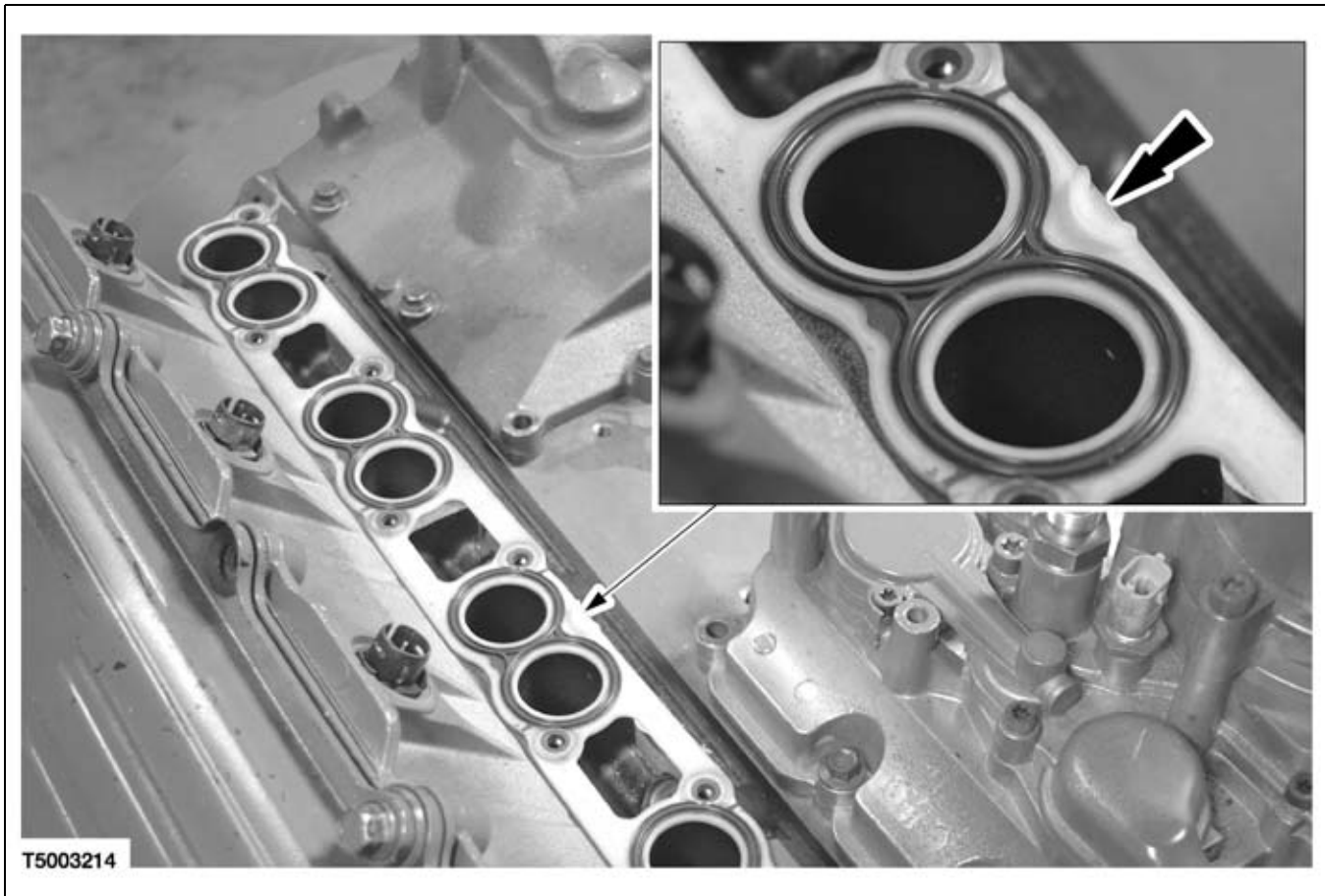
- The intake manifold provides a path for the coolant to flow from the EGR cooler to the front cover.
- When reinstalling the intake manifold, be sure to install the rubber seal between the intake manifold and the front cover.
- The intake manifold and EGR cooler are removed together as a single unit.
- An improperly installed gasket creates a boost leak.
- Be sure to put the tab face up and toward the center of the engine.
- The gaskets are reusable.



2004.25 Intake Manifold

The intake manifold was updated starting with the 2004.25 version of the 6.0L diesel engine. The rear runner has been eliminated.

LESSON 2: THEORY AND OPERATION

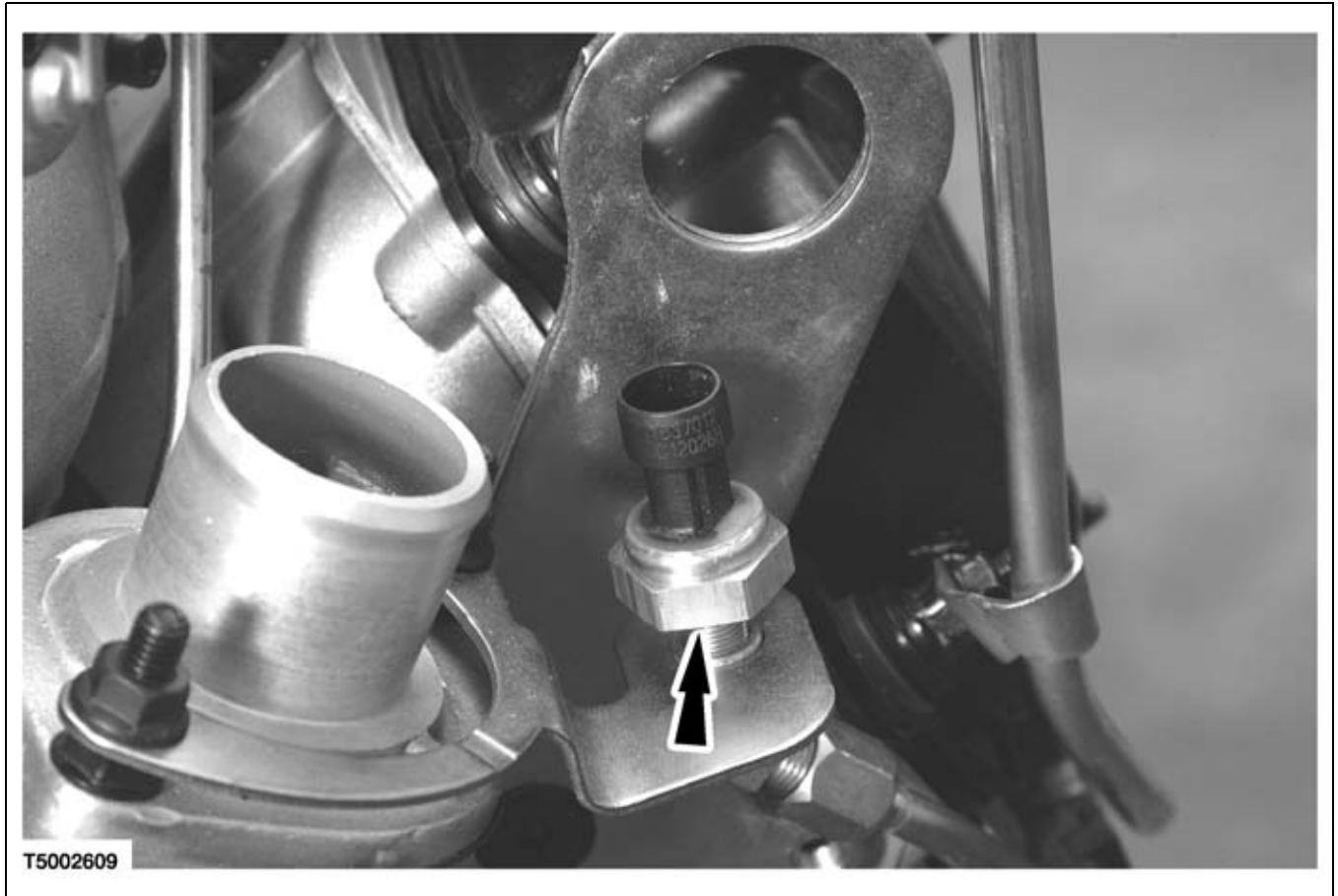


Intake Manifold Locating Tabs

Unlike the 7.3L engine, the 6.0L engine uses intake manifold gaskets.

