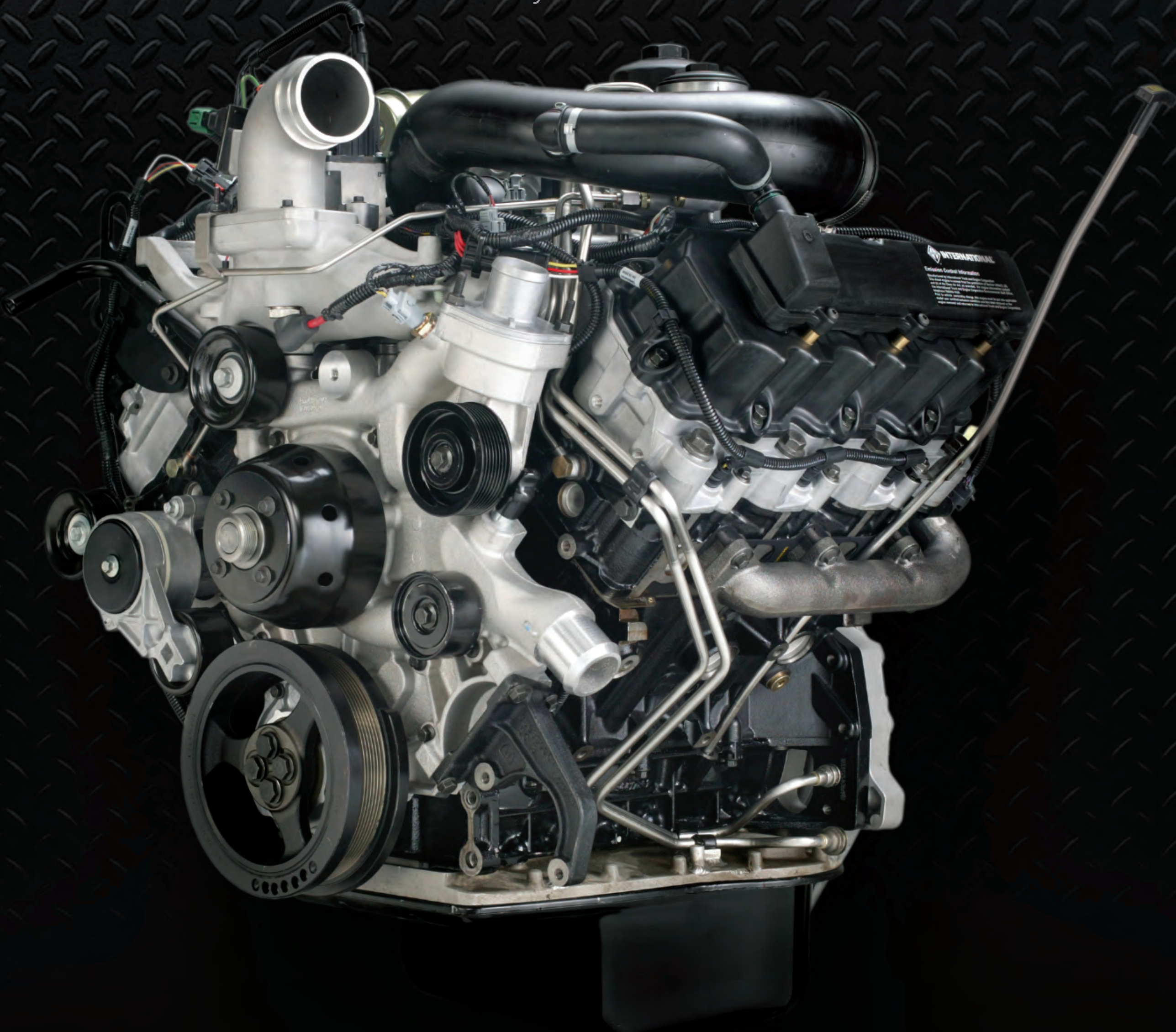
INTERNATIONAL®

# VT 275 V6 ENGINE

model year 2005



# FORWARD

This publication is intended to provide technicians and service personnel with an overview of technical features of the International® VT 275 Diesel Engine. The information contained in this publication will supplement information contained in available service literature. Consult the latest SERVICE and DIAGNOSTIC manuals before conducting any service or repairs.

## Safety Information

This manual provides general and specific service procedures and repair methods essential for reliable engine operation and your safety. Since many variations in procedures, tools, and service parts are involved, advice for all possible safety conditions and hazards cannot be stated.

Departure from instructions in this manual or disregard of warnings and cautions can lead to injury, death, or both, and damage to the engine or vehicle.

Read safety instructions below before doing service and test procedures in this manual for the engine or vehicle. See related application manuals for more information.

## Safety Instructions

### Vehicle

- Make sure the vehicle is in neutral, the parking brake is set, and the wheels are blocked before doing any work or diagnostic procedures on the engine or vehicle.

### Work Area

- Keep area clean, dry and organized.
- Keep tools and parts off the floor.
- Make sure the work area is ventilated and well lit.
- Make sure a First Aid Kit is available.

### Safety Equipment

- Use correct lifting devices.
- Use safety blocks and stands.

### Protective Measures

- Wear protective glasses and safety shoes (do not work in bare feet, sandals, or sneakers).
- Wear appropriate hearing protection.
- Wear correct clothing.
- Do not wear rings, watches, or other jewelry.
- Restrain long hair.

### Fire prevention

- Make sure charged fire extinguishers are in the work area.

NOTE: Check the classification of each fire extinguisher to ensure that the following fire types can be extinguished.

1. Type A - Wood, paper, textiles, and rubbish
2. Type B - Flammable liquids
3. Type C - Electrical equipment

### Batteries

- Batteries produce highly flammable gas during and after charging.
- Always disconnect the main negative battery cable first.
- Always connect the main negative battery cable last.
- Avoid leaning over batteries.
- Protect your eyes.
- Do not expose batteries to open flames or sparks.
- Do not smoke in workplace.

### Compressed Air

- Limit shop air pressure for blow gun to 207 kPa (30psi).
- Use approved equipment.
- Do not direct air at body or clothing.
- Wear safety glasses or goggles.
- Wear hearing protection.
- Use shielding to protect others in the work area.

### Tools

- Make sure all tools are in good condition.
- Make sure all standard electrical tools are grounded.
- Check for frayed power cords before using power tools.

### Fluids Under Pressure

- Use extreme caution when working on systems under pressure.
- Follow approved procedures only.

### Fuel

- Do not over fill fuel tank. Over fill creates a fire hazard.
- Do not smoke in the work area.
- Do not refuel the tank when the engine is running.

### Removal of Tools, Parts, and Equipment

- Reinstall all safety guards, shields and covers after servicing the engine.
- Make sure all tools, parts, and service equipment are removed from the engine and vehicle after all work is done.

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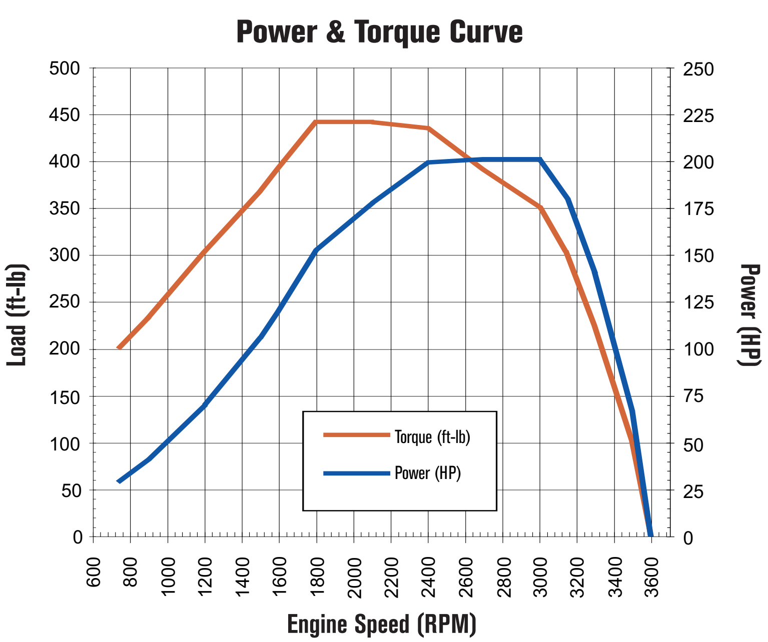
# DIRECT INJECTION TURBOCHARGED DIESEL ENGINE

# VT 275 FEATURES

- 90° V6
- Offset Crankpins
- Rear Gear Train
- Primary Balancer
- Regulated Two-Stage Turbocharging System
- Four Valves per Cylinder
- Cooled Exhaust Gas Recirculation
- Electro-Hydraulic Generation 2 Fuel Injection System
- Top Mounted Oil and Fuel Filters

## VT 275 ENGINE SPECIFICATIONS

| | |
|---|---|
| Engine Type | 4-stroke, direct injection diesel |
| Configuration | V6, pushrod operated four valves / cylinder |
| Displacement | 275 cu. in. (4.5 liters) |
| Bore | 3.74 in. (95 mm) |
| Stroke | 4.134 in. (105 mm) |
| Compression Ratio | 18.0:1 |
| Aspiration | Twin turbocharged and charge air cooled |
| Rated Power | 200 hp @ 2700 rpm |
| Peak Torque | 440 lb-ft @ 1800 rpm |
| Engine Rotation, Facing the Flywheel | Counterclockwise |
| Injection System | Electro-hydraulic generation 2 fuel injection |
| Cooling System Capacity (Engine Only) | 11 quarts |
| Lube System Capacity (Engine Only) | 13 quarts with oil filter (14 quarts at overhaul) |




### Horsepower and Torque

- The VT 275 engine is offered with only one horsepower and torque rating for the 2005 model year. The engine creates 200 horsepower at 2700 rpm and 440 lb-ft of torque at 1800 rpm. The engine has a high idle speed of 2775 rpm with automatic transmission. The engine idle speed is set at 700 rpm and is not adjustable.

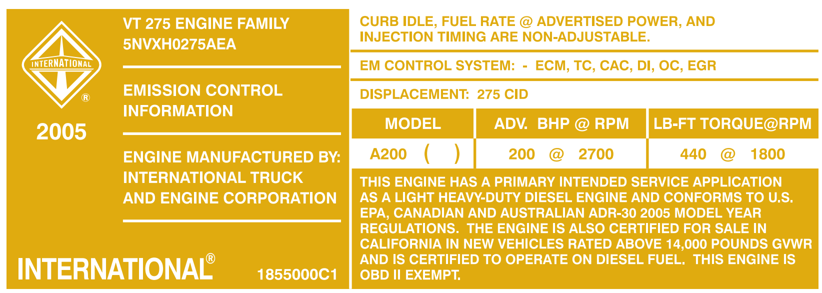
## Engine Serial Number

- The Engine Serial Number (ESN) for the VT 275 is located on a machined surface at the left rear corner of the crankcase just below the cylinder head.
- The ESN identifies the engine family, the build location, and the sequential build number.
- **Engine Serial Number Example**
  4.5HM2Y0135617
  4.5 = Engine displacement
  H = Diesel, Turbocharged
  M2 = Motor Truck
  Y = Huntsville
  0135617 = Build Sequence


## Emissions Label

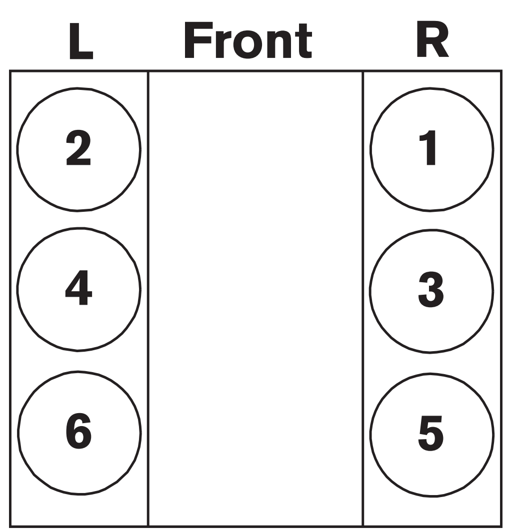
- The Environmental Protection Agency (EPA) emissions label is on top of the breather, toward the front, on the left valve cover. The label includes the following:

  -Advertised horsepower rating
  -Engine model code
  -Service application
  -Emission family and control system
  -Year the engine was certified to meet EPA emission standards.

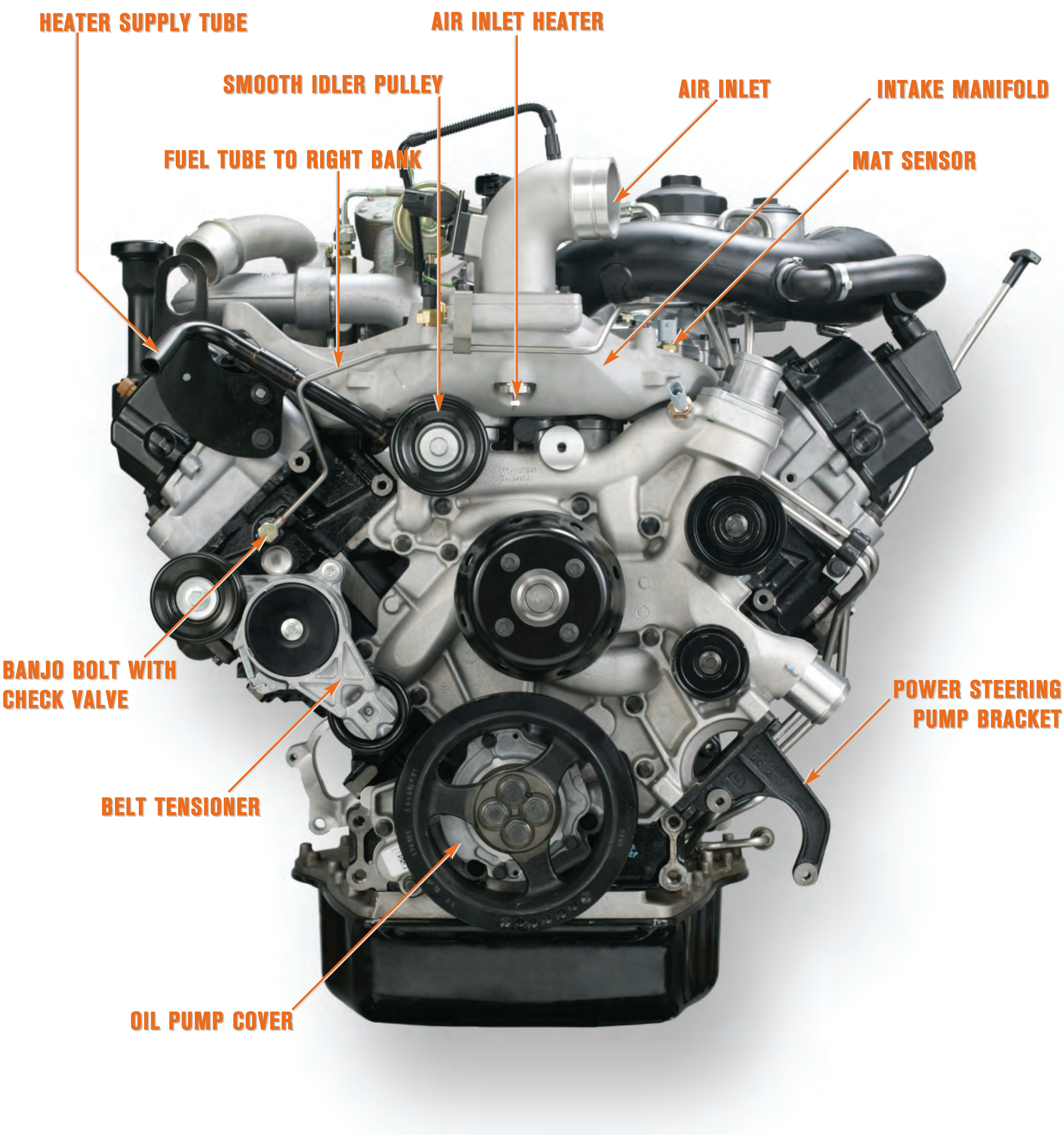



## Cylinder Numbering

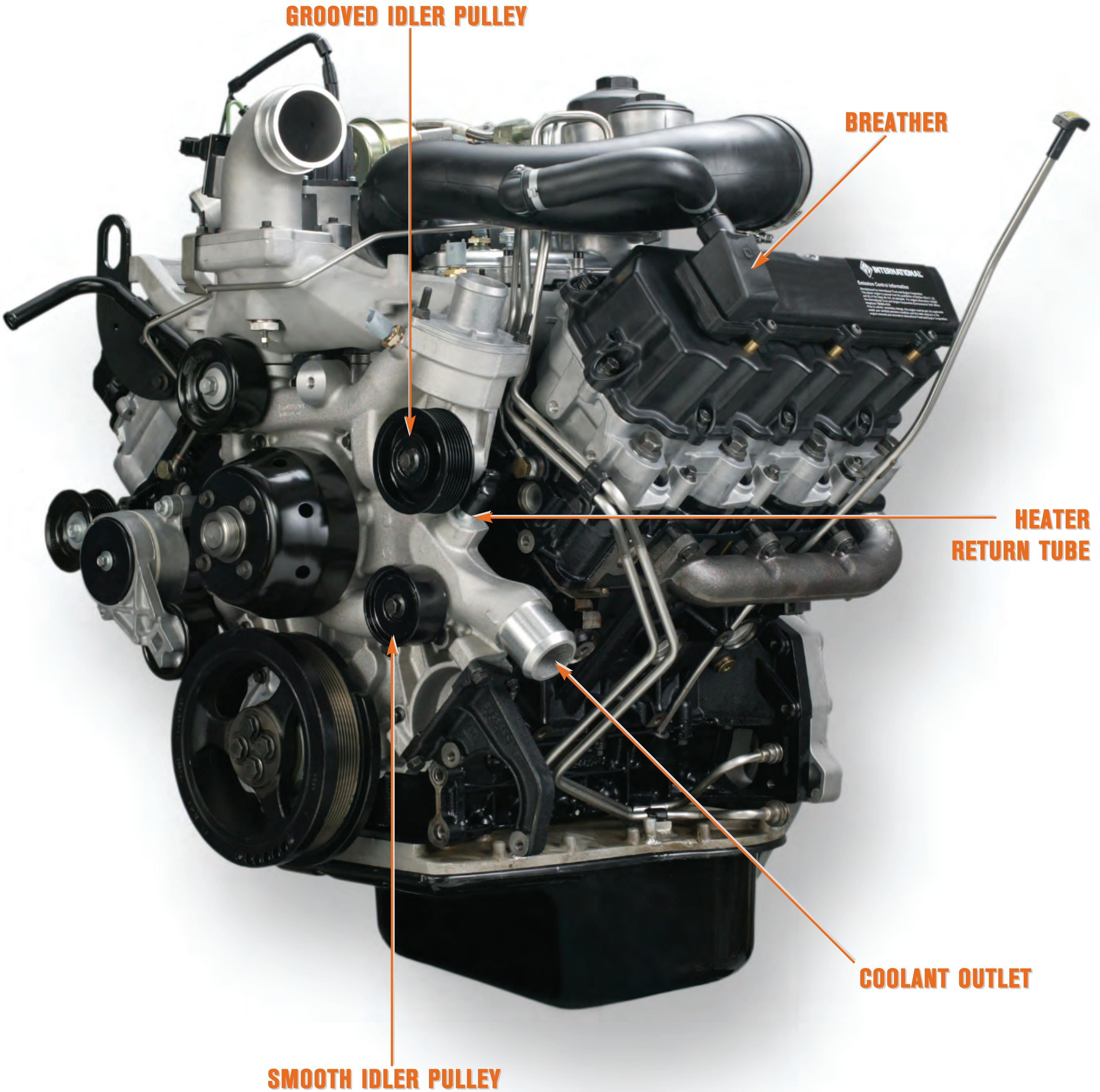
- The cylinders on the VT 275 are numbered from the front of the right bank 1, 3, 5 and from the front of the left bank 2, 4 and 6.
- The engine firing order is 1-2-5-6-3-4



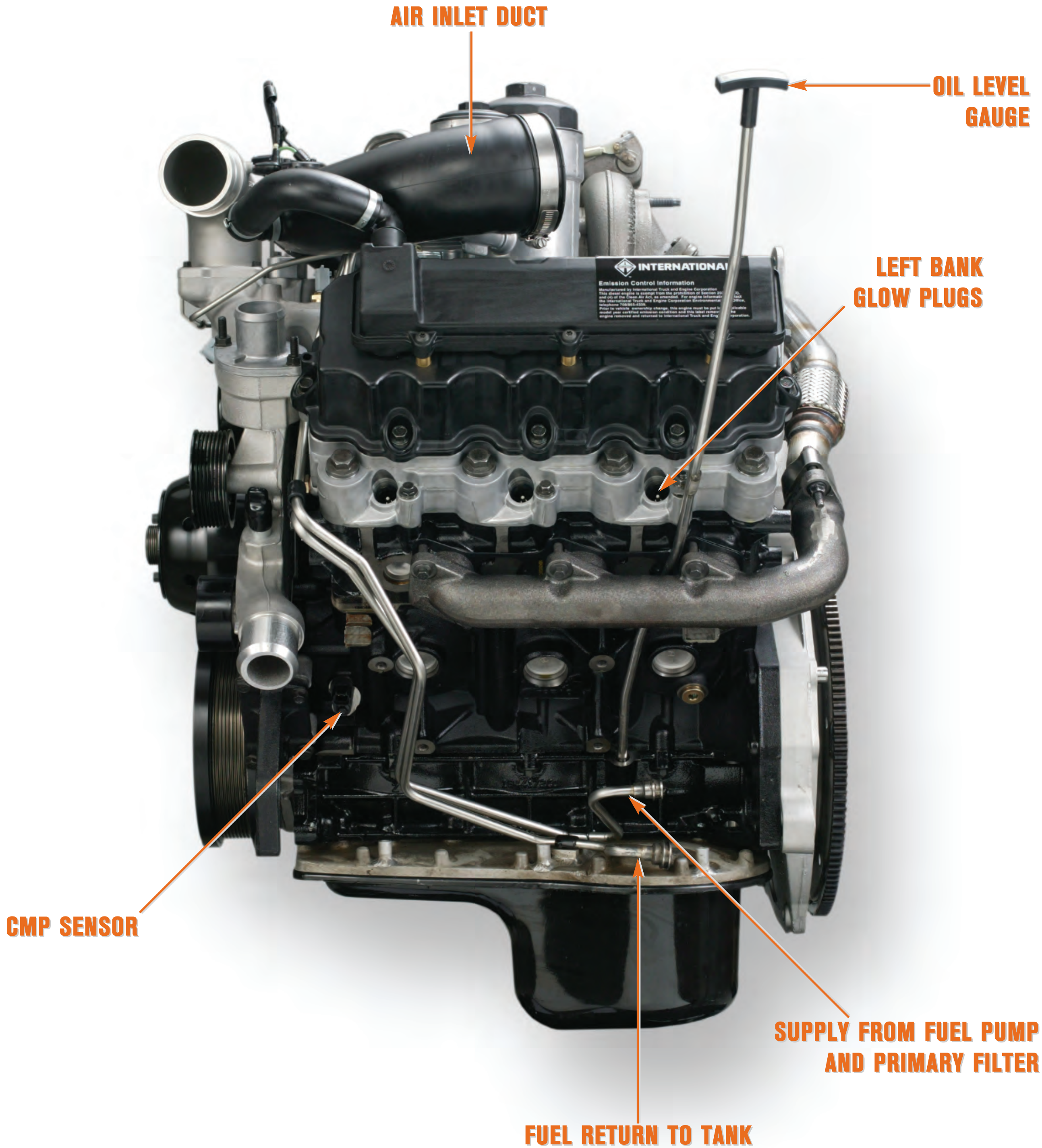
# COMPONENT LOCATIONS - FRONT OF ENGINE

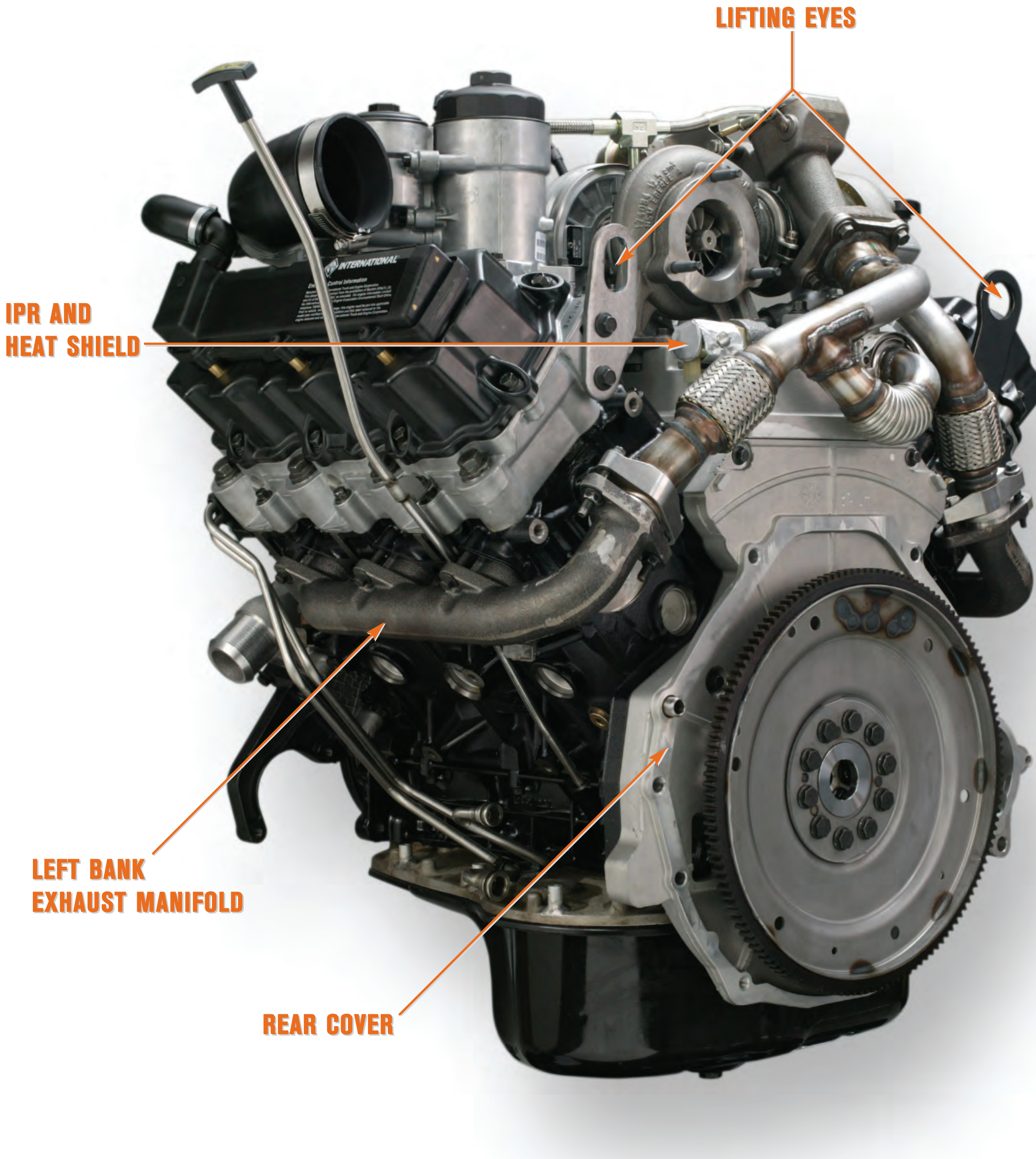


# COMPONENT LOCATIONS - LEFT FRONT OF ENGINE

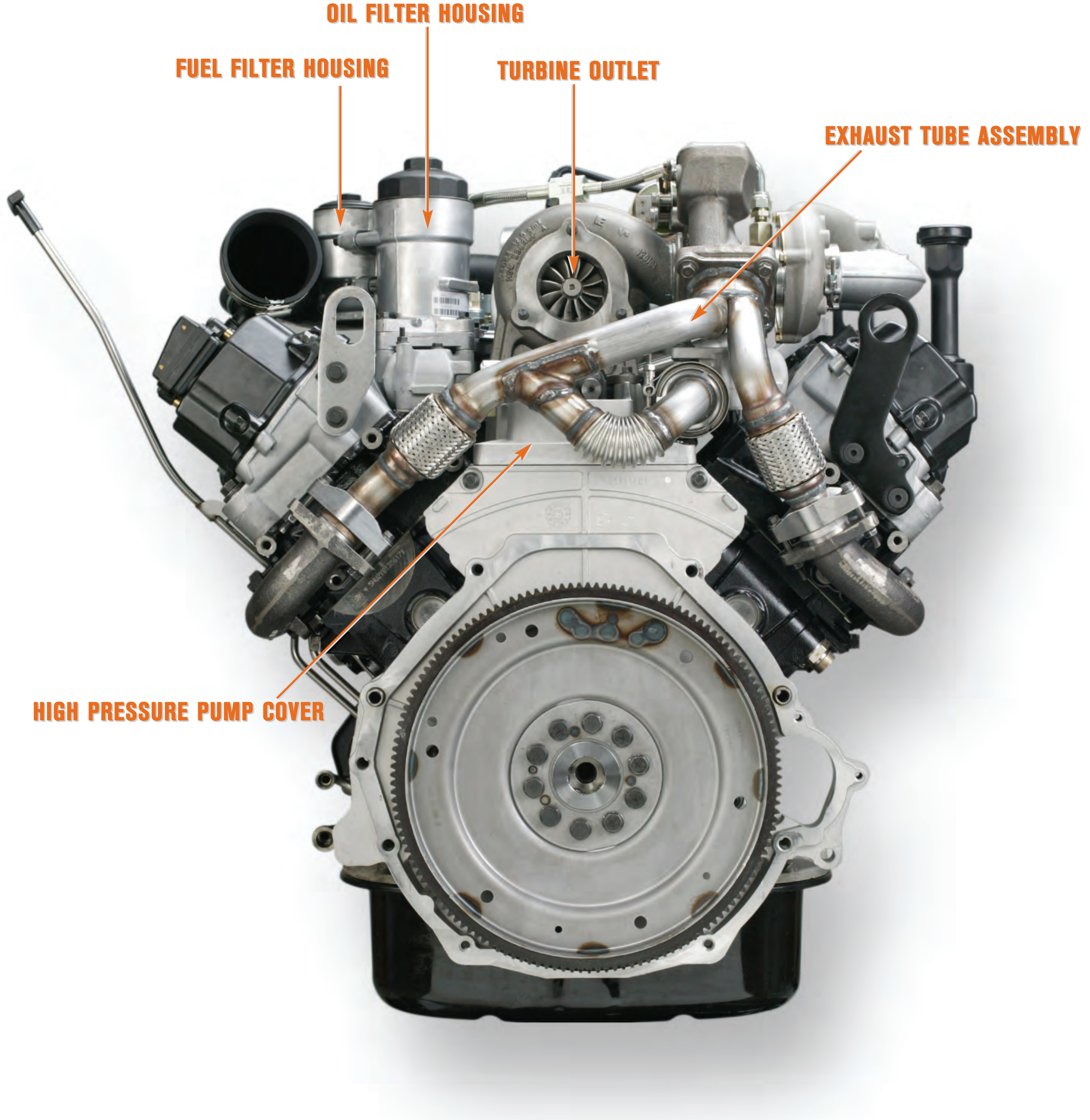


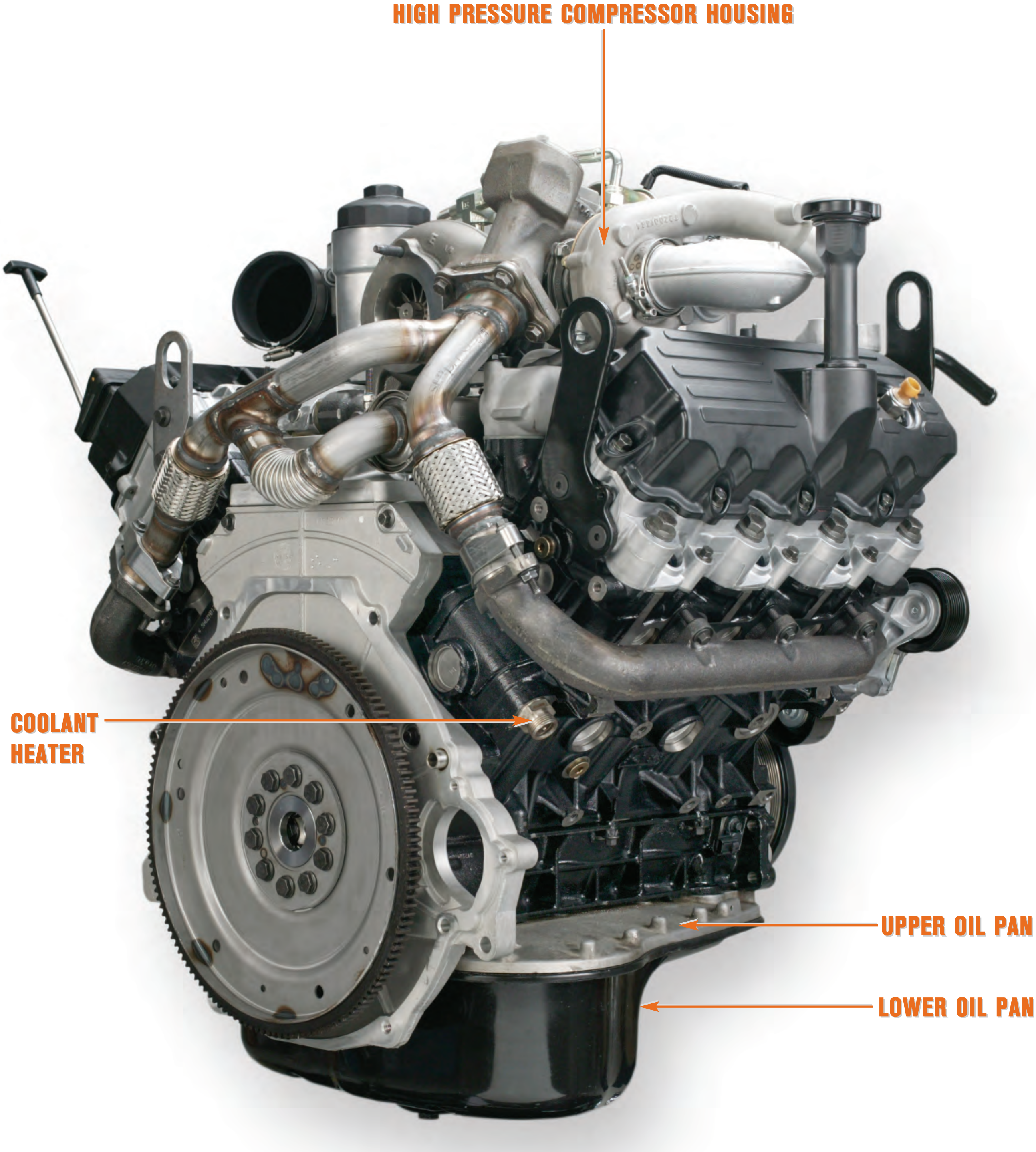
# COMPONENT LOCATIONS - LEFT SIDE OF ENGINE



