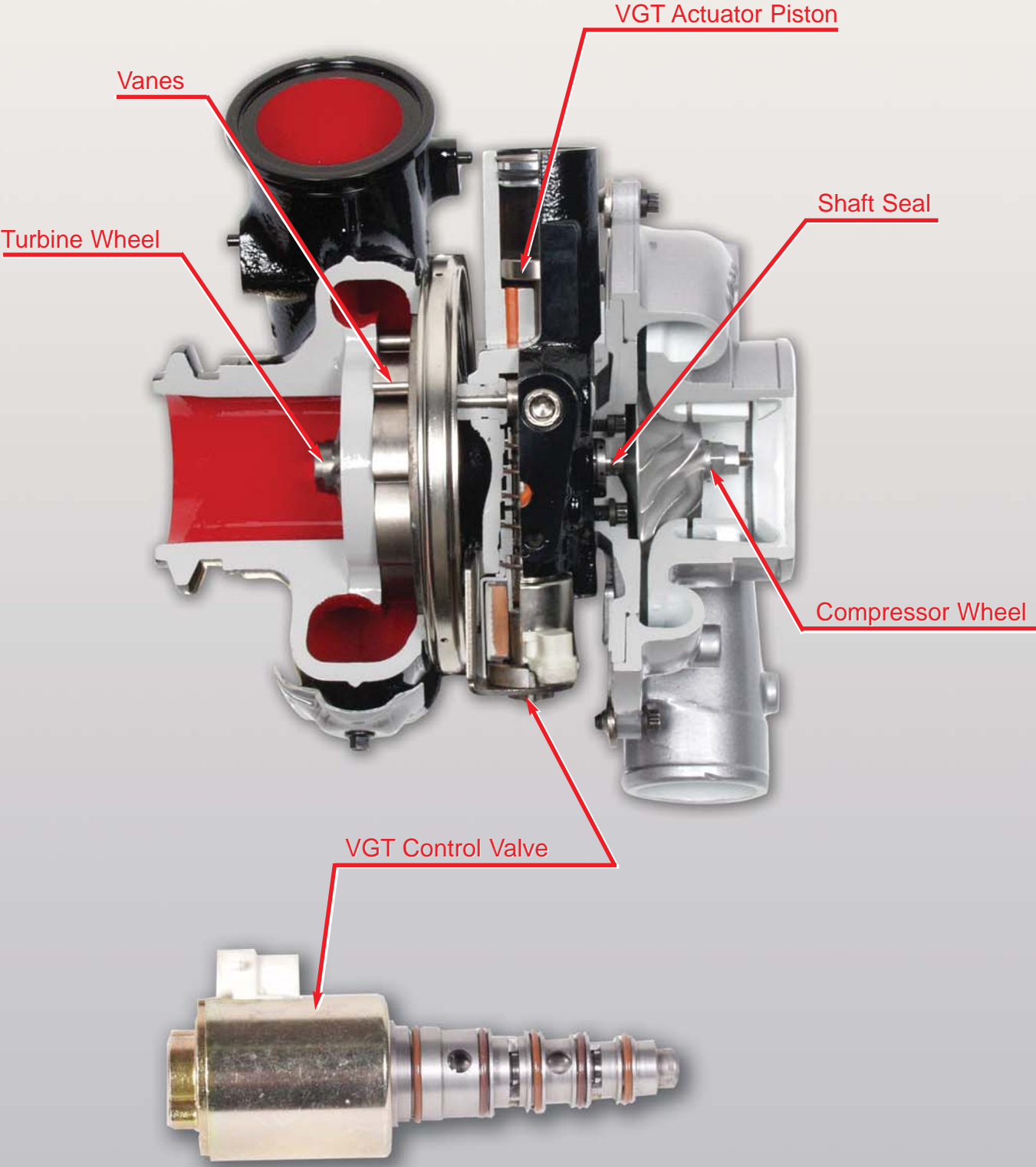


# Technician Turbocharger Guide for the 6.0L *Power Stroke* Engine



# TURBOCHARGER DESCRIPTION AND BASIC OPERATION

The turbocharger for the 6.0L *Power Stroke* engine is designed to improve throttle response by providing boost control at low and high speeds.

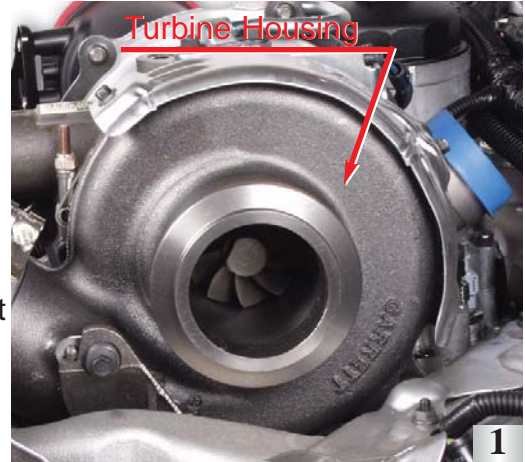
The Variable Geometry Turbocharger (VGT) is electronically controlled by the vehicle's PCM and is hydraulically actuated using pressurized lube oil.