- When replacing the intake manifold gaskets, be sure to place the locating tabs in the proper position.

Exhaust Pressure (EP) Sensor

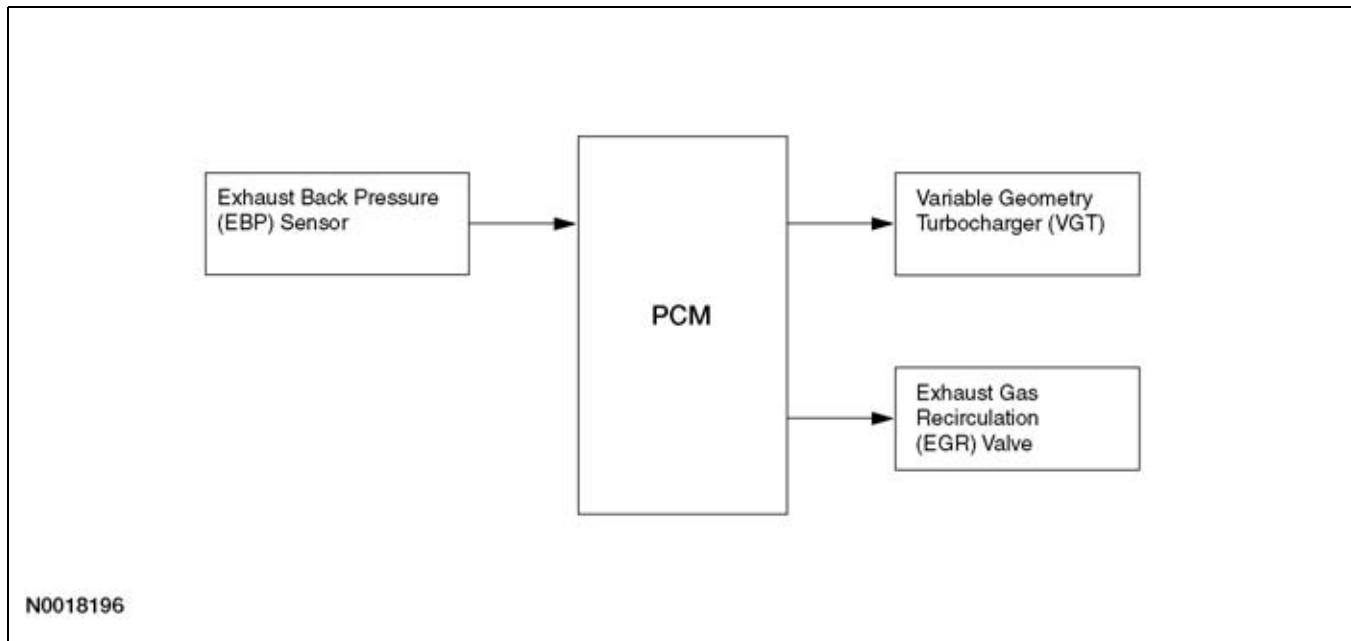


Exhaust Pressure (EP) Sensor

The EP sensor on the 6.0L is mounted on the front left side of the engine.

- The PCM uses the EP sensor to monitor exhaust backpressure, which is used to control the VGT solenoid and the EGR valve.
- An EP sensor VREF shorted to ground shuts down the PCM and prevents engine startup. Other shorts set a code, but do not shut down the PCM.
- An open EP sensor will set a code.

LESSON 2: THEORY AND OPERATION



Exhaust Pressure (EP) Sensor Block Diagram

The PCM uses information from the EP sensor to control the VGT and EGR systems.

- The EP is a variable-capacitance sensor.
- It uses 5 VDC VREF generated to produce an analog EBP signal.

Intake Air Temperature 1 (IAT1) Sensor



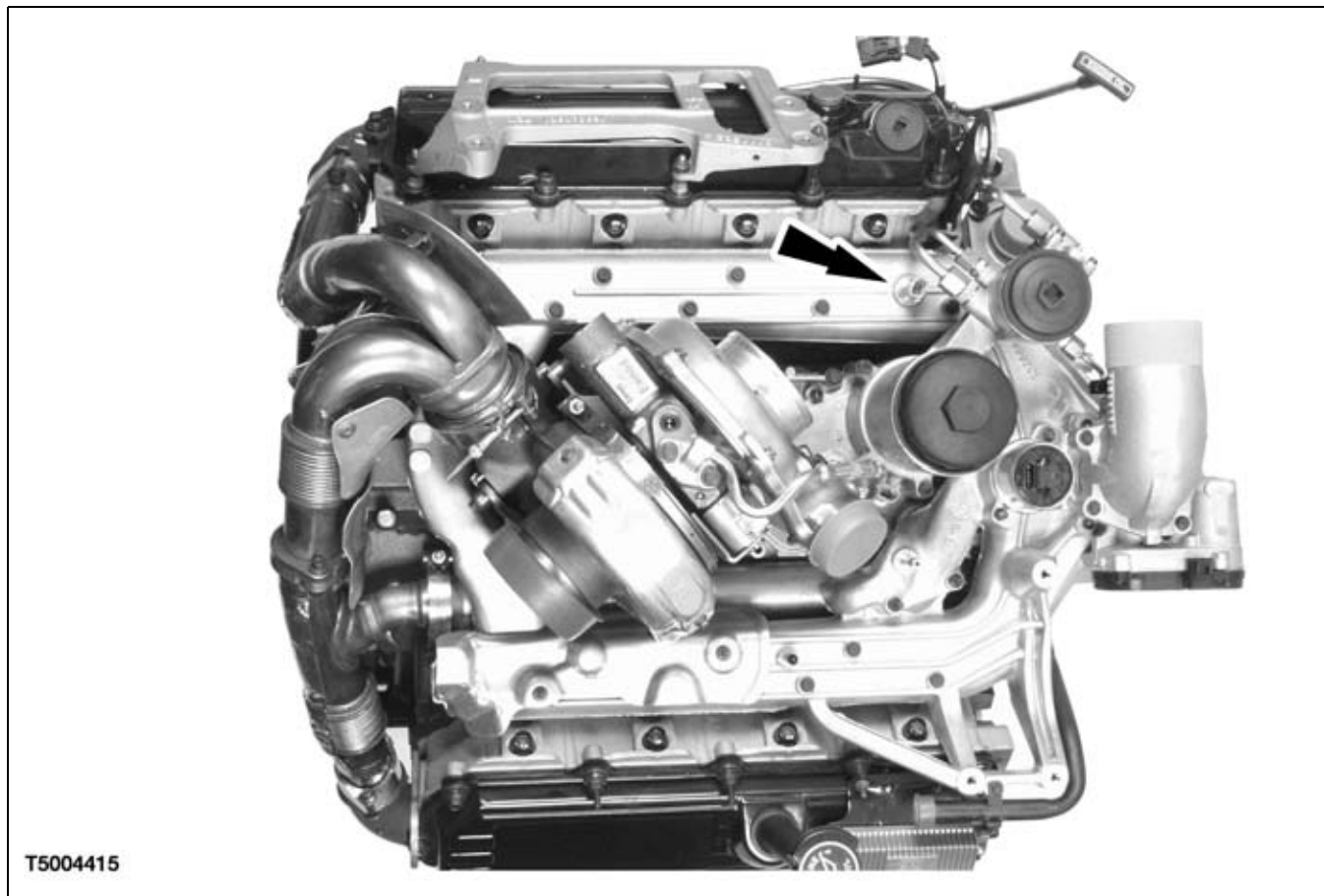
Intake Air Temperature 1 (IAT1) Sensor

The IAT1 sensor on the 6.0L diesel engine performs the same function as the IAT on the 2002/2003 7.3L engine. The PCM uses input from the IAT1 sensor to monitor ambient air temperature and determine when to close the VGT vanes to increase exhaust pressure. The IAT1 is integrated into the MAF sensor.