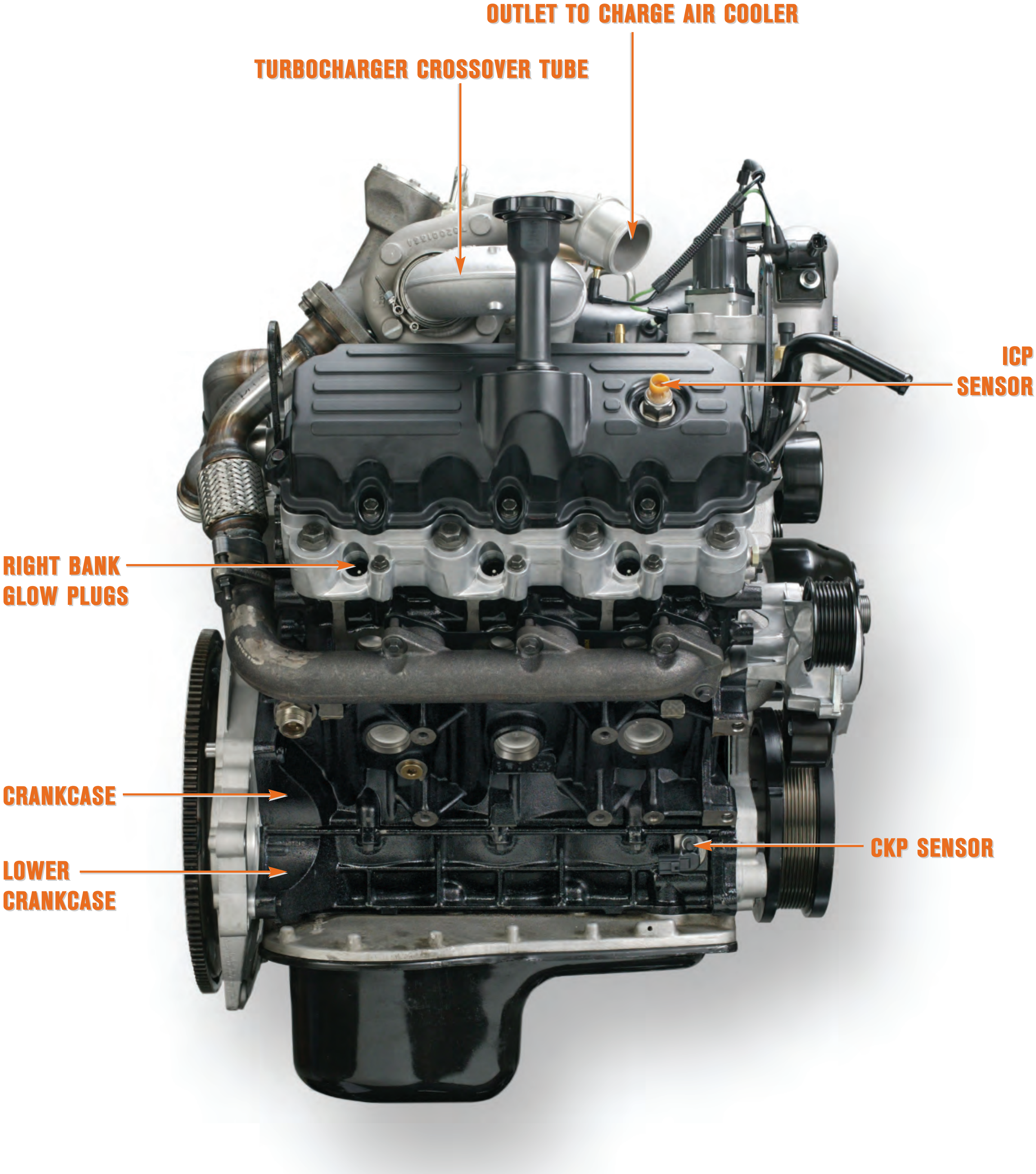

LIFTING EYES
IPR AND
HEAT SHIELD
LEFT BANK
EXHAUST MANIFOLD
REAR COVER

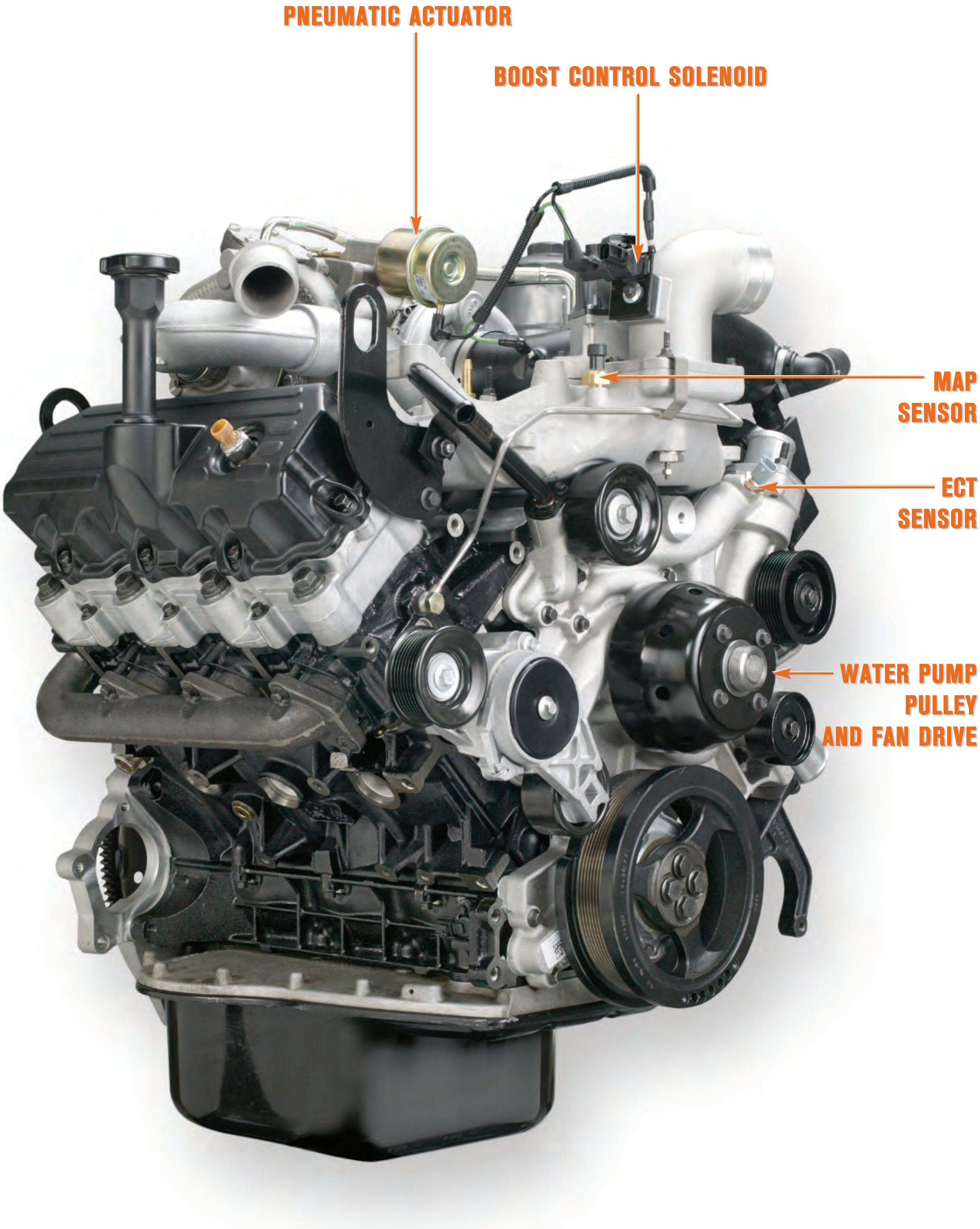
# COMPONENT LOCATIONS - REAR OF ENGINE



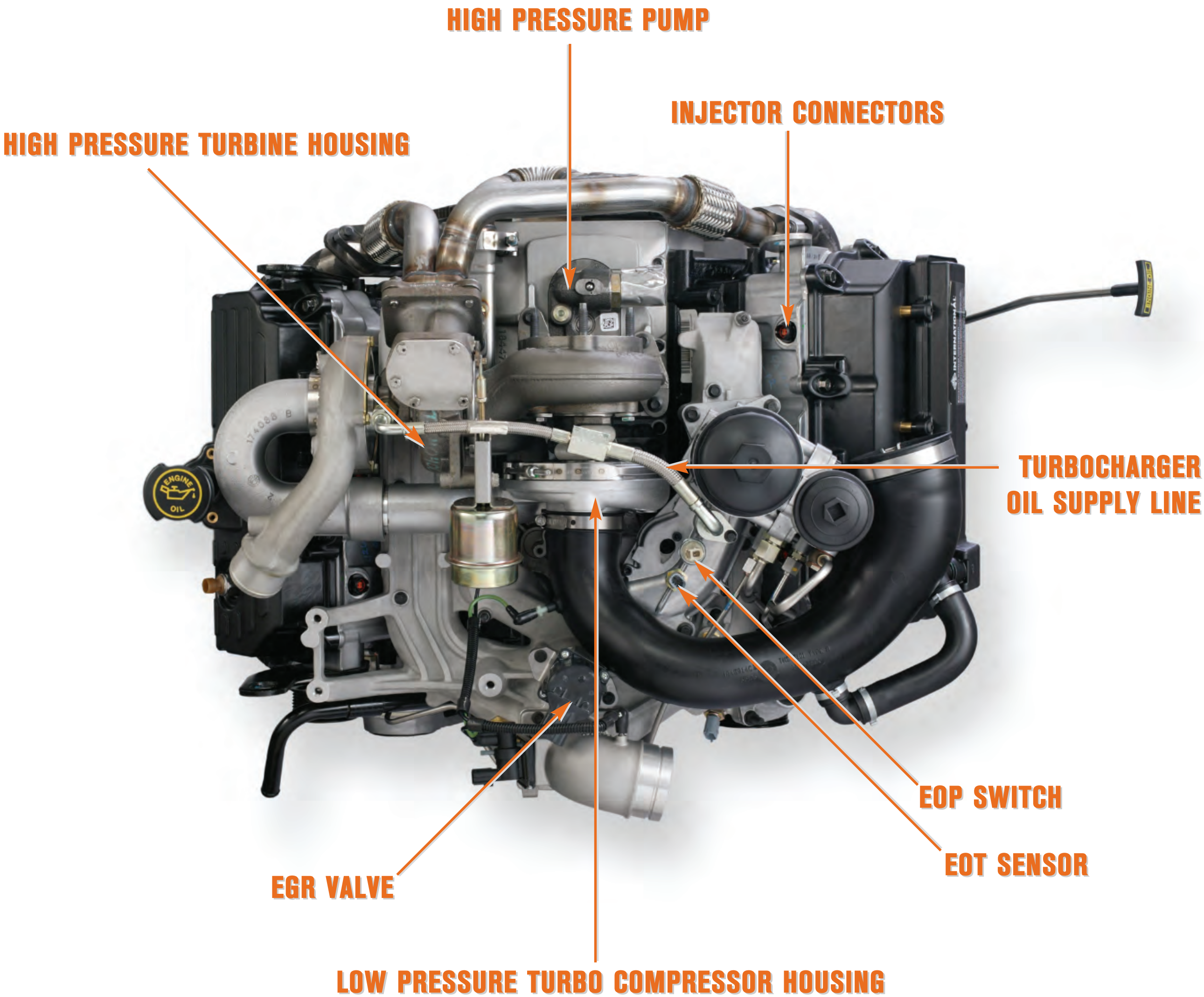

HIGH PRESSURE COMPRESSOR HOUSING
COOLANT HEATER
UPPER OIL PAN
LOWER OIL PAN

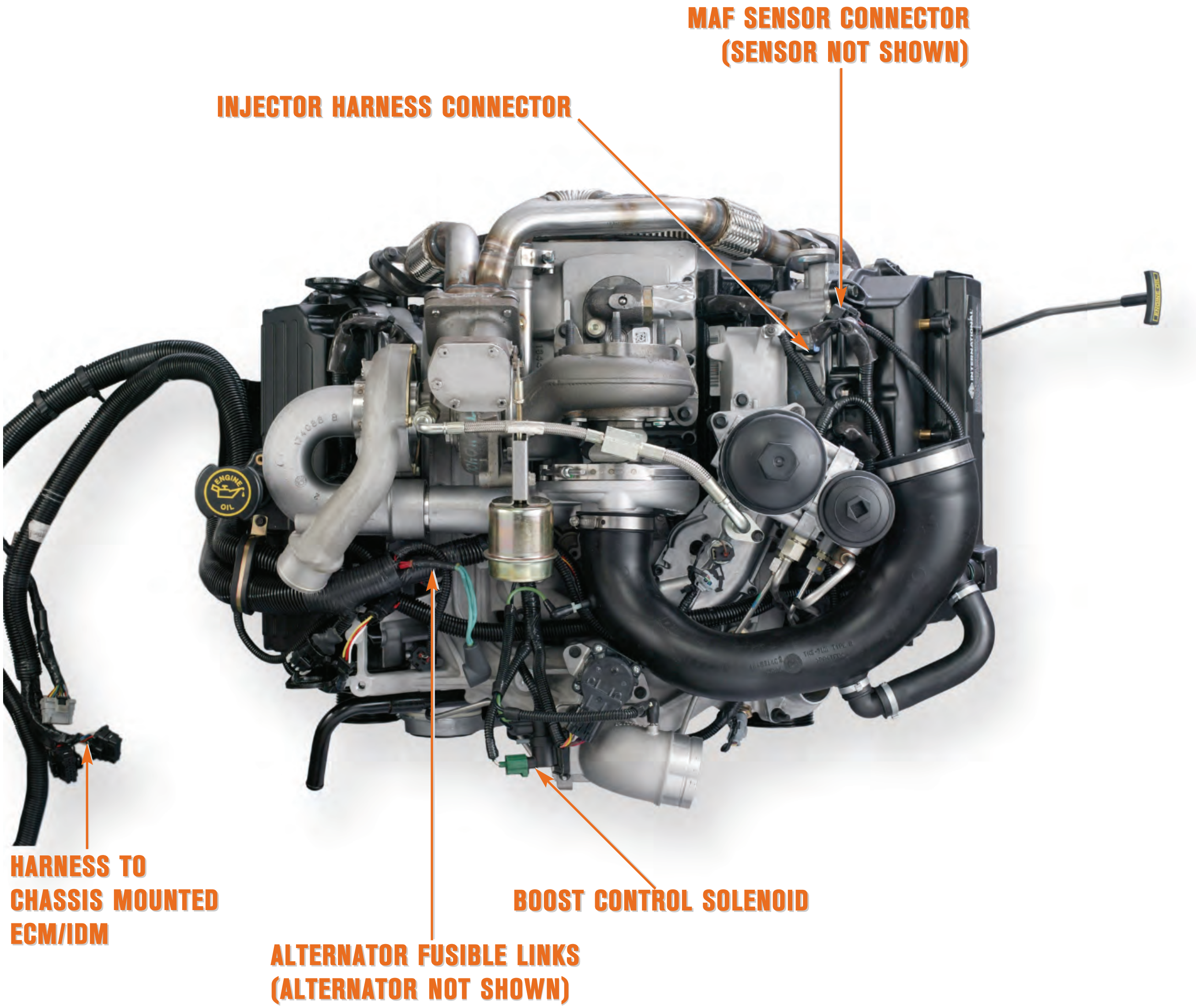
# COMPONENT LOCATIONS - RIGHT SIDE OF ENGINE

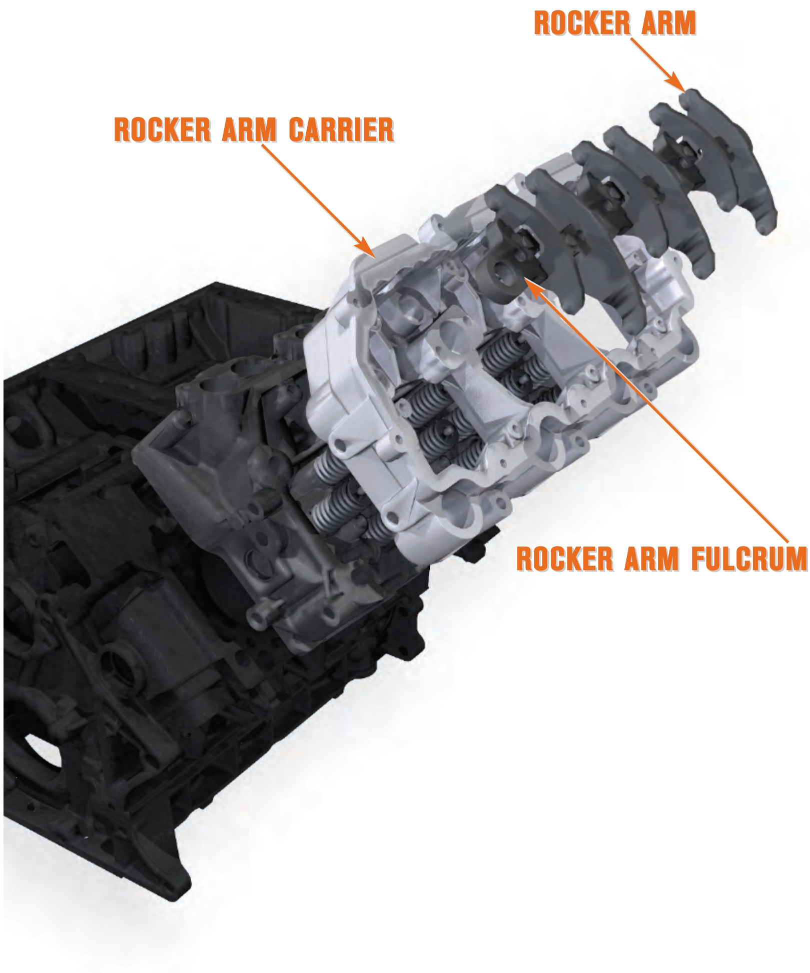



PNEUMATIC ACTUATOR
BOOST CONTROL SOLENOID
MAP SENSOR
ECT SENSOR
WATER PUMP PULLEY AND FAN DRIVE

# COMPONENT LOCATIONS - TOP OF ENGINE WITHOUT HARNESS




MAF SENSOR CONNECTOR
(SENSOR NOT SHOWN)
INJECTOR HARNESS CONNECTOR
HARNESS TO
CHASSIS MOUNTED
ECM/IDM
BOOST CONTROL SOLENOID
ALTERNATOR FUSIBLE LINKS
(ALTERNATOR NOT SHOWN)



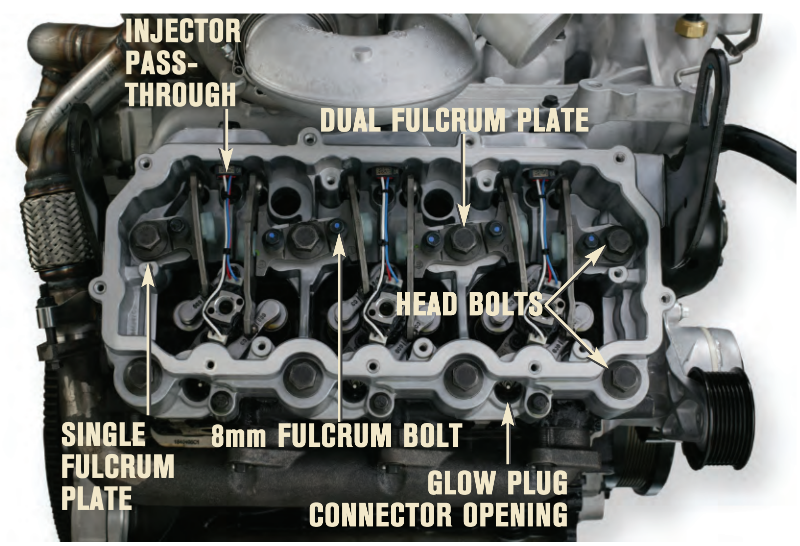

## Cylinder Head Assembly

- The VT 275 has an aluminum rocker arm carrier for each cylinder head. The carrier holds the fulcrum plates and the attached rocker arms and can be removed as an assembly from the cylinder head without removing the rocker arms.

- Each rocker arm pivots on a steel ball located by detents in the fulcrum plate. Four head bolts on each cylinder head pass through the two single and two dual fulcrum plates serving to clamp the plates to the carrier.

- The cylinder head is sealed to the crankcase deck surface with a shim type gasket that must be replaced if any of the head bolts are removed. The 14mm head bolts are torque to yield and cannot be reused.

- The carrier is sealed to the cylinder head with a push-in-place gasket. The cylinder head and carrier are clamped to the crankcase with eight 14mm bolts. Six additional 8mm bolts around the perimeter clamp the carrier to the cylinder head and four additional 8mm bolts serve to clamp the top of the head to the crankcase. Two hollow dowels in the cylinder head are used to align the rocker arm carrier to the cylinder head.

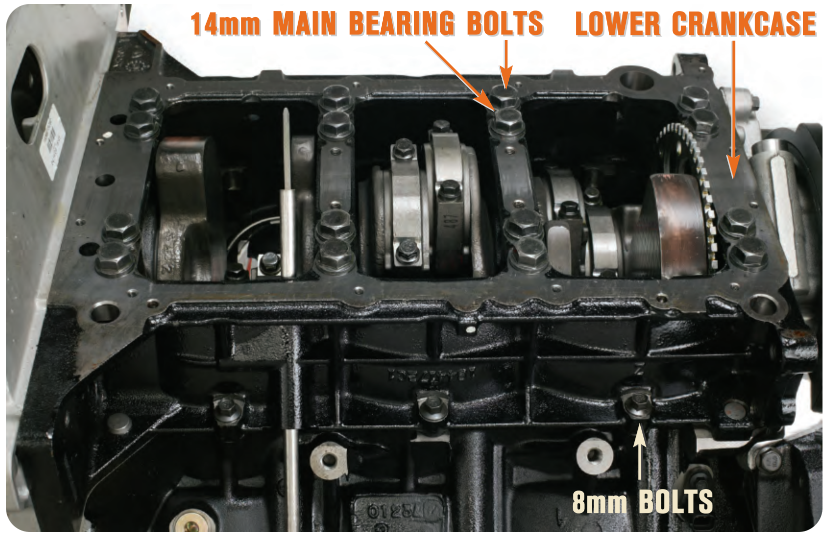



## Rocker Arm Carrier

- The rocker arm carrier serves as an attachment point for the fulcrum plates and the rocker arms. In addition to the head bolts, single fulcrum plates are attached to the rocker arm carrier with one 8mm bolt. The dual fulcrum plates are attached with two 8mm bolts. The fulcrum plates are marked with E and I as assembly aids to show the valves they support. The E and I must be visible after assembly to the head. In addition, the carrier provides a passage for each snap-in-place injector pass-through and the push-in-place glow plug connectors.

## Crankcase Assembly

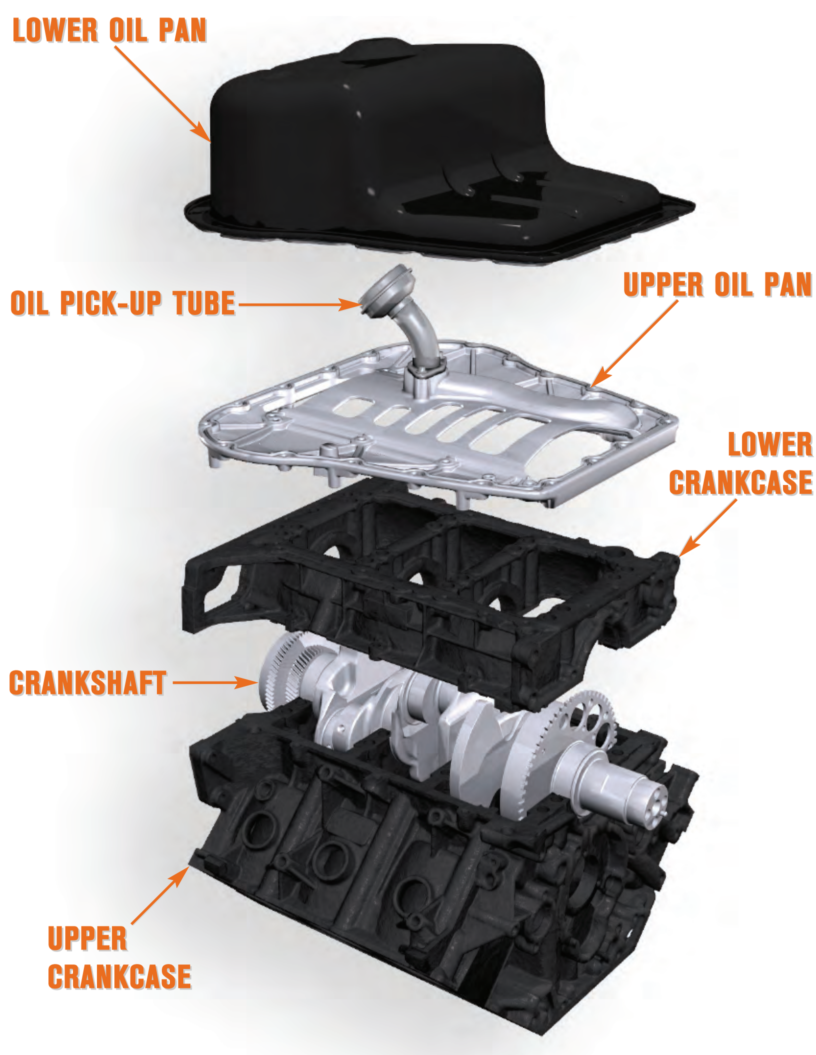
- The VT 275 has four main bearings but replaces the traditional individual main bearing caps with a one-piece lower crankcase assembly. The lower crankcase is made of cast iron and is stronger than the individual caps. The lower crankcase is attached to the crankcase with sixteen 14mm main bearing bolts of two lengths with the shorter bolts to the outside. Three additional 8mm bolts are used on each side at the perimeter. The lower crankcase is sealed to the crankcase with two push-in-place seals.

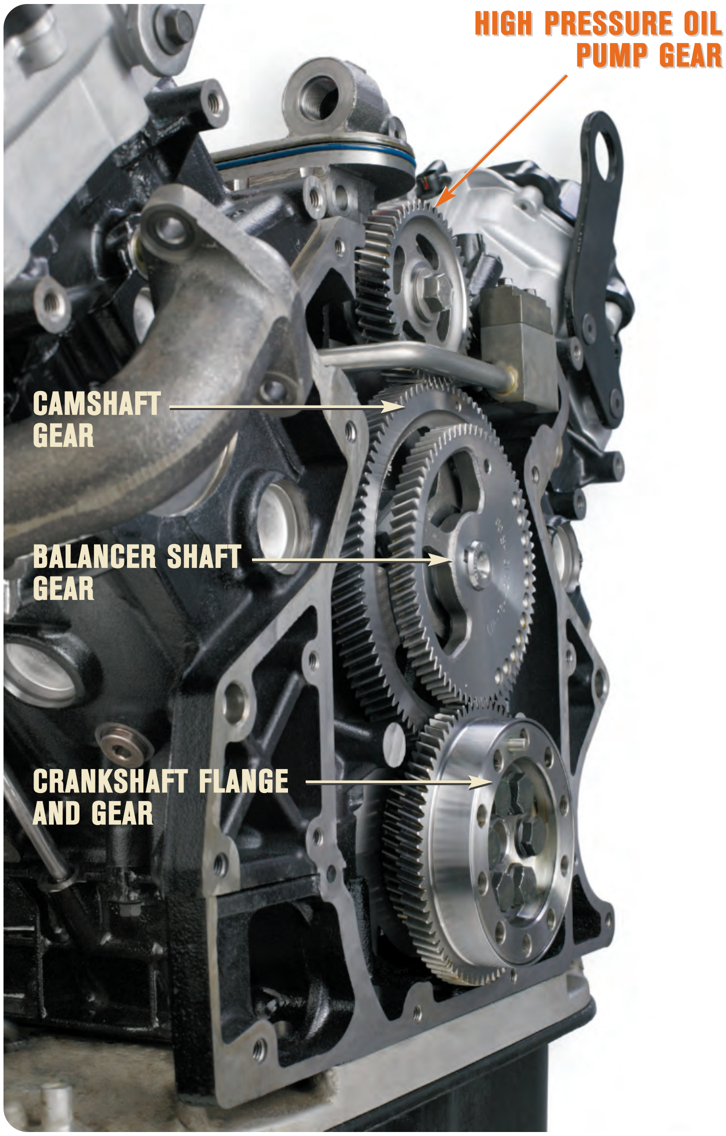



## Crankcase and Oil Pan

- The upper oil pan bolts to the lower crankcase and is sealed with a full perimeter push-in-place gasket. The lower sheet metal oil pan is sealed to the upper cast aluminum oil pan with a full perimeter push-in-place gasket. The upper oil pan is wider than the crankcase and allows for greater oil pan capacity without increased depth.

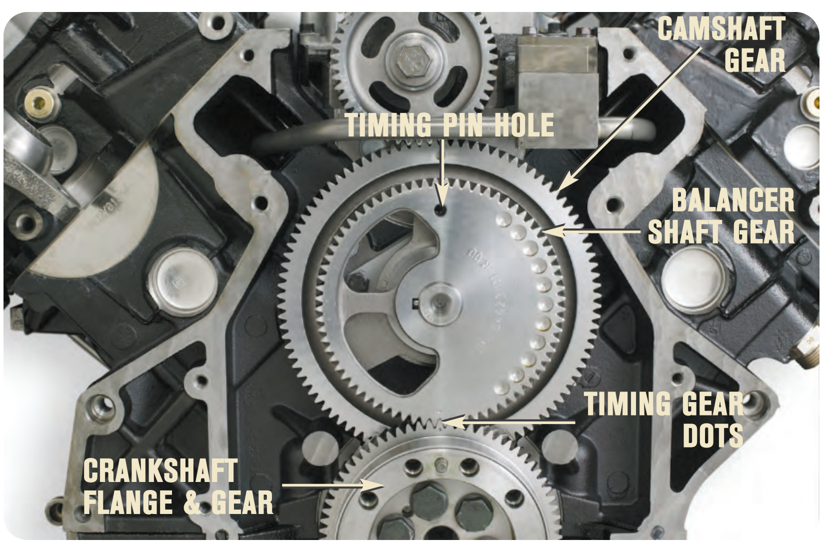
- The oil pickup is sealed to the upper oil pan with an O-ring and attached with two 6mm bolts. Oil pulled through the oil pickup tube passes through a passage cast in the upper oil pan to the lower crankcase. The lower crankcase has a machined passage that takes oil to a front cover passage that leads to the oil pump. Openings in the upper oil pan allow oil to return to the pan during engine operation but also serve to keep oil in the pan away from the rotating crankshaft.






## Rear Gear Train

- The VT 275 gear train is located at the rear of the engine. The crankshaft gear is a press fit on the crankshaft and drives the camshaft gear directly. The crankshaft flange with integral gear is pressed on the end of the crankshaft then clamped with six 12mm bolts. The camshaft gear must be timed to the crankshaft gear during assembly to maintain the correct relationship.
- The rear flange gear drives the primary balance shaft gear at a one-to-one ratio. The balance shaft runs through the hollow camshaft to the front of the crankcase and has the balance shaft counterweight bolted to the front of the shaft. The flange gear and balance shaft gear must be timed to maintain the correct relationship between the balance shaft counterweight and the crankshaft.
- The high-pressure oil pump is located in the Vee of the engine and is driven directly off the camshaft gear. The oil pump gear does not require timing.
- **Note:** The crankshaft gear that drives the camshaft is located behind the flange gear.

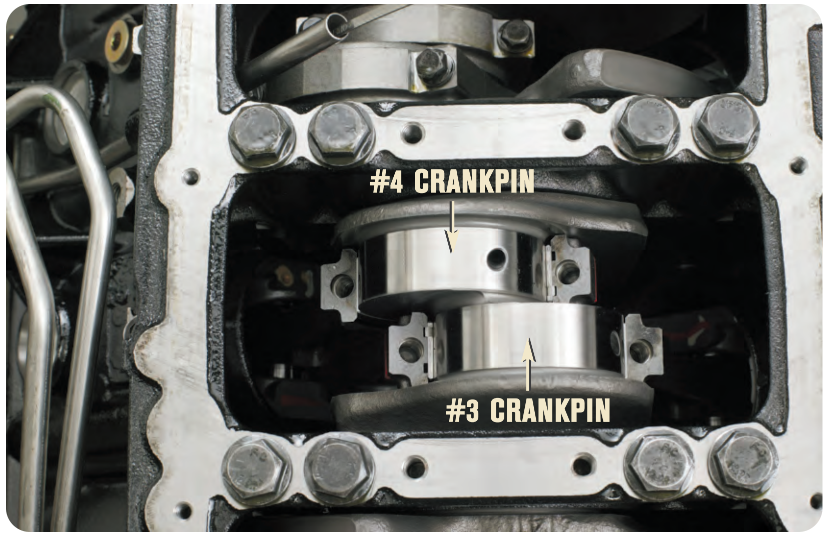



## Gear Timing

- The camshaft and balance shaft must be timed to the crankshaft for proper engine operation. During reassembly a timing pin that aligns the camshaft gear and the balance shaft gear is placed through the gears and into a hole machined in the crankcase, then the crankshaft is installed while aligning the balance shaft and flange gear dots. If only the balance shaft is out of the engine, the shaft can be installed while aligning the balance shaft gear and flange gear dots.

## Offset Crankpins

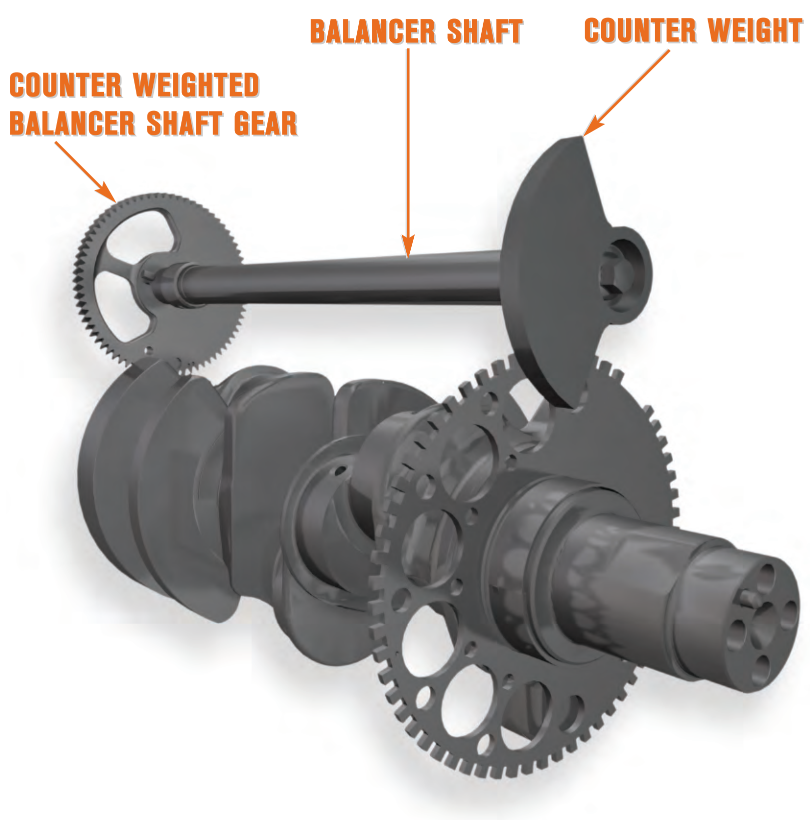
- The 4-stroke engine requires 720° of crankshaft rotation to complete all four strokes of the cycle. In a multi-cylinder engine dividing the 720 degrees by the number of cylinders will equal the ideal crankshaft rotation between combustion events in the firing order. The VT 275 achieves equal spacing of the combustion events by splitting the crankpins and staggering the individual journals 30°.




## Balance Shaft Timing

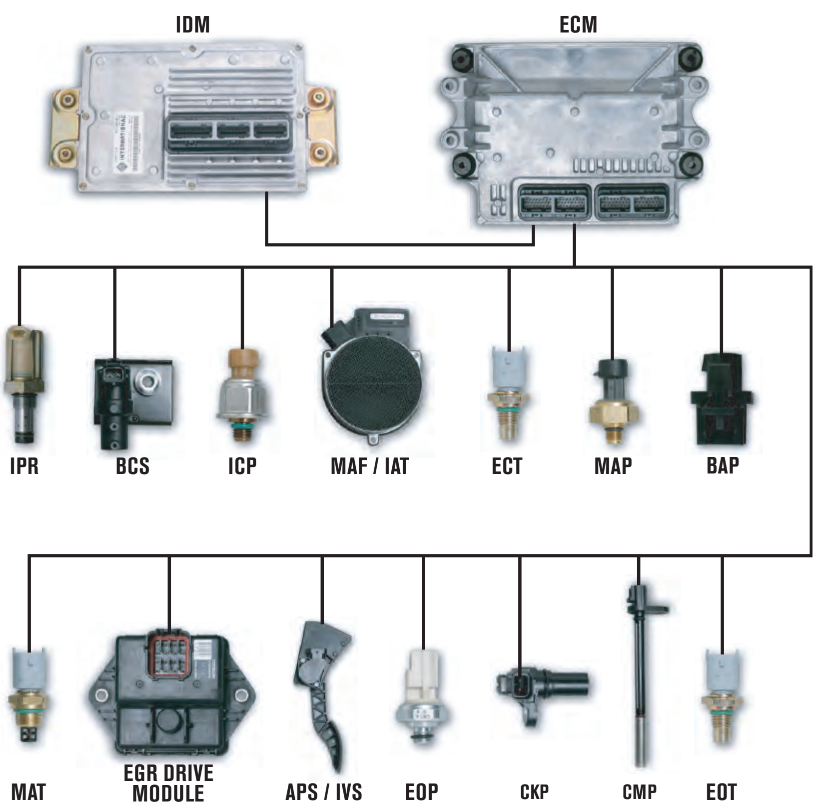
- The crankshaft counterweight, flywheel, and damper are used to offset the rotating and reciprocating forces developed in the 90° V6 engine, but these components alone will not offset the couple imbalance. Couple imbalance is created when two or more forces act on the crankshaft at different points along its length. Couple imbalance, if not offset, results in pitch and yaw forces on the engine that are felt by the vehicle occupants as a vibration.

- Couple imbalance forces in the engine are offset by the balance shaft forces as it rotates at crankshaft speed but in the opposite direction.



# ELECTRONIC CONTROL SYSTEM

- ECM and IDM control system
- Dual magnetic pick-up timing sensors
- Electric motor driven EGR valve
- ECM boost control




## System Features

- The VT 275 engine uses the Diamond Logic™ II Control System. The electronic control system features an Engine Control Module (ECM) and an Injector Drive Module (IDM).

- The Exhaust Gas Recirculation (EGR) valve is positioned by an ECM controlled electric stepper motor. The system uses an EGR drive module to communicate commands from the ECM to the EGR valve.

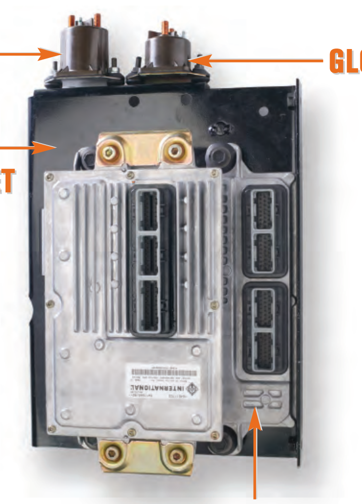
- VT 275 engines use two magnetic pick-up sensors to determine crankshaft speed and position and camshaft position. Magnetic pick-up sensors feature high reliability and accuracy.

- The VT 275 engine uses a twin turbocharger with ECM boost control.

## ECM

- The ECM uses sensor inputs to control the Injection Pressure Regulator (IPR), the EGR valve, the boost control solenoid, the glow plug relay and the inlet air heater relay. The ECM also shares sensor data with the IDM over communication links between the two modules.

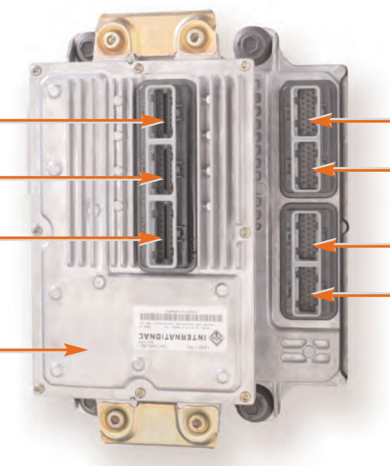
- The IDM is mounted on brackets cast into the ECM. The ECM and IDM are then mounted with vibration isolator grommets to the control module assembly bracket. The bracket is bolted to the truck's frame directly behind the passenger side of the cab and serves as the mounting point for the inlet air heater relay, the glow plug relay, and the Power Distribution Center (PDC).

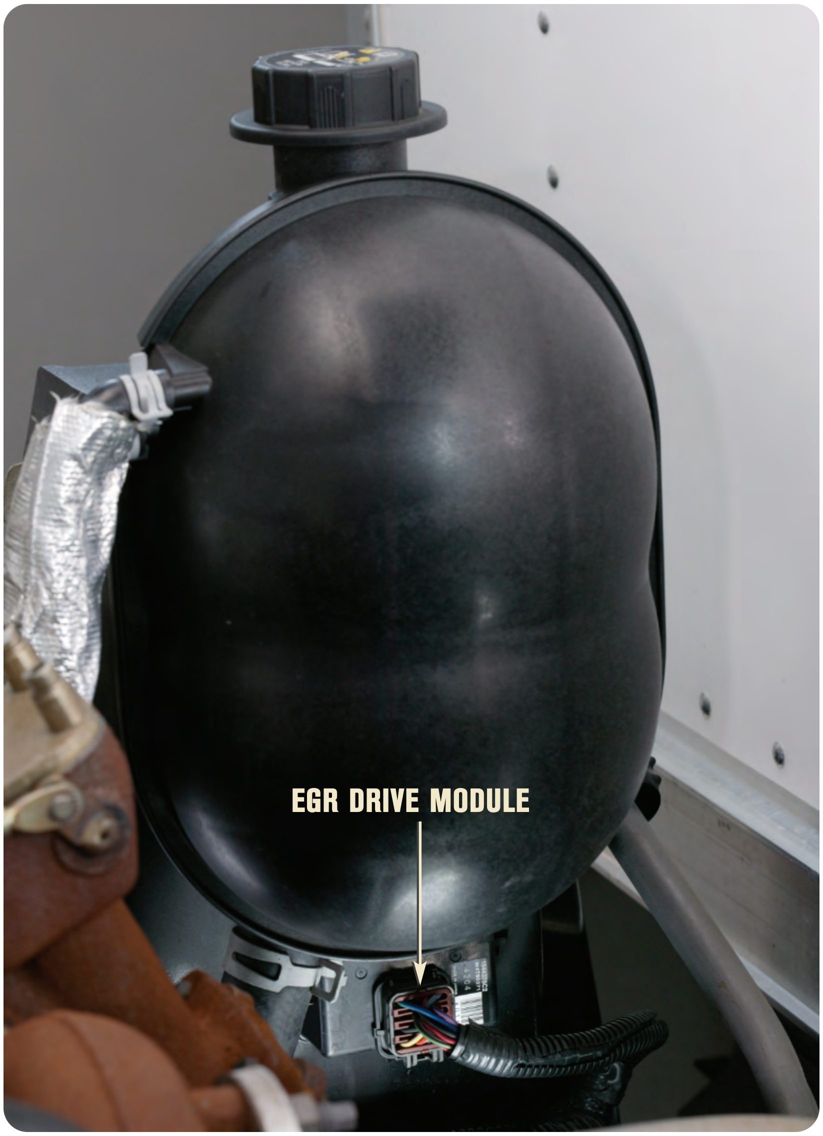



## IDM

- The Injector Drive Module (IDM) receives sensor information from the ECM over three communication links: the CAN 2 link, the CMPO circuit, and the CKPO circuit. The IDM uses this information to calculate injection timing and duration. The IDM controls injector operation through 48-volt signals to the twin injector coils.

- The ECM has four connectors. The connectors are called X1 through X4 with ECM X1 being the top ECM connector as mounted on the truck. The IDM has three connectors with IDM X1 being the top connector as mounted on the truck. The ECM X1 and X2 connectors are for engine sensor inputs and X3 and X4 are for chassis inputs. The IDM X1 and X2 connectors are for injector operation and X3 is for chassis inputs and communication between the ECM and IDM.

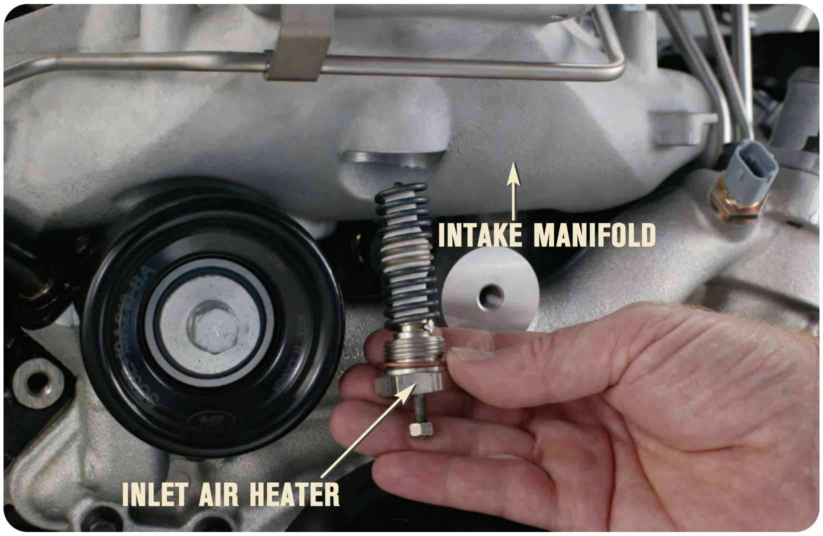





## EGR Drive Module

- The EGR Drive Module is mounted below the de-aeration tank. The module receives the desired EGR valve position from the ECM over the engine CAN 2 link. The module then sends a series of voltage and ground signals to the Motor U, V, and W terminals of the EGR valve. The voltage signals are Pulse Width Modulated (PWM) to control current flow to the motor field coils.