The VGT may also be referred to as Electronic Variable Response Turbocharger (EVRT).

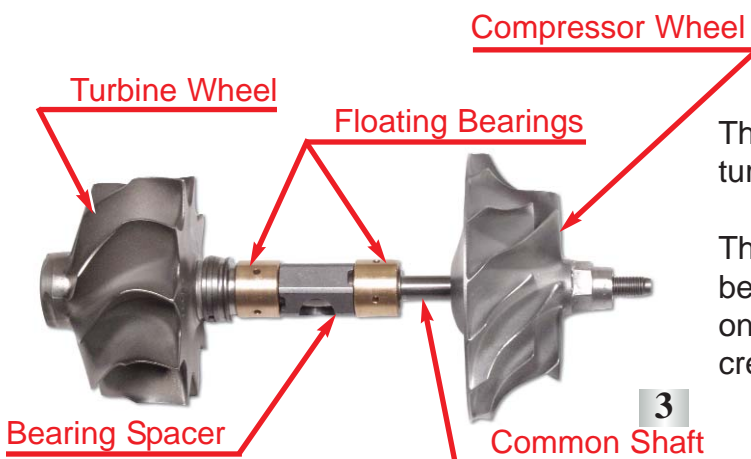
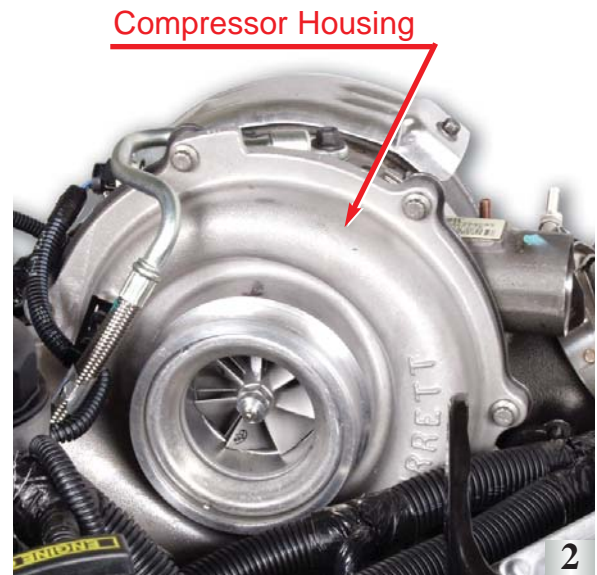
The VGT uses a turbine wheel that is similar to a conventional turbocharger but the turbine housing has changed.

The turbine housing contains vanes that control the effective internal size of the housing. These vanes are hydraulically actuated and electronically controlled.

When the vanes of the turbocharger are closed, the engine will have a higher exhaust back pressure and create more heat which will in turn warm the engine faster in cold ambient conditions.



The compressor on the VGT is similar to the compressor on a conventional turbocharger.



The compressor wheel is connected to the turbine via a common shaft.

The shaft is supported by two (2) floating bearings. This bearing design uses an oil film on the inner and outer diameter in order to create a virtual friction free bearing.

The VGT control valve is commanded by the PCM, based on engine speed (CKP sensor) and load (calculated value based on MFDES (Mass Fuel Desired) at a specified RPM). The PCM uses EP (Exhaust Pressure) to act as a closed loop control for the VGT and to monitor its performance.

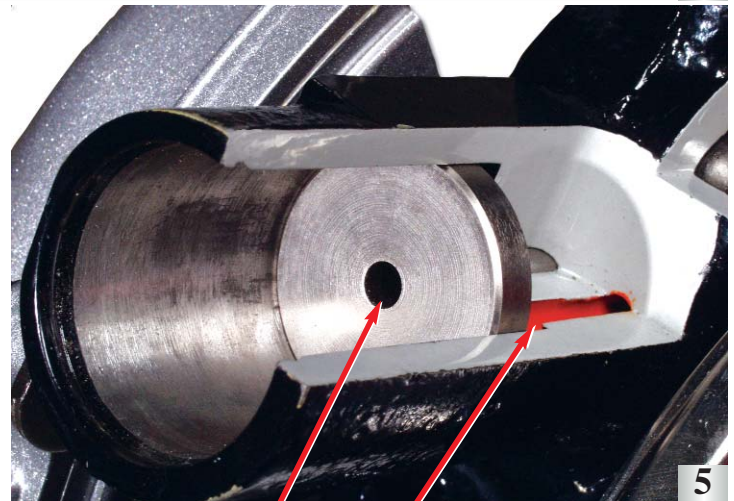
The command can be viewed on WDS as VGT# and is described in % closed. A low % means the vanes are commanded to an open state. A high % means the vanes are commanded to a closed state. The magnetic field generated by this signal moves a shaft in the control valve (VGTCV). This movement meters engine oil through the valve to either side of the piston. This design feature reacts quickly to changes in demand based on driving conditions. When one side of the piston is pressurized, the opposite side is vented.