- The IAT1 sensor is a thermistor-type sensor with a variable resistance that decreases as the temperature increases.
- The PCM uses the changes in IAT1 voltage to determine the current ambient air temperature.
- The IAT1 sensor circuit is grounded through the PCM chassis harness connector.
- If the IAT1 sensor gives a faulty reading, the PCM could command the turbocharger to underboost or overboost.

LESSON 2: THEORY AND OPERATION

Intake Air Temperature 2 (IAT2) Sensor



IAT2 Sensor

The intake air temperature sensor 2 (IAT2) on the 6.0L diesel engine performs the same function as the manifold air temperature (MAT) sensor on the 7.3L engine.

- The intake air temperature 2 (IAT2) sensor is mounted in the intake manifold on the left side.
- The IAT2 is a thermistor-type sensor.
- The PCM uses the IAT2 signal to measure manifold air temperature to help determine the proper fuel delivery.
- The IAT2 signal is transmitted to the PCM.

OBJECTIVES

- Describe WDS use for diagnosing turbocharger concerns.
- Describe diagnosis for the variable geometry turbocharger.
- List parameter identification (PIDs) for the turbocharger system.

LESSON 3: DIAGNOSTICS

DIAGNOSTIC GENERAL INFORMATION



Technician Using WDS

First attempt to verify/recreate the symptom. Then, look for any vehicle modifications or aftermarket items that may contribute to the symptom. A check of applicable TSBs and OASIS messages may be useful.

- Refer to the Symptom Index in Section 3 of the PC/ED and select the symptom that best describes the vehicle symptom. For multiple symptoms, select the one that is most noticeable.

NOTE: When referring to the PC/ED, be sure to use the one available on the PTS website, as it will be the most current.

- Go to the Symptom Chart indicated in the Symptom Index.
- Begin the chart at the first step.
- Follow the instructions in each step including the preliminary checks.
- If a step contains a test procedure or question without a reference outside the step, perform the test step or answer the question, and continue as directed.

- If the step sends you to a specific area for testing, a Pinpoint Test Step or a Workshop Manual section, go to the procedures in the PC/ED. Follow the directions given in those procedures, including directions to other tests or sections. If a damaged part is found, repair/replace as directed. If no fault is found and diagnosis in that area is complete, return to the Symptom Chart and continue as directed.
- During diagnosis, if directed to test a system/component that is not contained on that vehicle, proceed to the next step.
- If the Symptom Chart for the vehicle symptom is completed and no fault is found, return to the Symptom Index to address the next most prominent symptom.
- After service, verify that the vehicle is operating properly and the original complaint is eliminated.

NOTE: If a symptom is determined to be intermittent, careful visual and physical underhood inspection of connectors, wiring harnesses and components is required. The Customer Information Worksheet may contain more detailed symptom information. Before beginning an in-depth diagnosis, start the engine and wiggle wires, tap on components, etc., while listening for an indication of a concern such as rpm change or relay clicking. Information about engine conditions is stored when a diagnostic trouble code (DTC) is set.

A couple of newly available tests for the 6.0L diesel engine are the power balance and the relative compression tests.

LESSON 3: DIAGNOSTICS

If Boost is Below Specification



Technician Torquing Clamp

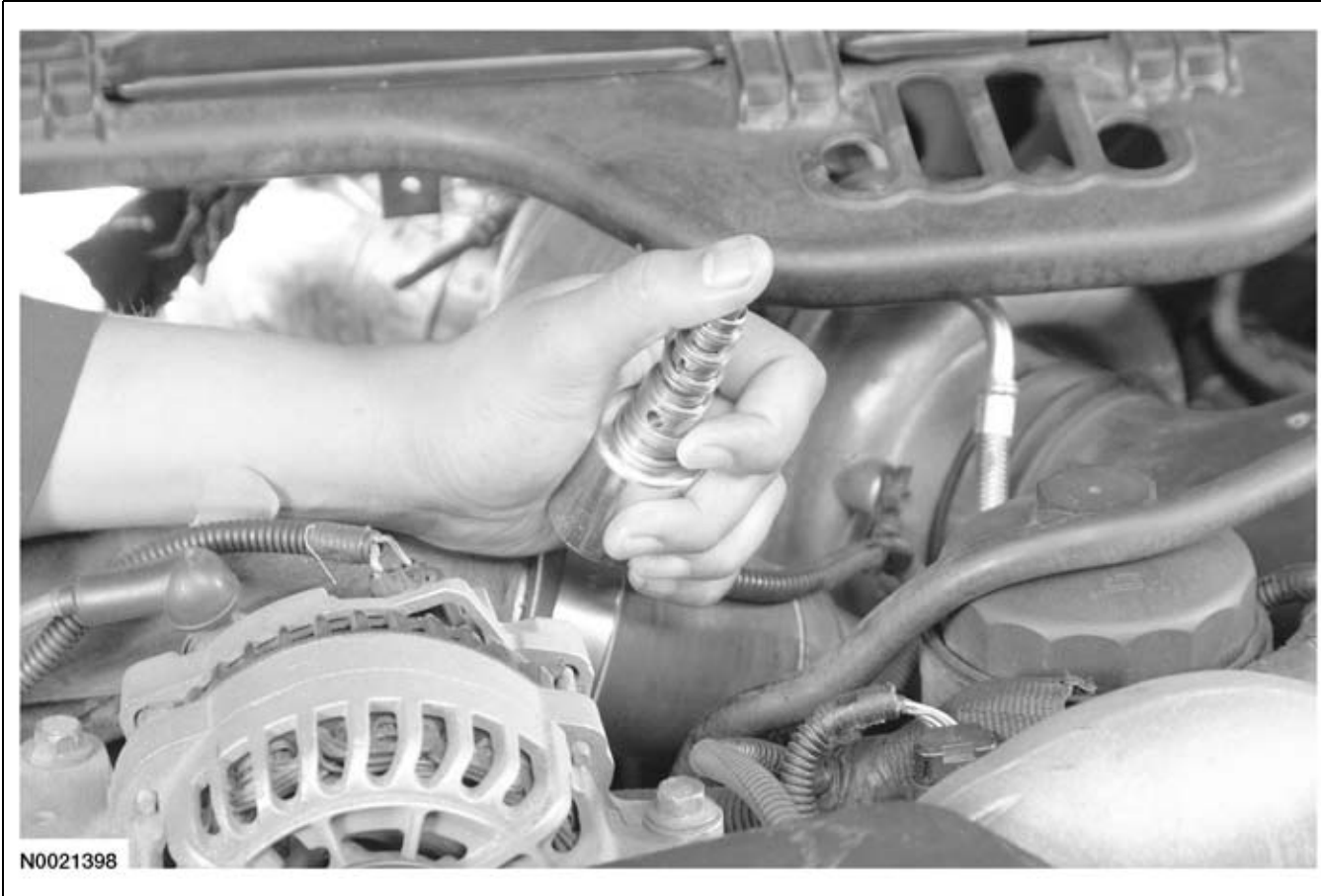
If boost is below specification, open the hood and perform a visual inspection.

- Make sure all charge air cooler (CAC) hoses are attached properly and the clamps are torqued to specification.
 - If the hoses are off, reattach the hoses and check for an overboost condition.
 - If the hoses on the charge air cooler continue to come off and the truck is not overboosting, inspect the CAC for tank split or a leak.
- Check for intake restrictions.
- Check to make sure there are no exhaust restrictions.
- With the engine off, check to make sure the inlet wheel on the turbocharger spins freely. If the wheel does not move, replace the turbocharger.
 - If the turbocharger has been recently replaced, check for debris in the exhaust tube between the turbocharger and the catalytic converter.
 - In some cases an old turbocharger wheel may be stuck in the exhaust tube.

- Low boost can be caused by the EGR system. A quick way to check this is by commanding the EGR open and closed.
 - Use the active command of the EGR_DC PID.
 - As the EGR is commanded open, the engine should become quieter.
 - If no sound change is heard, suspect the EGR valve is sticking.
 - Also look at the EGR position.

LESSON 3: DIAGNOSTICS

Checking VGT Operation



Technician Feeling Cam Follower Movement

To check VGT operation, first perform a KOEO. Also look at the MAP, BARO, and EP readings. If these appear unusual, address these before checking VGT operation. Then raise engine speed to 3,500 rpm and hold it at that point while monitoring exhaust pressure (EP) and manifold gauge pressure (MGP).