- The module receives battery voltage and ground through the 12-way engine-to-chassis connector. The module supplies a reference voltage to three position sensors within the EGR valve. The drive module uses the sensor signals to determine the percent of valve opening.



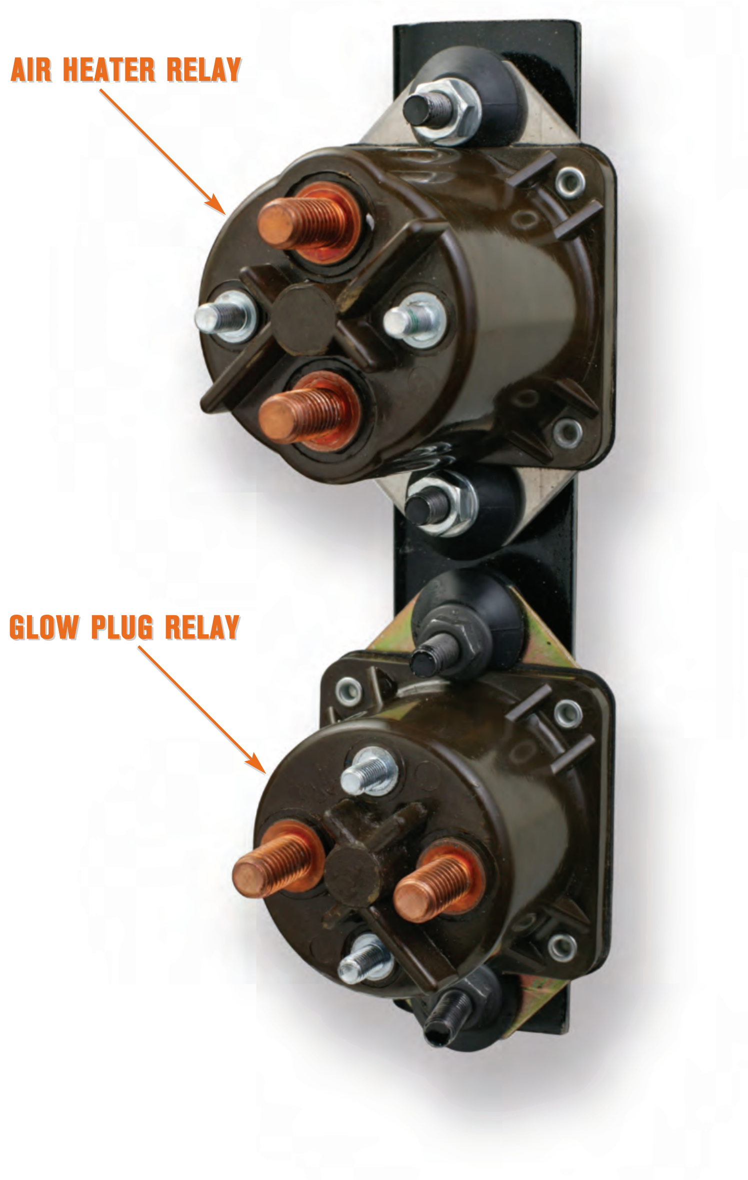

## Inlet Air Heater Element

- The Inlet Air Heater element is located in the lower side of the intake manifold and projects through the manifold and into the inlet air stream.

- The element warms the incoming air to aid cold start and reduce emissions during warm-up. The ECM turns the inlet air heater on for a predetermined amount of time, based on engine oil temperature, intake air temperature, and barometric air pressure. The inlet air heater can remain on while the engine is running to reduce white smoke during engine warm-up.

## Inlet Air Heater Relay

- The Inlet Air Heater (IAH) element is used to improve cold start operation, reduce emissions and white smoke, and improve engine warm-up. The relay is mounted next to the Power Distribution Center and is the taller of the two relays. The IAH relay receives battery power from the starter power-feed terminal and the normally open terminal connects to the element through the harness. One end of the relay coil is grounded through the engine 12-way connector. The relay closes when the coil receives voltage from the ECM.

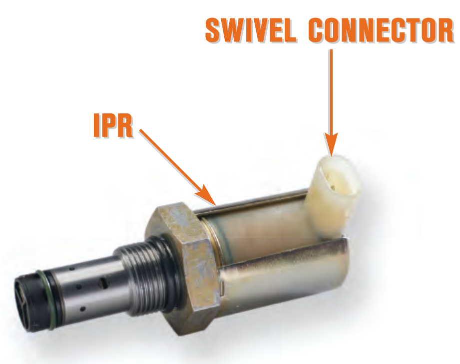



## Glow Plug Relay

- Glow plugs are used to improve cold engine starting. Glow plug operation is controlled by the ECM through the glow plug relay. The glow plug relay is mounted next to the Power Distribution Center and is the shorter of the two relays. The relay common terminal is connected by jumper to the common terminal of the Inlet Air Heater relay. The normally open terminal connects to the glow plug harness. One end of the relay coil is grounded through the engine 12-way connector. The relay is closed when the other end of the coil receives voltage from the ECM.

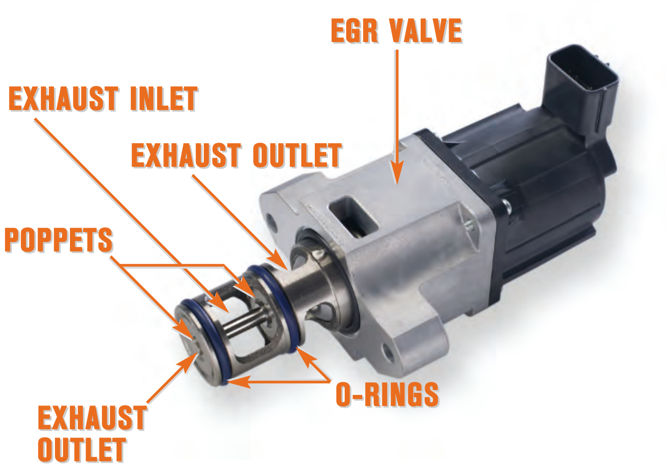
## Injection Pressure Regulator (IPR) Valve

- The IPR mounts to the high-pressure pump and controls the amount of oil allowed to drain from the high-pressure system. When the ECM increases the IPR signal duty cycle, the valve blocks the oil's path to drain and pressure rises. When the ECM reduces the duty cycle, a larger volume of oil is allowed to drain from the system and pressure is reduced. The valve contains a pressure relief valve for the system that opens if system pressure reaches 4500 psi. The IPR is protected by a heat shield that must be reinstalled after servicing.




## Boost Control Solenoid

- The turbocharger boost control solenoid valve is controlled by the ECM. When the ECM signal to the Boost Control solenoid is high, the valve opens, allowing pressure in the pneumatic actuator to vent into the turbo inlet duct. When the ECM signal is low, the valve closes, and pressure to the actuator equals boost pressure in the intake manifold.

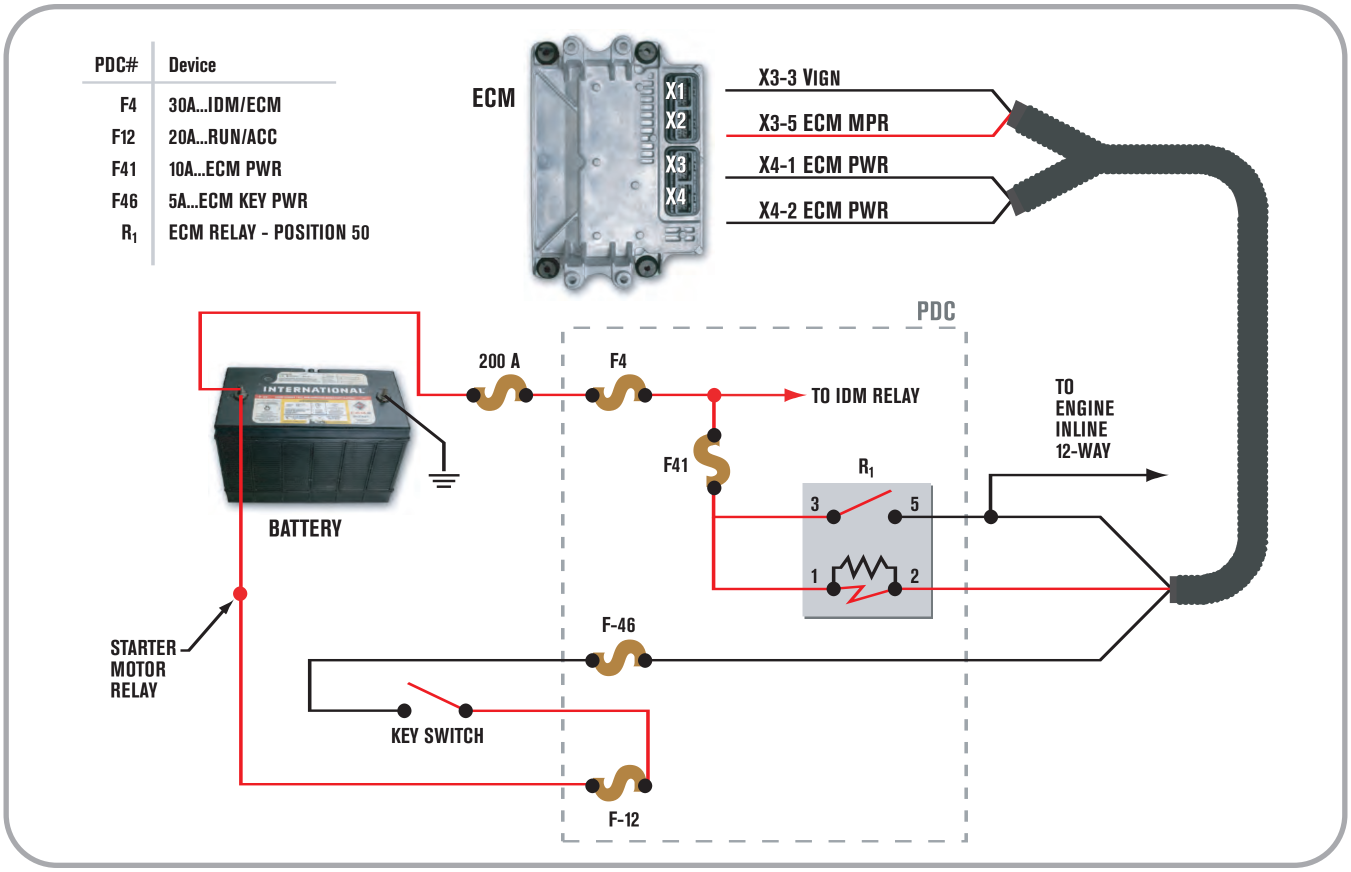



## Exhaust Gas Recirculation (EGR) Valve

- The EGR valve is used to control the percent of exhaust gas in the intake charge. The EGR valve consists of circuit board mounted position sensors, field coils surrounding an armature, and the valve group. The valve group has two poppet valves mounted to a common stem. When the drive module provides voltage and ground to the field coils in the proper sequence, stepped armature rotation occurs. A threaded rod engaged in the center of the rotating armature pushes or pulls against the spring loaded valve stem to force the valve to open or close.


## Mass Air Flow (MAF) Sensor

- The Mass Air Flow (MAF) sensor is mounted with ductwork between the turbocharger inlet and the air filter element. The sensor applies voltage to a low resistance thermistor exposed to the fresh air portion of the intake charge. The MAF sensor circuitry measures the increase in voltage required to offset the cooling effect of the air flow over the thermistor. This voltage is then converted into a variable frequency that is sent to the ECM. The MAF value can be read with MasterDiagnostics® software in lb./min.




## ECM Relay Circuit Operation

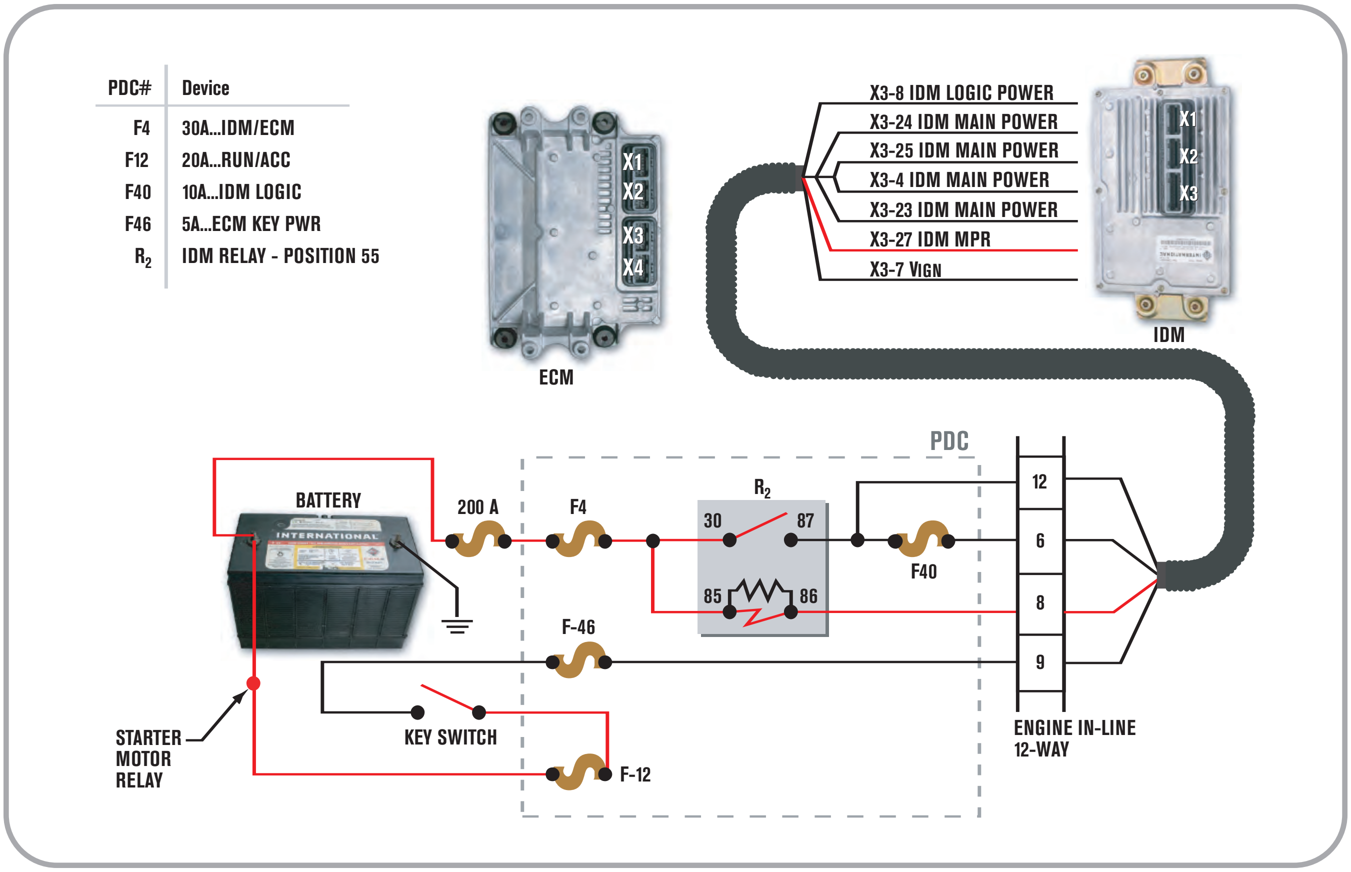
- The ECM controls its own power up and power down process. When the key is OFF, the ECM stays powered up for a brief period. The ECM then powers down after internal housekeeping functions have been completed.

### Key Power

- The Run/Accessory position of the key switch receives battery voltage from the Power Distribution Center (PDC) fuse F-12. When the key is ON, the switch supplies battery voltage through fuse F46 to ECM pin X3-3. Battery voltage is available at all times through fuses F4 and F41 to ECM relay pins 1 and 3. The two fuses are in series, with F4 feeding both the IDM and ECM relays, and F41 dedicated to protecting the ECM circuit alone. Pin 1 supplies voltage to the relay coil.
- Pin 2 connects the coil to pin X3-5 of the ECM.
- When the key is ON, voltage supplied to pin X3-3 signals the ECM that the operator is going to start the engine. The ECM then supplies a ground circuit to pin X3-5. When this occurs, current flows through the ECM relay coil and creates a magnetic field causing the relay to latch. When latched, the relay connects pin 3 to pin 5 and supplies current to the ECM through pin X4-1 and X4-2.

### Shut Down

- When the key is OFF and voltage is removed from ECM pin X3-3, the ECM shuts down the engine but keeps the ECM powered up briefly until the internal house keeping is completed.




## IDM Relay Circuit Operation

- The IDM controls its own power up and power down process. When the key is OFF, the IDM stays powered up for a brief period. The IDM then powers down after internal housekeeping functions have been completed.

### IDM Power Up

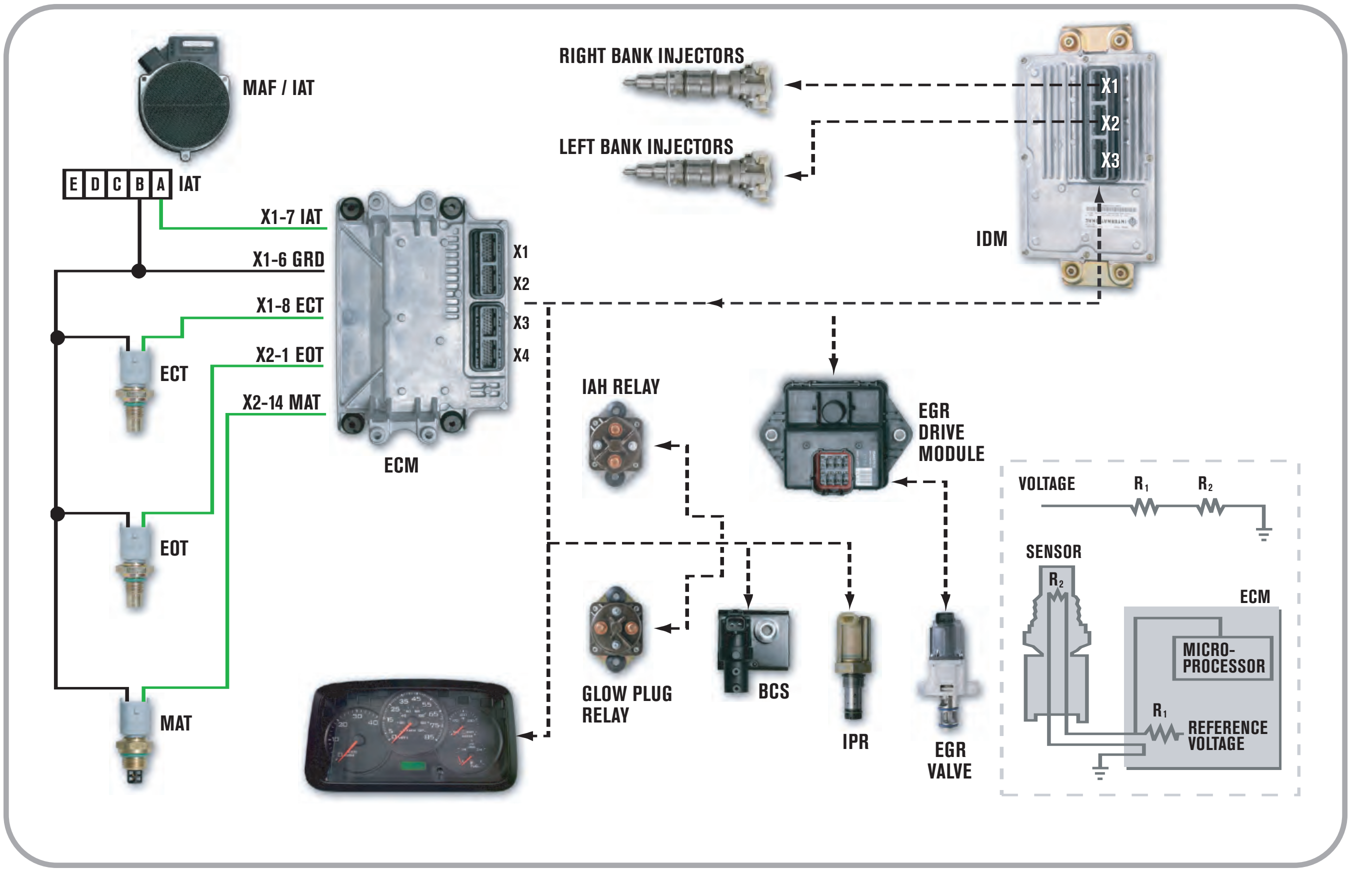
- The key switch receives battery voltage from the Power Distribution Center (PDC) F-12 fuse. When the key is ON, the switch supplies battery voltage through F-46 fuse and pin 9 of the engine 12-way connector to pin X3-7 of the IDM.

- Battery voltage is available through the PDC F-4 fuse to IDM relay pin 30 and 85 at all times. Pin 85 supplies voltage to the relay coil. Pin 86 takes that voltage through pin 8 of the engine 12-way connector to pin X3-27 of the IDM.

When the key is ON, voltage supplied to pin X3-7 signals the IDM to provide a ground circuit to pin X3-27. When this occurs, current flowing through the IDM relay coil builds a magnetic field that causes the relay to latch. When latched, the relay connects pin 30 to pin 87 and supplies current through pin 12 of the engine in-line 12-way connector to pin X3-4, X3-23, X3-24, and X3-25 of the IDM. Four pins receive voltage to spread the current draw over multiple pins.

### IDM Logic

- The IDM also requires voltage for the internal logic circuit. When the IDM relay latches, pin 87 of the relay supplies voltage to the IDM logic circuit through the F-40 fuse in the PDC. The F-40 fuse feeds through pin 6 of the engine in-line 12-way connector to the IDM pin X3-8.




## Temperature Sensor Operation

- There are four, two-wire temperature sensors on the VT 275 engine. Each sensor contains a resistor whose value varies depending on temperature. The ECM supplies a separate reference voltage to each temperature sensor. Then, the sensor conditions its voltage to produce the sensor signal.

### Sensor Circuit

- A temperature variable resistor is a thermistor. Each thermistor is connected to a current-limiting resistor of fixed value within the ECM. The thermistor and the resistor make a series circuit with a reference voltage applied at one end and a ground at the other. The voltage in the circuit between the two resistors changes as the thermistor's resistance changes. When the temperature is low, the sensor's resistance is high and the signal voltage is high. When the temperature is high, the resistance is low and the signal voltage is low.

### Engine Coolant Temperature (ECT) Sensor

- The ECT sensor is mounted in the front cover. The body of the sensor is exposed to coolant as it returns from the cylinder heads. The ECT signal is input into the optional engine warning protection system, coolant compensation, glow plug operation and the instrument cluster temperature gauge.

### Engine Oil Temperature (EOT) Sensor

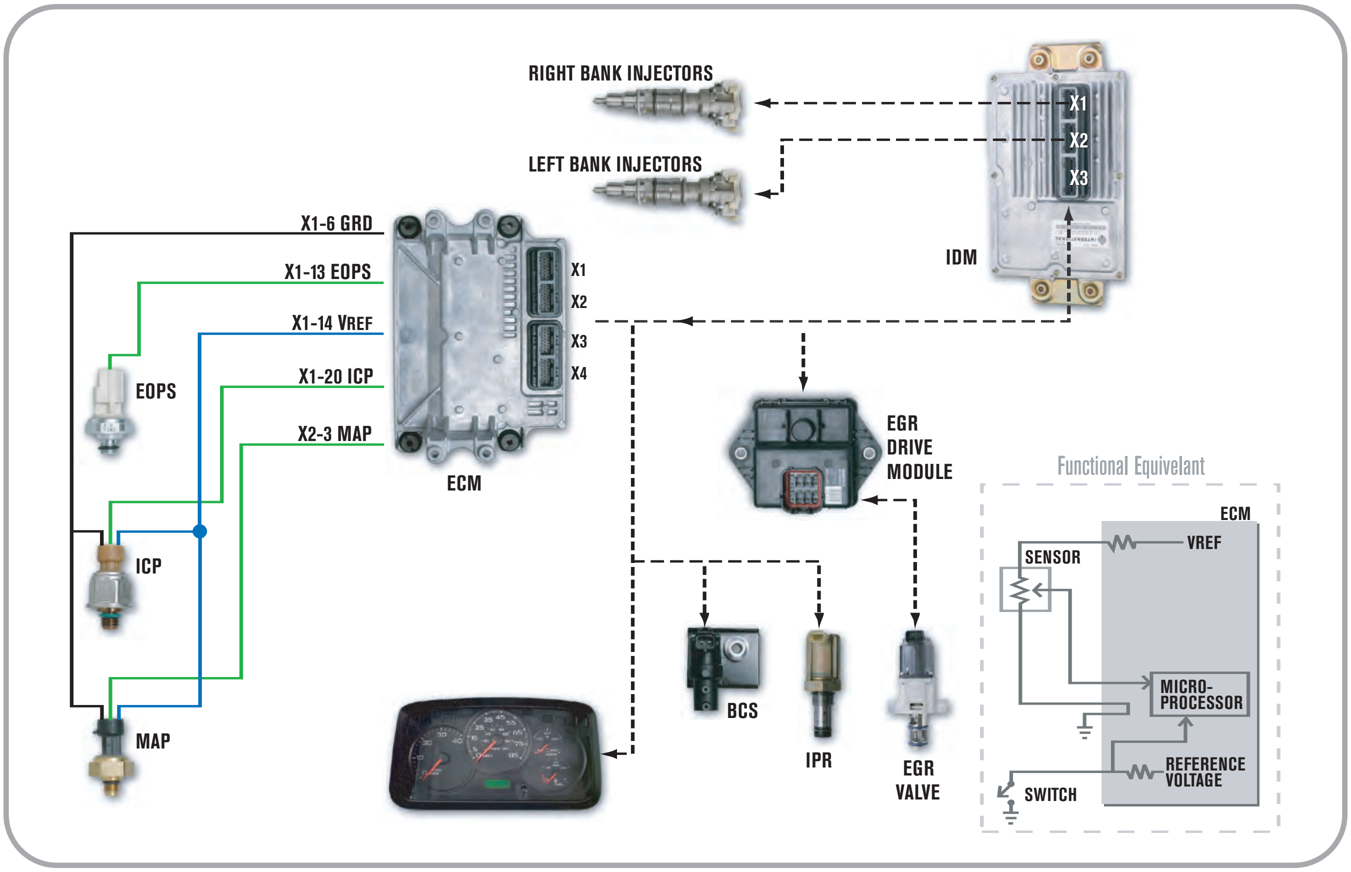
- The EOT sensor is mounted in the oil filter adapter. The EOT signal allows the ECM to compensate for viscosity changes in the oil due to temperature. The EOT signal is input into calculations that determine the fuel quantity and timing.

### Manifold Air Temperature (MAT) Sensor

- The MAT sensor is mounted towards the front of the left bank leg of the intake manifold. The MAT sensor measures the temperature of the air in the intake manifold. The ECM uses this information in calculations that control the EGR valve operation.

### Intake Air Temperature (IAT) Sensor

- The IAT sensor is contained within the Mass Air Flow (MAF) sensor housing. The MAF sensor is mounted to the inlet duct leading to the turbocharger. The ECM uses the IAT information to control injection timing and fuel rate when starting cold.




## Pressure Sensor Operation

- The Manifold Absolute Pressure (MAP) sensor, the Injection Control Pressure (ICP) sensor and the Engine Oil Pressure Switch (EOPS) are used to send pressure information to the ECM.

- The MAP and ICP are three-wire pressure sensors. Three-wire pressure sensors receive a reference voltage and a ground from the ECM. The sensor returns a portion of the reference voltage, proportional to the pressure, back to the ECM as a signal.

### Injection Control Pressure (ICP) Sensor

- The ICP sensor is a Micro Strain Gauge (MSG) style sensor. The MSG type sensor has a small strain gauge that senses changes in pressure. Sensor mounted electronic circuitry converts the change into a signal voltage proportional to the pressure being measured. The ICP sensor is used to make corrections to the IPR signal and to continually check the performance of the Injection Control Pressure system.

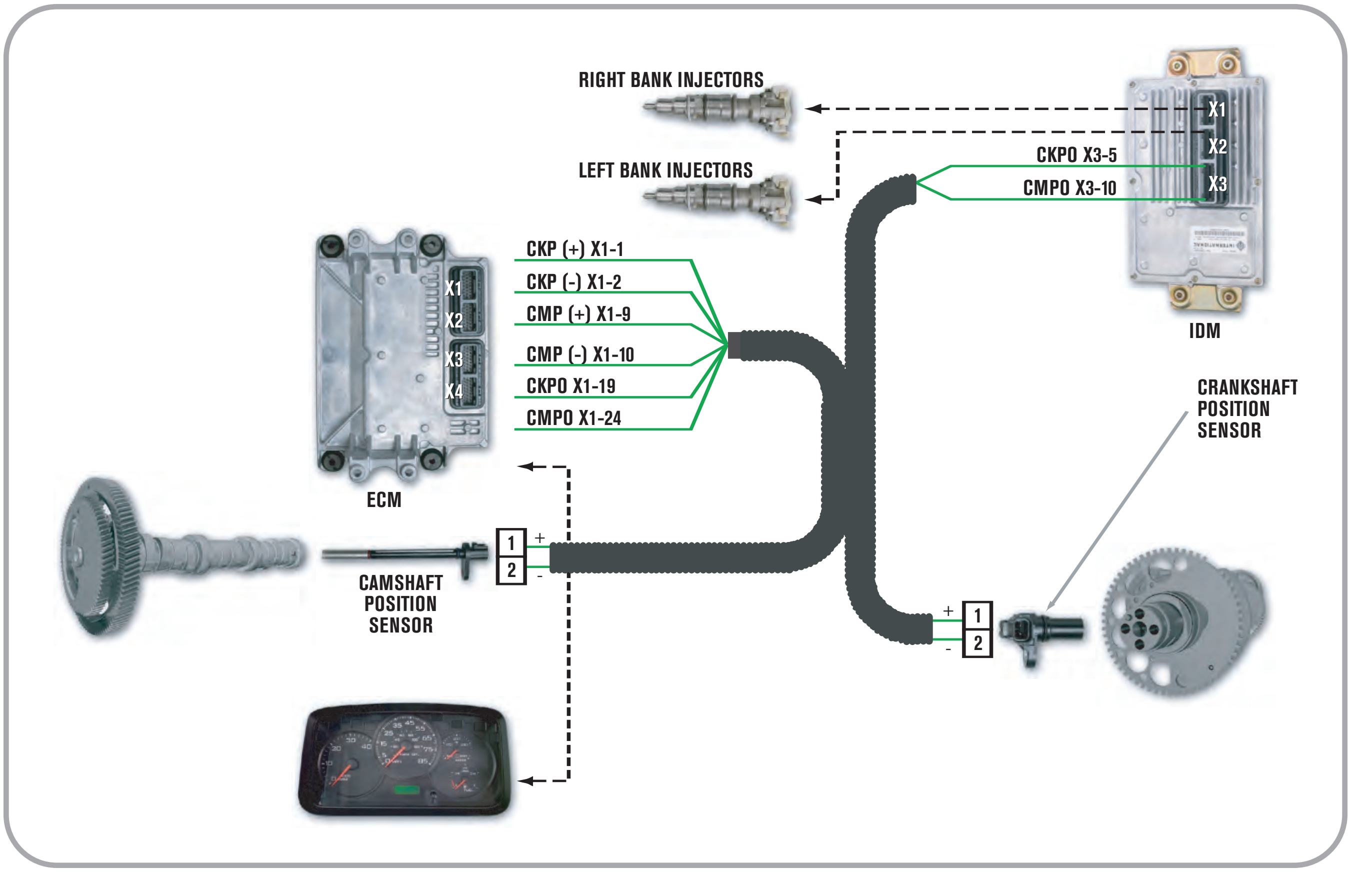
### Manifold Absolute Pressure (MAP) sensor

- The MAP sensor is a variable capacitance style sensor. In a variable capacitance sensor, the pressure being measured deflects a ceramic disk towards a metal disk. The two materials make up a variable capacitor. Sensor mounted circuitry converts the capacitance into a signal voltage proportional to the measured pressure. The MAP sensor measures turbocharger boost in the intake manifold. The MAP signal is input into calculations that determine fueling quantities and the desired EGR valve position.

### Engine Oil Pressure Switch (EOPS)

- The EOPS is used to detect oil pressure and is an input to the dash cluster and the engine warning protection system. The switch is normally open with the engine off but closes when oil pressure reaches 5 to 7 psi. The ECM sends 5 volts through a current limiting resistor to the EOPS and reads the voltage between the resistor and the switch. When oil pressure is low, the switch is open and the ECM reads 5 volts.

When the oil pressure is greater than 5 to 7 psi, the switch is closed, the circuit is shorted to ground, and the ECM reads a low voltage. When the ECM detects oil pressure, MasterDiagnostics® will display 40 psi. When the oil pressure is below 5 psi, MasterDiagnostics® will display 0 psi.




## Magnetic Pick-Up Sensors

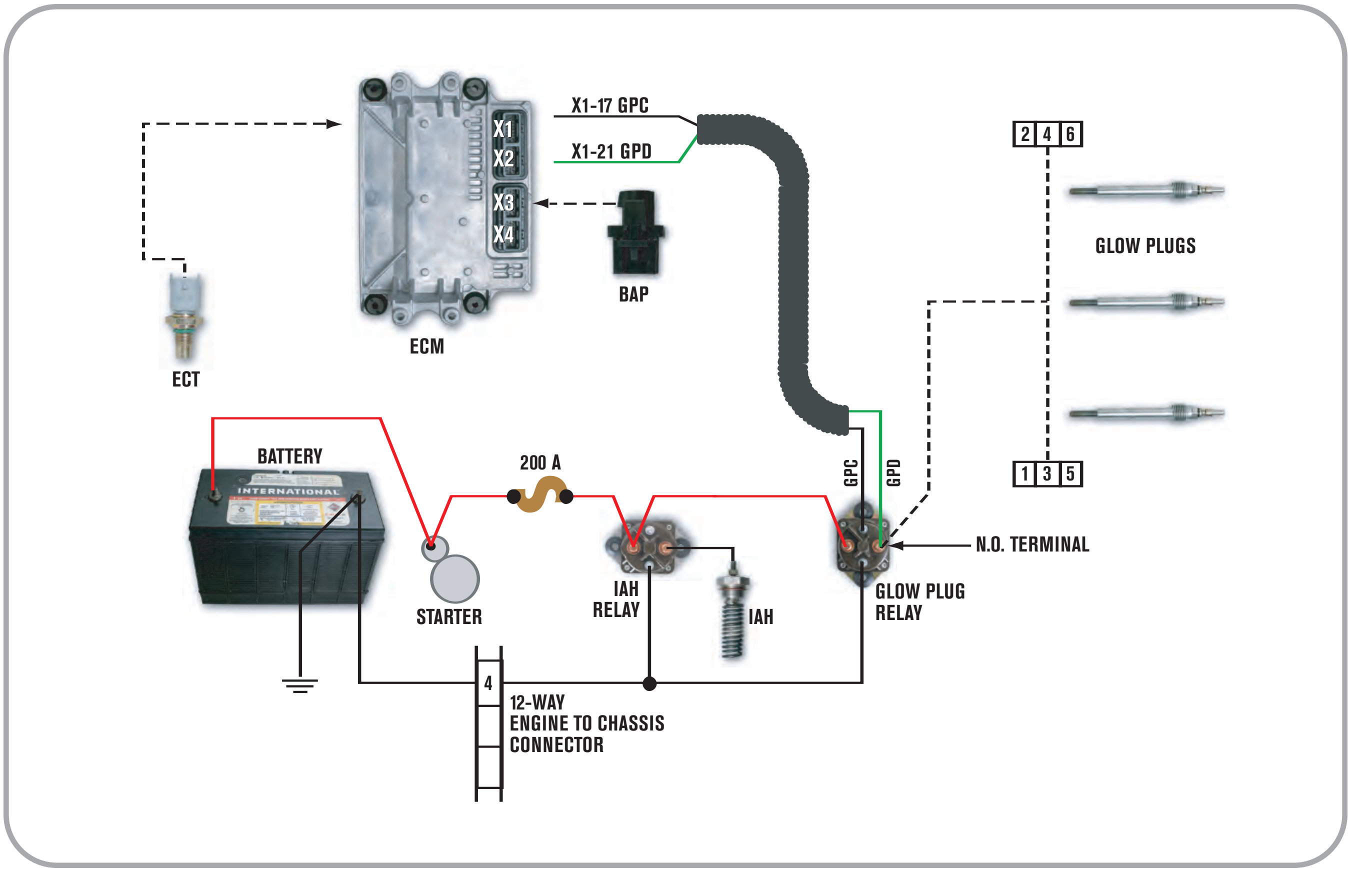
- The Camshaft Position (CMP) sensor and Crankshaft Position (CKP) sensor are both magnetic pick-up type sensors. Each sensor contains a permanent magnet core surrounded by a coil of wire. The sensor generates a signal through the collapse of a magnetic field created by a moving metal trigger. Movement of the trigger induces an Alternating Current (AC) voltage in the sensor coil.

### Camshaft Position (CMP) Sensor

- The CMP sensor is mounted on the left front of the crankcase. The CMP sensor reacts to a single peg pressed into the camshaft. The peg passes the sensor once per camshaft revolution producing an AC signal in the coil.
- The ECM uses the AC signal to determine the position of the camshaft. The ECM converts the AC signal to a square wave output. The output signal, Camshaft Position Output (CMPO), is sent to the IDM for fueling calculations. The ECM conditions the CMP signal and sends it out as the TACH signal for body builder use.

### Crankshaft Position (CKP) Sensor

- The CKP sensor is mounted on the right front of the lower crankcase. The CKP sensor reacts to a sixty-minus-two tooth trigger wheel affixed to the front of the crankshaft. The sensor produces pulses for each of the 58 teeth as they pass the magnet. The two tooth gap allows the ECM to calculate the position of the crankshaft.
- The ECM uses the CKP signal to determine the position and speed of the crankshaft. The ECM converts the AC signal to a square wave output, Crankshaft Position Output (CKPO), and sends it to the IDM for fueling calculations.
- The ECM needs both the CKP and CMP signals to calculate engine speed and crankshaft position. From the CKP signal the ECM can determine the speed of the crankshaft and the position of each piston relative to Top Dead Center. From the CMP sensor the ECM can determine the current stroke of each (i.e., compression or exhaust).




## Glow Plug System

- The VT 275 uses glow plugs to aid cold starts. The ECM turns on the glow plugs prior to engine cranking to increase the temperature of the cylinders. Glow plug operation is controlled by the ECM through the glow plug relay. The glow plugs have full voltage if battery voltage is normal, or pulse width modulated to control the current if battery voltage is above normal.

  The ECM calculates glow plug on-time based on coolant temperature and barometric pressure. The required time to warm up the cylinders decreases as engine coolant temperature increases. Warm up time decreases as barometric air pressure increases. The glow plugs may continue to be energized after start-up to reduce emissions.

### Relay Operation

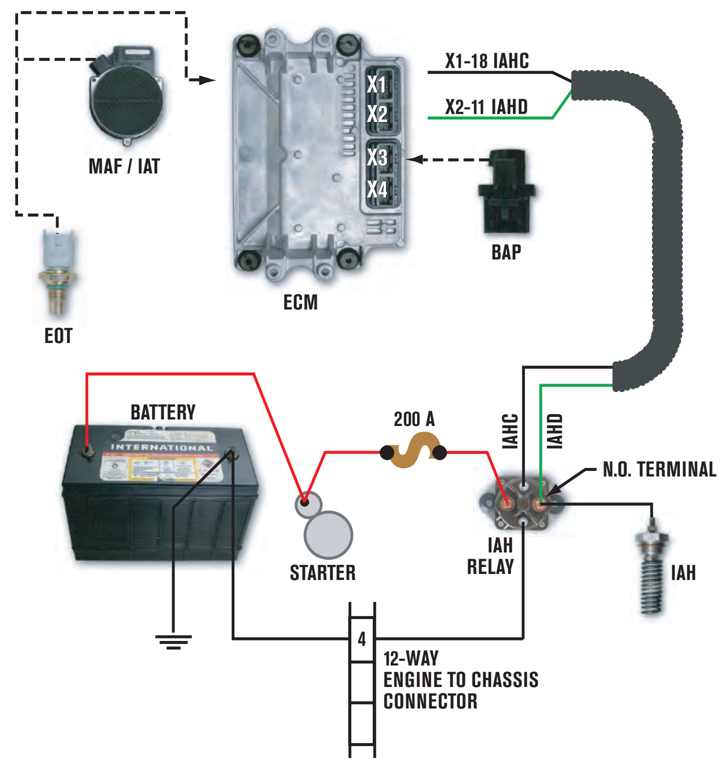
- The glow plug relay receives battery voltage to its common terminal from the starter power-feed terminal. The normally open terminal connects to the individual glow plugs through the glow plug harness. One end of the relay coil is always grounded through pin 4 of the engine 12-way connector. The ECM supplies 12 volts to the other end of the coil through ECM pin X1-17 in order to close the relay contacts.