Depending on which side of the piston is pressurized, the vanes either open or close. A cam follower at the end of the valve assembly provides feedback to the valve allowing it to reach a parked position during times the vanes are not commanded to move.



Cam Follower

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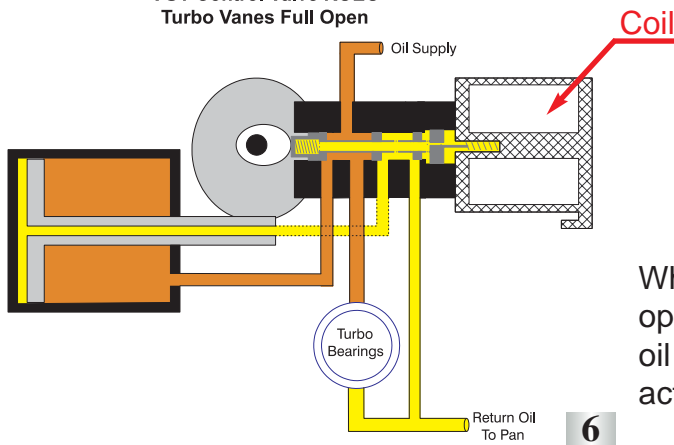


Oil Supply, Outer Side of Piston

Oil Supply, Inner Side of Piston

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VGT Control Valve KOEO  
Turbo Vanes Full Open



Coil

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When the VGTCV is commanded to the full open position, low or no duty cycle, oil from the oil supply line is directed to the open side of the actuator piston.

Oil on the closed side of the piston is then directed through the hollow shaft of the actuator piston, back to the VGTCV, and then to drain.

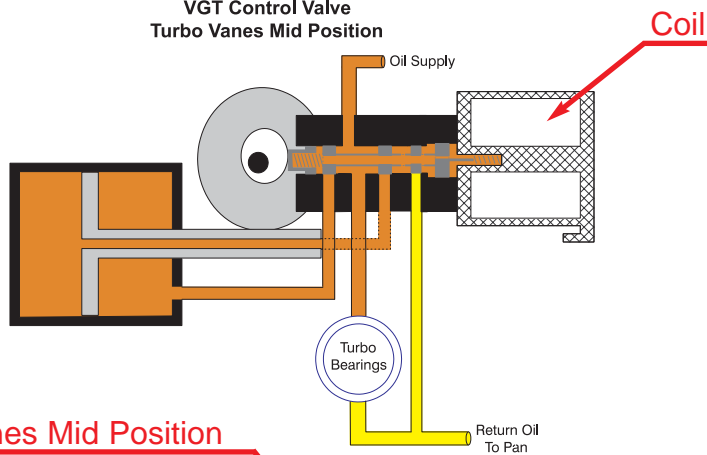
Note: If the VGTCV is disconnected the valve will default to the open position.

Vanes Open Position



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VGT Control Valve  
Turbo Vanes Mid Position



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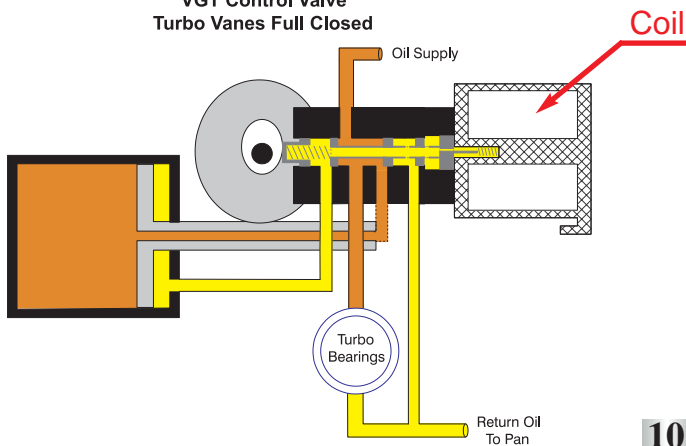
Once the desired turbocharger vane position is obtained, the VGTCV goes to a parked position and both the open and closed sides of the actuator piston are blocked off.

Vanes Mid Position



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VGT Control Valve  
Turbo Vanes Full Closed



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When the VGTCV is commanded to the full closed position, high duty cycle, oil from the oil supply line is directed through the actuator piston to the closed side of the piston.