- Exhaust pressure should be between 20 and 28 psi and manifold gauge pressure should be between 2 and 6 psi.
- If MGP and EP are both high:
 - Disconnect the VGT control valve electrical connector and rerun the test.
 - If MGP and EP change with the electrical connector disconnected, inspect the wiring harness and connections.
 - If MGP and EP do not change (lower) when the VGTCV is unplugged, remove the valve from the turbocharger.
- Plug the VGTCV into the engine harness, being careful to handle the valve by its solenoid body only.
- Then apply pressure to the cam follower with your thumb while actuating the valve with the WDS and look for movement.
 - If the valve does not move, replace the valve.

VGTCV Electrical Test

The VGTCV can be tested electrically, using a digital volt-ohm meter (DVOM) to measure the resistance of the actuator coil.

- The resistance should be between 3.4 and 4.2 ohms @ 73°F EOT.
- If the engine is hot, the resistance should be between 4.4 and 5.3 ohms @ 200°F EOT.



CAUTION: Do not raise the engine rpm above 1,200 while controlling the VGT. Doing so can cause damage to the turbocharger or engine.

- Using WDS in datalogger mode, highlight the rpm PID and command the engine to approximately 1,200 rpm.
- Command the VGT to 0% and record the EP.
 - Exhaust pressure should be between 10 and 18 psi.
 - Manifold gauge pressure should be between 0 and 2 psi.
- Then highlight the VGT%. Increase it to 85% and record the EP and MGP.
 - Exhaust pressure should be between 19 and 27 psi.
 - Manifold gauge pressure should be between 0.5 and 3 psi.
- If all readings are within these ranges and the compressor wheel is not contacting the housing, do not replace turbocharger.
- If the readings are not within these ranges, proceed with further diagnosis.

LESSON 3: DIAGNOSTICS

Turbocharger Noise Concerns



Checking Turbocharger Endplay

Noise is a common reason for replacing the turbocharger. A large percentage of these replacements, however, are unnecessary because the turbochargers are not bad. Compared to the turbocharger on the 7.3L Power Stroke diesel, the VGT is louder under some conditions, due to increased boost and compressor speed. This is normal and should not be a cause for replacement.

- Refer to the turbocharger diagnostic guide on the PTS website for additional information.

Exhaust Leaks



Exhaust Gaskets

Turbochargers have been replaced for noise concerns when the concern is exhaust misalignment at the connections and bad or missing gaskets. Before replacing a turbocharger for a noise complaint, inspect for the following:

- The flange on the passenger side exhaust up pipe requires a metal gasket just above the EGR cooler connection.
- If the metal gasket at the V-band clamp and EGR cooler is missing, damaged or the clamp misaligned, it could be misdiagnosed as a turbocharger failure.
- Misaligned clamps and pipes can cause a noise concern. Pay particular attention to the turbine inlet and outlet.
- If the turbocharger itself is responsible for excessive noise, check for wheel-to-housing rub and bearing failure.

LESSON 3: DIAGNOSTICS

Turbocharger Blade Visual Inspection



Good Turbocharger Blades

Whenever the turbocharger is removed, it is a good idea to inspect the blades. Good turbocharger compressor blades are clean and straight. There should be no large gaps between the compressor housing and the compressor wheel and no visible damage to the blades.



Foreign Object Damage

This compressor wheel shows signs of some foreign object (nuts, bolts, screws, etc.) coming in contact with the blades while they were spinning.

LESSON 3: DIAGNOSTICS



Dirt Ingestion

Dirt ingestion is also called “dusting.” The compressor wheel blades show signs of erosion from dirt entering the intake air system. The blades are rounded off and thin.

Turbocharger Damage Due to Aftermarket Modifications

Aftermarket performance-enhancing PCM programs, propane-injection packages and modification to the exhaust system may negatively affect the life of the turbocharger. This is particularly true in high altitudes where the “thin” air offers lower resistance for the wheels to turn. The higher wheel speeds created by the “thin” air and the performance enhancements typically result in a fractured turbine wheel blade. Wheels with blades missing on modified engines cause low power, vibration and, ultimately, turbocharger failure. Overspeeding the turbocharger may also cause turbocharger thrust bearing failure, increasing the axial endplay of the turbocharger shaft and wheel-to-housing contact.

LESSON 3: DIAGNOSTICS

VGTCV Replacement



VGTCV and Plastic Tube

If the VGT control valve is to be replaced under warranty:

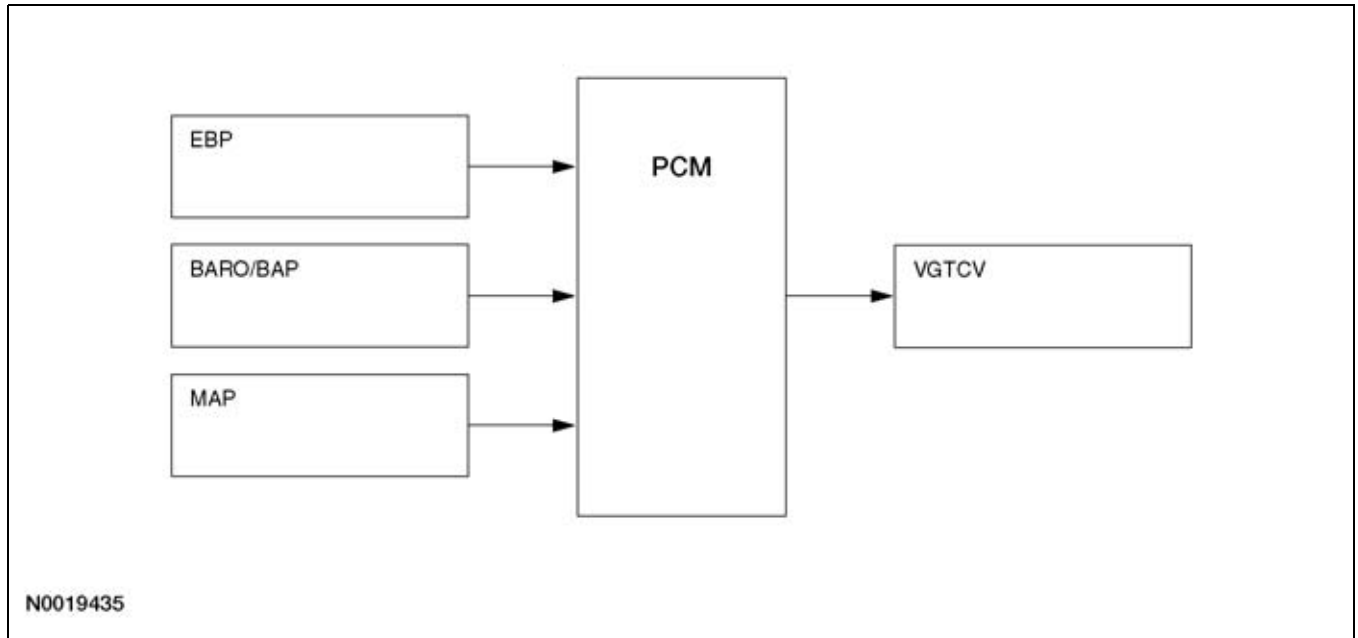
1. Remove the suspect control valve from the turbocharger and immediately place it in a plastic tube container provided with service kit base No. 6F089. Handle the valve by the solenoid body only. Do not attempt to clean or wipe oil from the valve. Do not let the valve come in contact with anything prior to placing it in the container. This includes rags or fabric gloves that can contaminate the valve mechanism with lint.

NOTE: The suspect control valve must be returned in the protective container for proper warranty credit.

2. Lightly lubricate the O-rings and install the valve into the bore.
3. Tighten the retaining bolt to 21-24 Nm (15-18 lb-ft) and reconnect the electrical connector.
4. After replacement, retest the VGT function as described earlier. If the concern is still present, refer to the turbocharger guide on the PTS website.

NOTE: When installing the new valve, use the same caution as during removal to prevent contamination of the new valve.