### Glow Plug Lamp

- The glow plug lamp is used as a wait-to-start indicator. The ECM lights the glow plug lamp at glow plug activation to signal the operator to wait for the cylinders to warm up.
- Both lamp operation and the glow plug operation are based on BAP and ECT values but are independent of each other.
- The glow plug operation may continue after the lamp is off.

### Glow Plug Diagnostics

- Glow plug diagnostics are used to determine if the relay is operating correctly when commanded on. An additional wire on the relay's normally open terminal connects to ECM pin X1-21. This circuit, GPD, allows the ECM to monitor the relay operation.
- The glow plugs can be turned on using the KOEO Glow Plug/Inlet Air Heater Test. The test can only be activated twice per key cycle.




## Inlet Air Heater Operation

- The VT 275 has an Inlet Air Heater (IAH) element mounted in the front of the intake manifold. The IAH is used to improve cold start operation, reduce emissions and white smoke, and improve engine warm-up. When the key is ON, the ECM determines if the element should be activated and for how long, based on barometric pressure and engine oil temperature. On time is limited to prevent heater element damage and to prevent damage to the intake manifold.

The heater relay delivers full voltage to the element if battery voltage is normal, or the relay is pulsed by the ECM to control the current if battery voltage is above normal. If the battery voltage is so low that the starter motor operation may be affected, the inlet air heater is disabled.

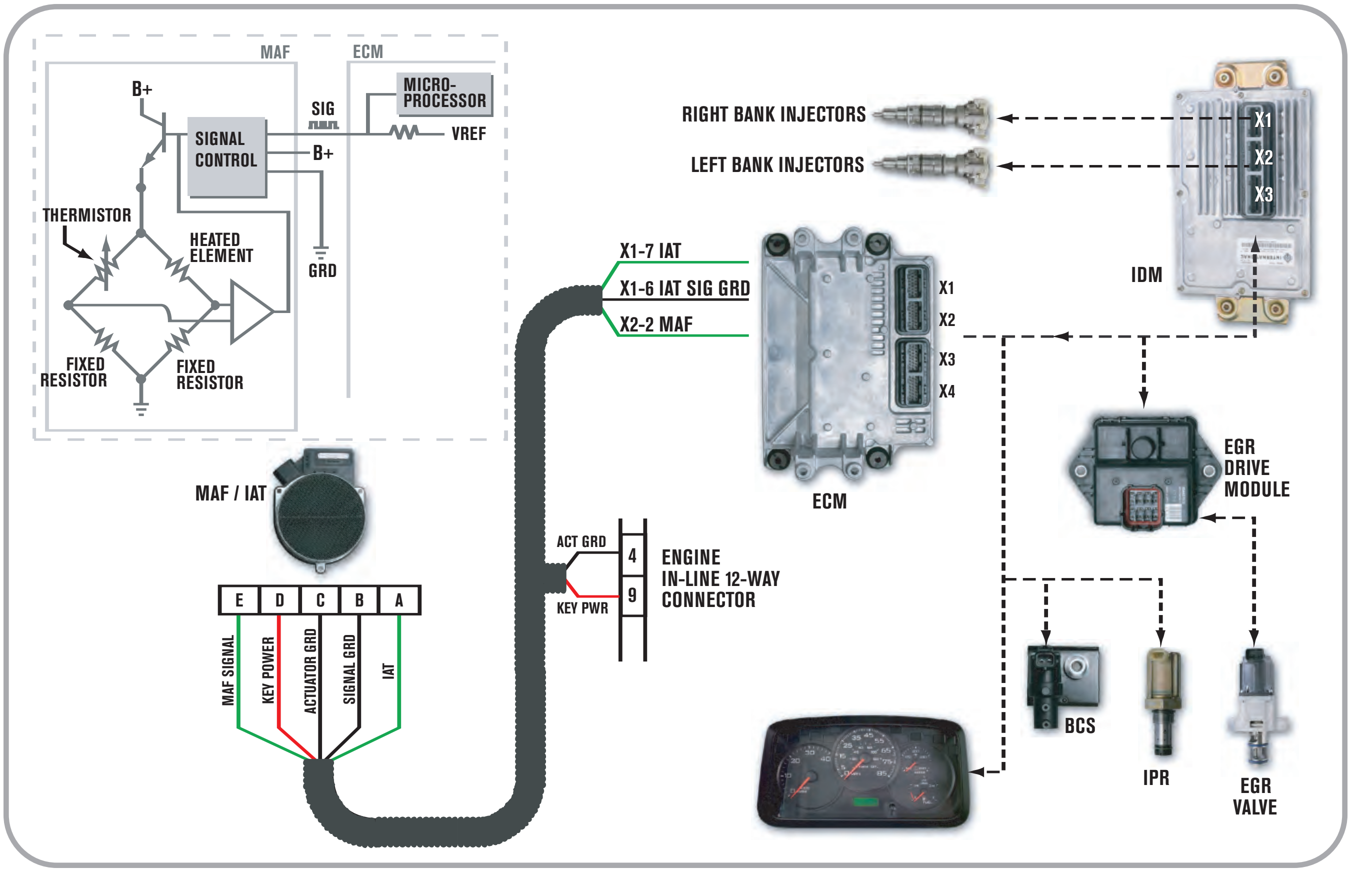
### Relay Operation

- The IAH relay receives battery power from the starter power feed terminal. The normally open terminal connects to the element through the harness. One end of the relay coil is always grounded through pin 4 of the engine 12-way connector. The other end of the coil receives 12 volts from ECM pin X1-18 to close the relay contacts.

### Inlet Air Heater Diagnostics

- An additional wire on the normally open terminal connects to ECM pin X2-11. This diagnostic circuit allows the ECM to determine if the IAH relay is on when commanded on by the ECM.

- The Inlet Air Heater can be turned on using the KOEO Glow Plug/Inlet Air Heater Test. The test can only be activated twice per key cycle. The ECM will delay the Inlet Air Heater operation for three seconds after the test is activated.




## Mass Air Flow (MAF) Sensor

- The MAF sensor is used to measure the mass of the fresh air portion of the intake air charge. To reduce Oxides of Nitrogen (NOx), a portion of the fresh air charge is displaced with cooled exhaust gases.

  The ECM calculates the total engine gas flow based on MAT, MAP and RPM. The ECM then determines the required EGR percent based on the current engine operating conditions. At this point, the ECM commands the exhaust portion of the total charge through the EGR valve while monitoring the fresh air portion through the MAF sensor.

### Sensor Construction

- The sensor housing contains two sensors, the MAF sensor and the Intake Air Temperature (IAT) sensor. The MAF sensor contains a heated element placed in the air stream. The amount of electrical power needed to maintain the element at the proper temperature depends directly on the mass of air moving over the element.

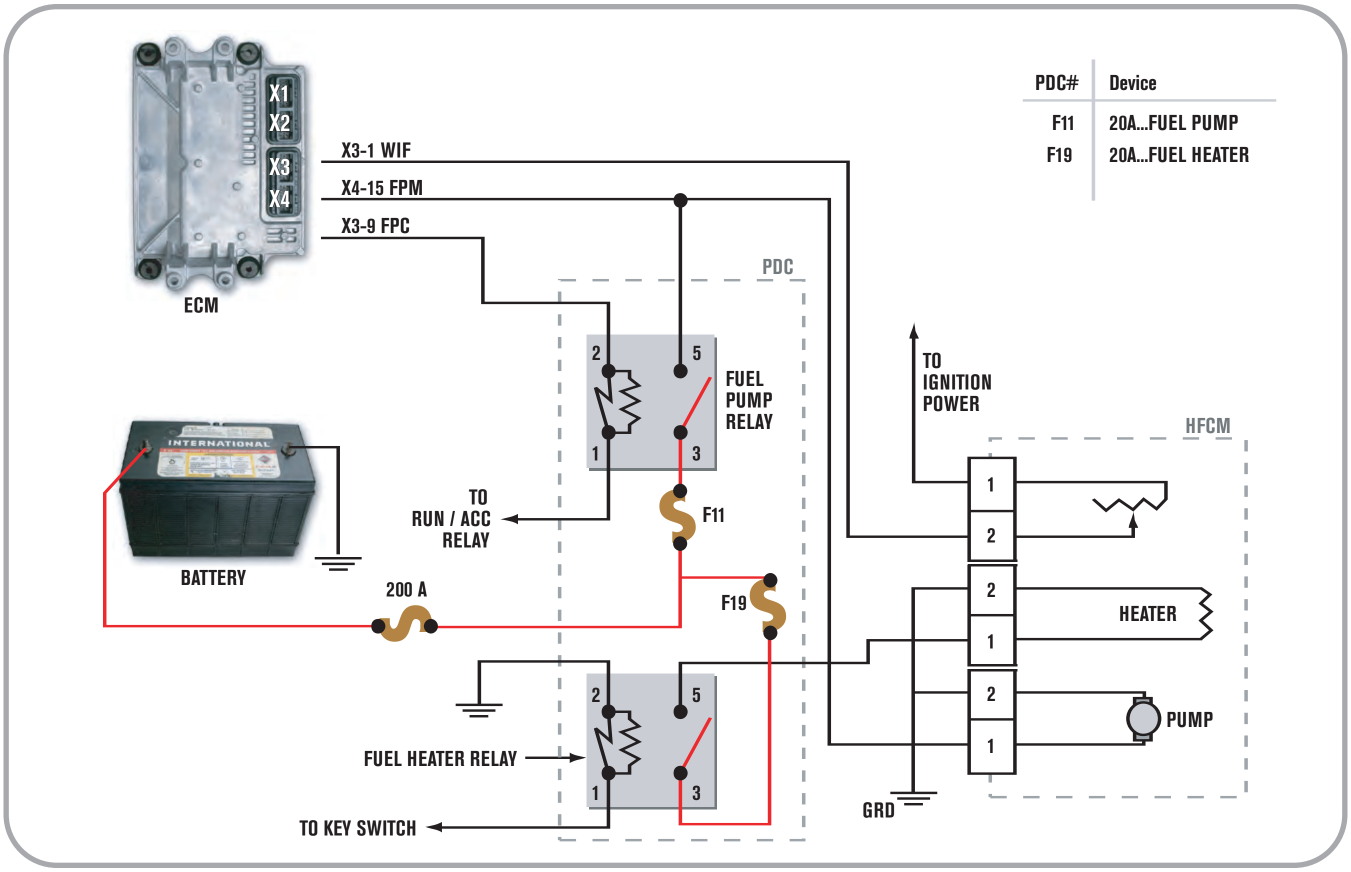
### Sensor Operation

- The MAF sensor is made up of two voltage divider circuits. A thermistor and a fixed resistor make up one voltage divider circuit, and the heated element and a fixed resistor make up the other voltage divider circuit. The two voltage divider circuits are combined into a bridge circuit with a common power supply and a common ground.
- During operation, when voltage is applied to the bridge, the temperature of the heated element increases and the resistance decreases. This affects the output of the divider circuit.

  The thermistor side is affected only by ambient air temperature. The divider voltages are compared and the input voltage to the bridge is increased or decreased until both divider voltages are equal.

  An increase or decrease in airflow will change the ratio between the divider voltages, which results in a change to the supply voltage.

  The signal controller circuit measures the voltage to the bridge and, based on that value, sends a frequency signal to the ECM. The correct key-on, engine-off frequency is 400±100 Hz.




## Pump Operation

- The VT 275 has an ECM controlled chassis mounted electric fuel pump. At key-on, the ECM will operate the fuel pump for up to 60 seconds to prime the system. Priming allows the pump to pressurize the system and to allow air in the system to bleed out through an orifice between the filter housing and the fuel return circuit.

  When the engine is in run mode, the pump will operate continuously. If the engine dies or is shut down, or if it is not started within 60 seconds, the ECM will stop the pump.

### Circuit Operation

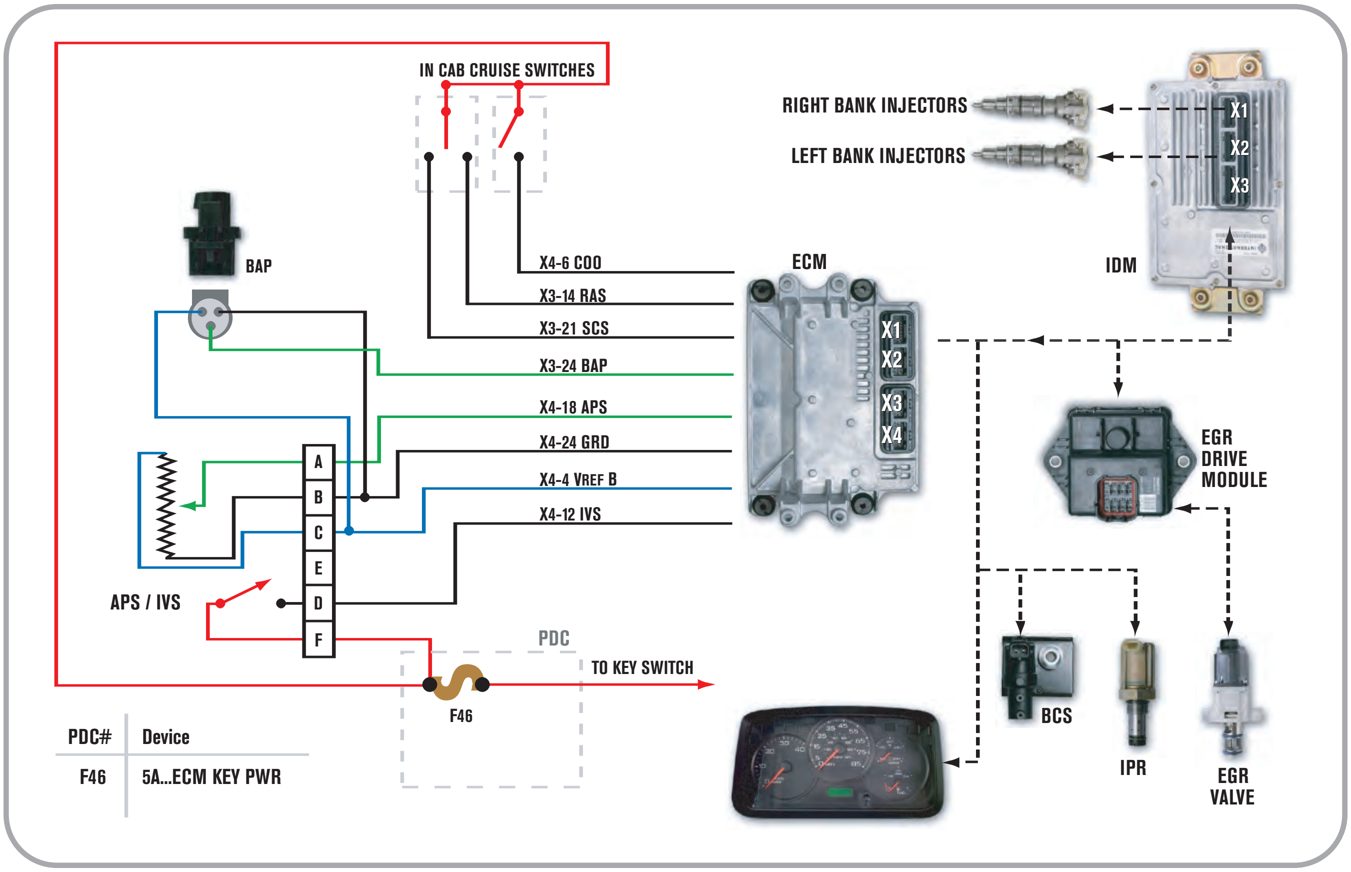
- To operate the pump, the ECM provides a ground at ECM pin X3-9 to latch the fuel pump relay. The relay takes power from fuse F11 and provides it to pin 1 of the pump connector. The ECM monitors the relay's operation through ECM pin X4-15. Battery voltage should be present at X4-15 when the relay is commanded on. If the ECM does not detect the voltage, a DTC will be logged.

### Fuel Heater

- The Horizontal Fuel Conditioning Module (HFCM) contains a fuel heater. When the key is ON, the fuel heater relay latches and provides power to pin 1 of the heater connector. The heater element contains a thermostat that controls the heater operation.

### Water-In-Fuel Sensor

- The pump module contains a Water-In-Fuel (WIF) sensor. The WIF sensor receives voltage from the key switch. If the filter detects water, the sensor sends the voltage to ECM pin X3-1. The ECM then activates the dash WIF lamp.




## Accelerator Pedal Position Sensor / Idle Validation Switch (APS/IVS)

- The APS/IVS sensor has two components built into one housing: the Accelerator Pedal Position Sensor (APS) and the Idle Validation Switch (IVS).

- The APS is a potentiometer type sensor. The ECM supplies a reference voltage (Vref) and ground to the potentiometer and the sensor sends a voltage signal back to the ECM indicating the pedal position. The idle validation switch receives 12 volts from the chassis harness and signals the ECM when the pedal is in the idle position. If the ECM detects an APS signal out of range high or low, the ECM will ignore the APS signal and operate at low idle.

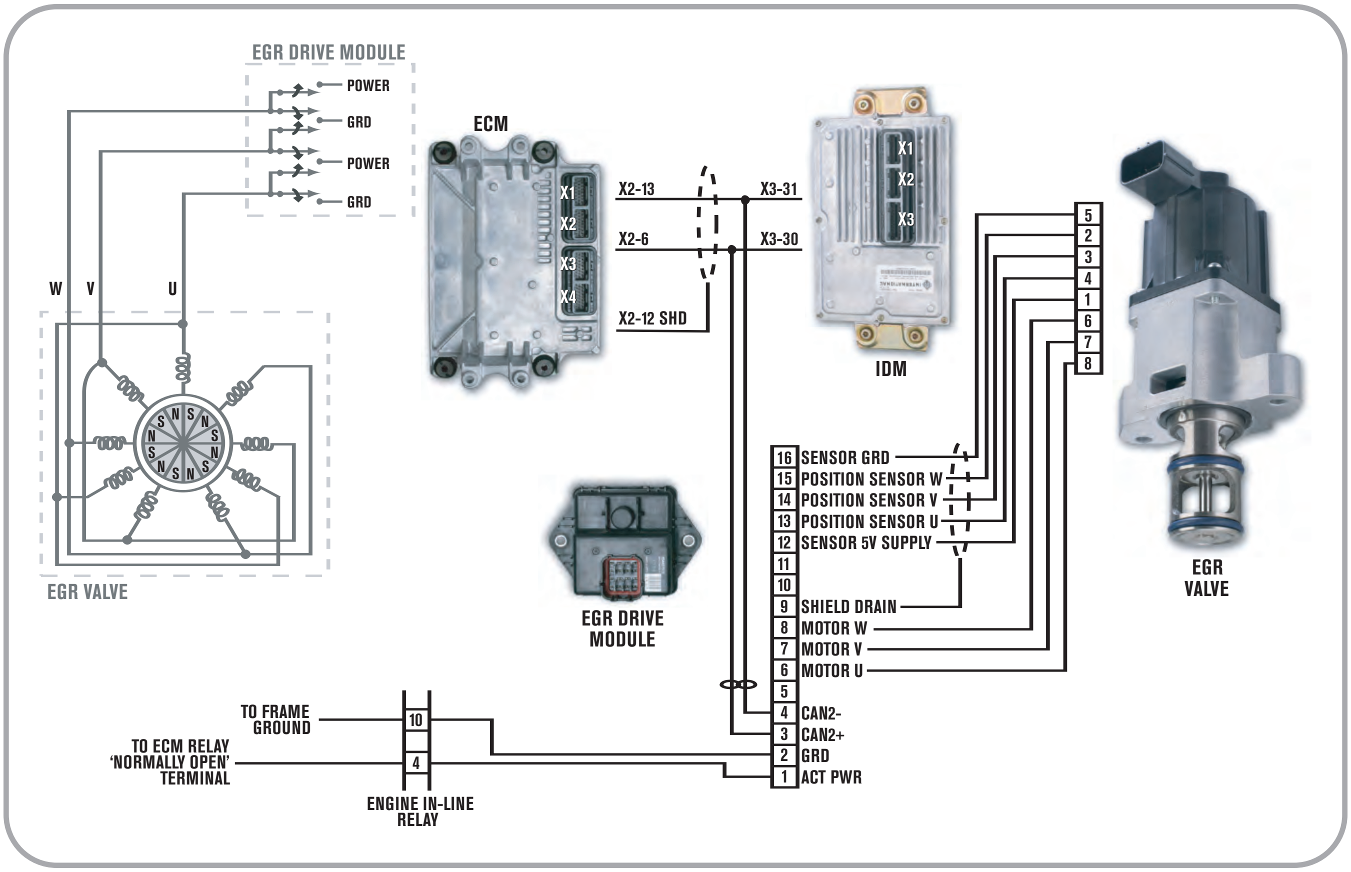
- If a disagreement in the state of IVS and APS is detected by the ECM, and the ECM determines that the IVS is at fault, the ECM will allow a maximum of 50% of APS. If the ECM cannot determine that the IVS is at fault, the engine will be restricted to low idle only.

### Barometric Absolute Pressure (BAP) sensor

- The BAP sensor is mounted in the cab. The BAP sensor provides altitude information to the ECM, so fuel quantity and timing, glow plug on time, intake heater on time, and the operation of the Boost Control Solenoid can be adjusted to compensate for air density changes.

### Cruise Control

- Cruise control operation is controlled through the ECM. Two switches in the cab are used to signal the operator's intention for speed control. The switches receive battery voltage through fuse 46 in the Power Distribution Center (PDC). The Cruise On/Off (COO) switch sends a voltage signal to ECM pin X4-6. With the COO switch on, the operator can use the Set (SCS) and resume (RES) switch to control the vehicle speed.




## EGR System

- The motor-actuated EGR valve is controlled and monitored by the EGR Drive Module. The module is connected to the engine CAN 2 link allowing bi-directional communication with the ECM.

### EGR Valve

- The EGR Valve poppet stem is positioned by a three-phase motor. The armature of the motor has twelve permanent magnet segments alternating as north or south poles of a magnet. The armature is surrounded by nine field coils divided into three sets or phases. Each phase has three coils wired in parallel and spaced 120° apart around the motor armature. One lead of each coil set is connected to the respective motor circuit on the drive module. The other leads from all of the nine coils are joined together.

Two coil sets are powered together to reposition the motor, with one set connected to power and the other to ground. Each powered coil set creates either a north or a south magnetic field depending on the direction of current flow through the coils.

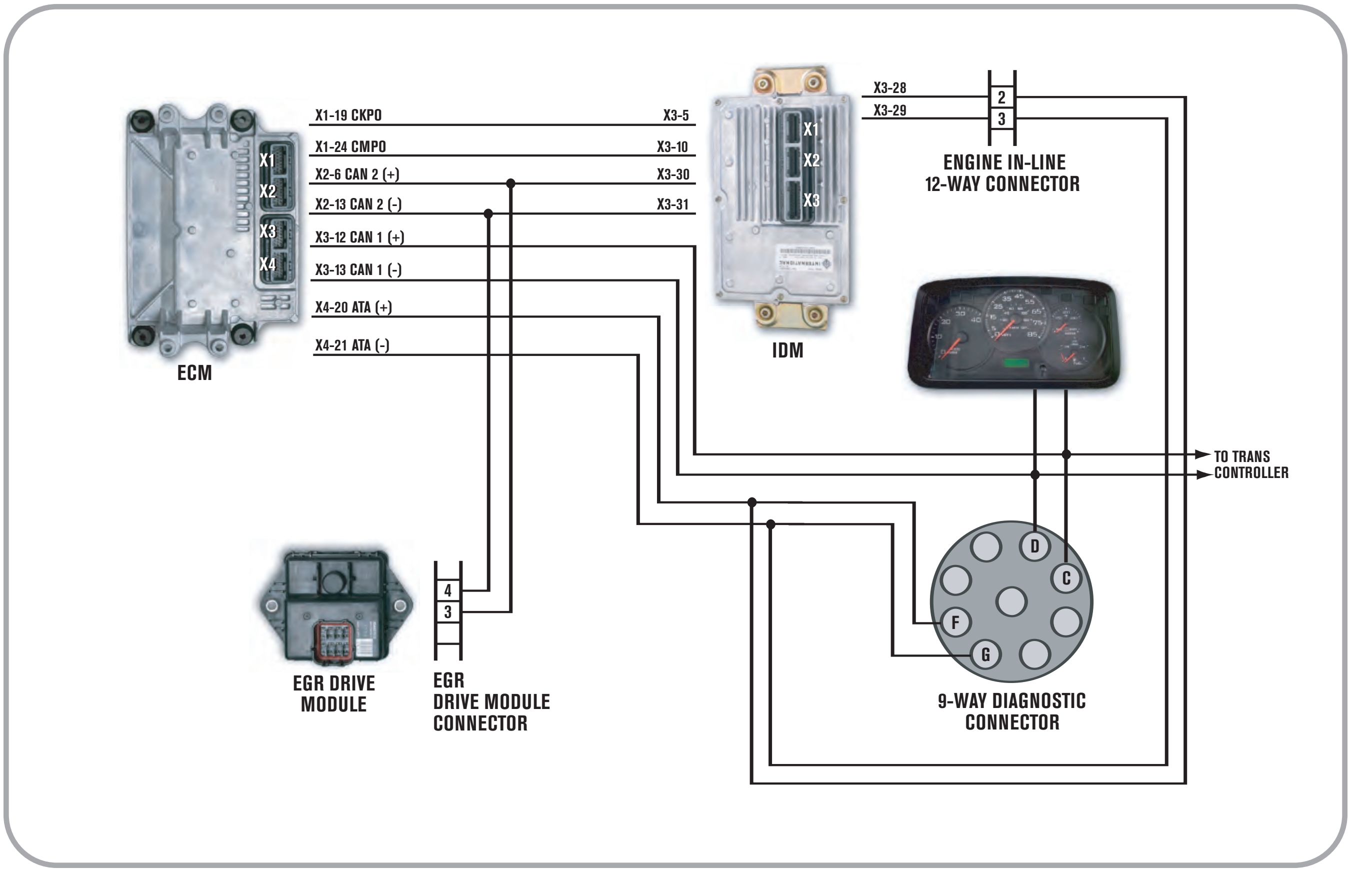
### Drive Module Operation

- The direction of current flow through the coil sets is controlled by the EGR Drive Module. When the integrated circuit in the module connects one coil set to ground, and one of the other two coil sets to a Pulse Width Modulated (PWM) power source, the magnetic fields created by the coils oppose the armature magnetic fields and a controlled rotation of the armature occurs.

The drive module constantly switches the coil sets (identified as Motor W, V, and U) from power and ground to continually produce rotation. Pulse width modulation is used to control the current.

### Communication

- Three Hall-Effect sensors are located on a circuit board at the top of the valve housing. The sensors are supplied power and ground through the drive module and produce a series of signals so the module can track the rotation of the motor and the opening position of the valve.




## ECM/IDM Communications

- The ECM and IDM communicate over three independent communication links. The three links are CMPO, CKPO, and CAN 2. In addition to communications with the IDM, the ECM also sends engine information over the CAN 1 link to the vehicle's instrument cluster and the 9-pin Diagnostic connector.

**CAN 2**

- The engine CAN 2 link is a two-wire, bi-directional communication circuit between the ECM and IDM and the ECM and the EGR Drive Module. The ECM and IDM use the link to share operating strategies, sensor information, diagnostic demands, and Diagnostic Trouble Codes (DTC). The ECM also shares desired EGR valve position with the EGR drive module over the CAN 2 link. The EGR Drive Module translates those messages and then commands the EGR valve motor. The EGR drive module monitors the valve action and communicates any faults back to the ECM over the CAN 2 link.

**Cam Position Output (CMPO)**

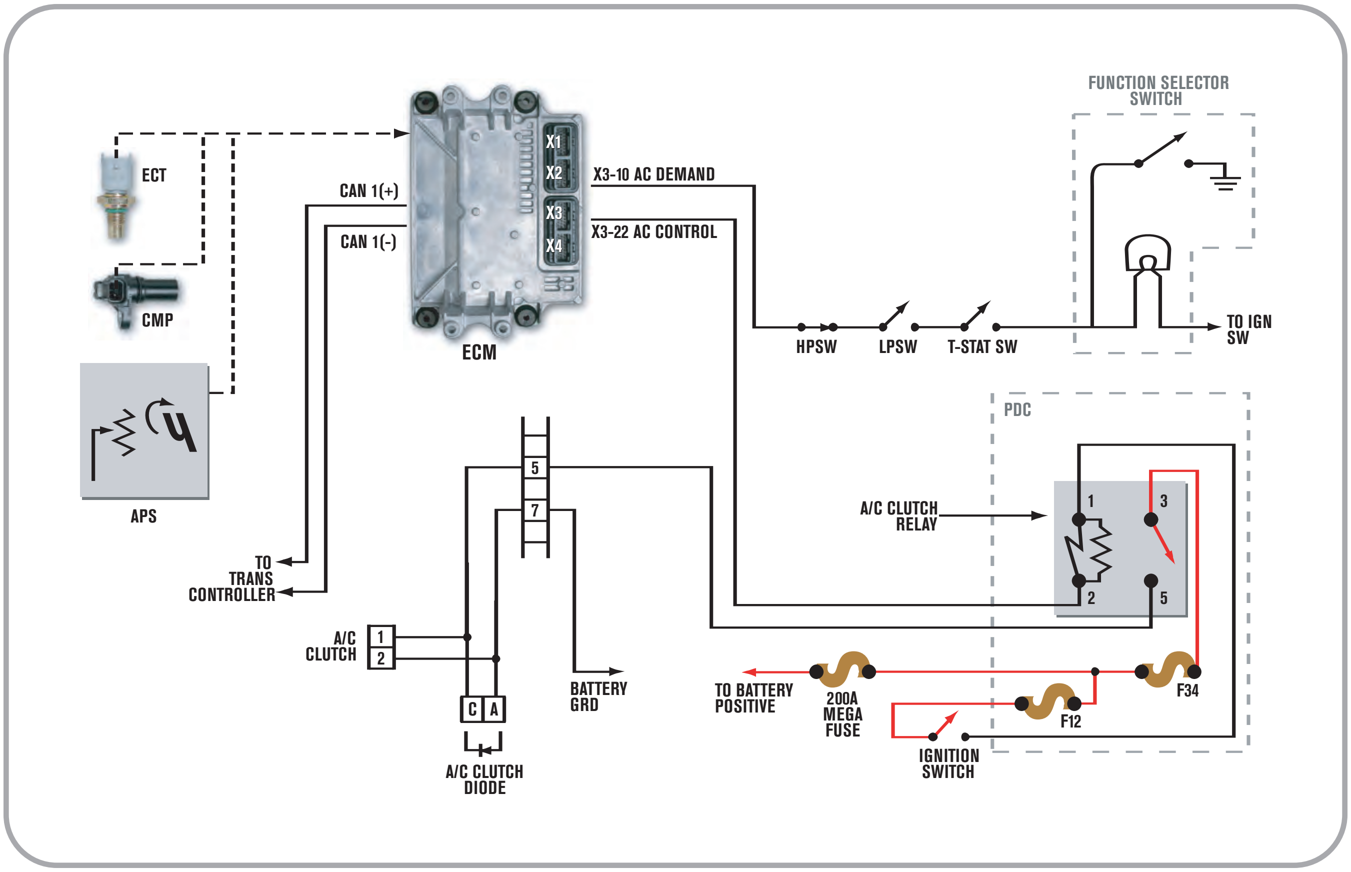
- The CMPO signal is a 0-12V digital signal used to communicate the camshaft position to the IDM. The CMPO signal is a square wave signal derived from the information contained in the camshaft position sensor's AC voltage signal. The ECM generates the CMPO signal by pulling down (switching to ground) a single wire 12V circuit that originates in the IDM. The IDM reads the signal and uses it for injector timing calculations.

**Crank Position Output (CKPO)**

- The CKPO signal is a 0-12V digital signal used to communicate the crankshaft position and speed to the IDM. The CKPO signal is a square wave signal derived from the information contained in the crankshaft position sensor's AC voltage signal. The ECM generates the CKPO signal by pulling down (switching to ground) a single wire 12V circuit that originates in the IDM. CKPO is used by the IDM for injector timing and fuel quantity calculations.

**American Trucking Association (ATA)**

- The ATA link is a 0-5V signal that enables communications between the ECM and the Master-Diagnostics software. The data communication link also allows for programming of the ECM and IDM.




## A/C Clutch Control

- The VT 275 ECM controls the A/C clutch. The ECM receives an A/C demand signal from the chassis, and engages the A/C clutch if engine conditions are correct. If conditions are not right, clutch action may be delayed. When the ECM receives the A/C demand signal, it considers engine run time (to avoid stalling at start up) and engine coolant temperature (to avoid compressor operation when liquid refrigerant may be present in the compressor). In addition, the ECM looks at transmission shift action (to avoid clutch action during a transmission shift), engine RPM (to avoid clutch overspeed), and APS percent (to avoid engagement during full throttle acceleration).

### A/C Demand

- The A/C demand signal originates at the ECM as a reference voltage on X3-10. The ECM supplies 5 volts to pin 10 and considers clutch engagement when the voltage is pulled low (shorted to ground) by the A/C on/off switch in the dash-located A/C Control Head.

The low-pressure switch (LPSW), high-pressure switch (HPSW), and the thermostat switch (T-STAT SW) are in series in the A/C demand circuit. If the compressor head pressure rises above 350 psi, the high-pressure switch opens and the demand signal will be 5V. If pressure on the low side of the compressor goes below 7 psi, the low-pressure switch will open and the demand signal will be 5V.

The last switch is the thermostat control in the A/C Control Head. If the thermostat is positioned so that in-cab temperature demands are satisfied, the thermostat will open and the demand signal will be 5V.

### A/C Control

- If the A/C demand signal is pulled low and the ECM determines that the clutch can be engaged, the ECM pulls the AC Control circuit low at pin X3-22. When pin 22 is low, a ground is provided for the A/C Clutch Relay. The relay latches and battery voltage is provided to the A/C clutch through pin 5 of the engine 12-way connector.

### Switches

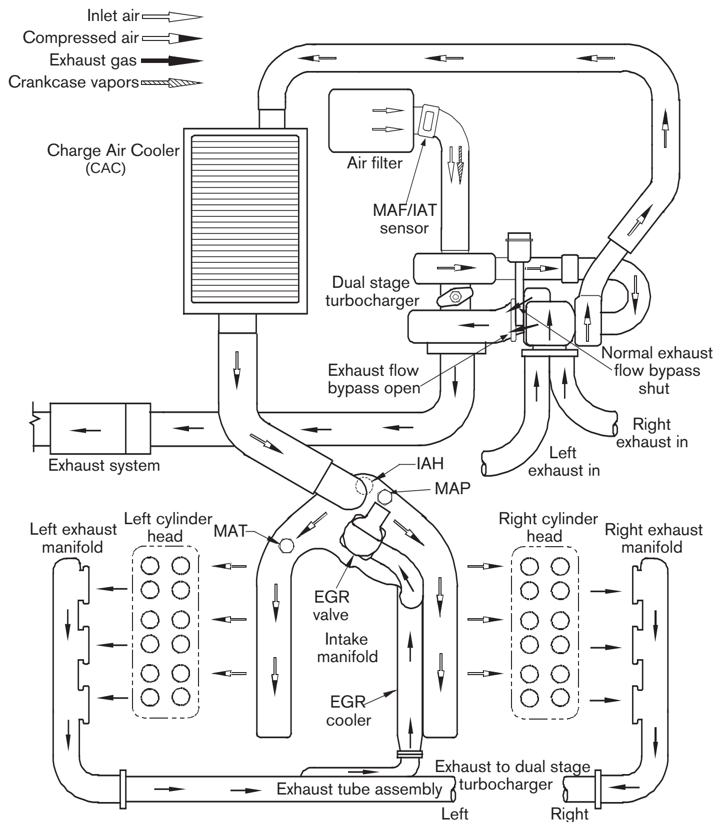
- The thermostatic switch (T-STAT SW) monitors evaporator core temperature to prevent freezing and to regulate cab temperatures.

- The low pressure switch (LPSW) prevents compressor damage in the event of a refrigerant leak.

- The high pressure cutoff Switch (HPSW) interrupts compressor operation in the event of high system pressures.

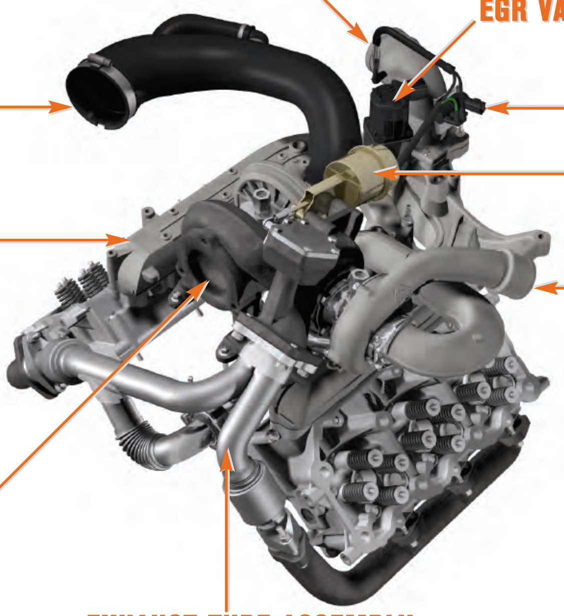
# Air Management System

- Regulated two-stage turbocharger
- Cooled exhaust gas recirculation
- Intake air heater




## System Features

- The Air Management System consists of the air filter, two-stage turbocharger, charge air cooler, intake manifold, Exhaust Gas Recirculation (EGR) cooler and EGR valve. The mass air flow sensor, the intake air temperature sensor, the manifold air temperature sensor, the manifold absolute pressure sensor, and the EGR valve position sensors within the EGR valve are all inputs from the system to the ECM. The ECM controls the system through the EGR valve, and the turbocharger boost control solenoid.




## System Operation

- The VT 275 uses a regulated two-stage turbocharger to boost the volume of air flowing into the cylinders. The system consists of two turbochargers with exhaust flow through the units controlled by the turbocharger boost control solenoid. The smaller of the two turbochargers is identified as the high-pressure turbocharger and is sized to provide boost for low to medium speeds. The larger turbocharger is the low-pressure turbo and is sized to work in tandem with the high-pressure unit to provide the boost and air flow needed for high-speed, high-load engine conditions.

- Air passes through the air filter element and the mass air flow sensor to enter the compressor of the low-pressure turbocharger. Air that leaves the low-pressure compressor flows through the crossover tube to the compressor inlet of the high-pressure turbocharger. Air from the compressor goes to the Charge Air Cooler (CAC).

- The CAC is mounted in front of the radiator. The cooler is an air-to-air heat exchanger that uses airflow to remove heat energy from the pressurized intake charge. Reducing the temperature of the air increases the charge density, which results in a more efficient engine with quicker engine response and reduced emissions.

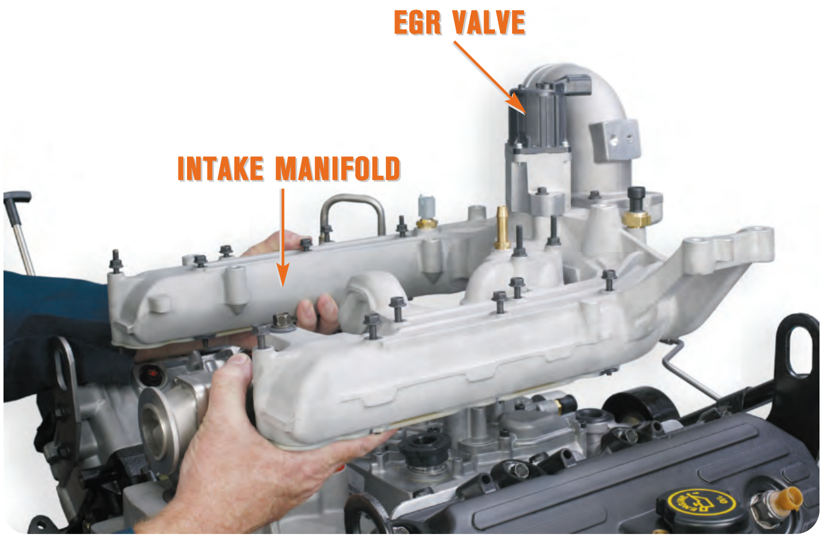
- After the CAC, the air flows through piping to the intake manifold where it is distributed to the cylinders.