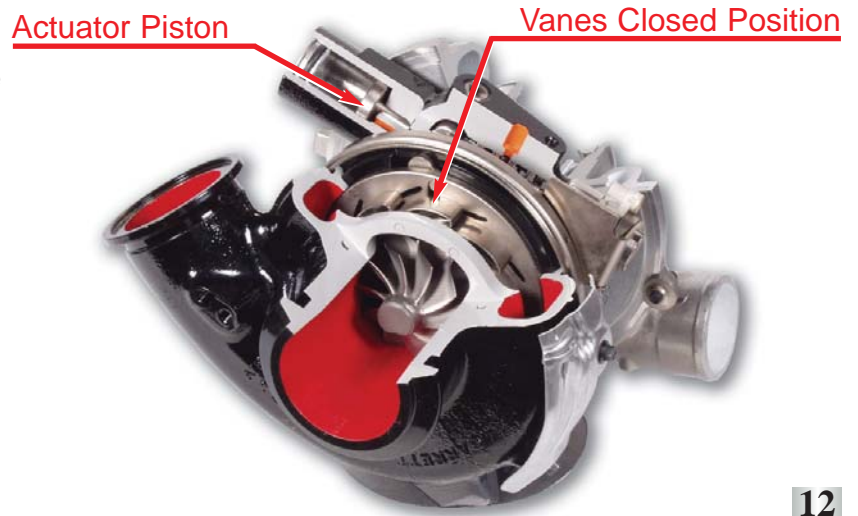
Vanes Closed Position

Oil on the open side of the piston is directed back to the VGTCV and then to drain.



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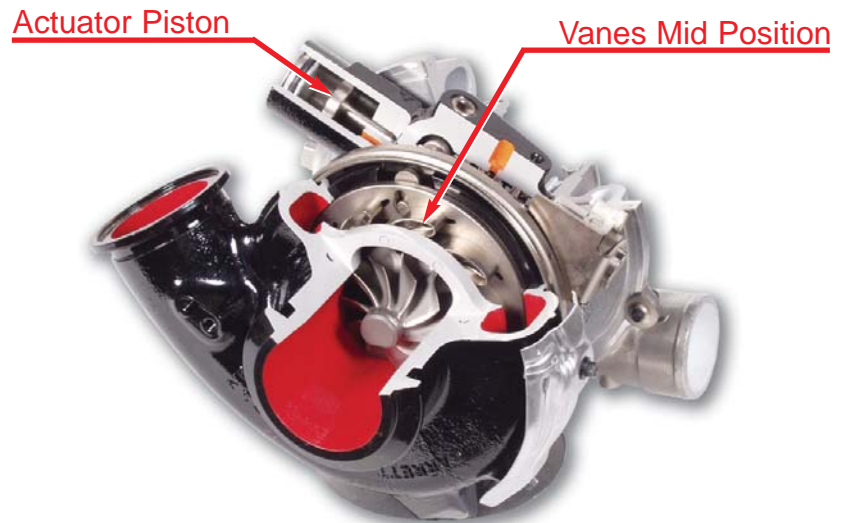
During engine operation at low engine speeds and load, little energy is available from the exhaust to generate boost. In order to maximize the use of the energy that is available, the vanes are closed. In doing so, the exhaust gas is accelerated between the vanes and across the turbine wheel increasing turbocharger wheel speed and “boost”. In general, this allows the turbocharger to behave as a smaller turbocharger.



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Closing the vanes also increases the back pressure in the exhaust manifold which is used to drive the exhaust gas through the EGR cooler and EGR valve into the intake manifold. This is also the position for cold ambient warm up.

During Engine operation at moderate engine speeds and load, the vanes are commanded partially open.

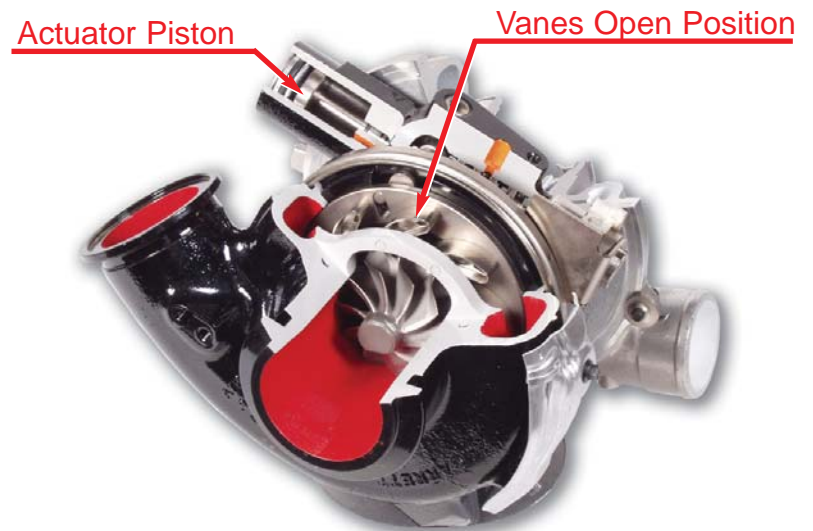


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The vanes are set to this intermediate position to supply the correct amount of boost to the engine for optimal combustion as well as providing the necessary back pressure for EGR operation.

**Note: The VGT control valve piston is coupled to the vanes through a shaft and the unison ring.**

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, therefore the vanes are commanded open preventing turbocharger overspeed.

Essentially, this allows the turbocharger to act as a large turbocharger, not creating excessive back pressure.

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## DIAGNOSTICS

When diagnosing a low boost concern, verify that there is no other concern that would cause low power. Since boost is created by the heat of expansion, anything that can cause low power will create low boost (ex. injectors, EGR, exhaust leaks, fuel pressure and quality, etc.). Before replacing a turbo for low boost all other systems must be tested.