VGT Diagnosis



VGTCV Operation

- The PCM determines positions for the variable vanes, using feedback from three sensors:
 - Exhaust backpressure (EBP) sensor
 - Barometric (BARO) absolute pressure (BAP) sensor
 - Manifold absolute pressure (MAP) sensor
- The WDS KOEO and KOER tests command the PCM/ECM to monitor the EBP, BAP and MAP sensors for out-of-range signals. Faults with the turbocharger or its related control circuit generally set a DTC.
- Refer to the PC/ED manual for additional information on how to identify the cause of DTCs related to the VGT.

LESSON 3: DIAGNOSTICS

Oil Leaks From Turbocharger



Turbocharger Oil Supply Line

If oil is found leaking from the back of the engine, the most likely place to look is the turbocharger mounted in the valley. Some possible leak points are:

- Oil supply connection
- Oil drain
- Center section
- Oil seepage from the pipes

To reduce leaks due to improper installation, the snap-to-connect turbocharger oil feed line has been replaced with an O-ring sealed, bolt-on line.

NOTE: Some oil carryover from the crankcase ventilation system is normal and may cause oil seepage from the charge air cooler hoses.

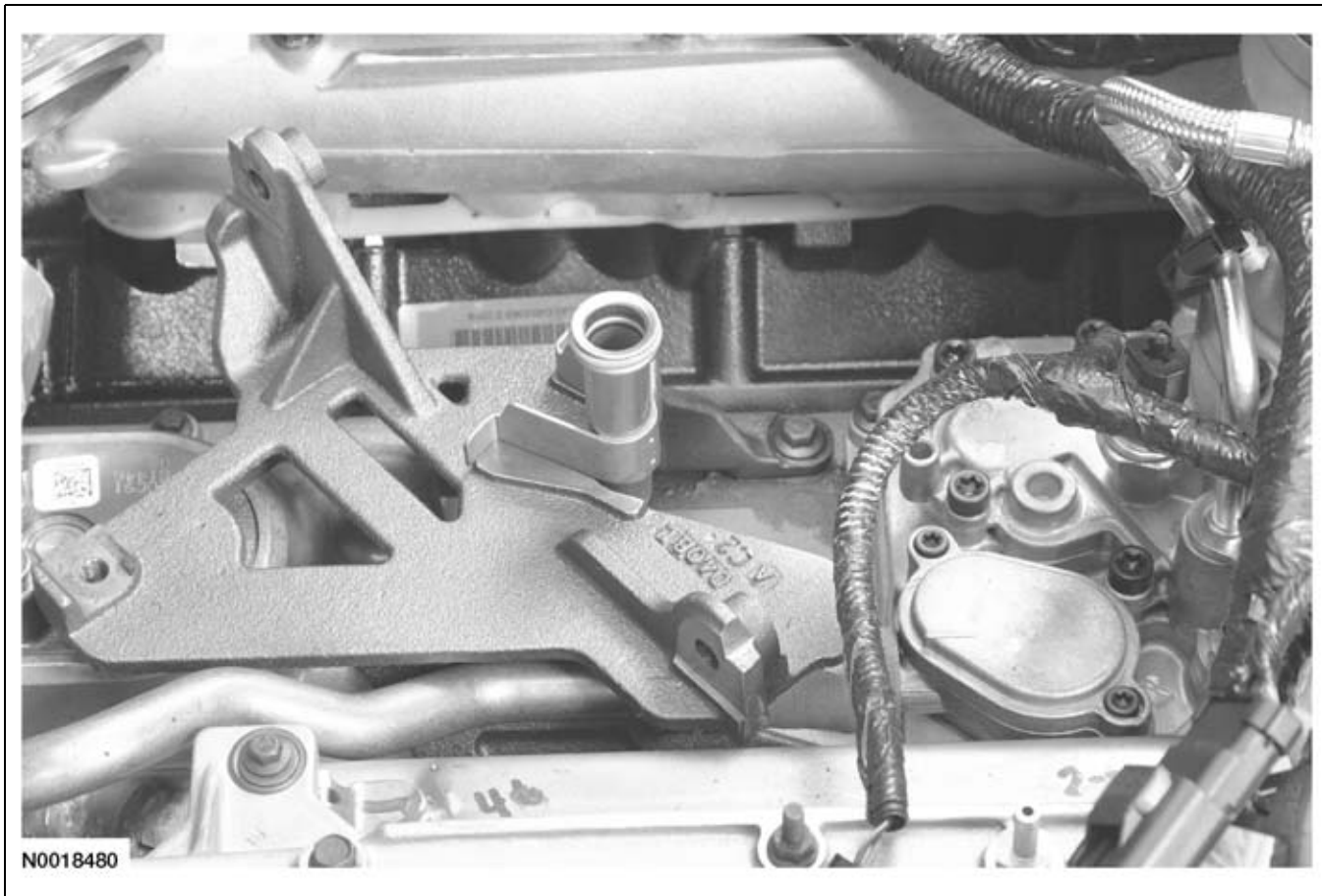
NOTE: When diagnosing an oil leak, begin by looking at the top and most forward point of the affected area.

NOTE: An oil leak that appears to stem from the center section may be coming from the oil feed line.

NOTE: Approximately 34 percent of turbocharger leaks come from the connection to the inlet pipe on top of the turbocharger. Approximately 28 percent of the turbocharger leaks stem from the turbocharger oil drain on the bottom of the turbocharger.

- In many cases when the turbocharger supply line is leaking, only the gasket needs to be replaced and the bolts torqued to 31 Nm (23 lb-ft).