- Exhaust flow from the cylinders exits the exhaust manifolds and spools up the high-pressure turbine. The exhaust passes through the high-pressure turbine and enters the low-pressure turbine. The exhaust gases then exit the turbine and flow out the exhaust system.

- A bypass valve controls the exhaust flow through a passage that allows a portion of the exhaust to bypass the high-pressure turbine and go directly to the low-pressure turbine. Part of the exhaust gas that leaves the left bank exhaust manifold is diverted to the EGR cooler. Heat energy is removed from the exhaust while in the cooler and transferred to the engine's coolant. The cooled exhaust gases then flow through a short internal passage in the intake manifold to the EGR valve. The EGR valve meters a portion of the cooled exhaust gases into the intake manifold where the exhaust displaces a portion of the fresh air charge.

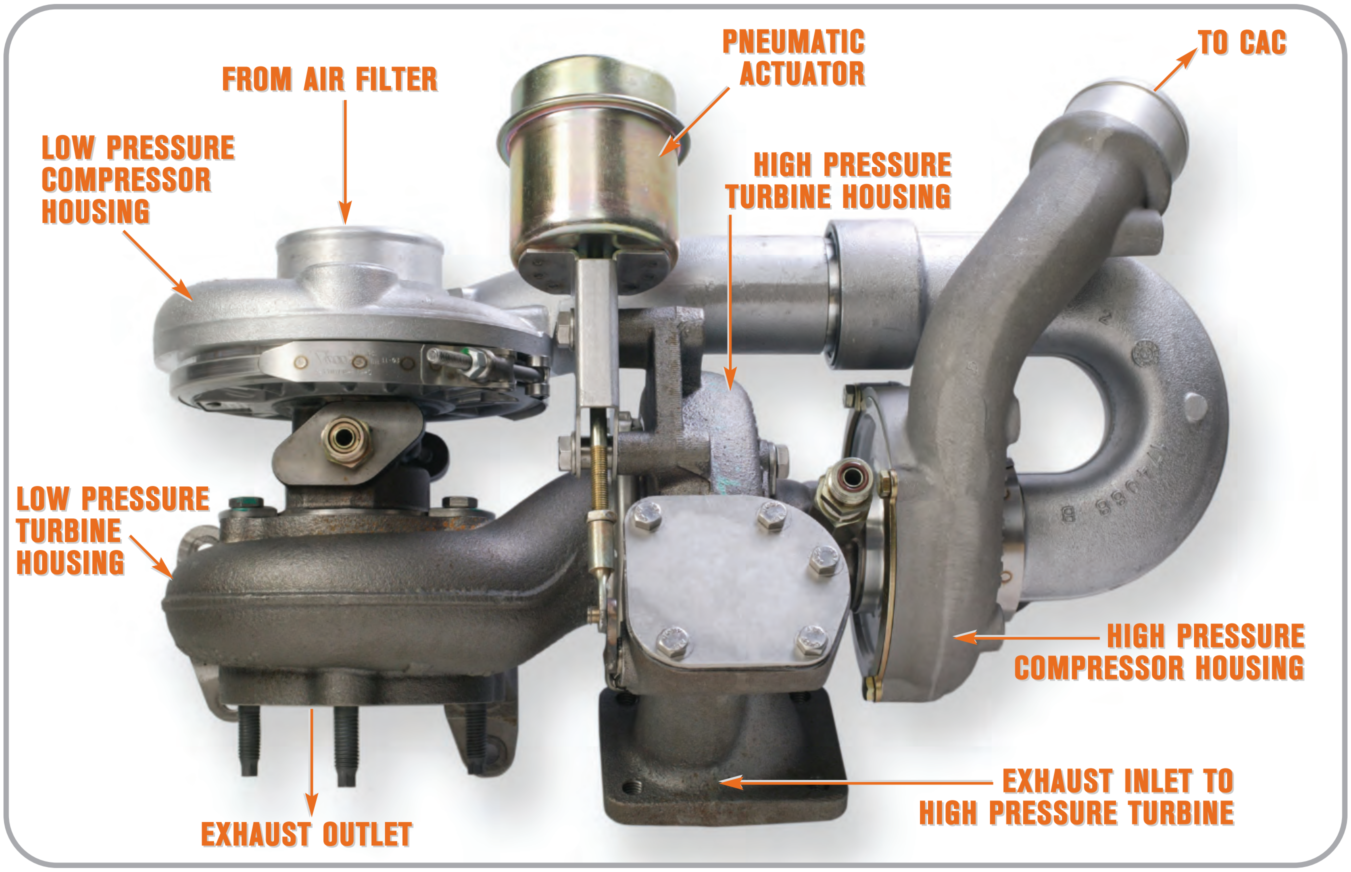

## Air Filter Restriction Gauge

- The filter restriction gauge is mounted on the air filter housing. The gauge allows the operator to check the condition without removing the filter. The restriction gauge can be reset by pushing the yellow button on the end.
- **Note:** The filter restriction gauge bellows will lock in position if restriction exceeds 26 inches of water. The filter should be replaced and the gauge reset.
- The filter element should be replaced if restriction passes 12.5 inches of $H_2O$ when tested at high-idle, no-load with a magnehelic gauge.




## Intake Manifold

- The intake manifold directs air from the charge air cooler to the intake ports in the cylinder heads. The manifold also provides an internal passage for exhaust gases from the EGR cooler to reach the EGR valve. Exhaust gas will flow into the intake manifold and mix with the intake charge when the EGR valve is open and the exhaust backpressure is higher than the boost pressure.
- The manifold has an additional internal passage for coolant from the EGR cooler to return to the front cover.




## Two-Stage Regulated Turbocharger

- The dual turbocharger consists of two turbochargers in series. The high pressure turbocharger is the smaller unit and is configured to provide boost at low speeds and loads. The low pressure turbo is the larger turbocharger and is configured to provide boost at higher speeds and loads.

**Exhaust Flow**

- Exhaust flow from the cylinders enters the turbine housing of the high-pressure turbocharger and causes the high-pressure turbine and compressor wheel to spin. Exhaust then exits the high-pressure turbo and enters the low-pressure turbine housing, causing the low-pressure turbine and compressor to spin.

**Intake Flow**

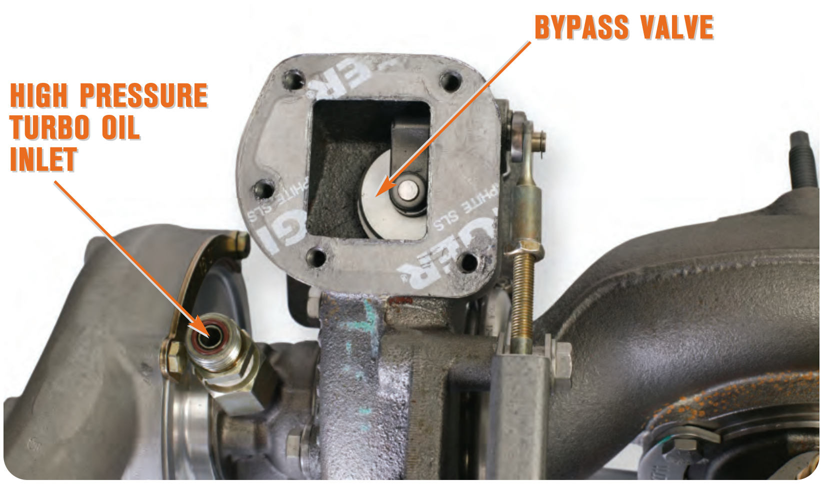
- Fresh airflow starts at the inlet of the low-pressure compressor housing, flows from the low-pressure compressor to the high-pressure compressor inlet and then exits directly to the charge air cooler piping.

**Operation**

- During operation, the high pressure turbo provides most of the boost at low speeds and light loads. as speed and load increases the low pressure turbo begins to provide the increased airflow.

- Under certain conditions the ECM can modify the air flow through the turbocharger by commanding the boost control solenoid (BCS) closed. When the BCS is closed, boost pressure builds in the pneumatic actuator, and when boost is sufficient, the actuator will open the bypass valve and divert some of the excess gas flow directly to the low pressure turbine.

- The high pressure turbocharger results in improved response and higher low speed boost capability providing improved low speed engine torque. The compounding capability of the two turbos in the mid range results in increased power, fuel efficiency and the ability to maintain power at higher altitudes. The larger compressor is capable of providing the airflow requirement without sacrificing the efficiency of the engine.

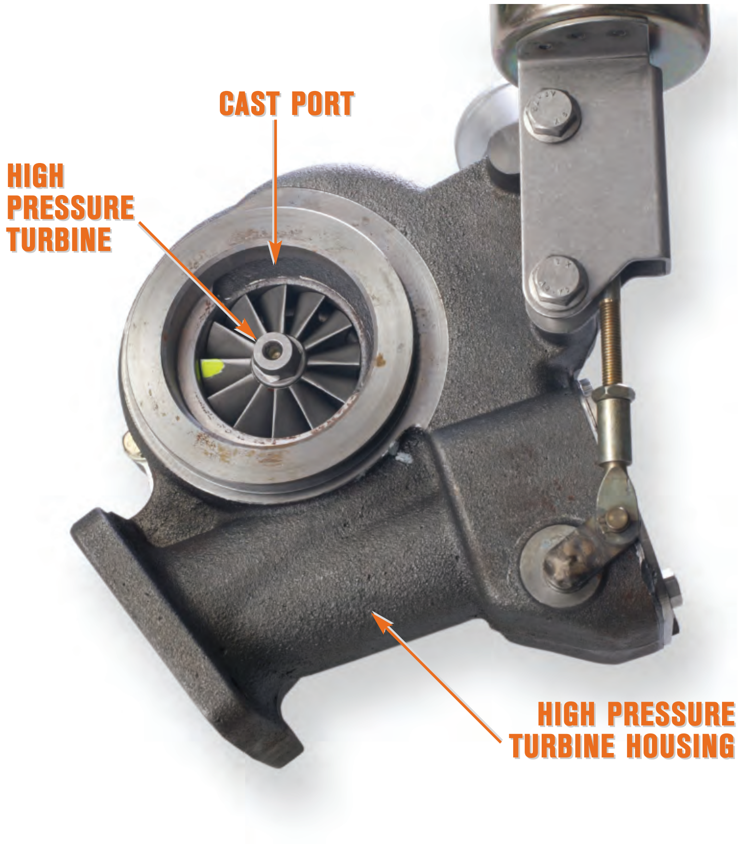



## Exhaust Bypass Valve

- The path that exhaust takes through the twin turbochargers is affected by the position of the exhaust bypass valve located under the metal plate on the top of the high-pressure turbine housing. With the bypass valve open, a portion of the exhaust enters the low-pressure turbine housing directly, bypassing the high-pressure turbine.

## Diverted Exhaust Gas Flow

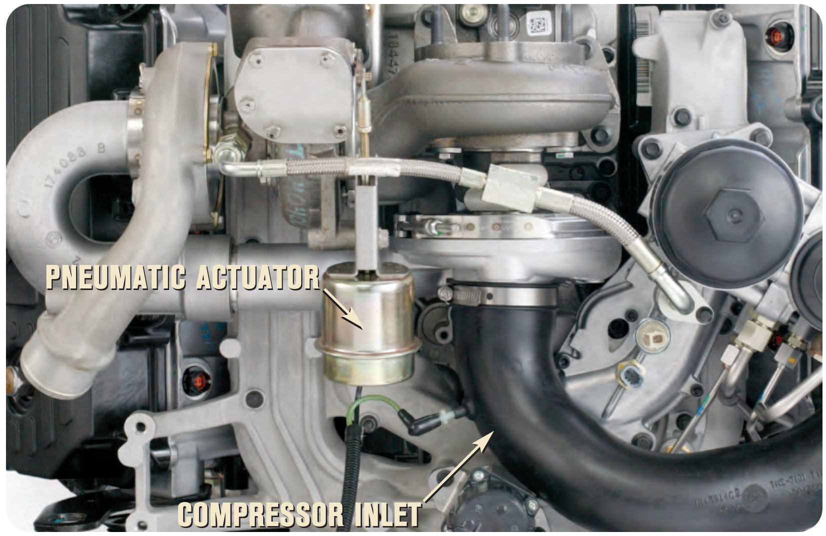
- With the bypass valve open, a portion of the exhaust gases bypass the high-pressure turbine. The gases pass through the bypass valve opening and through a port cast into the high-pressure turbine housing. The exhaust flow exits at the inlet to the low-pressure turbine.

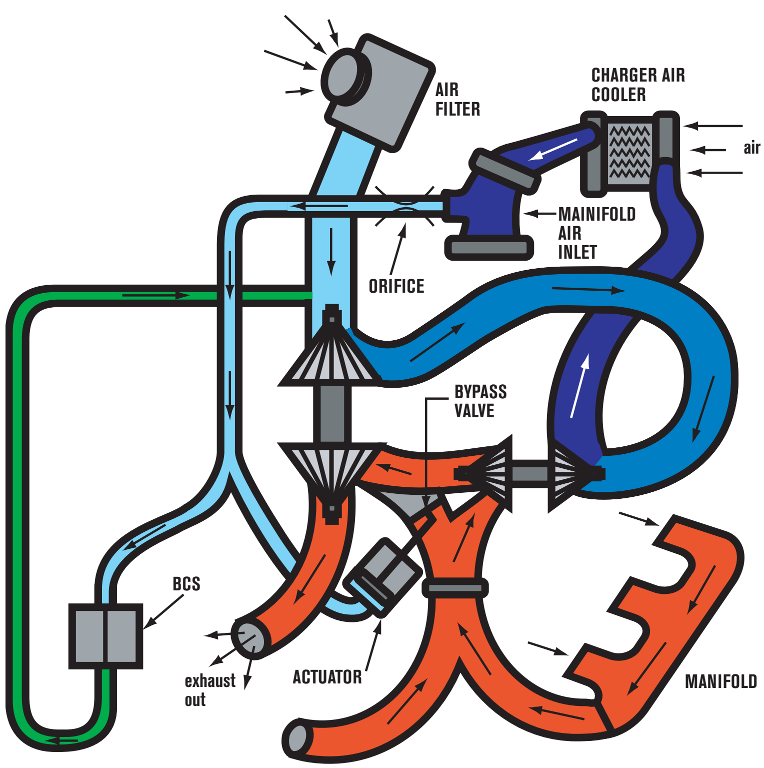


## Turbocharger Actuator

- The pneumatic actuator for the bypass valve receives intake manifold boost pressure from the intake elbow through a plastic tube. When the Pulse Width Modulated (PWM) signal to the boost control solenoid is 100%, the valve is open, and the boost pressure is vented to the inlet duct. With boost vented, the pneumatic actuator will be in the relaxed position.

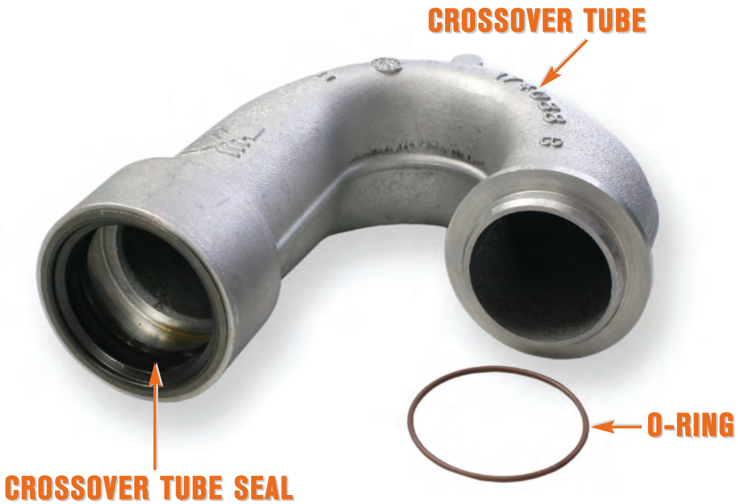
- When conditions occur that would result in higher boost pressure than desired, the ECM reduces the PWM signal to 0%. The low signal causes the valve to close, boost builds in the actuator, and if boost is high enough, the actuator opens the diverter valve.




## Actuator Line Routing

- The ECM controls the venting of the actuator through the Boost Control Solenoid (BCS). Proper operation of the pneumatic actuator is dependent on the routing of the pneumatic lines. The actuator is connected through the black plastic tube to the rubber tee at the intake manifold elbow. The rubber tee at the intake manifold elbow is also connected to the BCS through a black plastic tube. The BCS is then connected to atmospheric pressure in the turbocharger inlet duct with a green plastic tube. When the BCS is open, the pressure in the black tube is vented to atmosphere through the green tube. When the BCS is closed, pressure in the manifold will build in the actuator.



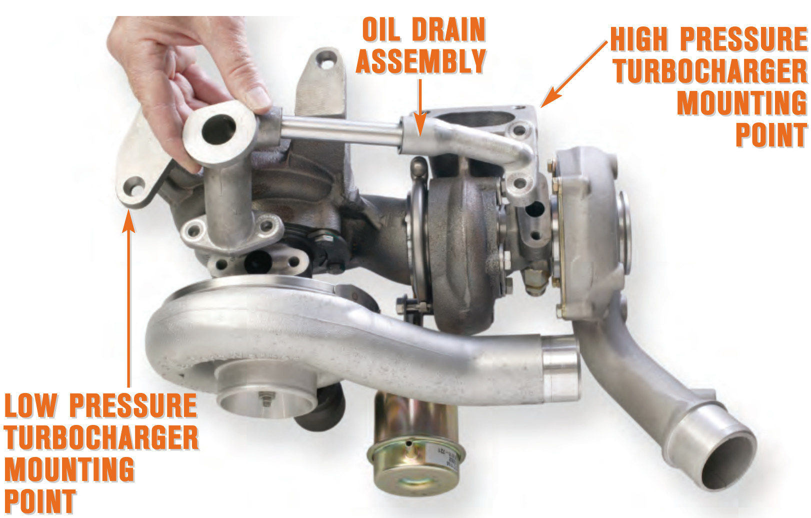

## Turbocharger Crossover Tube

- Air from the low-pressure turbocharger compressor outlet is routed to the high-pressure turbocharger compressor inlet through the crossover tube. The crossover tube is sealed at the inlet of the high pressure turbocharger with an O-ring and at the low pressure compressor discharge with a press-in seal. If the crossover tube is removed, the seal and O-ring must be replaced. The Turbocharger Crossover Seal Remover/Installer (ZTSE4676) is required to remove and replace the seal.

## Turbocharger Mounting

- The turbocharger is mounted to the engine at two points. The low-pressure turbine housing is bolted to the high-pressure pump cover and the high-pressure turbine housing is bolted to the exhaust tube assembly. The two turbochargers are connected by the turbine-mating V-band clamp that allows for minor angular variances in the mounting surfaces. In addition, the oil drain tube assembly is made of three pieces, and allows for changes in the mounting points.

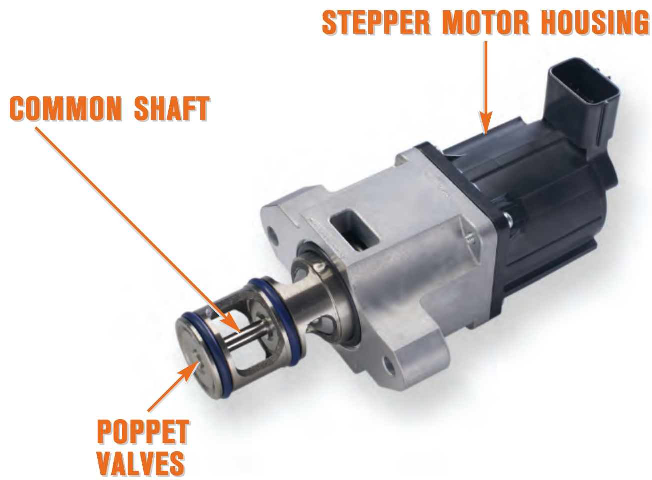
- **Note:** Removal of the turbocharger will change the relationship of the two mounting points and require that a special mounting and torque sequence be used. See the Service Manual for further details.

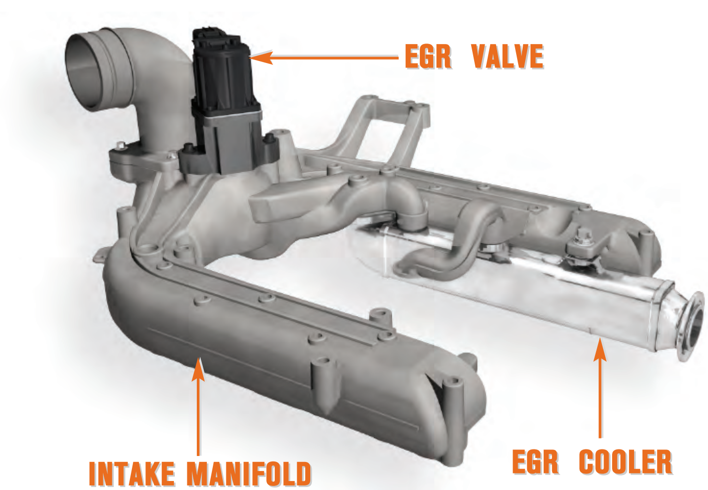


## EGR Valve

- The EGR valve consists of a stepper motor and two poppet valves connected by a common shaft. When inserted into the manifold, the valve aligns with the port in the intake manifold that connects to the EGR cooler. When the valve is open, exhaust gases flow from the cooler and enter the manifold through the open poppet valves.

- The EGR valve opens when the ECM commands the EGR drive module to position the valve. The drive module then sends signals to the stepper motor to produce armature rotation. When the armature turns, the poppet valves move off their seats.



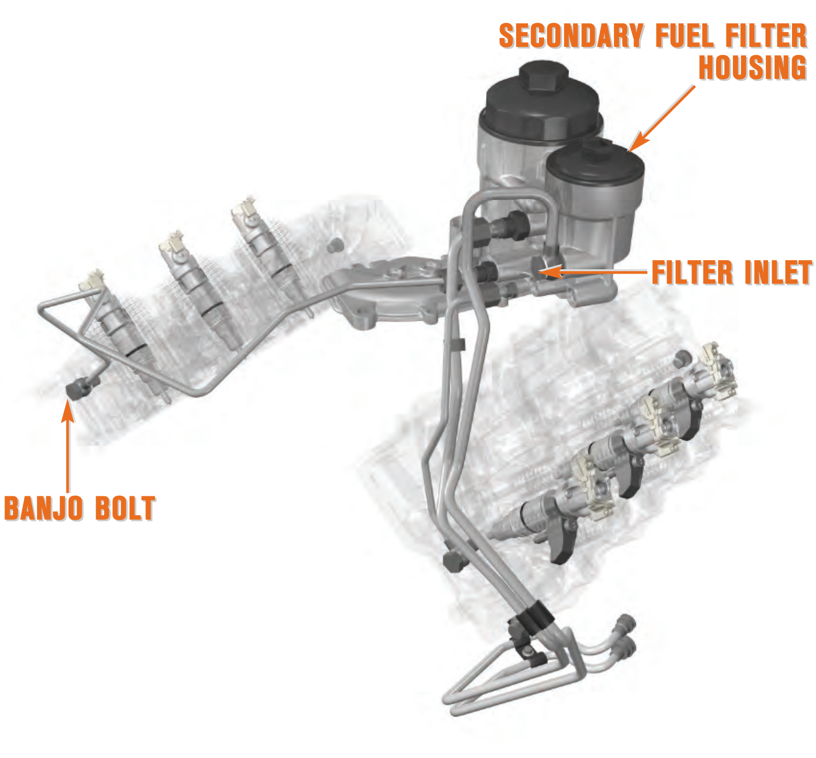

## EGR Flow

- The ECM-controlled Exhaust Gas Recirculation (EGR) valve meters cooled exhaust gases in the intake charge air to reduce Oxides of Nitrogen (NOx) emissions. Exhaust gases from the exhaust pipe assembly are directed to the EGR cooler. Gases flowing through exhaust passages in the cooler lose heat energy to engine coolant flowing through the coolant passages in the cooler. The cooled exhaust gases travel from the cooler into a passage cast into the intake manifold. The EGR valve fits into the exhaust passage and is sealed with two O-rings.

- When the EGR valve opens, exhaust gases flow into the intake charge air from both the top and bottom of the passage, providing better distribution of the gases.

# FUEL SUPPLY SYSTEM

- Chassis-mounted electric fuel pump
- Water-in-fuel detection
- Electric fuel heater
- Chassis-mounted primary fuel filter
- Engine-mounted secondary fuel filter element

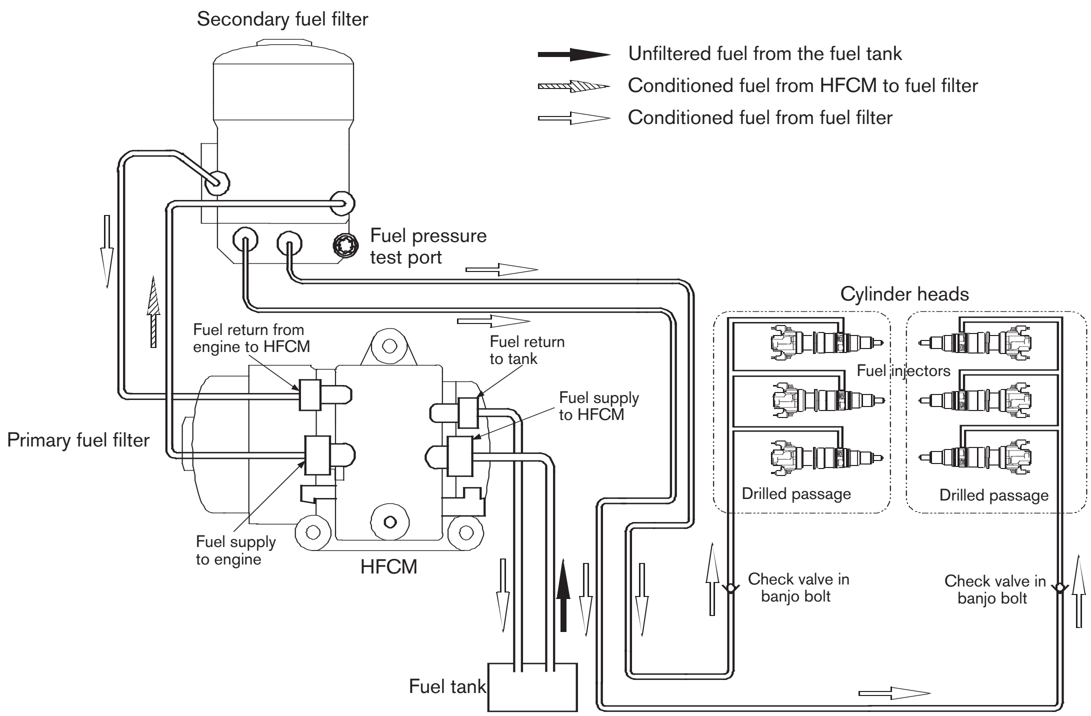



## System Features

- The VT 275 uses a chassis-mounted electric fuel pump. The pump is mounted with the fuel heater and primary filter in the Horizontal Fuel Conditioning Module (HFCM). The fuel pump relay, which is located in the Power Distribution Center (PDC), is controlled and monitored by the ECM.

  Water separated from the fuel in the HFCM is detected by the Water-in-Fuel (WIF) sensor. The sensor is an input to the ECM, which controls the WIF dash lamp through the CAN 1 link.

- The HFCM has both an electric fuel heater and a temperature controlled recirculation valve. The valve regulates recirculation through the system to assist the heater in warming the fuel.
  The secondary filter and fuel pressure regulator valve are mounted on the engine.



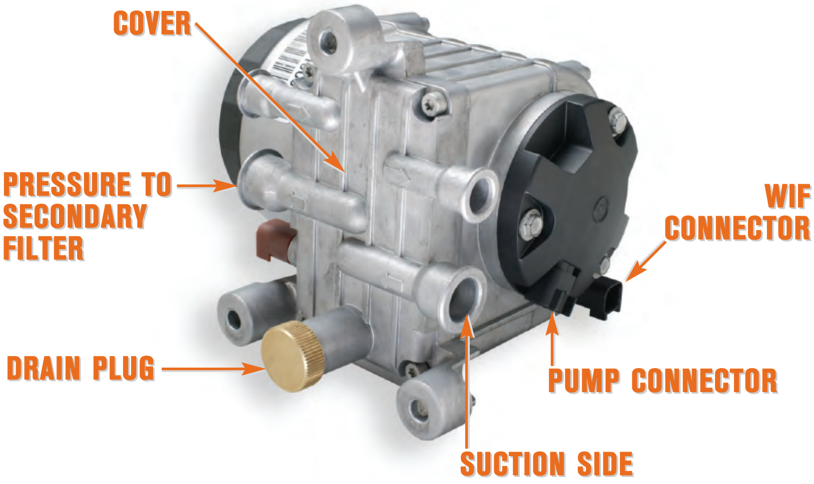

## System Operation

- The fuel pump, fuel heater, pressure relief valve, Water-in-Fuel (WIF) sensor, recirculation valve, water drain and primary filter are all located in the Horizontal Fuel Conditioning Module (HFCM). The secondary filter, pressure regulator and banjo bolts are mounted on the engine.

- The ECM uses the fuel pump relay to activate the fuel pump at key-on. Fuel drawn from the tank contacts the electric fuel heater, passes through the one-way check valve, and enters the filter where water is separated. Fuel passes through the filter media and enters the pump inlet while water settles to the bottom of the housing until the level of water activates the WIF sensor. Pressurized fuel from the pump is routed to the engine-mounted filter. Fuel flows through the filter, then through individual steel lines to the cylinder heads. Each line is attached to the cylinder head with a banjo bolt. Each bolt contains an orifice and a check valve. Once in the head passages, fuel is distributed to the injectors.

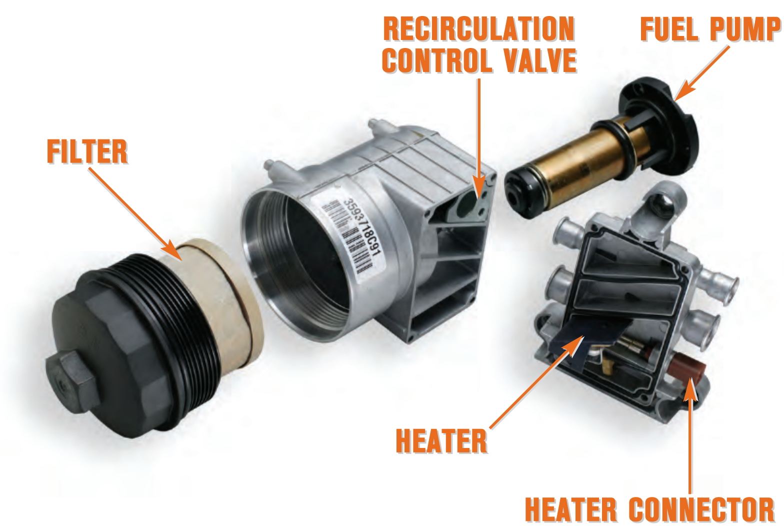
- Fuel is exposed to the pressure regulator in the secondary filter housing. The regulator returns excess fuel to the HFCM where it is directed to either the fuel tank or the pump inlet, depending on fuel temperature.

- Both filter elements push open a fuel passage valve when inserted into their respective housings. Without the filter in place, fuel will not flow through the system. The engine could start without the filter, but will not run properly.




## Horizontal Fuel Conditioning Module (HFCM)

- The HFCM is chassis mounted on CF500 and CF600 trucks. The module is mounted on the inside of the left frame rail behind the cab. The module is mounted with the cover/mount facing the rail. The module contains the fuel pump, fuel filter, WIF sensor, heater and the recirculation control valve. The water drain valve and all fuel connections are mounted on the module cover. The lower connection on the pump end of the module is the suction side to the tank and the lower connection on the filter side is pressure to the engine-mounted filter. The drain valve is accessible through a hole in the frame rail.



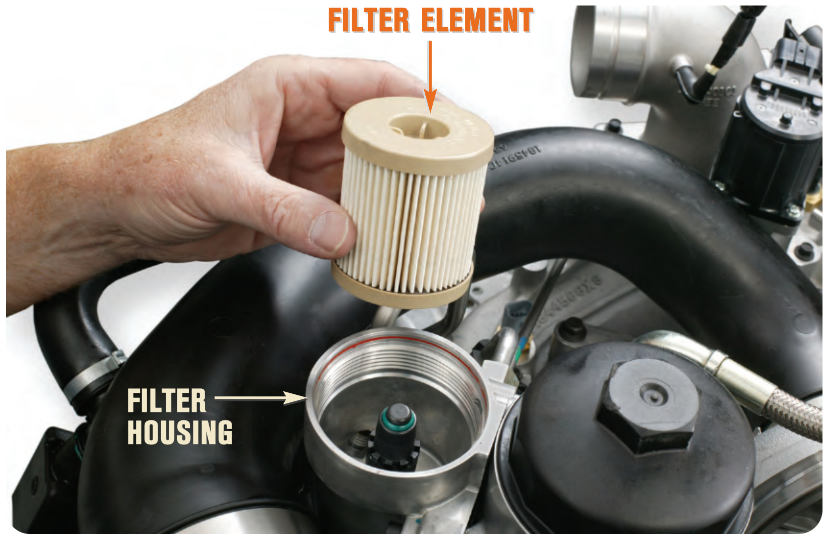

## Primary Fuel Filter and Fuel Heater

- The HFCM contains a 10-micron primary fuel filter. The replaceable filter element opens a fuel passage in the end of the pump when the filter is inserted into the housing. Without the filter in place, sufficient fuel will not pass through the system for correct engine operation.

- Fuel from the tank is exposed to the electric fuel heater as it enters the HFCM module. The heater is controlled by the key switch start/run circuit and is self-regulating. The heater comes on when fuel temperature is below 50°F (10°C) and goes off at 80°F (27°C). Return fuel from the engine is recirculated to the suction side of the filter until the fuel temperature is sufficient to cause the recirculation valve to close. After the valve closes, all returned fuel is directed back to the tank.

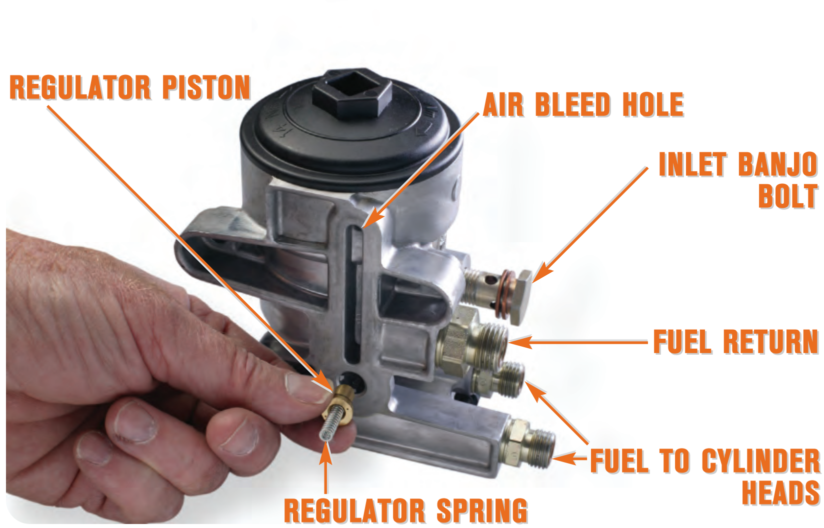
## Secondary Fuel Filter

- The secondary filter is a top-loaded, engine-mounted fuel filter. Fuel enters the filter housing under pressure from the fuel pump through the inlet line and banjo bolt. Fuel passes through the 4-micron filter element and through the filter stand pipe to enter the two fuel lines to the cylinder heads.
- The filter standpipe contains a valve that is opened by the filter when it is installed in the housing. Without the filter in place, sufficient fuel will not pass through the system for correct engine operation.



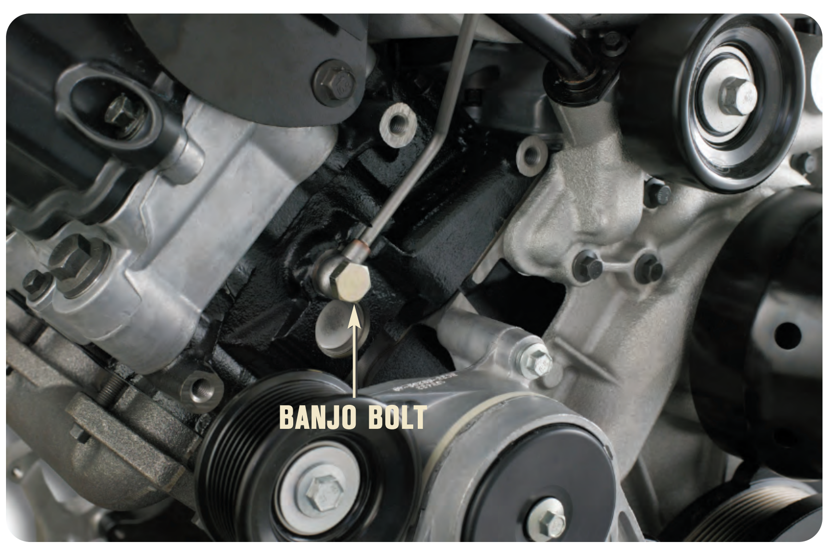

## Fuel Pressure Regulator Valve

- The fuel pressure regulator is located between the fuel filter housing and the oil filter housing. Fuel pressure pushes the regulator piston against the regulator spring. When fuel pressure exceeds 45 psi, the regulator begins to open and fuel passes back to the horizontal fuel conditioning module.
- The fuel filter housing contains an air bleed to allow any air in the system to pass back to the fuel tank.



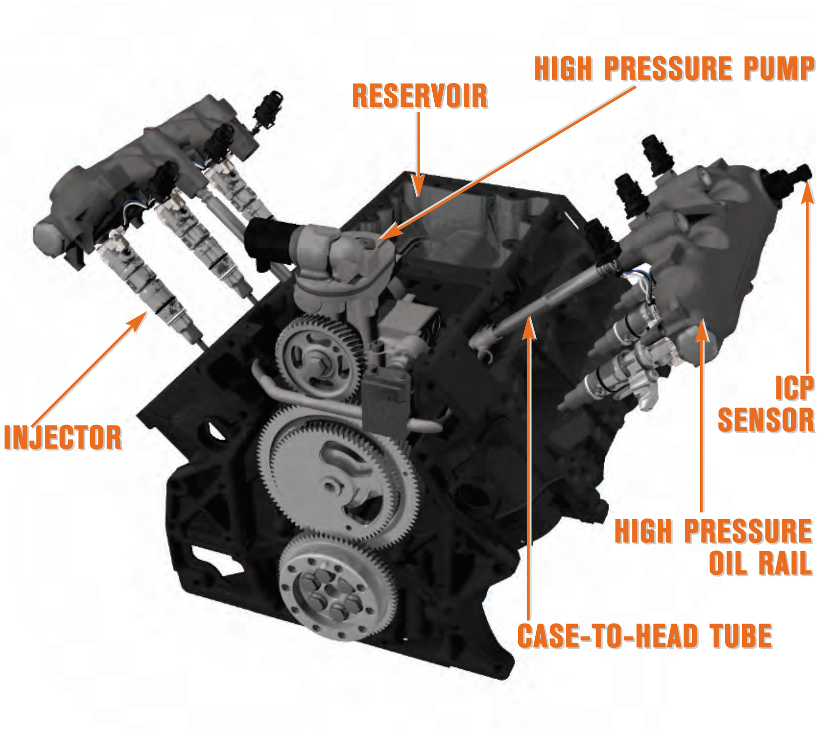

## Fuel Inlet Check Valves

- Fuel passing through the filter enters steel lines that lead to the right and left bank cylinder heads. Each line is attached to the cylinder head with a banjo bolt that contains a one-way check valve and a small orifice. The orifice and check valve minimizes pressure pulses in the fuel rail, resulting in smoother delivery of fuel to the injectors.
- Each fuel line fitting is sealed to the cylinder head by two copper gaskets that must be replaced if the bolt is removed.