**Verify that MAP, BARO, EP PIDs are within 1.5 PSI with Key On Engine Off (KOEO).**

**NOTE: All values are based on a vehicle equipped with a production exhaust system.**

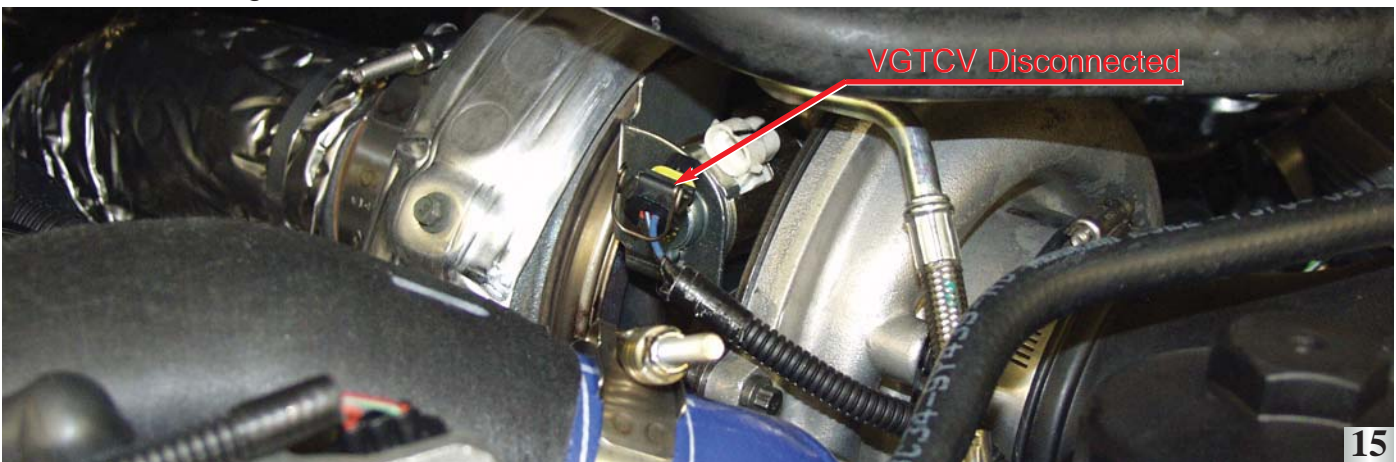
### Test 1 - Checking VGT operation

- Using WDS in datalogger mode, highlight the RPM PID and command the engine to approximately 1200 RPM and the EGRDC# PID to 0%.
- Then highlight the VGTDC# and increase it to 85% and record the EBP\_G (Exhaust Pressure) & MGP (Manifold Gauge Pressure).
- Next command the VGT to 0% and record the EBP\_G and MGP PIDs. At 85% the EBP\_G should be below 7.3 PSI and MGP should be above 0.87 PSI. At 0% the EBP\_G should be below 0.73 PSI and MGP should be below 0.45 PSI.
- If it is within this range and no compressor wheel to housing contact is present then do not replace turbocharger. If it does not move or is not within this range then proceed to Test 2.

**Note: Do not raise the engine rpm above 1200 while controlling VGT or turbo/engine damage may occur.**

### Test 2

- Raise engine speed to 3500RPM and hold it at that point while monitoring EBP\_G and MGP.
- EBP\_G should be between 5 and 13 psi and MGP should be between 2 and 6 psi.
- If MGP and EBP\_G are both high, disconnect the VGT control valve electrically and rerun the test.
- If MGP and EBP\_G change inspect the wiring harness and connections.
- If MGP and EBP\_G do not change (lower) when VGTCV is disconnected remove the valve from the turbo, being careful to handle the valve by its solenoid body only, and plug it into the engine harness.
- Then apply pressure to the cam follower (tip of the valve) with your thumb while actuating the valve with the WDS and look for movement.
- If the valve moves then proceed with Test 3, If the valve does not move replace the valve.
- The VGTCV (base part # 6F089) can be tested electrically, measure the resistance of the actuator coil using a DVOM, the resistance should be between 3.42 & 4.18 ohms @ 73°F EOT. If the engine is hot the resistance should be between 4.4 to 5.3 ohms @ 200°F EOT.



If the valve is to be replaced use the following procedure:

Immediately upon removal from turbocharger, place the suspect control valve in plastic tube container provided with service kit base #6F089. Handle the valve by it's solenoid body only. Do not attempt to clean or wipe oil off of 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 could contaminate the valve mechanism with lint. Suspect control valve must be returned in the protective container for proper warranty credit.

**Note: When installing the new valve use the same caution as removal as to not contaminate the new valve.**

Lightly lubricate the o-rings and install the valve into the bore. Tighten the retaining bolt to 15-18lb/ft (21-24Nm) and reconnect the electrical connector. After replacement retest the engine as stated above and if concern is still present then replace the turbocharger assembly.