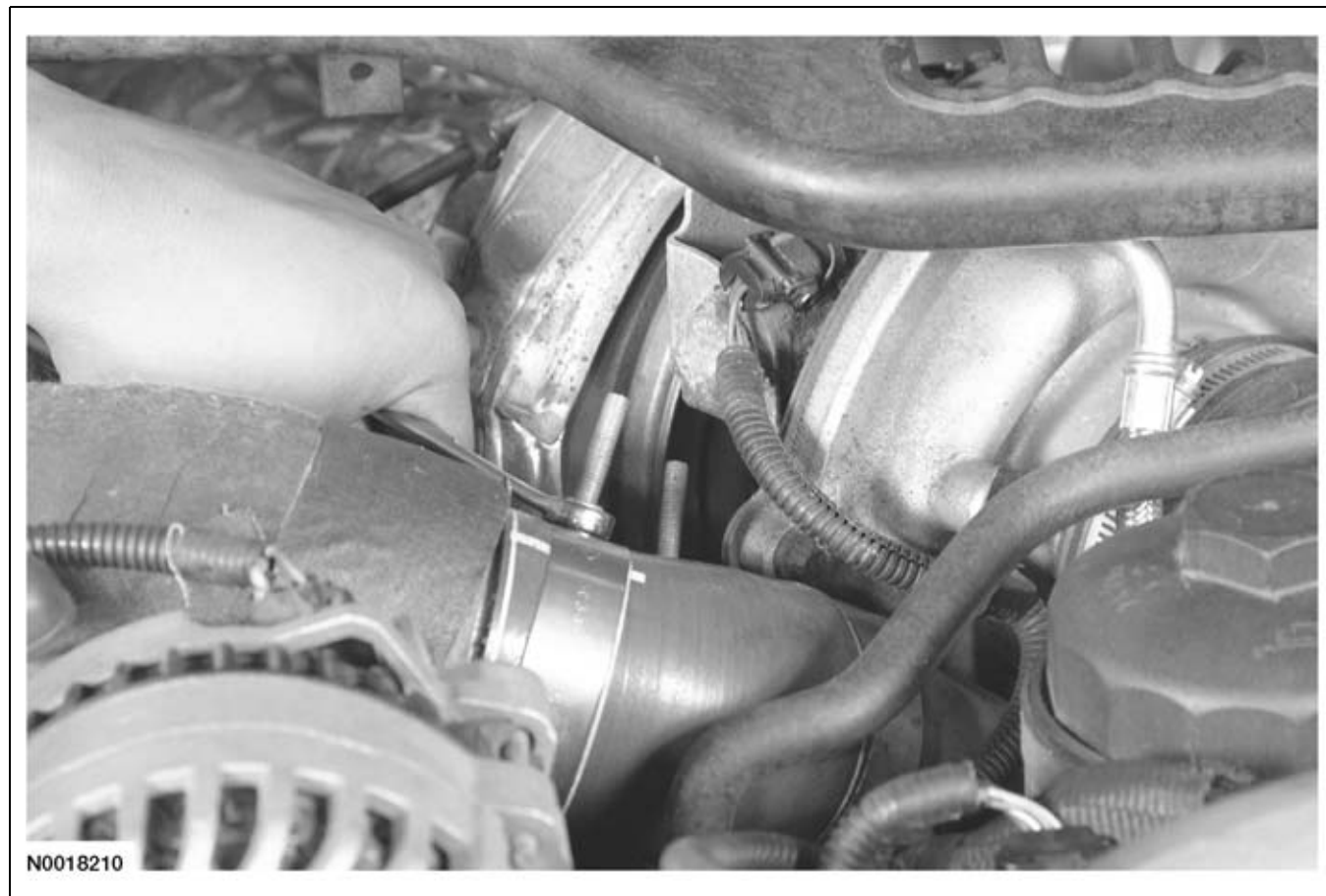
LESSON 3: DIAGNOSTICS



Turbocharger Oil Drain Tube

- If pooling oil is found under the turbocharger:
 - Inspect the turbocharger oil drain tube for evidence of weeping or leaking.
 - Inspect the bottom of the compressor housing for CAC or PCV related oil leaks.
- The oil leak may be caused by a leaking O-ring or damaged drain tube. Replace the O-rings or drain tube as necessary.
- Replacing the turbocharger for an oil leak when the oil supply line or drain tube is faulty increases the cost of repair more than tenfold.

Turbocharger Removal



CAC Pipe Removal

The highlights of the turbocharger removal procedure are listed here. For additional information, refer to the service manual.

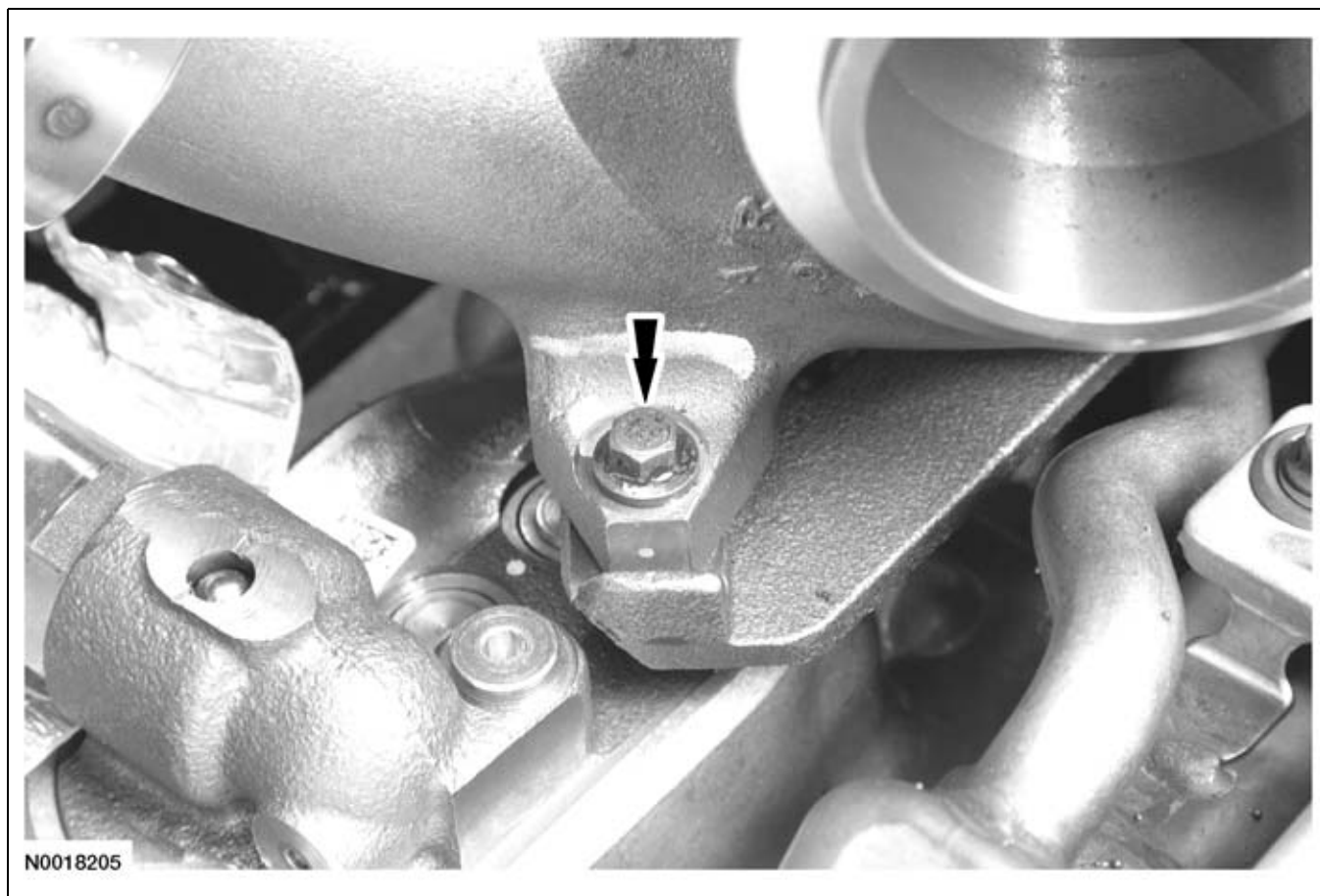
1. Remove the turbocharger intake tube.
2. Disconnect the charge air cooler inlet pipe.

LESSON 3: DIAGNOSTICS



Oil Supply Tube Flange

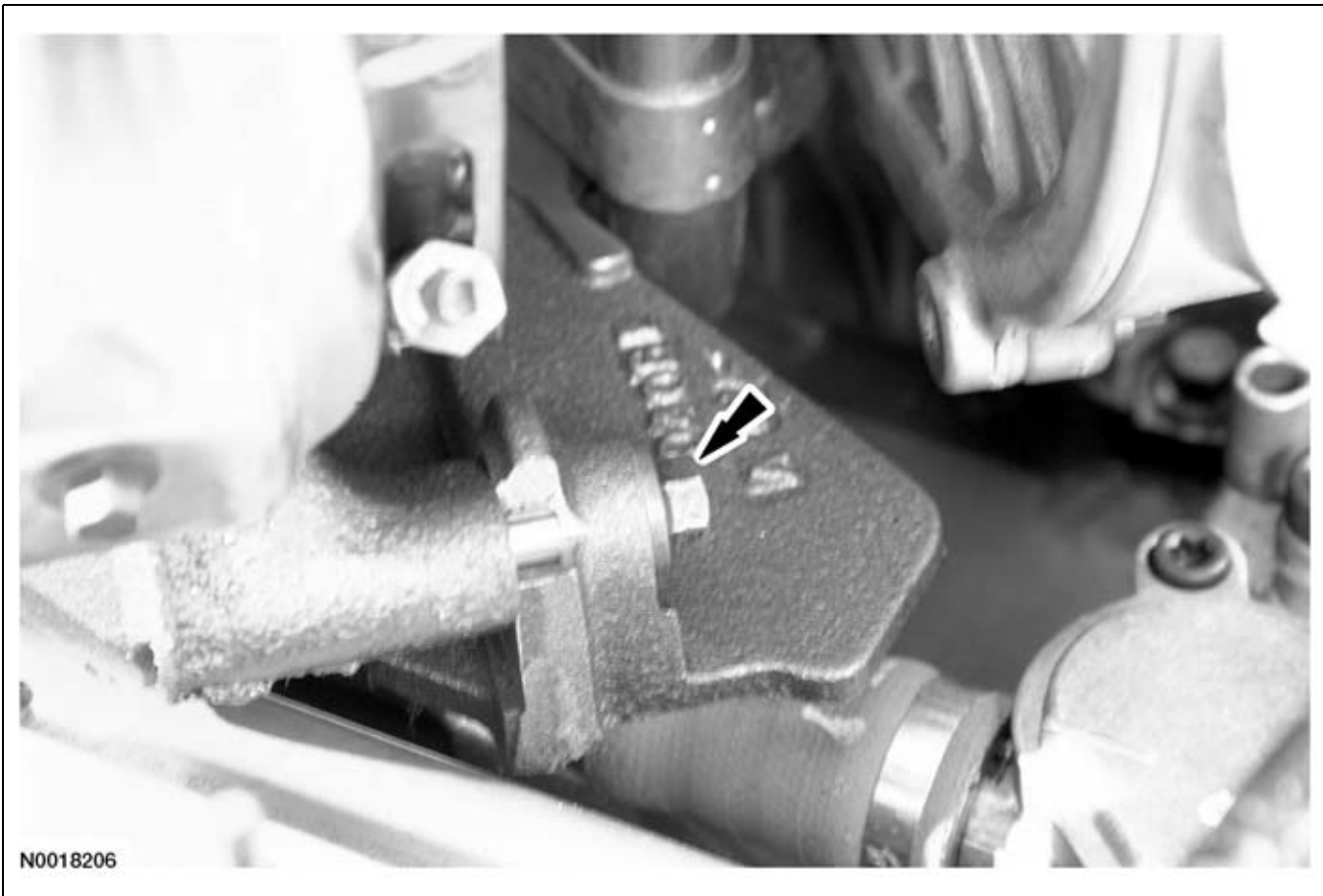
3. Remove the oil supply tube.
4. Remove the turbocharger outlet tube clamp.
5. Remove the turbocharger inlet tube clamp.