# FUEL MANAGEMENT SYSTEM

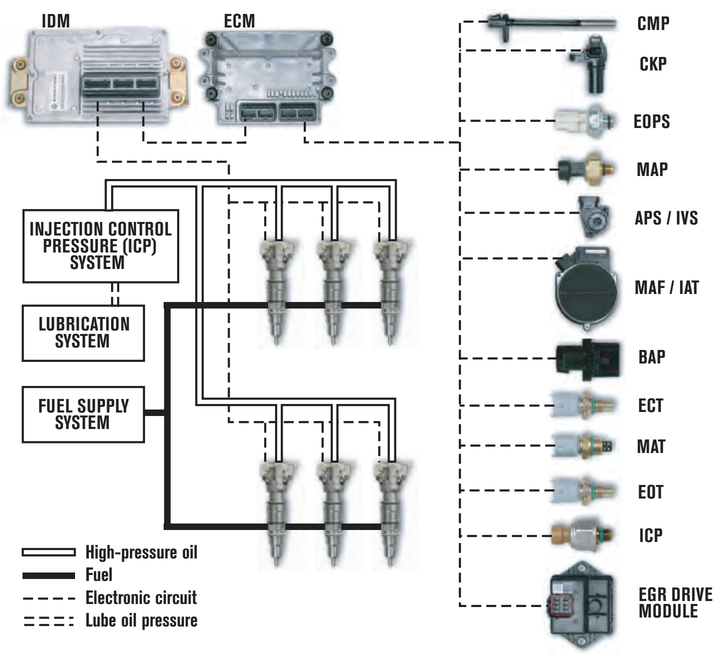
- Electro-hydraulic injectors
- Crankcase integrated high-pressure reservoir
- Gear driven rear mounted high-pressure pump
- Rail mounted ICP sensor




REAR OF ENGINE

## System Features

- The VT 275 engine uses electro-hydraulic injectors. The injectors use lube oil under high-pressure to provide the mechanical force needed to inject fuel into the combustion chamber.
- The reservoir for the high-pressure pump is cast into the front of the crankcase Vee. The reservoir is supplied by the lube oil pump and is used to provide a constant supply of oil to the high-pressure pump.
- The high-pressure pump is mounted at the rear of the crankcase Vee and is gear driven off the rear gear train.
- The Injection Control Pressure (ICP) sensor is mounted on the right bank high-pressure rail.




## System Operation

- The high-pressure oil system is composed of the reservoir, high-pressure pump, injection pressure regulator, rear branch tube, case-to-head tubes, high-pressure rails and the injection control pressure sensor.

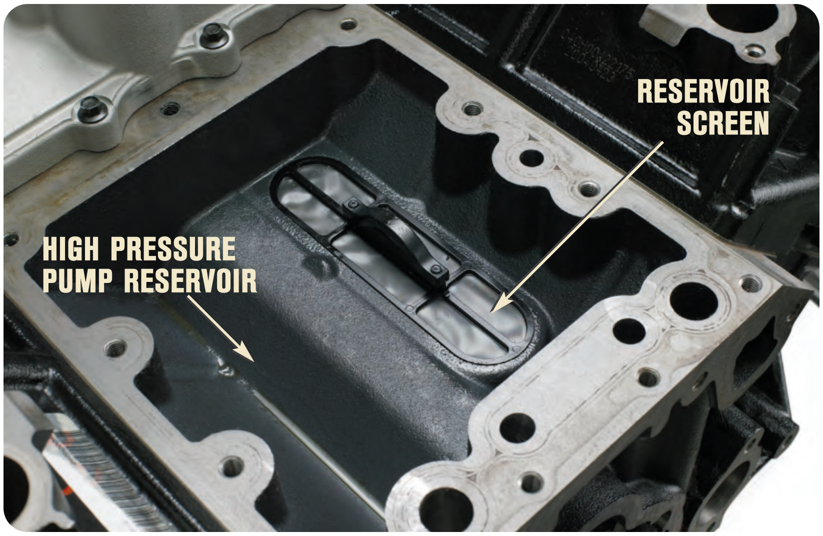
- The crankshaft driven lube oil pump supplies the reservoir. The reservoir stores the oil under low-pressure to supply the high-pressure pump. The Vee-configured, four-piston high-pressure pump is mounted at the rear of the crankcase Vee and is driven off the rear gear train. The pump is a positive displacement pump capable of high-pressures. Oil discharged by the pump enters the rear branch tube. The branch tube serves to transfer the oil to the case-to-head tubes.

- The high-pressure rails are mounted above the injectors. Oil from the pump enters each rail through a case-to-head tube and a check valve built into the port plug. Oil from the rail can then enter the top of the injector.

- As each injector spool valve opens, oil pushes the intensifier piston down, pressurizing the fuel below the plunger. Fuel pressure acts on the bevel of the nozzle needle. When the force on the needle exceeds the Valve Opening-Spring Pressure (VOP) the needle lifts and forces fuel into the combustion chamber.

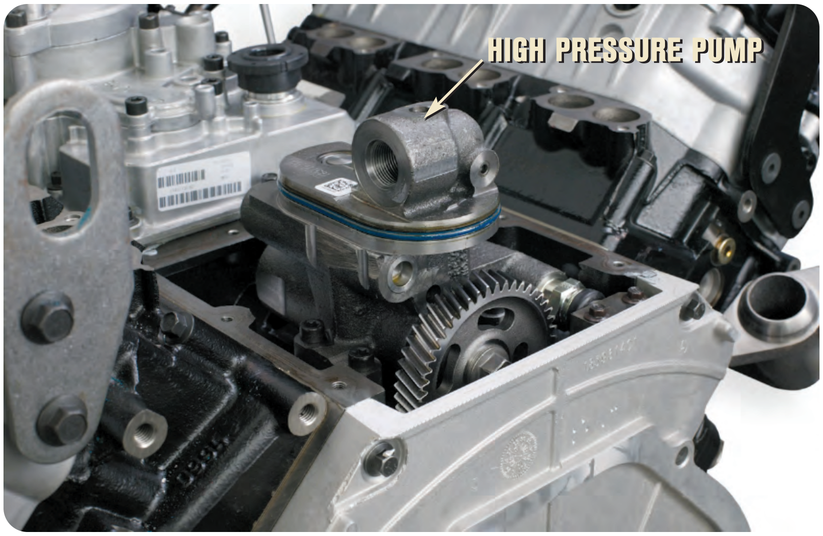
- When the spool valve closes, pressure pushing on the intensifier piston is vented. With pressure on the plunger relieved, injection stops and low-pressure fuel from the fuel supply system refills the barrel and plunger area of the injector.

- The ICP sensor allows the ECM to monitor the injection control pressure. The ECM commands the injection pressure regulator to vary the pressure according to operating conditions.



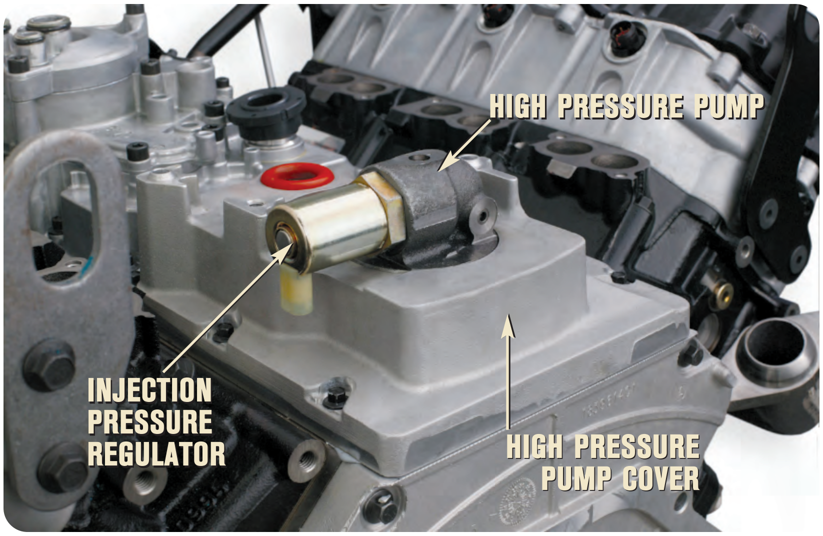

## Oil Reservoir

- The reservoir for the high-pressure pump is cast into the front of the crankcase Vee. The reservoir receives oil under pressure from the crankshaft driven lube oil pump. The reservoir holds approximately one quart (one liter) of oil.
- A raised cavity in the bottom of the reservoir feeds oil from the reservoir to the high-pressure pump.
- A 150-micron screen in the oil reservoir filters any large debris that may be in the oil before it reaches the pump.




## High Pressure Pump

- The high-pressure pump produces the injection control pressure. The pump is mounted under the pump cover at the rear of the crankcase and has four pistons arranged in a Vee configuration. The pump is gear driven off the camshaft gear. The pump aligns with an O-ring sealed passage that leads to the reservoir. Pump output is directed to the branch tube assembly through a quick disconnect adapter. The pump, which protrudes through the top of the pump cover, is sealed at the cover opening with an O-ring.

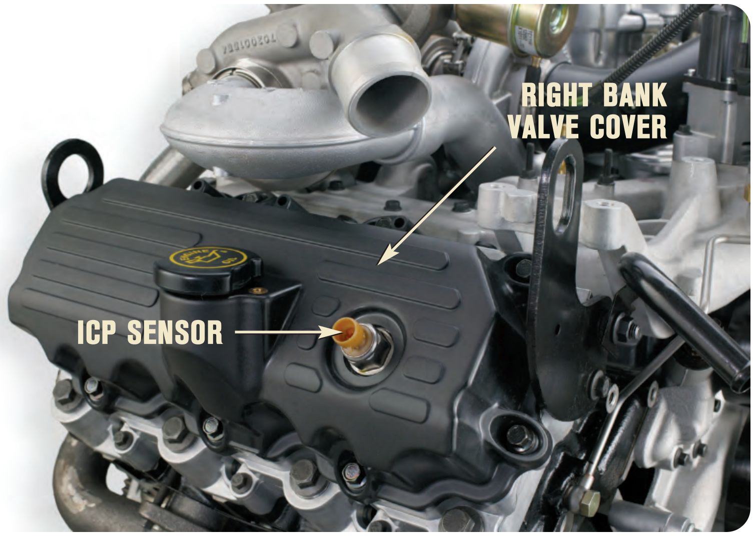



## Injection Pressure Regulator

- The Injection Pressure Regulator (IPR) mounts on the high-pressure pump.
- The pump moves more oil than the system requires, so excess oil is drained from the system to control the pressure. The ECM commands the IPR in order to increase or decrease the amount of oil drained from the system. The IPR coil swivels on the IPR so the connection can be positioned pointing down after the IPR is tightened.

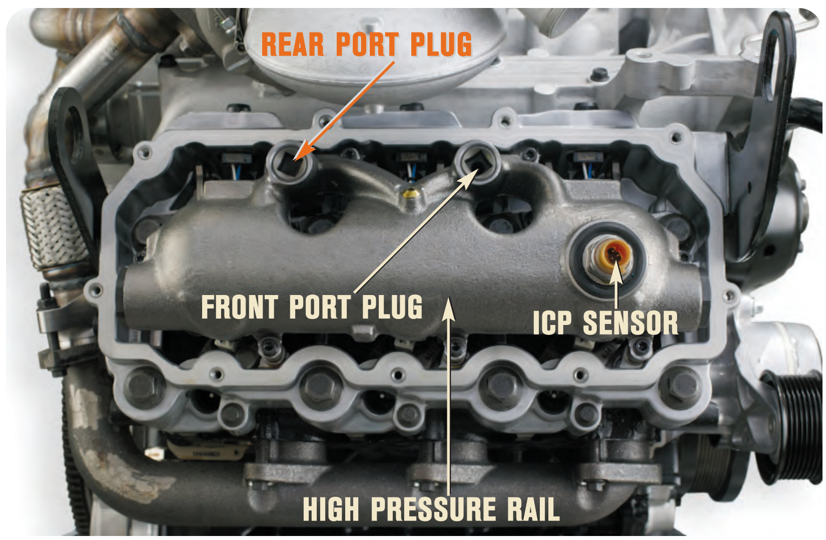
## Injection Control Pressure Sensor

- The Injection Control Pressure (ICP) sensor mounts on the right bank high-pressure rail but protrudes through the valve cover and is accessible without removing the valve cover.
- The sensor measures pressure in the rail and produces a signal that is sent to the ECM. The ICP sensor is the feedback device for the operation of the IPR. The ECM constantly checks the pressure to determine if the system is performing correctly. When the ECM detects variations, the IPR command is corrected to achieve the desired results.



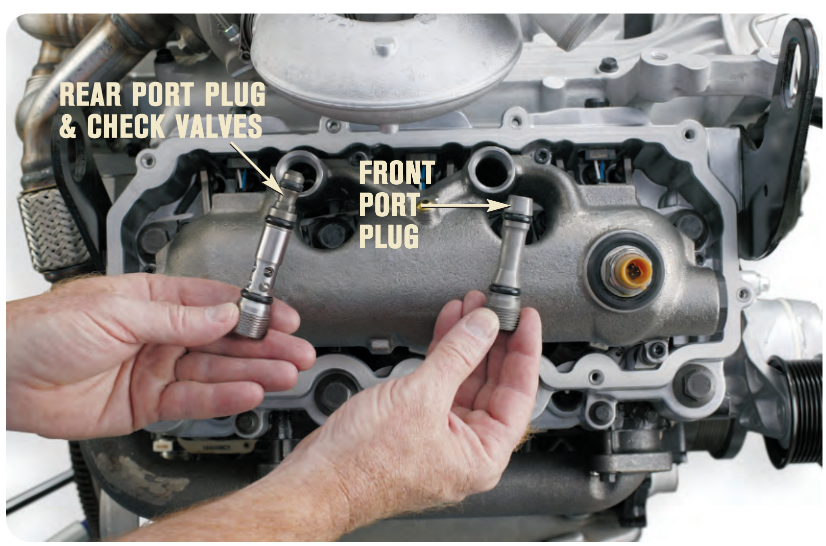

## High Pressure Oil Rail

- A high-pressure rail is mounted over each bank of injectors. The rail serves as a reservoir of high-pressure oil for use by the injectors. The rail is connected to each injector with a short tube that fits through the injector O-ring. The tubes have the ability to swivel to align with the injector openings.
- The rail does not need to be drained before removal.




## Port Plugs and Tubes

- There is one O-ring sealed case-to-head tube assembly for each bank of cylinders. The case-to-head tube connects the branch tube assembly in the tappet area to the rail through the rear port plug. The rear port plug contains a one-way check valve that dampens pressure pulsations caused by injector operation.
- The front port plug is used to block oil from leaking into the valve train area. Both port plugs must be in place for the engine to build ICP sufficient to start the engine.



# INJECTOR OPERATION

- Electro-hydraulic
- Two control coils
- Spool valve controlled inlet
- 48 volt operation
- short coil on-time
- self extracting clamps

### Fuel Injector Features

- The VT 275 fuel system uses electro-hydraulic injectors. The injectors utilize lube oil pressurized by the high-pressure pump to provide the mechanical force needed to inject fuel into the cylinders. Each injector has two coils.
- The IDM selectively signals the coils with 48 volts to control the position of the spool valve that directs oil flow into and out of each injector. After being positioned, the spool is held in position with residual magnetism. The coils draw 20 amps.
- No special tools are required to remove the injector from their bores. The injectors are self-extracted from their bore when the hold down clamp is removed.

## Spool Valve

- The open and close coils move the spool valve from side to side using magnetic force.
- The spool valve has two positions. When the valve is in the open position, oil flows from the high pressure oil rail into the injector. When the valve is in the closed position, oil drains from the injector back to the crankcase.

## Intensifier Piston

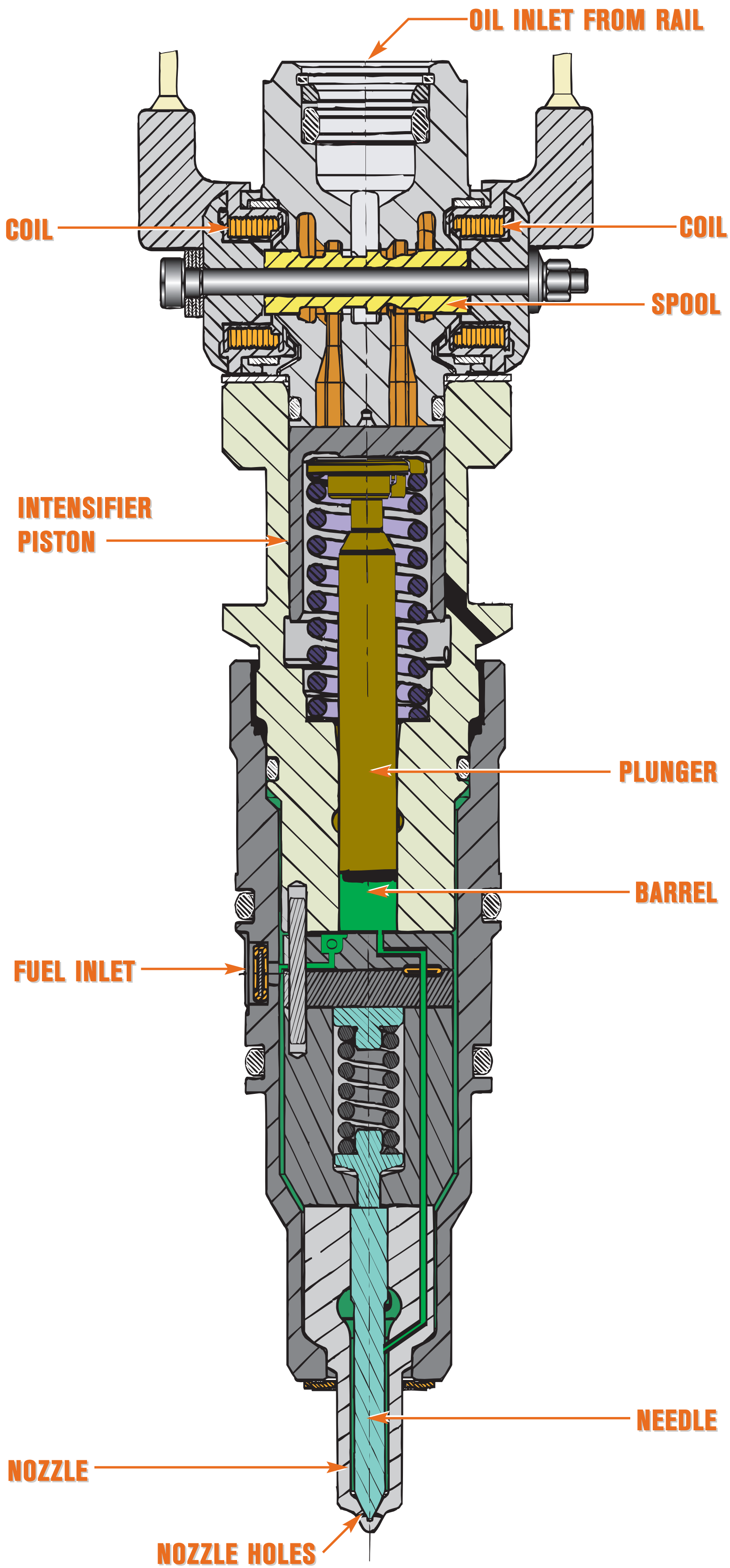
- Since the intensifier piston is approximately seven times greater in surface area than the plunger, the fuel pressure under the plunger is approximately seven times greater than the injection control pressure.

## Barrel & Plunger

- The barrel and plunger of the injector is where high fuel pressure is generated by the movement of the plunger.
- Plunger coating reduces the possibility of scuffing and poor performance.

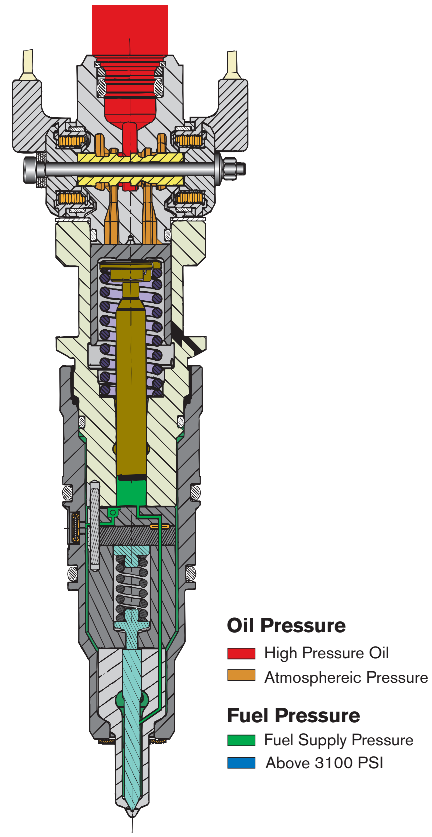
## Nozzle

- The nozzle needle opens when fuel pressure, pushing on the bevel of the needle, is greater than the spring pressure holding the needle closed. At that point, the needle lifts and fuel under high pressure passes through the nozzle holes.



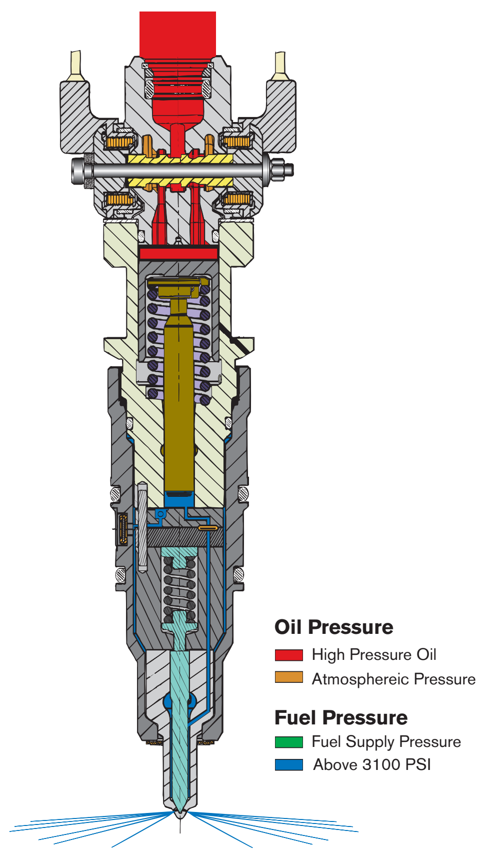
## Fill

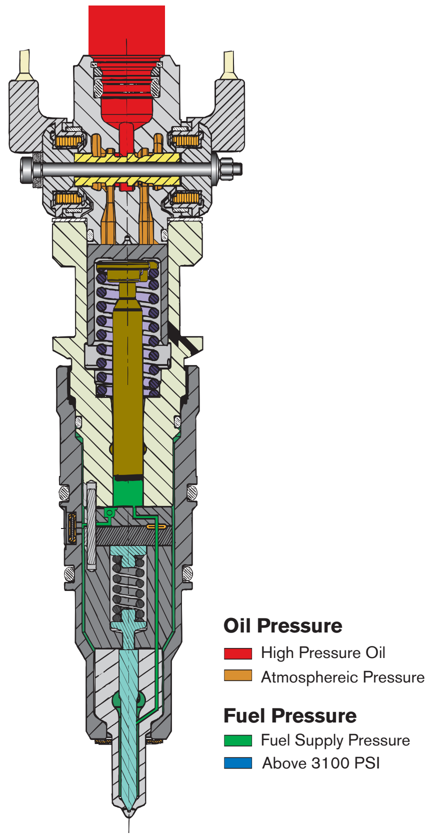
- During the fill stage, the spool valve is in the closed position. High pressure oil from the oil rail cannot pass through the spool valve.
- Low pressure fuel passes through the fuel inlet check valve and fills the plunger cavity.
- The needle control spring holds the needle on its seat so that fuel cannot enter the combustion chamber.




## Injection

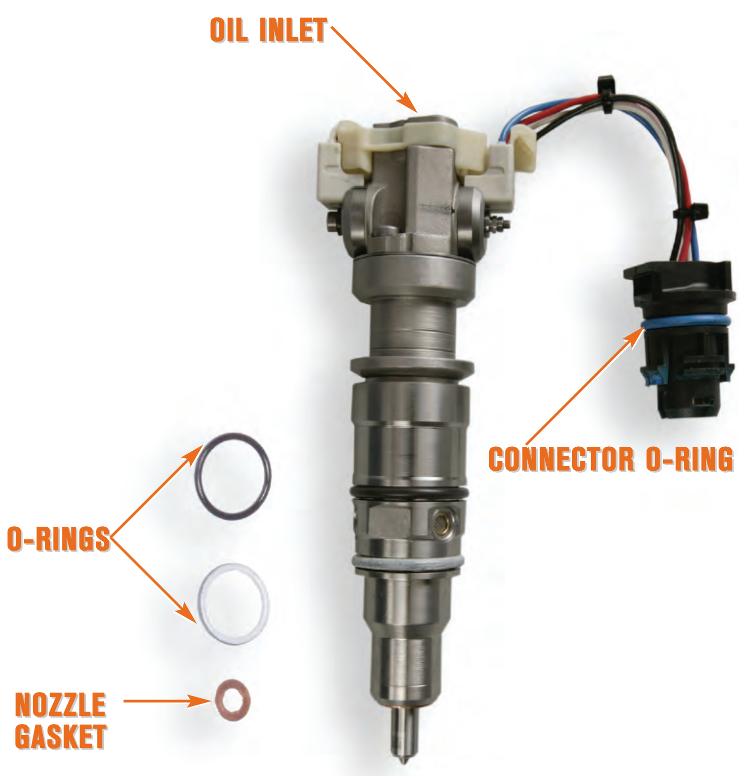
- The injector drive module energizes the open coil, and the spool valve moves to the open position. The Injector Drive Module turns off the current to the coil, but the spool remains in the open position.
- High pressure oil flows to the intensifier piston. Fuel pressure builds when the plunger moves downward. The fuel inlet check ball seats due to an increase in fuel pressure under the plunger.
- When fuel pressure rises above the valve opening pressure, the nozzle needle lifts off its seat and injection begins.






## End of injection

- When the injector drive module determines that the correct amount of fuel has been delivered, it sends a current to the close-coil of the injector. The spool valve closes, and high pressure oil flow into the injector stops.
- Oil above the intensifier piston flows past the spool valve through the exhaust ports out into the valve cover area. The intensifier piston and plunger return under spring pressure to the fill position.
- Fuel pressure under the plunger decreases until the nozzle needle control spring forces the needle back onto its seat and injection stops.

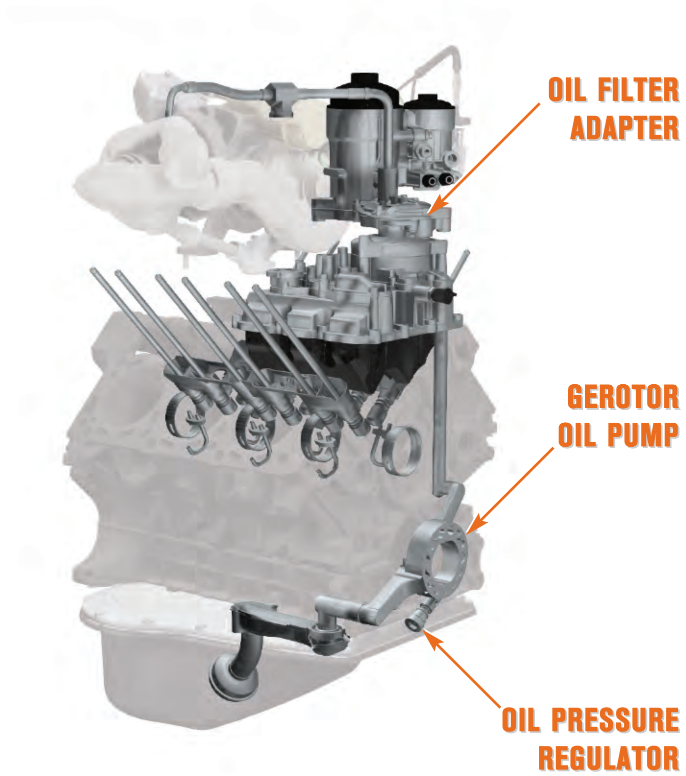



## Injector Sealing

- The injector has two replaceable O-rings on the outside of the body. These O-rings seal the fuel inlet area. In addition, the injector has a copper gasket where the nozzle passes through the cylinder head into the combustion chamber.
- The oil inlet o-ring is contained in the top of the injector. This o-ring can not be replaced.
- The injector has two coils with a single 4 pin pigtail lead that connects to the valve cover gasket pass-though connecter pigtail.

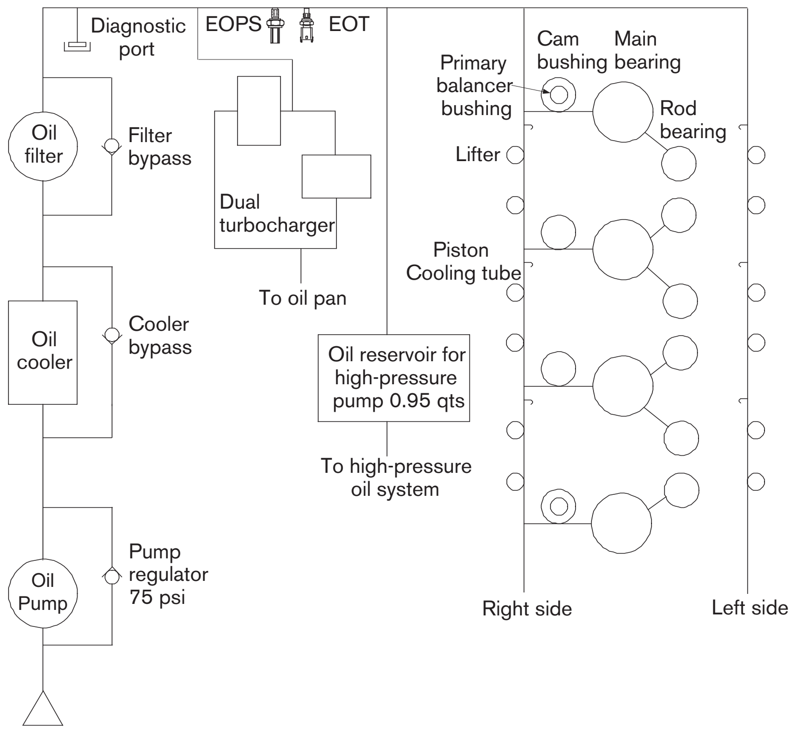
# LUBRICATION SYSTEM

- Crankshaft driven lube oil pump
- Integrated oil cooler
- External oil pressure regulator
- Easy access canister oil filter
- Piston cooling jets




## System Features

- The crankshaft driven oil pump is located behind the vibration damper and is integrated into the front cover.
- The oil pressure regulator valve is located in the front cover below the oil pump and is accessed by removing the pressure regulator end plug.
- The oil cooler is located under the oil cooler cover in the engine's Vee. The cooler occupies a portion of the space in the high-pressure reservoir.
- The oil filter is a canister style filter located on top of the engine.
- Oil spray through the piston cooling jets is used to reduce piston crown temperatures.




## System Operation

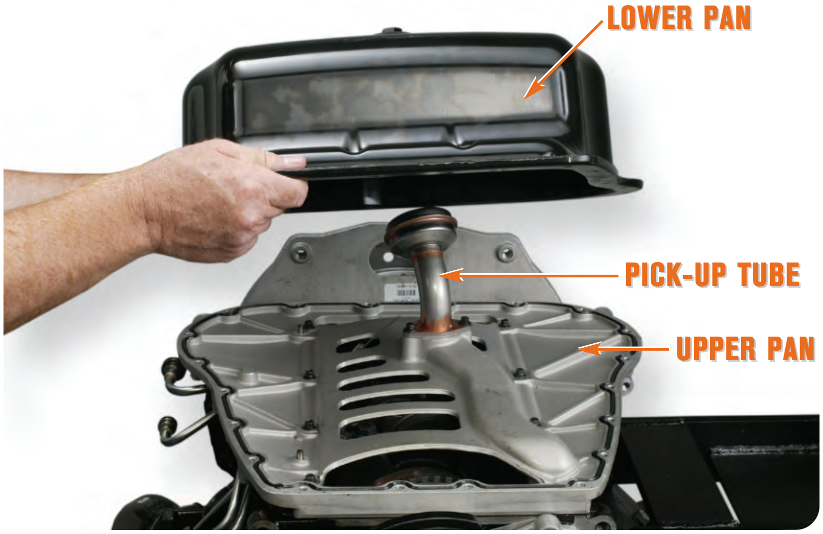
- Oil is drawn from the oil pan through the pick-up tube, upper oil pan, lower crankcase and the front cover passage that leads to the oil pump gear set. The oil is moved under pressure by the crank-driven gear set to the outlet port of the pump where pressurized oil is exposed to the pressure regulator valve. If the pressure is high, the excess oil is returned to the inlet side of the pump. Oil then enters the vertical passage in the crankcase that takes the oil to the oil cooler cover.

- Oil entering the oil cooler cover is directed to the cooler and oil cooler bypass valve. If the oil is cold and thick, the bypass allows oil to enter the filter without moving through the cooler. After passing through the cooler, oil enters the oil adapter assembly and is directed to the filter. The top of the filter standpipe contains the oil filter bypass valve, which allows oil to bypass the filter if the filter is restricted. After passing through the filter, oil returns to the cooler cover assembly and is directed to the high-pressure pump reservoir and the crankcase passages.

- Cooled and filtered oil enters two oil passages at the top of the crankcase. The right passage leads to the right bank oil galley where oil is directed to the crankshaft main bearings, camshaft, right bank lifters, and the right bank piston cooling jets. The left passage leads to the left bank oil gallery where oil is directed to the left bank lifters and cooling jets. Spray from the cooling jets removes heat from the crown of the pistons.

- Lubrication of the connecting rod bearings is through drilled passages from the main bearing journals to the rod journals.

- Each lifter directs oil up the hollow push rod to the rocker arm, where oil from the push rod splash-lubricates the rocker arm and valve stem. The rear gear train is lubricated by splash oil thrown off the rear main bearing and drain oil from the injection pressure regulator.

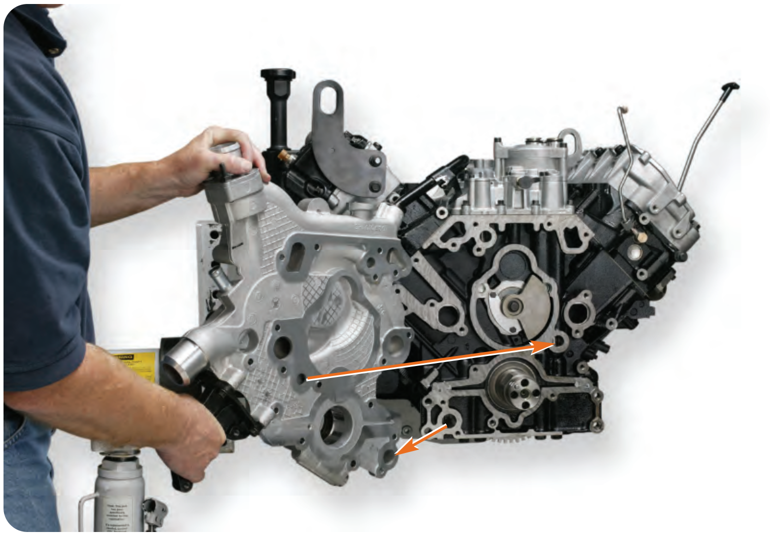



## Upper and Lower Oil Pan

- The VT 275 uses a two-piece oil pan. The upper oil pan is cast aluminum and serves to adapt the lower sheet metal pan to the crankcase. The upper pan also serves as a baffle to keep oil in the pan away from the crankshaft.
- The pick-up tube bolts to the upper oil pan. The upper pan has a cast passage that connects the pick-up tube to the lower crankcase.
- The upper pan is sealed on both sides with a push-in-place gasket.

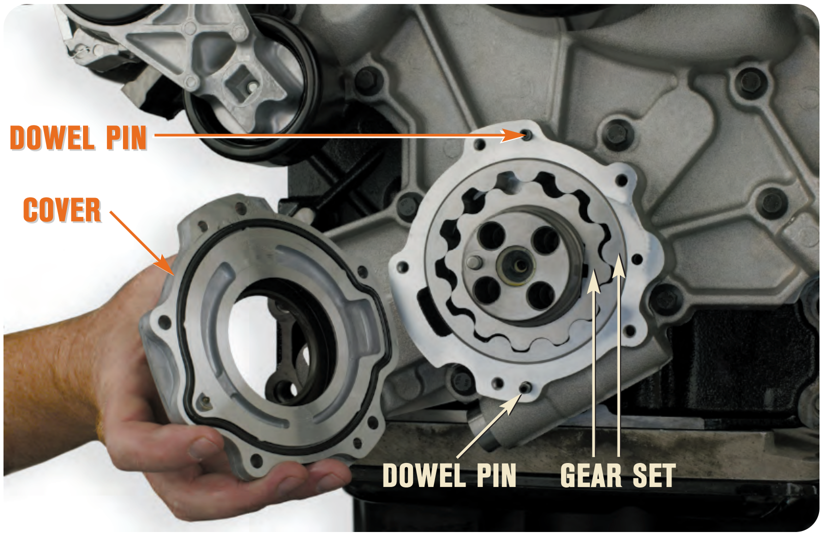
## Front Cover Oil Flow

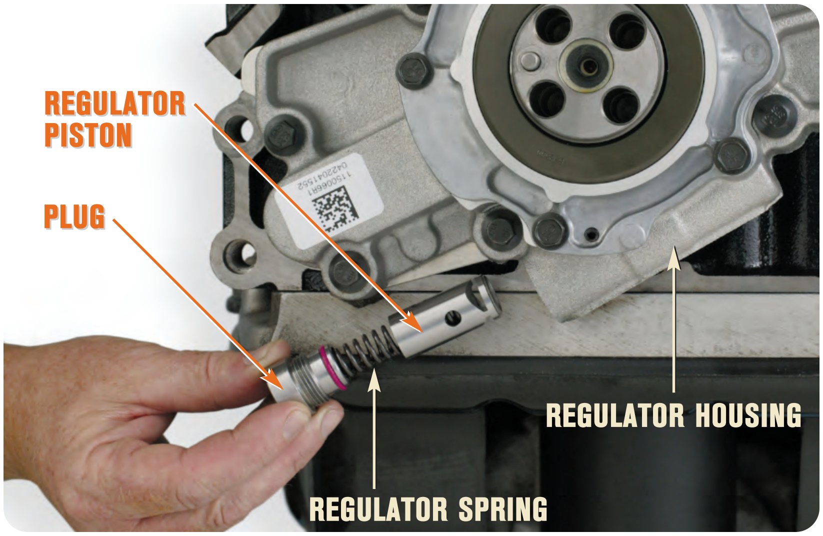
- Oil flows from the lower crankcase to the oil pump through a passage in the back of the front cover. When the crankshaft turns the oil pump, oil pulled from the oil pan is pushed from a passage in the front cover to the vertical passage in the crankcase that takes oil to the oil cooler cover. Two dowels in the front cover ensure the oil pump is concentric with the crankshaft.
- All of the passages from the front cover to the crankcase are sealed with a silicon-in-metal, one-piece gasket.



## Gerotor Pump

- The gerotor style oil pump is integrated into the front cover with the gear set driven off two flats on the nose of the crankshaft. The gear set rides directly on the surface of the crankcase front cover.
- The gears are a matched set, and should be marked before disassembly so they can be reassembled with the same side facing out.
- The oil pump front cover is located with two dowel pins and sealed with a press-in-place gasket.




## Oil Pressure Regulator Valve

- The oil pressure regulator valve is responsible for regulating the maximum pressure in the lubrication system. The regulator, which can be removed with the engine in the chassis, is located in the front cover just below the gerotor oil pump cover.
- The face of the regulator piston is exposed to the pressurized oil. When pressure exceeds 75 psi, the piston is depressed against spring pressure enough to expose a port that allows excess oil to be relieved to the suction side of the pump.


## Oil Cooler

- The stacked-plate type oil cooler is mounted to the bottom of the oil cooler cover. When the cooler cover is set in place on the crankcase, the cooler sets in the high-pressure oil reservoir. The water pump circulates coolant through the cooler to remove excess heat from the engine oil.

- The coolant and oil are separated by multiple plates that create passages in the oil cooler. The cooler cover and cooler are not serviced as separate components.