### Test 3

#### No-Load Boost Pressure Test

RPM	VGTD#	EBP_G	MGP
Idle	60-82%	0-6 psi	0-1 psi
WOT	30-45%	4-18 psi	2-9 psi

#### Full-Load Boost Pressure Test

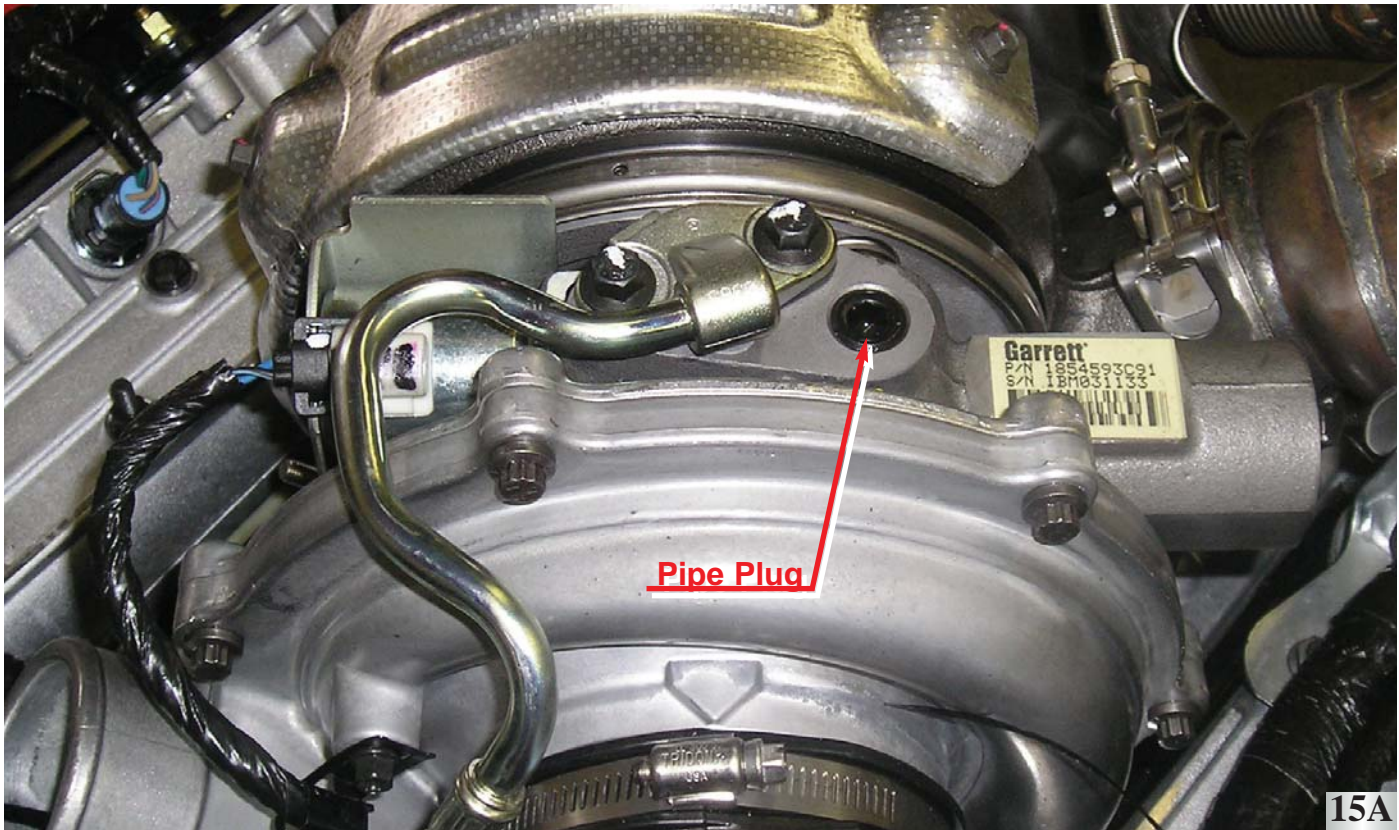
- Road test - Select an area and appropriate transmission gear in which the vehicle can be safely operated to obtain the desired engine speed at wide open throttle.
- Begin test at 3300 RPM and slowly apply the brake until the engine has slowed to 2400 RPM.
- Using WDS, select the PIDs listed below and make a 30 second recording to capture this event.
- Review the WDS recording and note the PID values at each of the specified RPM levels.
- If all values are within the specified range listed, the engine is operating as intended. If a specific failure can be identified, repair as nessecary. If a failure is suspected with the turbocharger assembly then proceed to Test 4.

RPM	3300	3000	2800	2600	2400
VGTD#	32-42%	35-45%	36-46%	38-48%	40-50%

- **EBP\_DES** should be 25-35 psi from 3300 to 2400 RPM under full load.
- **EBP\_G** should be within 2 PSI of the EBP\_DES.
- **MGP** should be 22-27 psi from 3300 to 2400 RPM under full load.
- Additional PIDs that may be helpful when diagnosing a low power complaint:  
APP, EGRVP, EGRDC#, ECT, EOT, ICP (voltage & pressure), ICP\_DES, IPR, Load, MFDES, INJ\_TIM, Fuel Pressure.