Turbocharger Rear Mounting Bolt

6. Remove the rear mounting bolt.

LESSON 3: DIAGNOSTICS



Front Mounting Bolt

7. Remove the front mounting bolts.



Turbocharger Oil Drain Tube

NOTE: Turbocharger mounting bracket removed for clarity.

8. Rotate the turbocharger toward the rear of the engine to gain enough clearance to remove the oil drain tube. Then remove the drain tube.

LESSON 3: DIAGNOSTICS

NOTE: In-vehicle clearance doesn't allow the turbocharger to be removed until the oil drain tube is removed.

NOTE: Be sure to replace both o-rings on the oil drain tube before installation.



Removing Turbocharger

9. Remove the turbocharger.

TURBOCHARGER BOOST SYSTEM PIDS



WDS

Parameter identification (PID) can be very helpful when diagnosing turbocharger concerns on the 6.0L diesel engine. To select PIDs, connect the diagnostic tool to the data link connector (DLC) and turn off all accessories. If the vehicle is equipped with a power take-off (PTO) system or auxiliary idle control, turn them off before initiating self-tests.

When recording PID information, it can be helpful to also record all APP, VSS and MFDES PIDs.

The PIDs for turbocharger are listed in the following table. For additional information, refer to the PC/ED.

Parameter Identification (PID) List

Acronym	Description	Measurement Unit
EBP	Exhaust backpressure	Volts/Pressure
MAF	Mass airflow	Num/Volts
MAP	Manifold absolute pressure sensor	Volt/Pressure
MGP	Manifold gauge pressure	Pressure
VGT_F	Variable geometry turbocharger fault	Fault

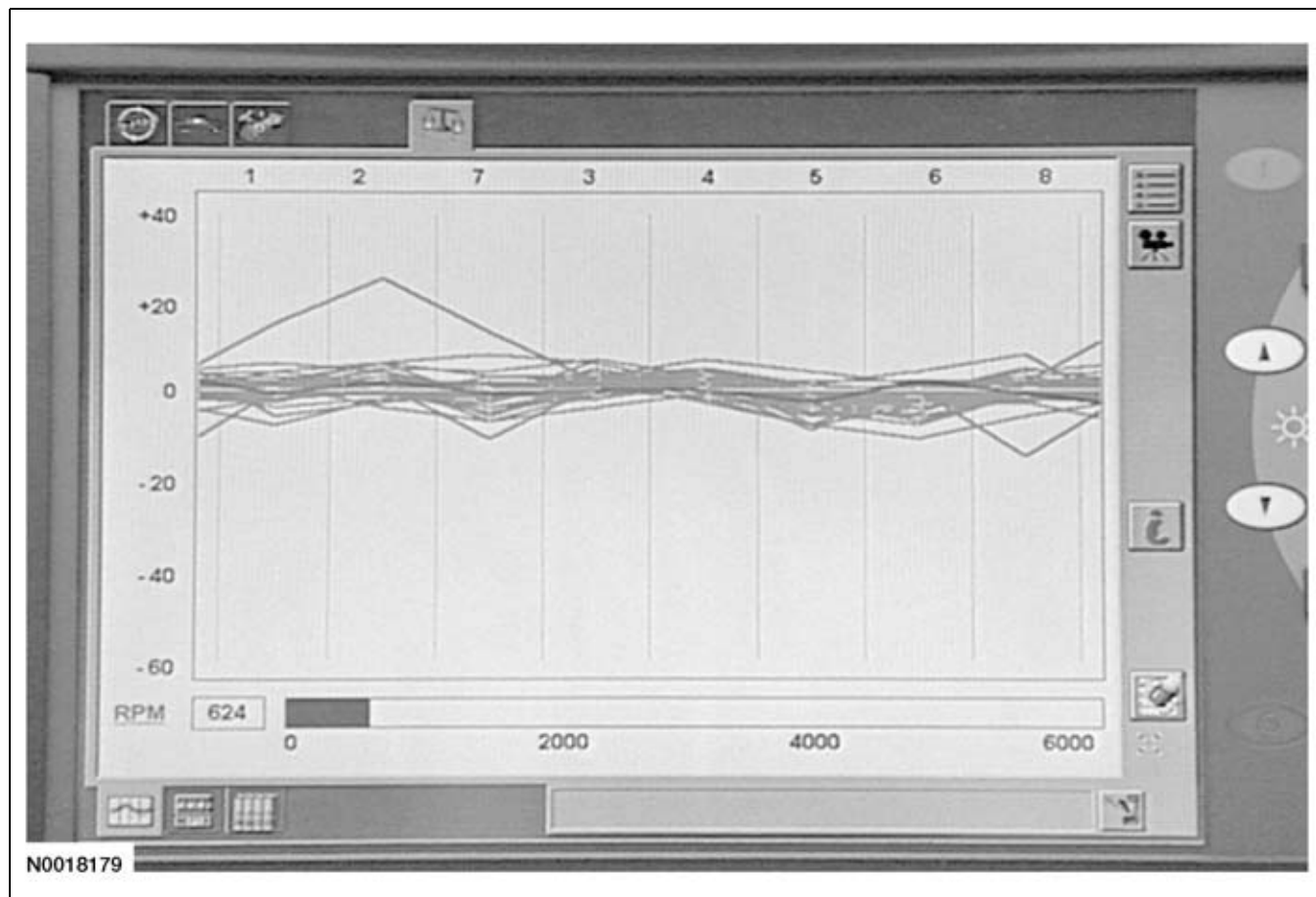
LESSON 3: DIAGNOSTICS

Parameter Identification (PID) List (Cont.)

Acronym	Description	Measurement Unit
VGTDc#	Variable geometry turbocharger duty cycle	Percent
IAT	Intake air temperature	Degrees Fahrenheit/Volts
IAT2	Intake air temperature 2	Degrees Fahrenheit/Volts
BARO	Barometric pressure	PSI, Volts, H2
EGRVPDES	EGR Valve position desired	Percent
EGRVP	EGR valve position	Voltage

- **Code P0046** is set when a short to ground, open, or short to power is identified in the VGTCV or wiring between the PCM and VGTCV. This circuit is a continuously monitored circuit that takes less than 1 second to set.
- **Code P0236** is set at idle when MAP is more than 70 kPa (10 psi) above BP and MGP is greater than 30 kPa (4.4 psi). In order for this fault to be set, MFDES must be below 14, rpm must be less than 850 and EGRP less than 0.10 open. All of these conditions must be met for at least 10 seconds before the code will be set.
- **Code P0237** is set when the MAP signal is lower than the specified value for a length of time set by an incremental counter. This code is used to detect a MAP circuit that is open or shorted to ground.
- **Code P0238** is set when the MAP signal is higher than the specified value for a length of time set by an incremental counter. This code is used to detect a MAP circuit shorted to power.
- **Code P2262** is set when MGP does not go above 5 kPa (0.7 psi) when the following conditions are met: rpm must be above 2,800, VFDES above 20, and EGRP below 0.10. All of these conditions must be met for at least 5 seconds before the code will be set. This code is used to detect a MAP sensor hose that has come off.