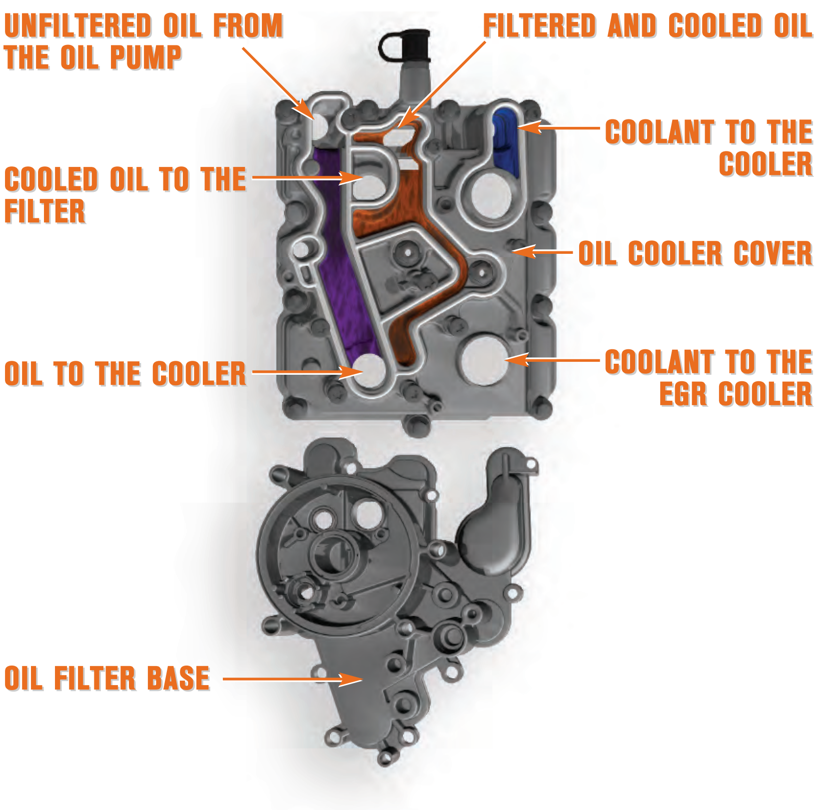
- The volume of the reservoir, with the oil cooler in place, is approximately one quart.

## Oil Cooler Housing and Oil Filter Base

- The oil cooler cover, oil filter base, and oil filter adapter all contain passages that direct the flow of oil. In addition, the oil cooler cover and the oil filter base both contain passages that direct the flow of coolant.

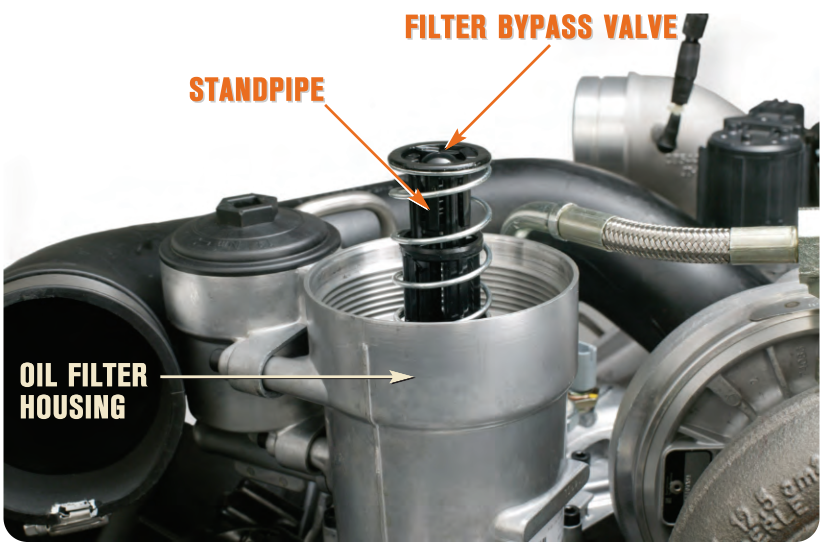
- Oil is routed from a passage in the crankcase to the oil cooler cover inlet where oil is directed rearward to the oil cooler. Oil flows through the cooler and is then directed through the oil filter adapter. Oil passes through the filter and down the standpipe, then back to the oil filter base where it's directed to the reservoir and the main oil galleries. Coolant is directed from a passage in the crankcase to the to the cooler cover. Coolant passes through the oil cooler and exits at the EGR cooler supply port.

- The oil filter adapter mounts the oil pressure switch and the oil temperature sensor, and feeds oil to the turbocharger lubrication line.



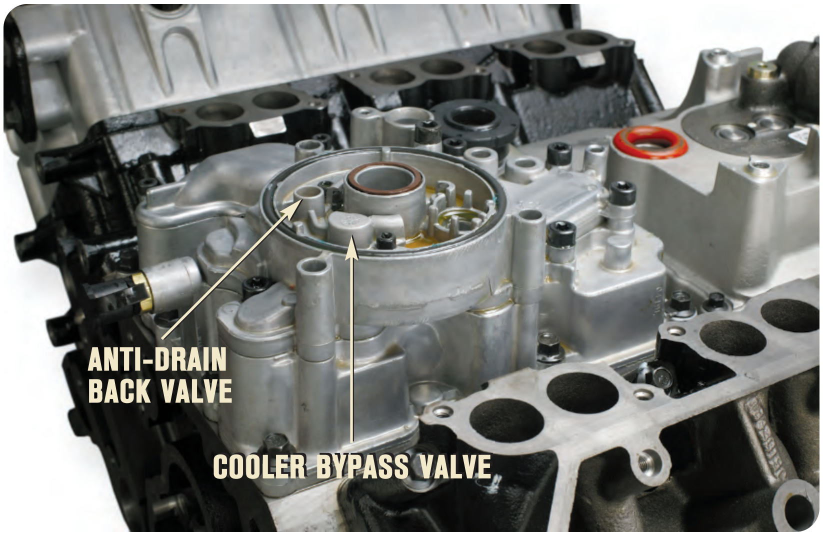
## Oil Filter

- The VT 275 uses a cartridge style oil filter located on top of the engine.
- When the oil filter is removed, the oil filter drain valve opens to allow oil to drain from the filter housing, through the adapter, and back to the oil pan.
  The oil filter element snaps onto the lid. This allows the filter element to be extracted without contact with the element.
- **Note:** The oil filter lid should be removed before draining the oil from the oil pan so that the oil can drain from the filter housing into the oil pan.


## Oil Filter Bypass

- The filter bypass valve is located at the top of the filter standpipe. The top of the oil filter element has a hole that matches the location of the valve. Unfiltered oil surrounds the filter, including the top of the filter and the bypass valve. The valve opens if there is a pressure difference of 32 psi between the outside of the paper filter material, which is unfiltered oil, and the inside of the filter paper.




## Oil Filter Base and Valves

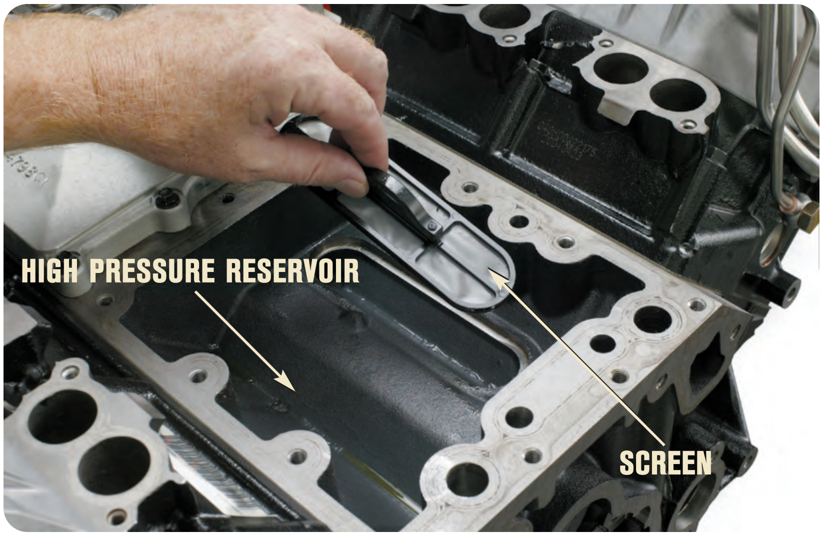
- Oil enters the filter base from the oil cooler through the anti-drain back valve. The valve is not spring loaded; instead the valve closes under its own weight when the engine is shut off. This keeps the oil in the filter housing from draining back into the lube system.

- The oil cooler bypass valve is in the filter base. This valve allows the oil to bypass the cooler when cooler inlet pressure is 25 psi higher than the unfiltered side of the oil filter. This protects the cooler from high-pressure during cold start up.

## Reservoir and Screen

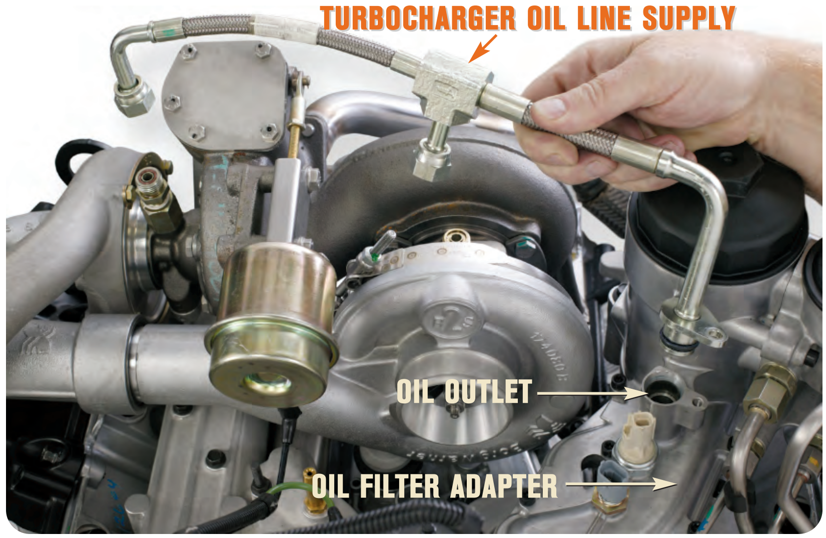
- The oil reservoir for the high-pressure oil pump is located under the oil cooler cover in the crankcase Vee. The reservoir holds approximately one quart after the cooler and cooler cover are put in place.

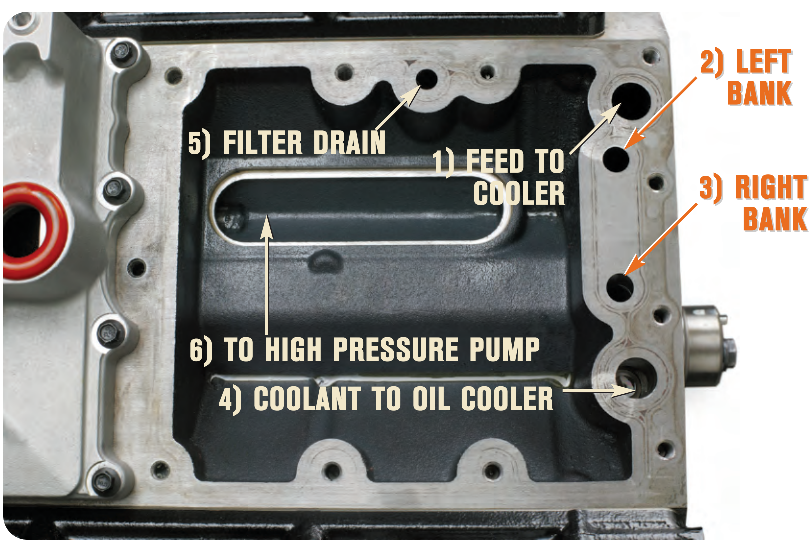
- The passage at the bottom of the reservoir is for oil feed to the high-pressure pump. The screen in the reservoir filters any large debris that may be in the oil before it gets to the high-pressure pump.



## Turbocharger Feed Line

- Pressurized oil from the filtered passage in the oil-filter adapter is supplied to each center section of the twin turbocharger. The oil is transferred through a hose to the turbocharger.
- The turbocharger ends of the hose are sealed with face seals. The oil filter adapter end of the hose pushes into a cavity on the filter adapter and is sealed with O-rings and retained by a single cap screw.



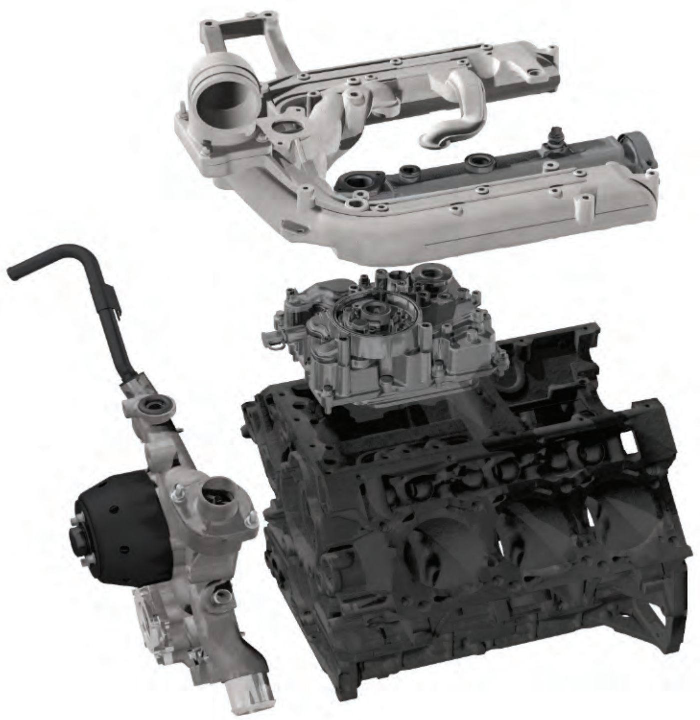

## Crankcase Oil and Coolant Passages

- There are six crankcase passages near the oil reservoir.

1. Oil feed to the cooler: Directs oil from the pump to the oil cooler.
2. Left Bank: Feeds filtered and cooled oil to the left bank tappets and piston cooling jets.
3. Right Bank: Feeds filtered and cooled oil to the right bank tappets, piston cooling jets, and the main bearings and cam bearings.
4. Coolant: Feeds coolant from the water pump to the oil cooler and the EGR cooler.
5. Filter Drain: Allows drain oil from the filter to reach the oil pan when the filter is removed.
6. Reservoir: Feed to the high-pressure pump.

# COOLING SYSTEM

- Modular water pump
- Stainless steel injector sleeves
- Stainless steel glow plug sleeves
- Extended life coolant

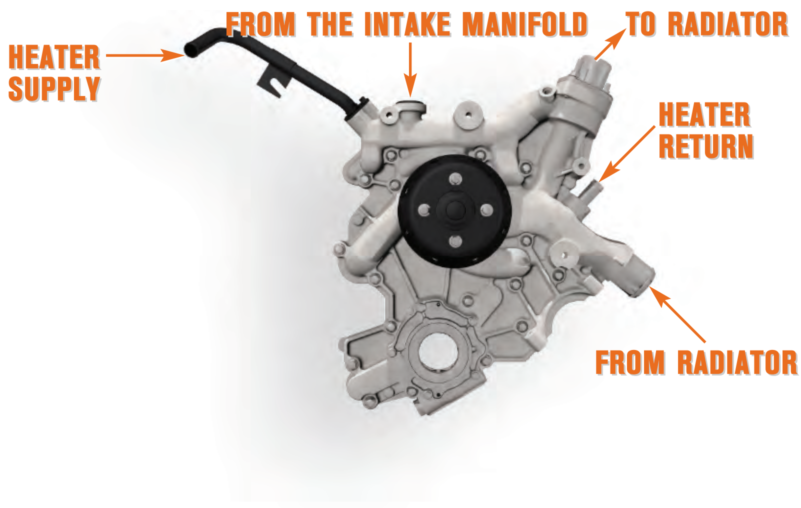


## System Features and Flow

- The modular water pump mounts in the front cover and draws coolant from the radiator via the coolant inlet on the front cover. The water pump pushes coolant through two ports on the front cover to matching ports on the crankcase. Coolant flows through the crankcase and cylinder passages, then returns to the front cover. Coolant is then directed to the thermostat where coolant flows to either the bypass port or the radiator, depending on the coolant temperature. Coolant leaving the water pump is also directed to the oil cooler where it travels between the plates of the oil cooler and then to the EGR cooler.

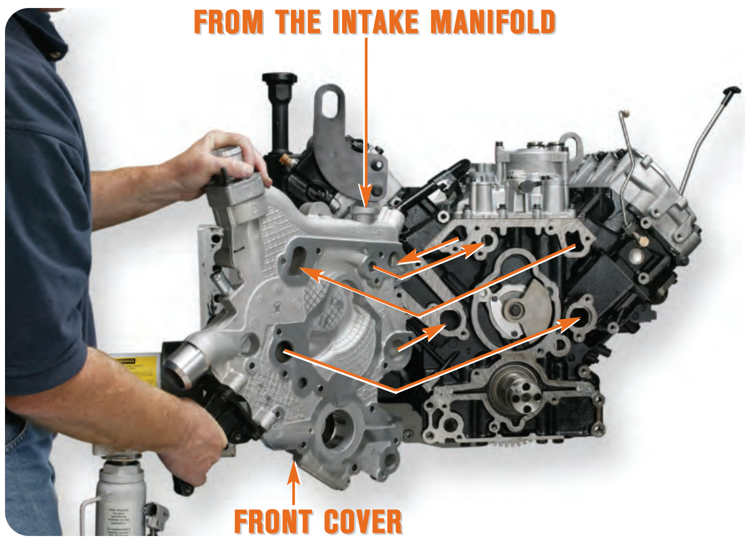
## Front Cover Flow

- Coolant is drawn into the water inlet by the water pump. Coolant is discharged from the pump to the crankcase coolant jackets. Coolant is also routed from the front cover through a crankcase passage to the oil cooler cover.
- Return coolant from the crankcase coolant jackets is directed to the thermostat by the front cover. If the thermostat is open, coolant flows to the radiator to be cooled. If the thermostat is closed, coolant is returned to the water pump via a bypass circuit in the front cover.



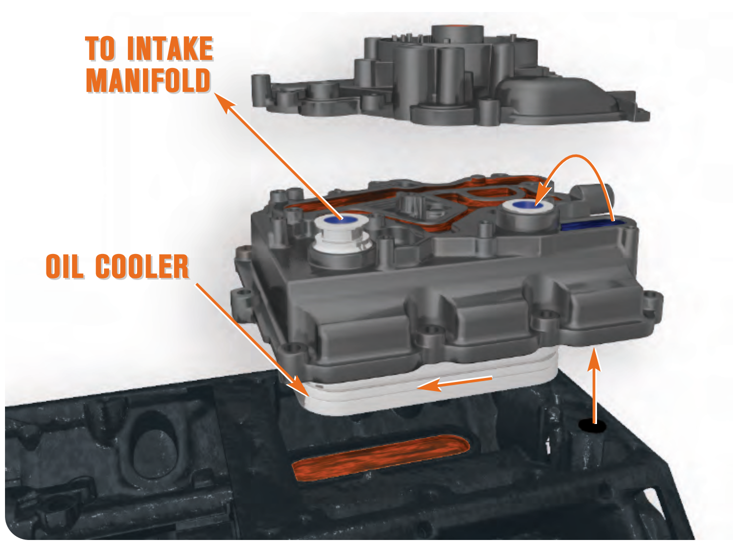

## Crankcase Flow

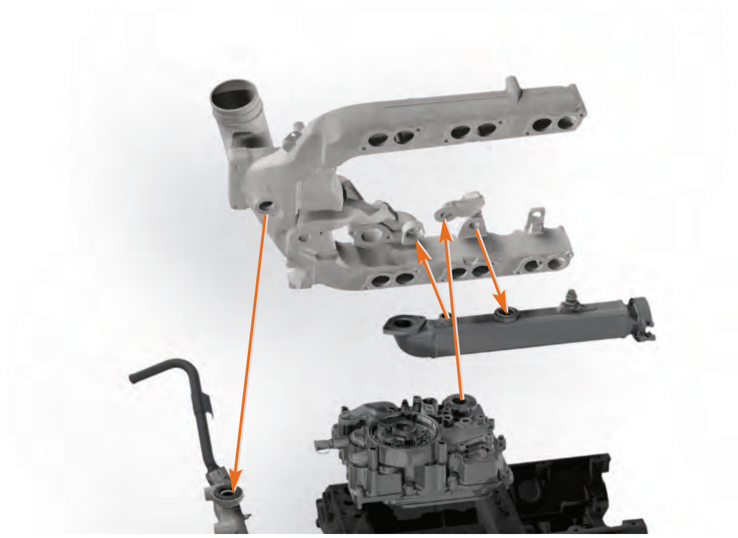
- Coolant is directed out of the front cover to the crankcase through three passages. Two of the passages route coolant through the crankcase water jackets to cool the cylinders and cylinder heads. The third passage routes coolant to the oil cooler via a passage in the crankcase.
- There are three passages for coolant return to the crankcase. Two receive coolant from the crankcase and one receives coolant from the intake manifold.




## Coolant Flow/Oil Cooler

- Engine coolant is routed to the oil cooler cover via a passage in the crankcase.
- The cooler cover directs the coolant through the oil cooler and then into the EGR cooler via the intake manifold.
- The oil cooler bundle is sealed at the cover with two O-rings at both the inlet and outlet pipe areas. To prevent mixing of oil and coolant, the area between the two seals is vented through a weep hole on the cooler cover. This allows leakage past either seal to weep out of the cooler cover.



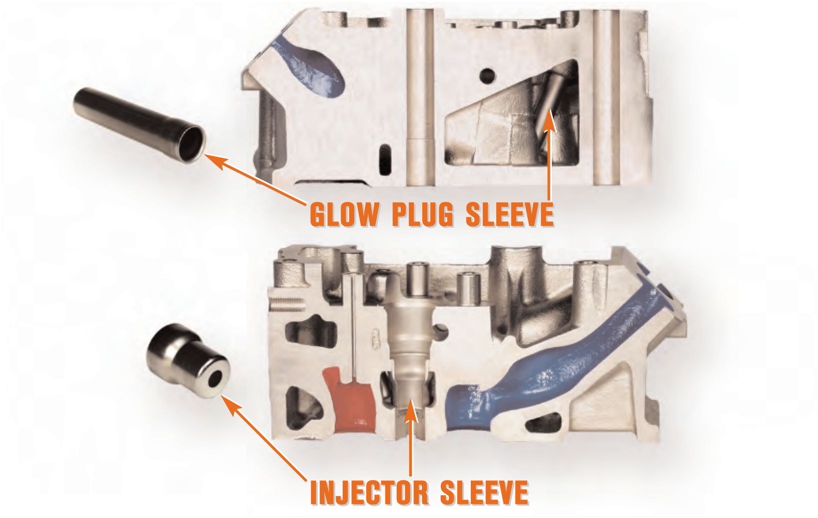


## EGR Cooler Flow

- Coolant flow from the oil cooler is directed through the cooler cover to the intake manifold. Coolant flows from the manifold into the EGR cooler then back into the manifold to return to the front cover.
- The EGR cooler is used to reduce the temperature of the exhaust before it reaches the EGR valve.


## EGR Cooler Seal

- The intake manifold fits over the oil cooler cover outlet to receive coolant flow from the oil cooler. The EGR cooler bolts to the manifold and has two coolant ports connected through O-rings to the manifold. The EGR cooler inlet to oil cooler cover seal consists of both a rubber seal and an O-ring.




## Glow Plug and Injector Sleeves

- The VT 275 uses stainless steel injector sleeves to seal coolant from the injectors. The injector sleeves are used to aid in the transfer of heat from each injector to the coolant. The injector sleeves are replaceable.
- Stainless steel glow plug sleeves are used to seal coolant from the glow plugs. The glow plugs sleeves are also replaceable.

## Service Intervals

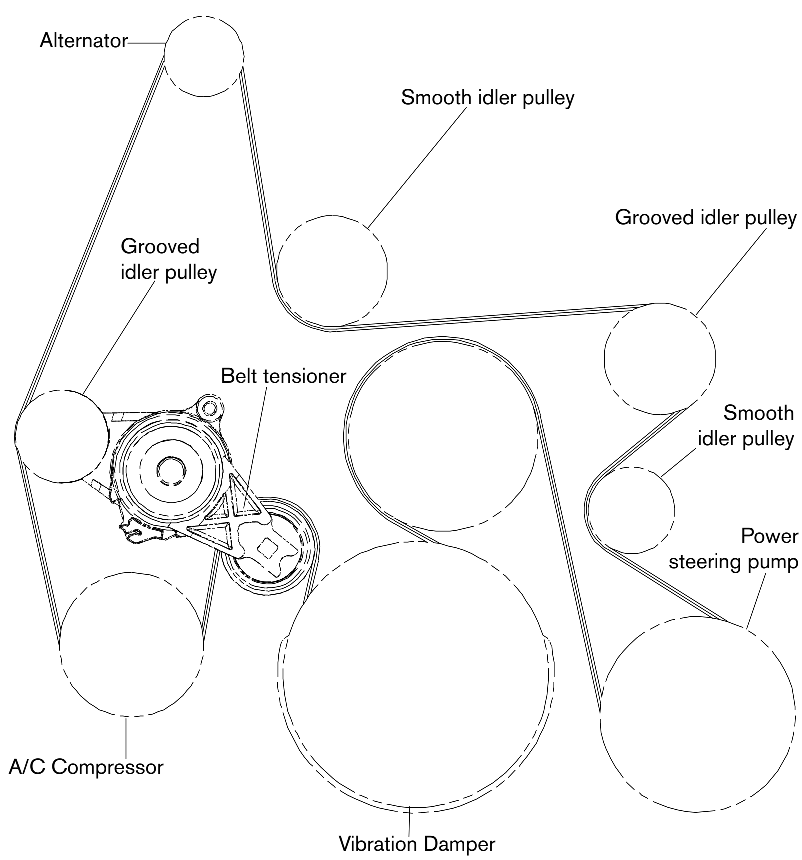
- The VT 275 is designed to use Extended Life Coolants.
- Extended life coolant can be identified by its red/orange color in contrast to conventional green or blue antifreeze.
- The service interval is 5 years, 300,000 miles or 12,000 hours if the chemical extender is added at 30 months, 150,000 miles, or 6000 hours.
- **Note:** Do not add supplemental coolant additives like DCA4 to long-life coolant.

| Service Intervals for the VT 275 Engine | |
|---|---|
| **Change Oil and Filter** | ***7,500 mi., or 6 months** |
| **Primary and Secondary Fuel Filters** | **22,500 mi., or 18 months** |
| **Coolant** **(Extended Life Coolant)** | **300,000 miles / 12,000 hours / 5 years** **(if extender is added at 30 months, 150,000 miles, or 6,000 hours)** |

*** See the Engine Operation and Maintenance Manual for the hours and gallons of fuel component for the correct oil change interval.**

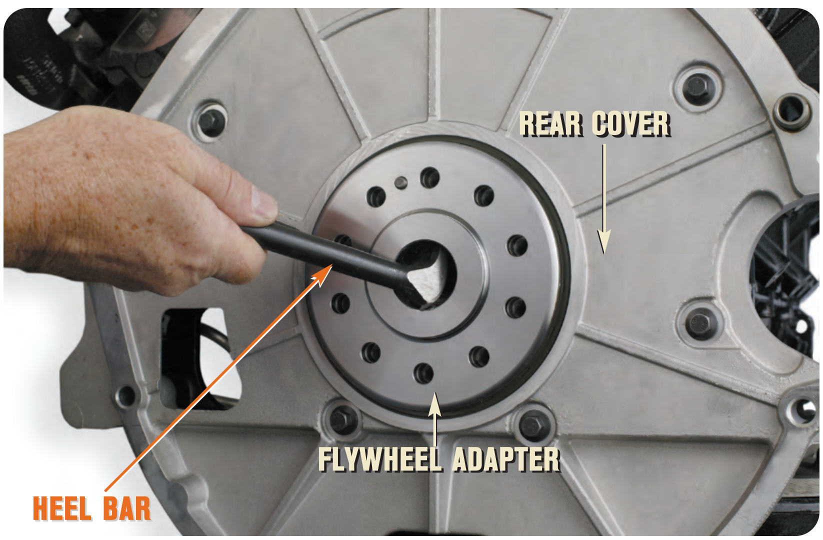
## Belt Routing

- The VT 275 uses one accessory drive belt. The belt must be routed correctly for the proper operation of the cooling fan, alternator, water pump and power steering pump.
- The engine uses a combination of grooved and smooth idler pulleys. The large diameter smooth pulley is located to the left of the engine's center when viewed from the front.
- The smaller smooth pulley is the lower idler on the right side of the front cover when viewed from the front of the engine.



# UNIQUE REPAIR PROCEDURES

**Consult service literature for latest information before attempting any repairs**




## Removing Flywheel Adapter

- The flywheel adapter can be removed using the edge of a heel bar by using the adjacent rear cover bolt for support. The heel bar may also be inserted into the adapter opening and supported on a crankshaft flange bolt to push the adapter off.


## Removing Seal

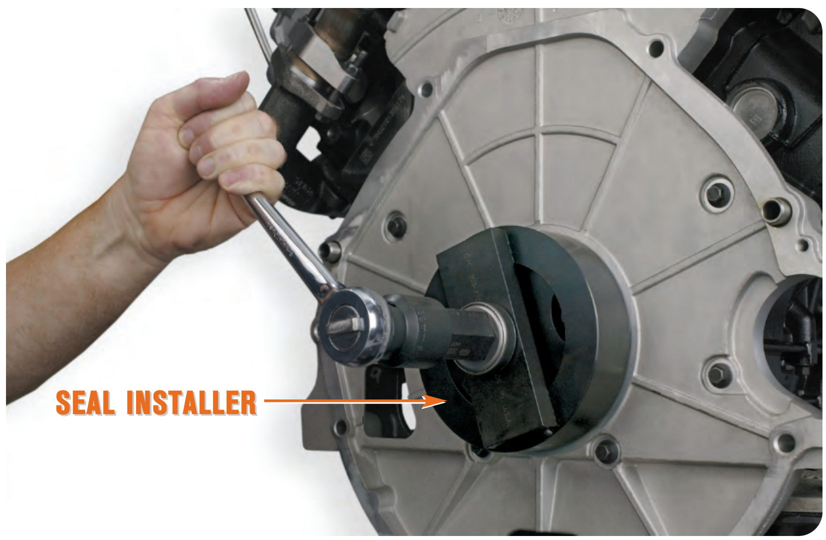
- Drill two small holes to fit the screw end of a slide hammer. Insert the slide hammer and pull the seal from the rear cover. The new seal is assembled with a wear sleeve. The wear sleeve must not be removed from the seal prior to installation.

## Seal Installer Base

- Place a 360° bead of Loctite® Hydraulic Sealant on the outer circumference of the crankshaft flange. Bolt the base of the rear main seal/wear sleeve installer to the crankshaft. Make sure the crankshaft dowel pin is in the recess provided in the face of the tool. Lubricate the outer diameter of the seal with a 50/50 mixture of soap and water (do not use any other lubricant). Side the seal over the base.

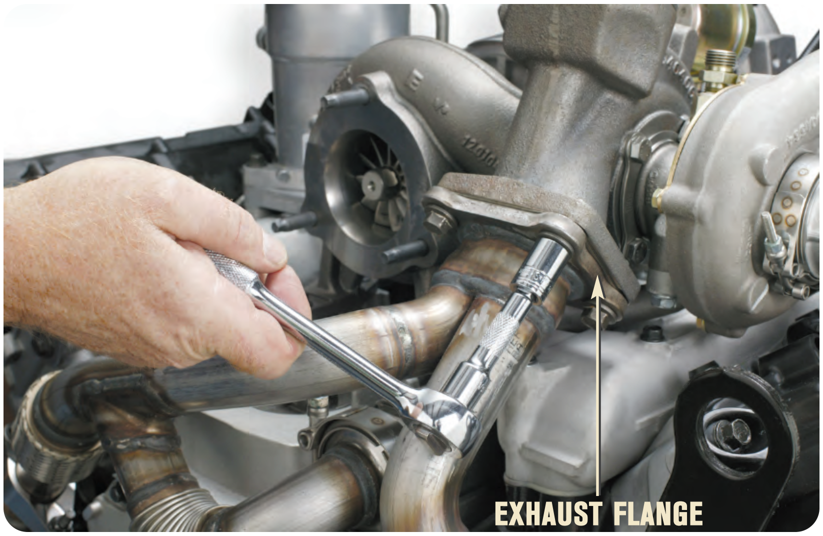

## Installing Seal & Wear Sleeve

- Position the rear seal/wear sleeve installer on the base. Place the thrust bearing and drive nut on the threaded shaft. Tighten the nut until the rear main oil seal bottoms out in the rear oil seal carrier. After the seal bottoms out remove the installer tool and base and install the flywheel adapter, making sure the dowel pin is lined up with the adapter holes.



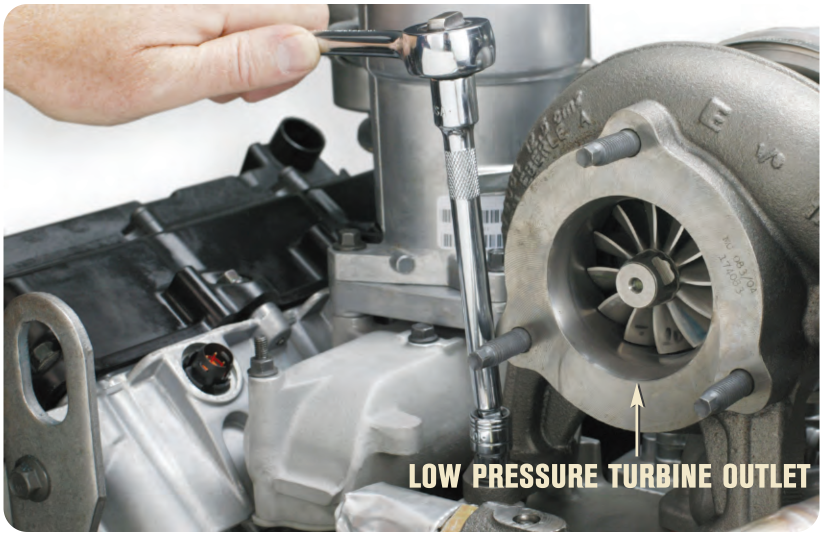

## Flexplate Bolts

- The flexplate bolts are not reusable. Install ten new flexplate bolts. Tighten all bolts in sequence to specification using the torque sequence. Use an alternating pattern across the center to evenly pull down the flexplate.



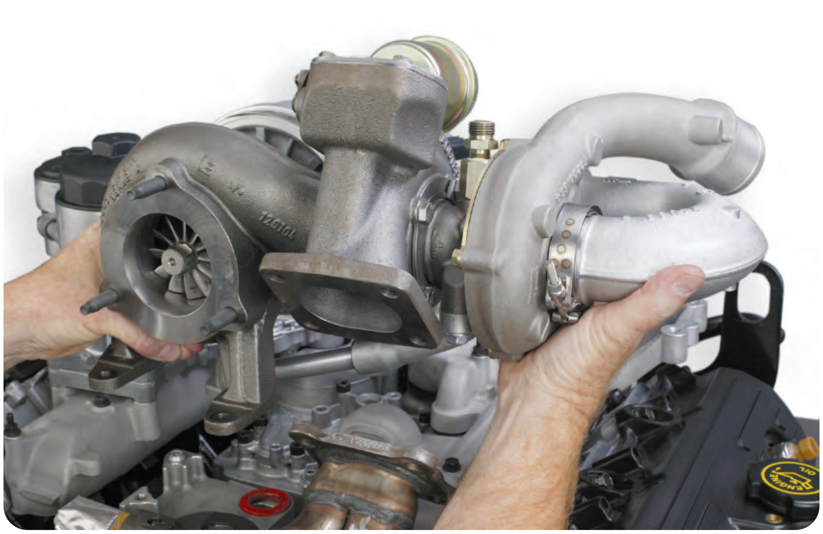

## Turbocharger Removal

- Remove the oil supply line at the turbocharger center sections and the oil filter adapter. Remove the air inlet duct clamp, duct mounting bolt and the breather tubing from the breather. Loosen and remove the four exhaust flange bolts.




## Removing Mounting Bolts

- Remove three turbocharger mounting bolts that mount the low-pressure turbocharger turbine housing to the high-pressure pump cover.

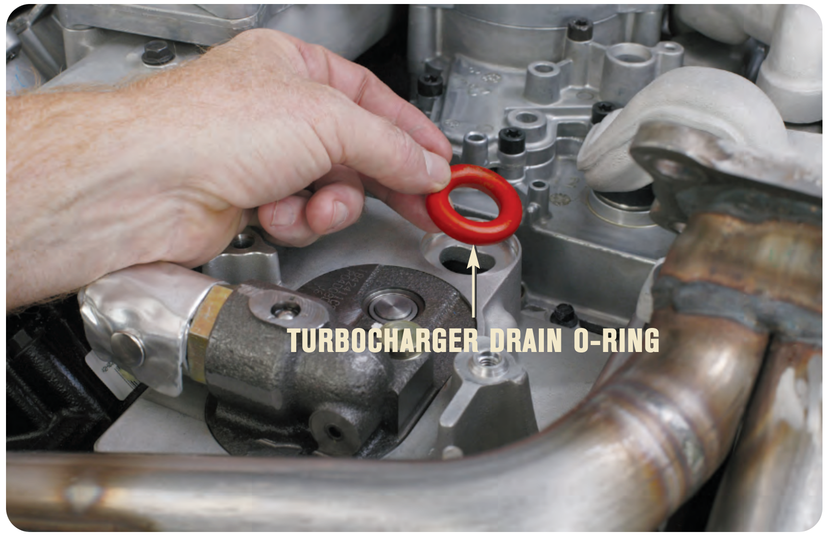


## Removing Turbocharger

- Lift the turbocharger from the high-pressure pump cover.

## Replacing O-Rings

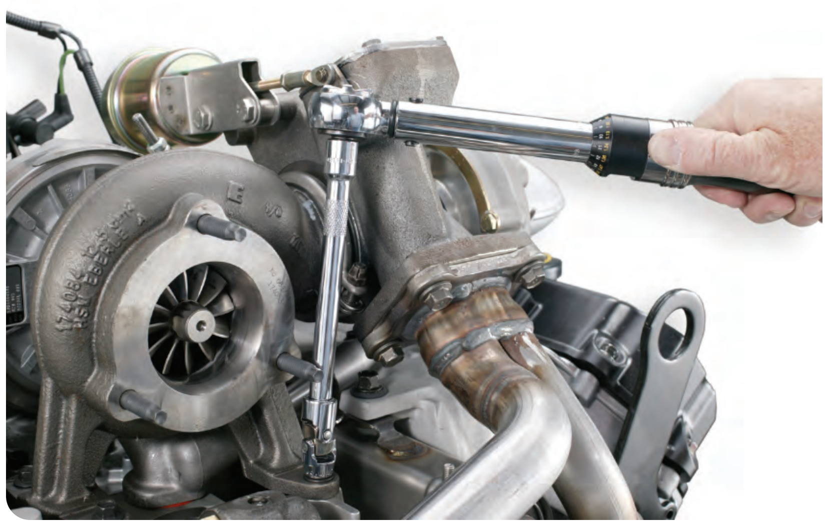
- Before reinstalling the turbocharger, replace the oil drain O-ring and the oil supply line O-rings.




## Turbocharger Installation

- Lower the Turbocharger onto the high-pressure pump cover. Install the three pump cover mounting bolts and hand-tighten. Apply anti-seize compound to the four exhaust pipe flange bolts and install hand tight with a new gasket. Loosen the crossover tube clamp and the turbine-mating clamp.

- The following torque procedure should be followed to assure the turbocharger parts are allowed to align correctly to the exhaust pipe assembly. First, torque the three turbocharger to pump-cover mounting bolts.



## Torque Turbine Mating Clamp

- Second, torque the exhaust pipe assembly to the manifolds. Third, torque the exhaust pipe to EGR cooler clamp. Fourth, torque the exhaust pipe assembly to the turbocharger inlet. This procedure correctly aligns the exhaust assembly; now torque the crossover tube clamp and the turbine-mating clamp. This procedure ensures that the two turbochargers are aligned before the components are tightened.


## Replacing Turbocharger Crossover Seal

- Place the holding fixture of the crossover tube seal installing tool into a vise. Clamp the crossover pipe into the fixture. Screw the threads of the removal tool into the seal.


## Removing Seal

- Install a side hammer into the seal remover tool and pull the seal out.