#### Test 4

- Remove the pipe plug from the top of the VGT actuator housing, located near the oil supply tube.
- Apply an index mark on the VGT control valve cam follower (tip of the actuator).
- With the engine running, use the WDS active command feature, increase the VGT% pid.
- While increasing the VGDC# PID from 20% to 85% watch the VGT control valve cam lobe for movement at each step.
- If movement is not observed replace turbocharger assembly.



## TURBOCHARGER NOISE

One common cause for turbo replacement is noise. A large percentage of the turbochargers replaced for noise are not bad. Compared to the turbocharger on the 7.3L Power Stroke, 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.

### Exhaust Leaks

Turbochargers have been replaced for noise concerns when the concern is exhaust mis-alignment at the connections and bad or missing gaskets. There are four (4) locations near the turbocharger that need to be inspected prior to replacing a turbocharger for a noise complaint. One of these is located in the exhaust up pipe on the passenger side, there is a flange that requires a metal gasket in the pipe just above the EGR cooler connection. There is also a metal gasket at the EGR cooler that is held in place with a V-band clamp. If the gasket is missing, damaged or the clamp misaligned, it could be misdiagnosed as a turbocharger failure. Two other leak points are at the turbine inlet and outlet; misaligned clamps and pipes can cause a noise concern. If the turbocharger itself is responsible for excessive noise, expect to find wheel to housing rub and bearing failure.



## Diagnosing Intake and Exhaust System Leaks

Check for charge air cooler, intake and exhaust system leaks using Rotunda Smoke Machine (EVAP Emissions Leak Detector - 218-00001) or equivalent.

For exhaust system leaks - connect leak detector to the EP tube and plug the exhaust tail pipe.  
For intake system leaks - connect leak detector to the MAP hose.

Fill the system with smoke and then using the smoke machine pressurize the exhaust / intake system to 20 psi.

If leaks are detected repair as necessary.

## BLADE DAMAGE



### Good Turbocharger:

Compressor blades are clean and straight. There are no large gaps between the compressor housing and the compressor wheel. No visible damage to blades. This turbocharger should not be replaced.

### Foreign Object Damage:

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

### Dirt Ingestion:

Also called dusting. The compressor wheel blades show signs of erosion from dirt entering the intake air system. The blades are rounded off and there is dirt accumulation in the compressor inlet.

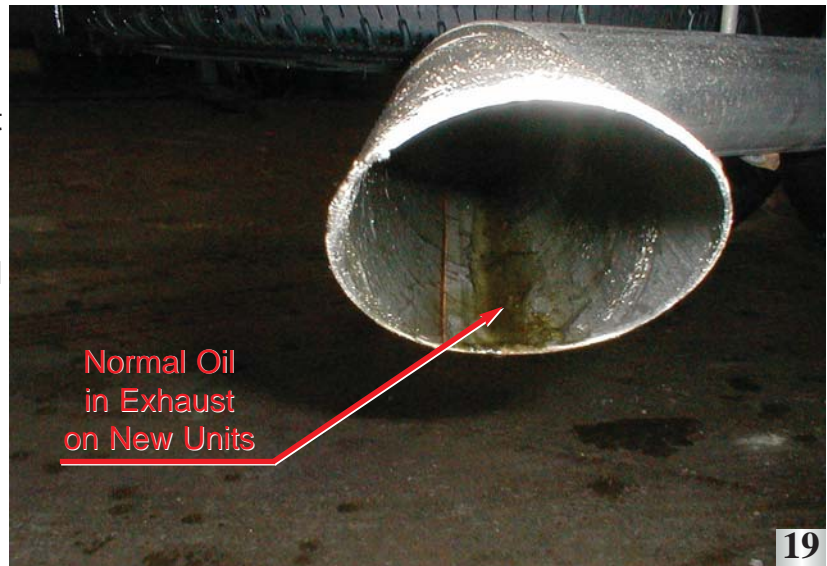
**Note:** For 6.0L Powerstroke diesel engines with engine oil diluted with four or more quarts of fuel, the turbocharger endplay needs to be checked (.001" - .004" allowable). Also check radial shaft movement by lifting the shaft up and rotating the shaft to check for compressor or turbine wheel to housing contact. If any wheel contact is noticed, the turbocharger must be replaced.

## AFTERMARKET MODIFICATION AND TURBO DAMAGE

Aftermarket performance enhancing PCM programs, propane injection packages and modification to the exhaust system, may negatively affect the life of the turbocharger, particularly in high altitude where the "thin air" offers less 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 will cause low power, vibration and ultimately turbocharger failure, that can lead to engine damage. Over-speeding the turbocharger may also cause turbocharger thrust bearing failure, increasing the axial endplay of the turbocharger shaft, and wheel to housing contact.