WDS Power Balance Test



WDS Power Balance Screen

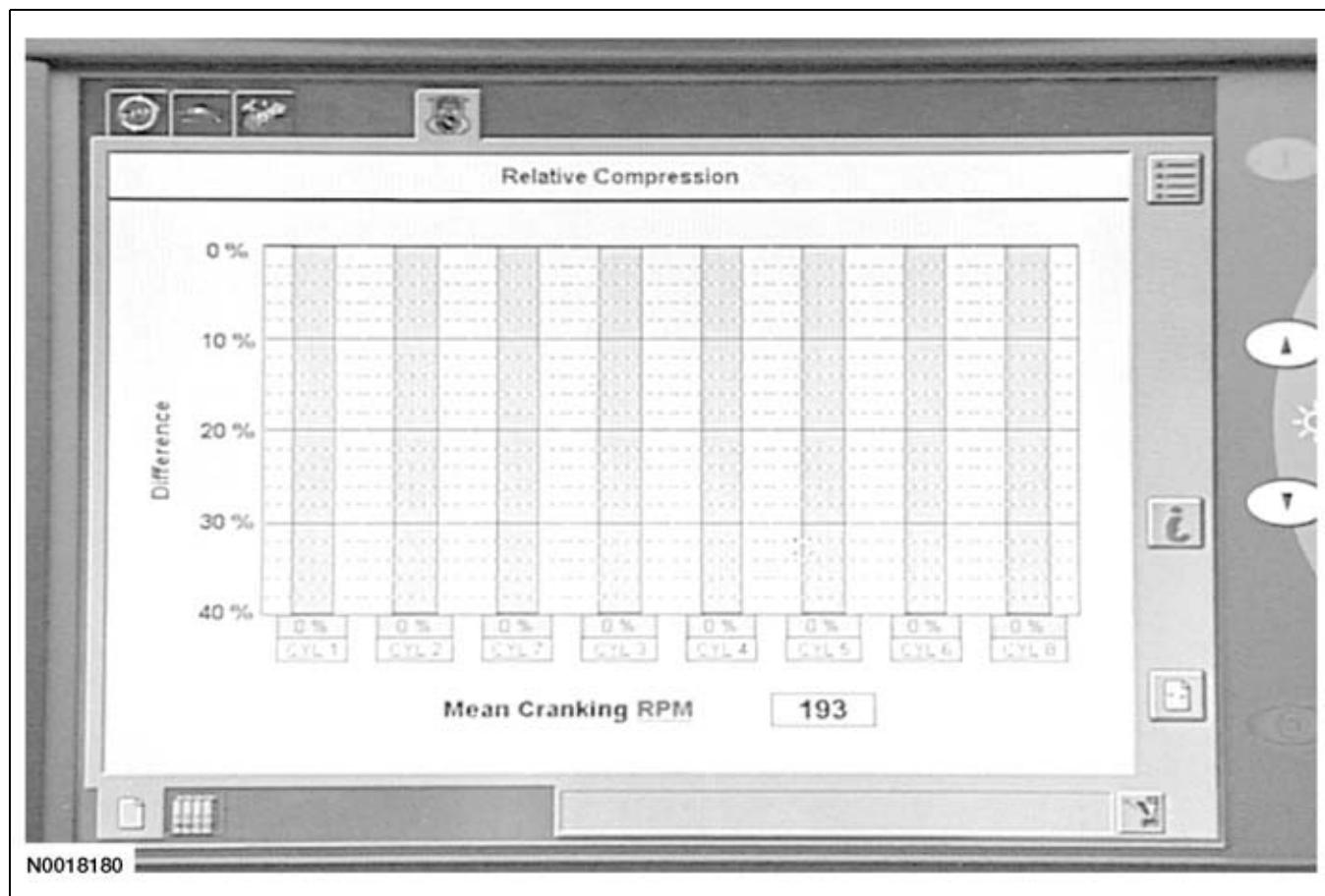
The power balance test compares the relative ability of each cylinder to produce similar power. This is the same test that technicians have used for many years on gasoline engines. The above figure is an example of the Power Balance tool available for the 6.0L diesel.

- Power Balance will identify a problem with the power contribution of a cylinder when the engine is running between 500 rpm and a calibrated maximum rpm.
- When the calibrated maximum rpm is reached the bar graph rpm will turn yellow, indicating that the data retrieved from the Data Communication Link may not be reliable.
- The rpm displayed at the bottom of the screen is the average rpm of all cylinders in a complete engine cycle.
- The rpm for each cylinder is calculated during the power stroke, and displayed as above or below the average rpm for the engine cycle.
- A drop in rpm identified in one or more cylinders may be caused by a fault in the fuel system, or the cylinder's relative compression.
- Power balance descriptions are available on the WDS by selecting the information icon on the right side of the screen.

LESSON 3: DIAGNOSTICS

- The library icon at the bottom left of the screen also contains additional information about the tool as well as help on interpreting the results.
- Power Balance also provides the ability to make recordings which allow for playback analysis of the results.

Relative Compression Test



WDS Relative Compression Screen

The relative compression test helps the technician identify a weak cylinder. The test results are displayed as a bar graph. This is the same type of test that has been used on gasoline engines for generations.

- The crank period is 10 seconds.
- Relative compression descriptions are available on the WDS by selecting the information icon on the right side of the screen.
- The library icon at the bottom left of the screen also contains additional information about the tool and help on interpreting the results.
- If the relative compression indicates a weak cylinder, verify with a manual compression check.

LESSON 3: DIAGNOSTICS

ACCESSING SERVICE INFORMATION

The screenshot shows the Ford Professional Technician Society (PTS) website. The header features the Ford logo and the text "Professional Technician Society". A navigation menu on the left includes links like "FMCDealer Home", "PTS Home", "PTS Top 5", "OASIS", "Rotunda Tools & Equipment", "Service Labor Time Standards", "Service Publications", "Technical Training", "Diagnostics", "Global Concern Reporting", "Owner Information", "Power Stroke Central", "Tech Communications & Tech Review Panel", "Quick Links", "Rewards and Recognition", "Rotunda Diagnostic Support", "STARS2 On Line", and "Technical Hotline". The main content area is divided into several sections: a "Welcome Douglas George" message, a "Web-based Training" section with links to "My Training" and "My Prior Approval", a "BUY TOOLS NOW!" banner for the "2005 Super Duty New Model Launch Site", a "What's New" section with updates from 08/02/04, and a "PTS Quick Links" section with dropdown menus for "Quick Links...", "New Model Launch...", and "Survey Corner". A sidebar on the right contains a "DASIS" section with a search bar and a "Go" button, a "Previous Vins" section with a text input field containing "1FDXF47P55EA00069" and a "clear" button, a "Symptom Category" section with a dropdown menu showing "Body", "Chassis", "Driveability", and "Driveline", and a "Symptom / DTE Codes" section with a "clear" button. The footer includes the text "Web Server: B2C Prod 3" and "N0018182".

Professional Technician Society (PTS) Website

The most comprehensive and up-to-date diagnostic information and diagnostic aids are posted on the PTS website. In addition to the PC/ED and service manuals, the PTS website includes a section entitled Power Stroke Central. Also, the hotline diagnostic tool is located at the PTS site.

- For additional information on 6.0L service information, refer to 6.0L Diesel Engine Diagnostic Processes class (course code 51G07F0).

ESSENTIAL SPECIAL SERVICE TOOLS

NOTES

APPENDIX: ESSENTIAL SPECIAL SERVICE TOOLS

GLOSSARY OF TERMS

NOTES