## NORMAL NEW ENGINE EXHAUST APPEARANCE

On very low mileage trucks, (typically less than 1000 miles) some turbochargers have been replaced because of an "oily residue" exiting the exhaust pipe. Be aware that during the manufacture of exhaust pipes, lubricants are used in the bending process and to prevent rust. Do not consider replacing the turbocharger just because oil is coming out of the tailpipe. The initial oil in the engine has had dye added, so inspect with a blacklight first. If it is thought that the oil is from the engine, loosen the exhaust pipe from the turbocharger outlet and look for signs of engine oil exiting the turbocharger. If the turbocharger is leaking oil into the exhaust, expect to find the bearings in the unit to be worn and for wheel rub to be present.



## FAULT CODE DIAGNOSTICS

**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 or 10 psi above BARO or MGP is greater than 30 kPa or 4.4 psi. In order for this fault to be set MFDES must be below 14, RPM must be less than 850, and EGRVP less than 0.10. 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 P0299** (2004 & 2005 MY only) will be set if the difference between EP\_G and EP\_DES meet any of the following conditions:

- Greater than 14 kPa or 2 psi with RPM below 800 for 15 seconds

- Greater than 20 kPa or 2.9 psi with RPM between 820 - 1995 for 30 seconds

- Greater than 80 kPa or 11.6 psi with RPM above 2000 for 90 seconds.

**Code P0478** is set when EP\_G is higher than EP\_DES by 260 kPa or 37.7 psi for greater than 30 seconds.

**Code P2262** is set when MGP does not go above 5 kPa or 0.7 psi when the following conditions are met: RPM must be above 2800, VFDES above 20, and EGRVP below 0.10. All of these conditions must be met for at least 5 seconds before the code would be set. This code is used to detect a MAP sensor hose that has come off.

## FAULT CODE DIAGNOSTICS CONT'D

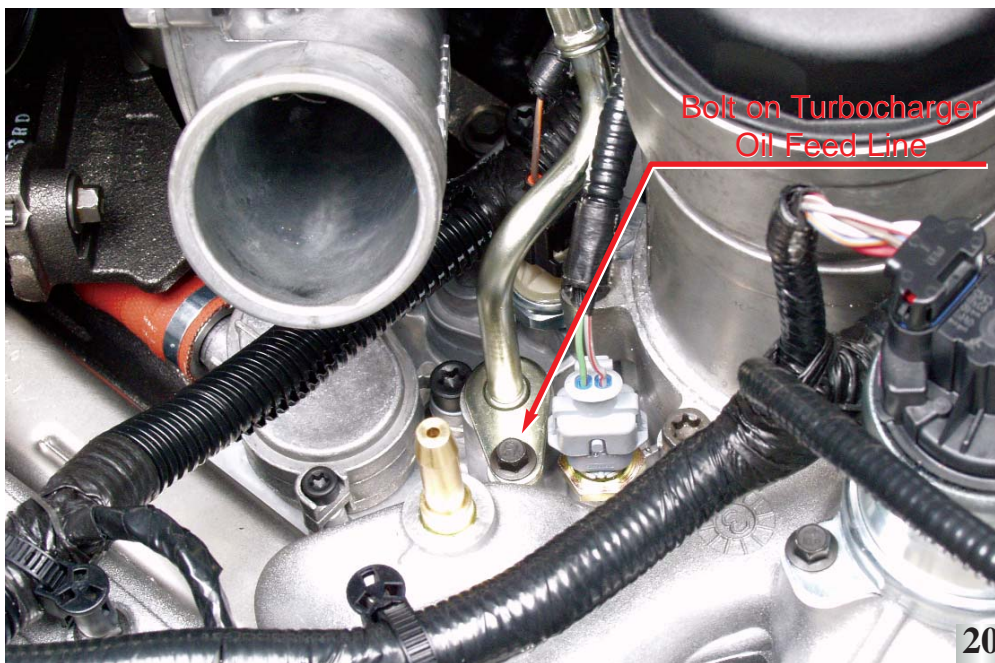
**Code P2263** is set when MGP does not go above 15 kPa or 2.2 psi when the following conditions are met: RPM must be above 2800, VFDES above 35, and EGRVP above 0.10. All of these conditions must be present for at least 5 seconds for this code to appear. This code is used to detect a charge air cooler hose that has become disconnected. This code can also be set if there is any condition present that would cause low power. For 2003 model year this code could also be set if the difference between EP\_G and EP\_DES is more than 14 kPa or 2 psi for more than 15 seconds at idle or 60 kPa or 8.7 psi for 60 seconds above 800 RPM.

## OIL LEAKS FROM TURBOCHARGER

If oil is found leaking off of the back of the engine, one place to look would be the turbocharger since it is mounted in the valley. Some of the possible leak points would be from the oil supply connection, oil drain, center section, and oil seepage from the pipes.

Note: oil carryover from the crankcase ventilation system is normal which may cause oil seepage from the charge air cooler hoses.

When diagnosing any oil leak it is best to start at the top and most forward point of the affected area. An oil leak that looks like it is coming from the center section may be coming from the oil feed line.



The snap-to-connect turbocharger oil feed line has been replaced with an o-ring sealed, bolt-on line. This was done to reduce leaks due to improper installation.