## Installing Seal

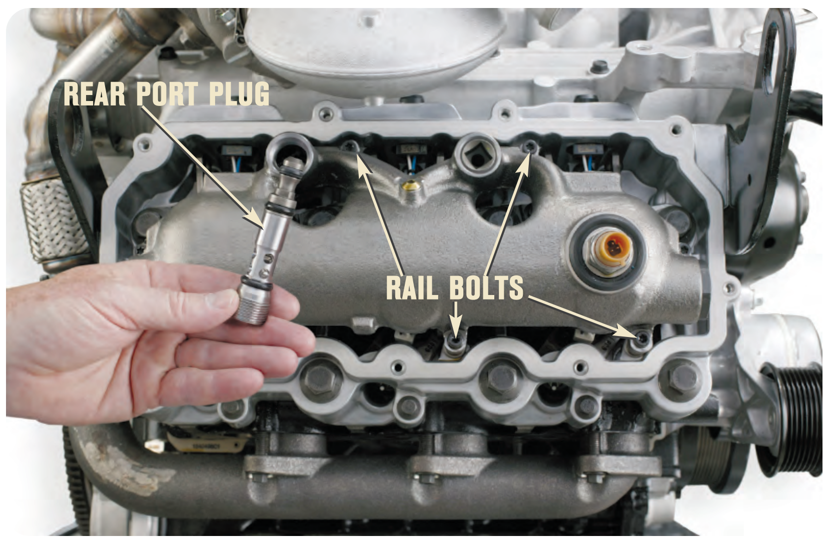
- Drive a new seal into the crossover tube using the seal driver and a hammer. Install a new O-ring on the other end of the crossover tube. Assemble the crossover tube to the turbocharger so the clamp bolt will be vertical with the turbocharger on the engine. A small amount of soap and water solution maybe needed to get the seal over the turbine inlet.

## Removing EGR Valve

- The EGR puller must be used when removing the EGR valve or the valve and intake manifold may be damaged.
- To remove the EGR valve, first remove the EGR valve mounting bolts that hold the valve to the intake manifold.
- Rotate the valve counterclockwise until the pins at the ends of the EGR puller arms will slip under the EGR valve housing tabs and into the holes. Hook the other end of the puller arms to the puller beam. Position the other two arms over the holes in the intake manifold. Turn the shaft clockwise to remove the EGR valve.

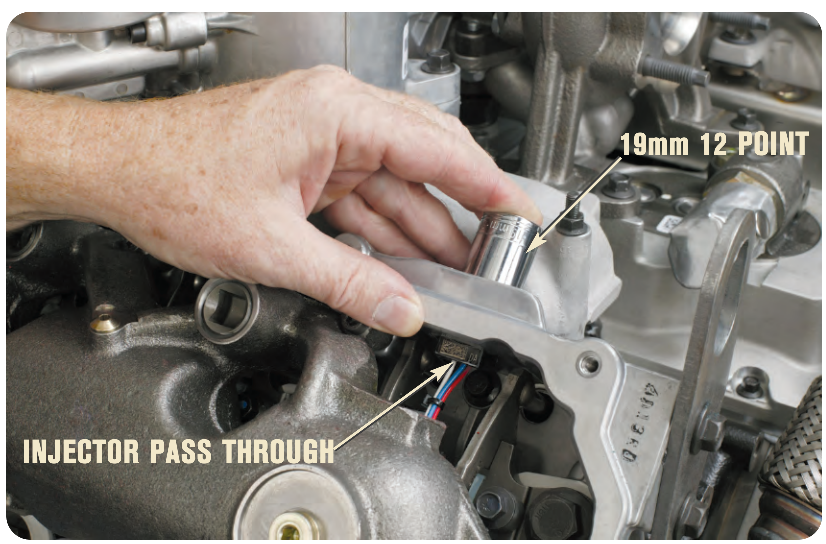

## Injector Removal

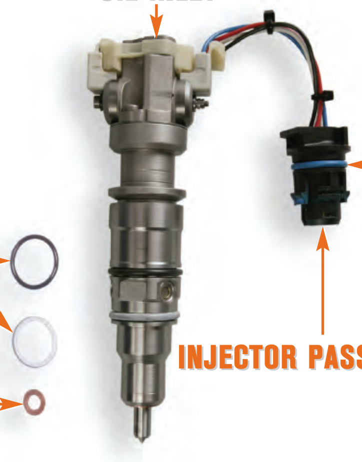
- After removing the valve cover, remove the rear port plug. The port plug may pull the case-to-head tube from the branch tube assembly. Remove the seven bolts that hold the oil rail to the rocker arm carrier. Pull the rail from the head.
- Oil is not drained from the rail prior to removal, so oil will leak from the rail as it is removed.
- **Note:** The port plug and case-to-head tube's O-rings are not replaceable. The port plug and case-to-head tube must be replaced if the O-rings are damaged.




## Injector Connectors

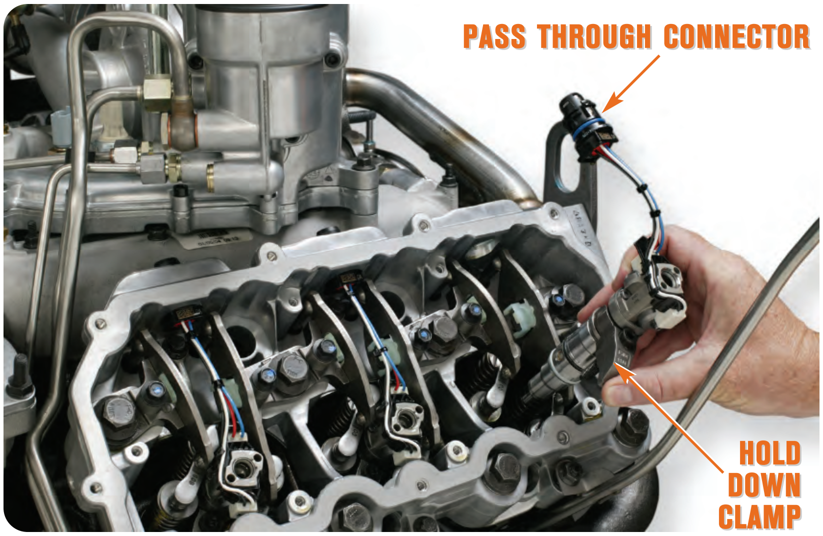
- The injector connectors on the VT 275 pass through the rocker lever carrier. Disconnect the injector harness from the injectors by depressing the metal bail on the harness connector body while pulling the harness connector from the injector. To remove the injector pass-through connector, use the Injector Connector Remover (ZTSE4650) or push the open end of a 12-point 19mm socket over the connector to release the clips. Carefully pull the connector body from the carrier. The injectors will be extracted when the injector hold-down clamp bolts are removed.





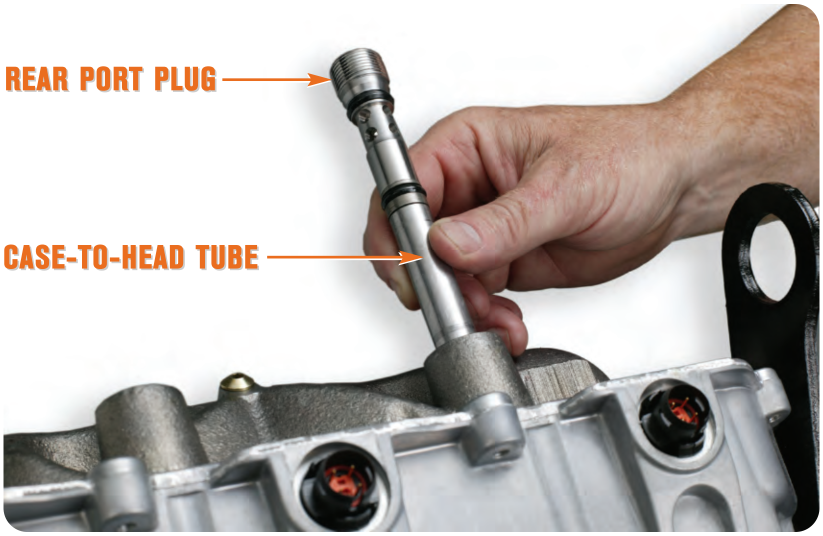

## O-Ring Replacement

- Carefully remove and replace the external O-rings. The injector nozzle gasket can be installed using a 12-point 9mm deep-well socket. The socket is used to apply even pressure around the gasket during installation.
- The connector O-rings should be replaced each time the injector is removed from the cylinder head.
- **Note:** Do not attempt to remove the oil inlet O-ring. It is not replaceable. If the O-ring is damaged, the injector must be replaced. Do not pull on the wires while working on the injector.




## Injector Installation

- Lubricate the upper and lower O-rings on the body of the injector. Place the hold-down clamp lug into the notch of the injector body. Lower the injector into the bore and use a #40 Torx bit to tighten the bolt to the specified torque. Install the injector pass through connector into the carrier, making sure that the connector snaps in fully.
- Lubricate the internal O-ring at the top of the injector.
- Install the rail over the injectors and start the bolts by hand. Torque the rail bolts using the proper sequence.

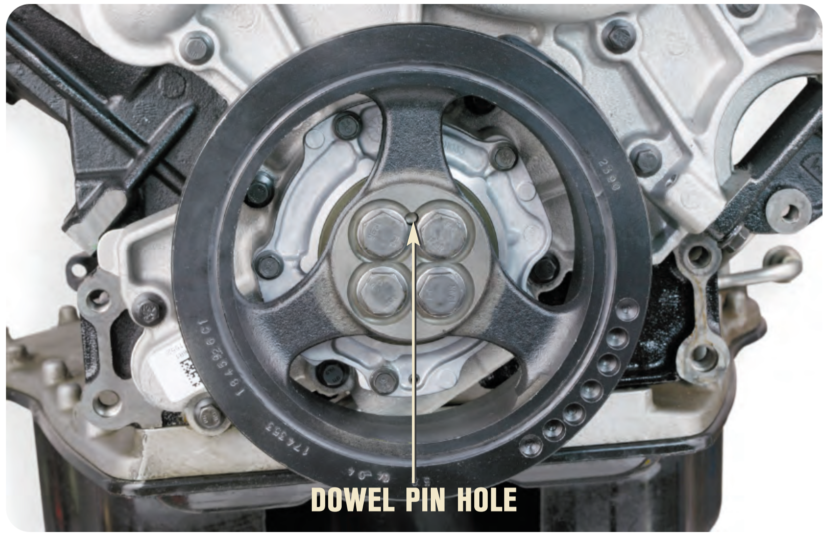



## Case-to-Head Tube Installation

- If the tube does not pull out with the port plug it will need to be removed after the rail is removed using the Case-to-head Tube Removal Tool (ZTSE4694). Before installation, lubricate the O-rings on the case-to-head tube and port plugs. Push the port plug into the tube and insert into the oil rail. Torque the port plug to specification.
- **Note:** The O-rings are not serviceable. Inspect the O-rings and replace the case-to-head tube and port plug if the seals are damaged.

## Position Crankshaft for Rocker Removal

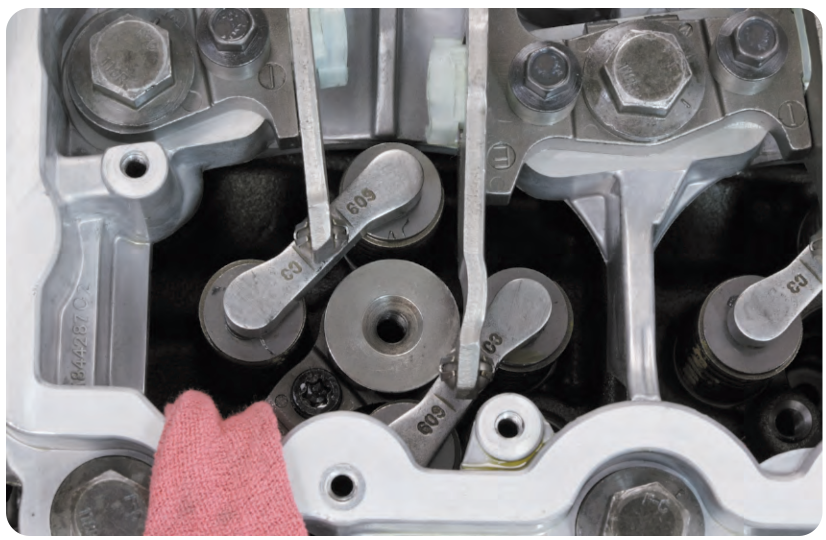
- Special Tool ZTSE4697 can be used to service the rocker arms, valve bridges or push rods. Rotate the crankshaft until the vibration damper dowel pin is in the twelve o'clock position. Wiggle the rocker arms for number 1 cylinder. If the rockers do not move freely, rotate the crankshaft one complete revolution. The rockers should now be loose on number 1 cylinder. Cylinders number 1, 2 and 4 can now be serviced. Rotate the crankshaft one revolution to service cylinders 3, 5 and 6.




## Installing Spring Compressor Base

- Remove the injector of the cylinder to be serviced. Insert the injector's hold-down clamp into the base of tool. Install the assembly as if installing an injector. Snug the hold-down bolt but do not torque.

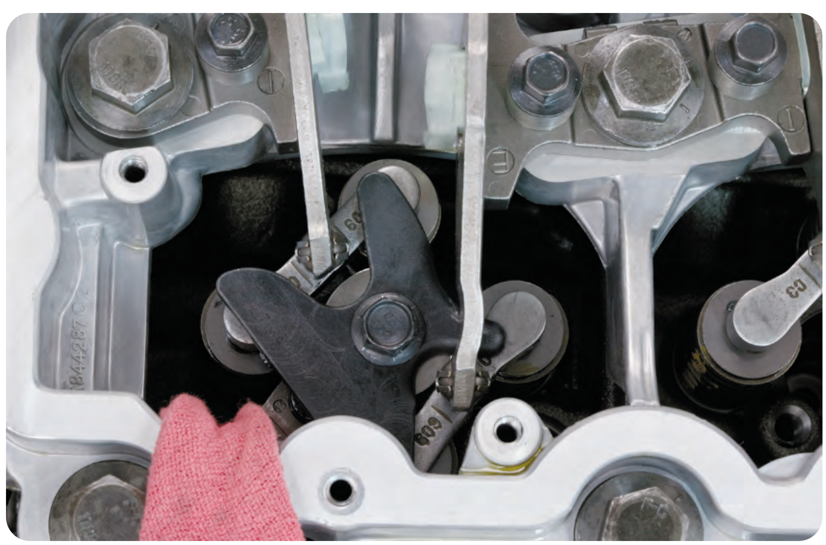
- **Note:** Use clean shop towels to plug any oil drain holes before removing any components.

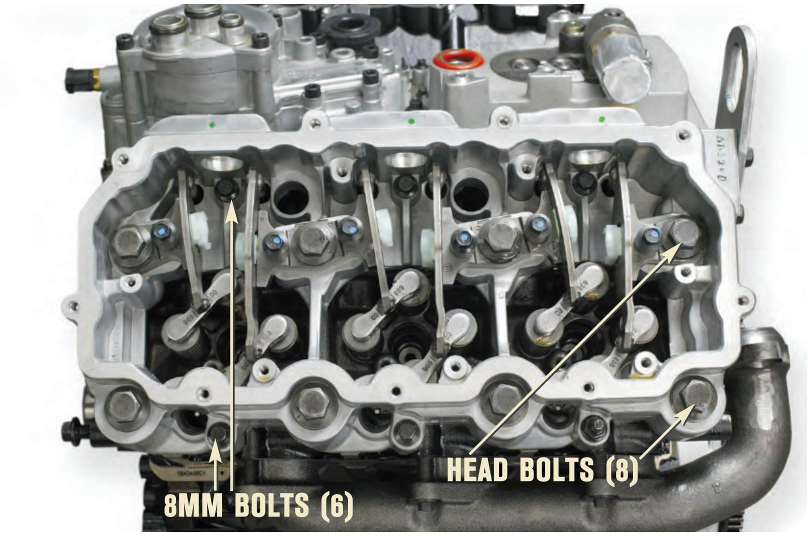


## Compressor Plate

- Install the valve spring compressor plate on top of the valve bridges. With the plate in position, install the compressor bolt. Turn the bolt with a hand wrench until the plate contacts the top of the base. The rocker arms may now be removed. If the valve bridges must be serviced, back out the compressor bolt and remove the plate to gain access. Reinstall the rocker arms using the compressor tool.

- **Caution:** Be careful not to drop the rocker arm ball into the engine.



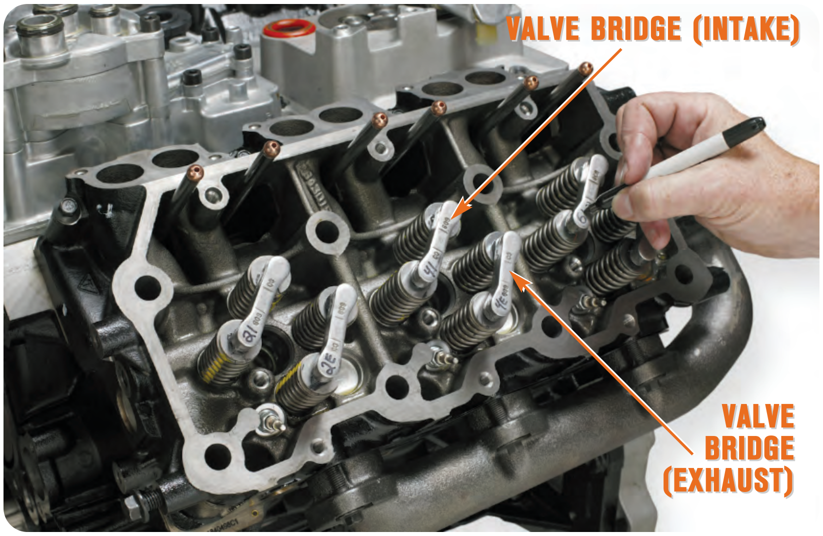



## Cylinder Head Removal: Rocker Carrier

- The rocker arm carrier is held in place with six small bolts and eight cylinder head bolts.
- Four additional small bolts at the top hold the cylinder head to the crankcase.
- **Note:** When any of the eight large cylinder head bolts are removed the head gasket and the cylinder head bolts must be replaced.

## Cylinder Head Removal Continued

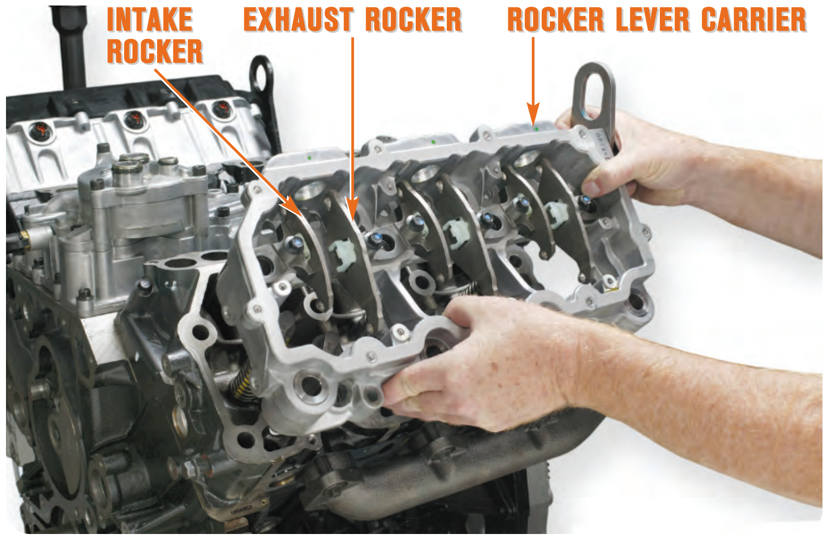
- The rocker arms, push rods and valve bridges must be installed in their original position during reassembly.
- The valve bridges can be marked with a permanent marker during disassembly.
- **Note:** If the rocker arms and/or valve bridges are not correctly installed premature valve train wear may result.

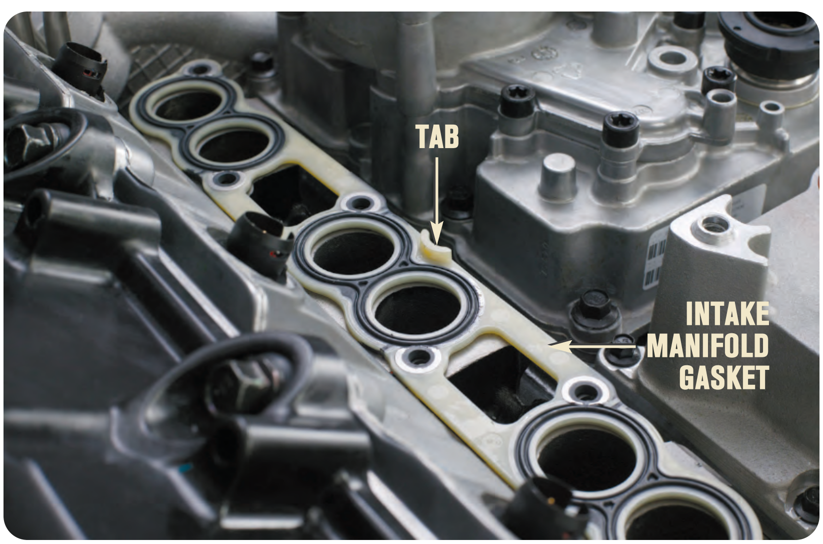


## Installing Head and Carrier

- Verify that the cylinder head dowel sleeves are installed in the crankcase. Install the new head gasket and two guide pins (locally made). Install the head and the four 8mm bolts across the top of the head. Install the push rods with copper ends to the rocker and the valve bridges in their proper location.

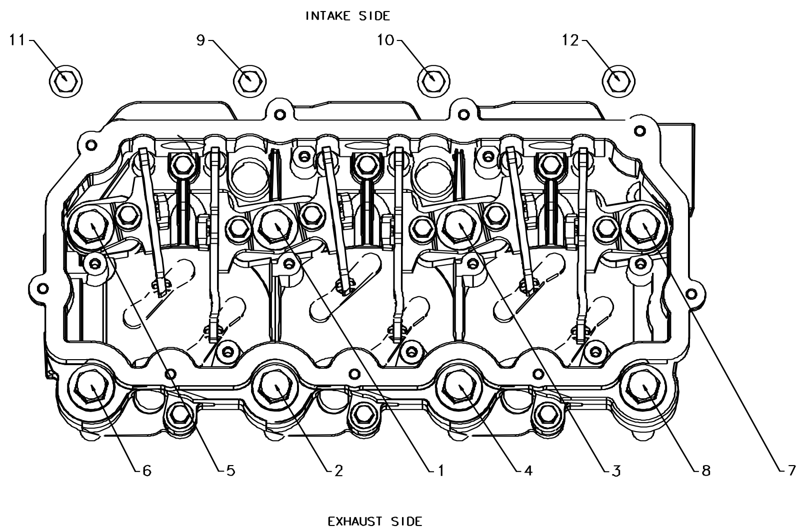
- Rotate the crankshaft until the damper dowel-pin hole is at six o'clock. Make sure the rocker arm carrier dowels are in the head and install the carrier. Verify dowel engagement into the carrier as the head bolts are tightened to specifications.




## Intake Manifold Gaskets

- The intake manifold gaskets must be oriented correctly upon reassembly. After the intake manifold is assembled to the engine, the gasket would be in the position as shown with the tabs facing up. To aid in reassembly, the gaskets can be held to the intake manifold by pushing the manifold bolts through the captured rubber washers on the gasket.

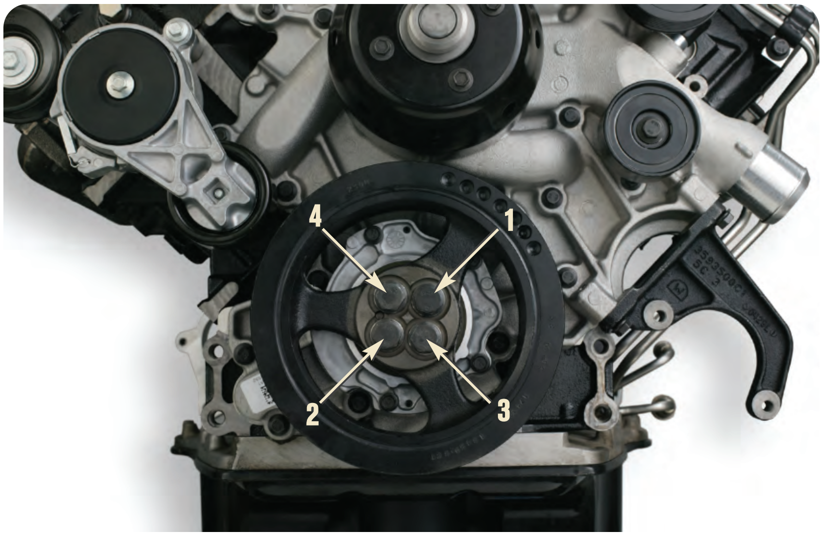



## Cylinder Head Torque Sequence

- Install new 14mm head bolts (lightly lubricated). Torque bolts 1 through 8 in sequence to 65 lb-ft (88 Nm).
- Torque bolts 1, 3, 5, and 7 to 85 lb-ft (116 Nm).
- Torque bolts 2, 4, 6, and 8 to 85 lb-ft (116 Nm).
- Tighten all bolts 1 through 8 in sequence 90 degrees.
- Tighten all bolts 1 through 8 a second time 90 degrees.
- Tighten all bolts numbered 1 through 8 a third time 90 degrees.
- Tighten all bolts 9 through 12 in sequence to 18 lb-ft.
- Tighten all bolts 9 through 12 in sequence to 23 lb-ft.

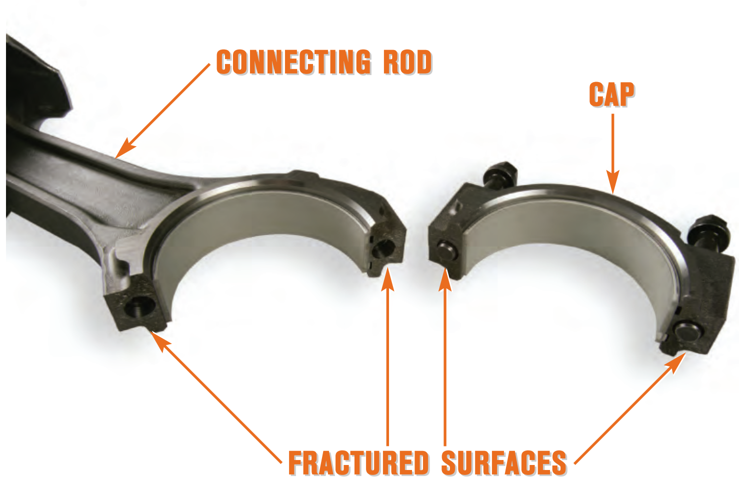
## Vibration Damper

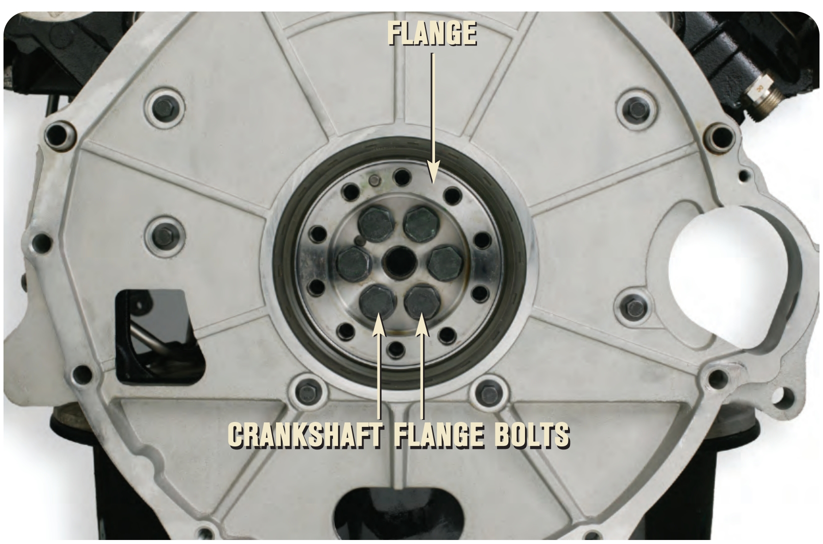
- If the vibration damper bolts are removed, they are not reusable and must be discarded. Torque the new bolts to specifications in the proper sequence.



## Connecting Rod

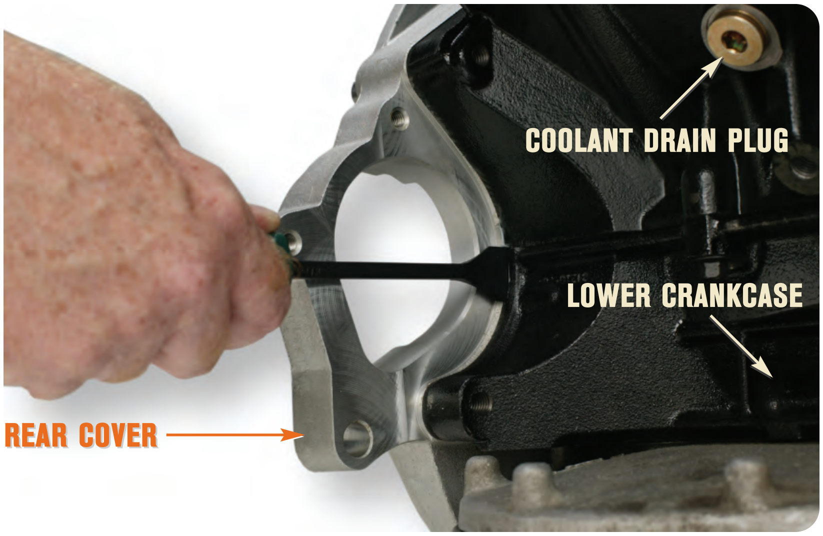
- The VT 275 engine uses fractured connecting rods. Do not alter the fractured mating surface of the rod or cap. Any alteration of the surface will result in severe engine damage. If the fracture surface is damaged by dropping the rod or by tightening the wrong cap to a rod, the connecting rod must be discarded.




## Crankshaft Flange Bolts

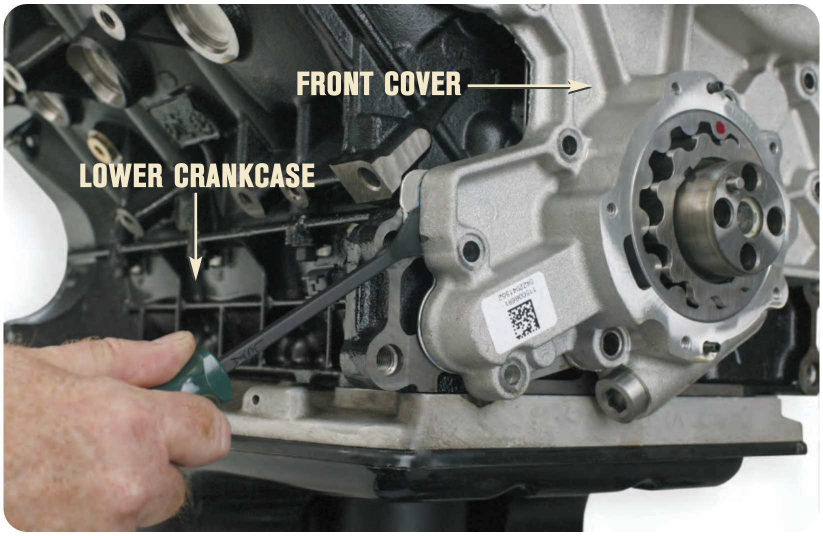
- The crankshaft flange is pressed on and bolted to the crankshaft during manufacturing. To prevent engine damage do not remove the crankshaft flange bolts under any circumstances.




## Rear Cover Removal

- Remove the rear cover bolts. Use a rubber hammer to loosen the cover from the crankcase but do not remove. Separate the rear cover from the crankcase gasket and the high-pressure pump cover gasket.

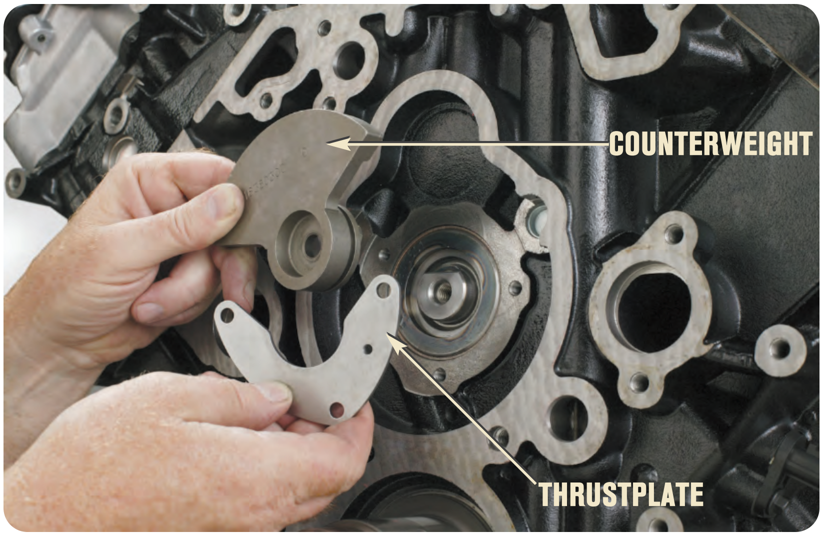
- **Caution:** Failure to separate the rear cover from the crankcase gasket and pump cover gasket could result in damage to both gaskets. Engine removal and disassembly would be required to replace the lower crankcase gasket. Replacing the pump cover gasket would require the turbocharger, intake manifold and pump cover to be removed.




## Front Cover Removal

- A small quantity of liquid gasket (RTV) is used at the crankcase to lower crankcase joint. Cut the sealant between the gasket and the front cover and between the gasket and the crankcase before removing the cover.

- **Caution:** To prevent engine damage cut the sealant where the crankcase and lower crankcase meet when removing the front cover. Failure to adequately cut the sealant prior to remove the front cover or the front cover gasket, could cause the lower crankcase gasket to be pulled out. Complete engine disassembly will be required to replace the crankcase gasket.

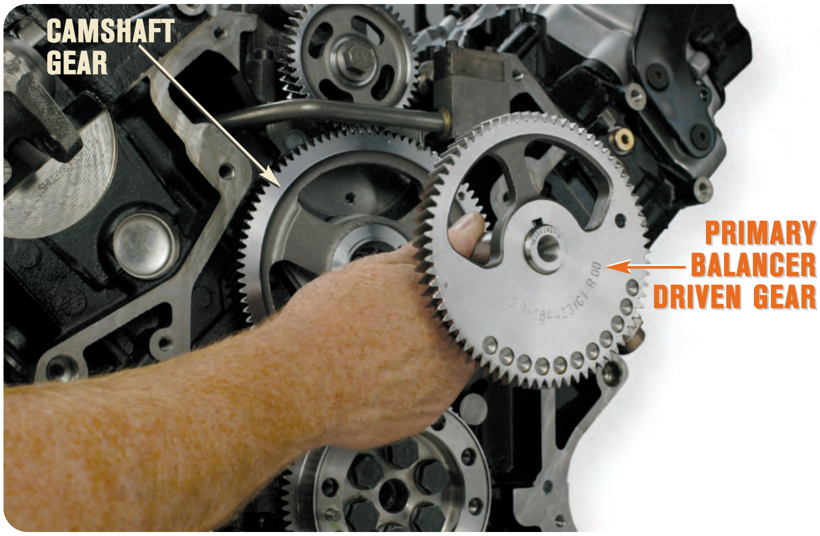



## Primary Balance Weight Removal

- The primary balancer shaft runs within the camshaft and turns the balance counterweight. To remove the counter-weight, remove the 10mm balance shaft counterweight bolt and the three 6mm thrust plate bolts (removal of the third bolt will require rotating the crankshaft to uncover the bolt). The thrust plate fits in a groove cut in the counterweight. The difference between the thickness of the thrust plate and the width of the groove cut in the counterweight determines the primary shaft endplay. The counterweight is timed to the primary balance shaft by a flat on the shaft and a flat on the counterweight.

## Balance Shaft Removal

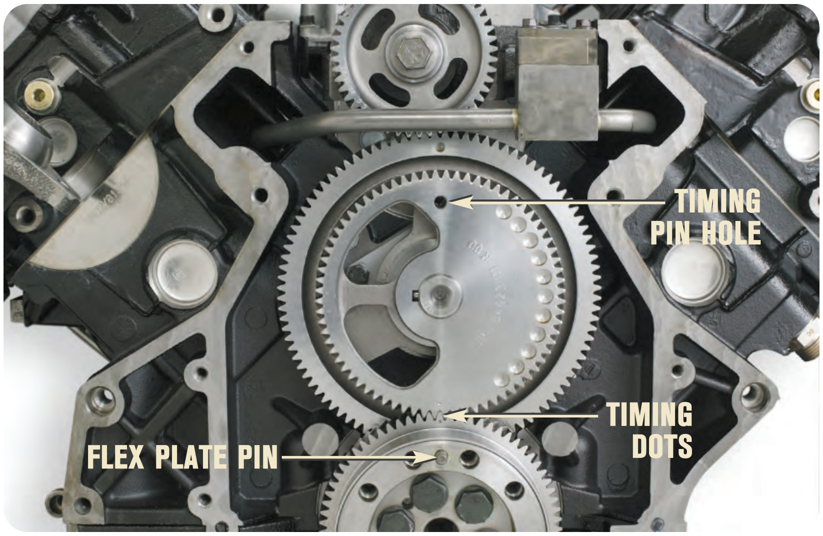
- The primary balance shaft rides within two bushings in the hollow camshaft. With the rear cover and the counterweight removed, the shaft can be extracted through the rear of the camshaft. The inner camshaft bushings are non-serviceable.




## Balance Shaft Timing

- The balance shaft is timed during reassembly by aligning the dot on the balance shaft gear with the dot on the crankshaft flange gear.

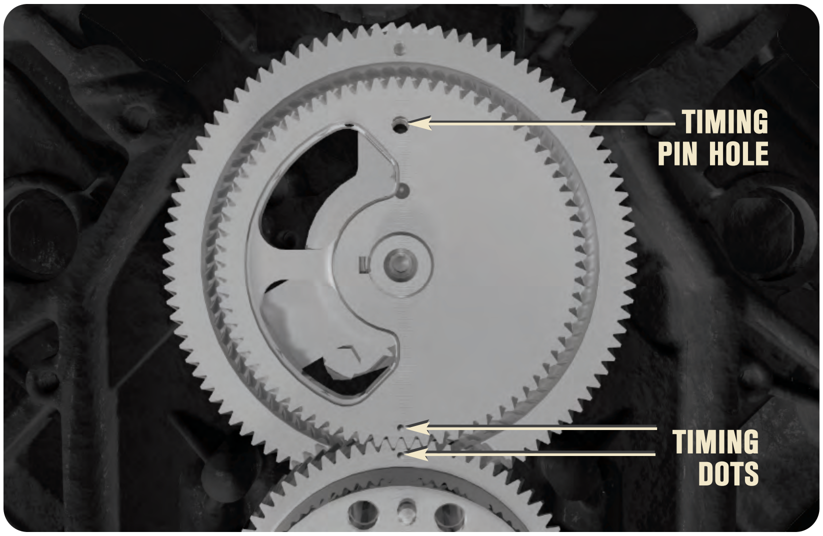
- With the dots aligned, the flex plate pin, the balance shaft gear dot, the flange gear dot and the timing-pin hole will be in a straight line.




## Camshaft Timing

- Camshaft timing is set during assembly. After installing the camshaft and the balance shaft, align the timing pin through the hole in each gear and insert the timing pin tool through the gears until it engages the crankcase hole. Align the dot on the balance shaft with the dot on the face of the crankshaft flange gear as the crankshaft is lowered into the crankcase main bearings.

- With the dots aligned, the flex plate pin, the balance shaft gear dot, the flange gear dot and the timing-pin hole will be in a straight line.



**ZTSE4687**
- Crankshaft Timing Tool

**ZTSE4690**
- ICP Adapter / Plug Kit

**ZTSE4517**
- Front Wear Sleeve Remover

**ZTSE4670**
- Glow Plug Connector Remover/Installer

**ZTSE4666**
- IPR Valve Socket

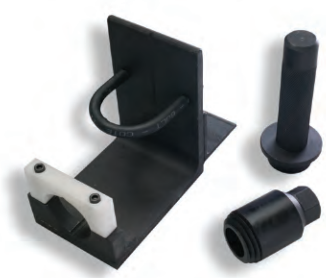
**ZTSE4698**
- Fuel Inlet Restriction Adapter

**Part No. 180971C91**
- Oil Fill Extension

**ZTSE4515A**
- Rear Seal/Wear Sleeve installer

**ZTSE4518**
- Rear Wear Sleeve Removal Tool

**ZTSE4581**
- Quick Release Tool



## ZTSE4676

- Turbocharger Crossover Seal Remover/Installer

## ZTSE4669

- EGR Valve Puller

## ZTSE4545

- EGR Cooler Test Plates

## ZTSE4685

- EGR Valve Puller Arm (offset)


## ZTSE4559

- Intake Port Magnetic Covers

## ZTSE4694

- Case-to-head Tube Removal Tool

## ZTSE4531

- Glow Plug Sleeve Remover

## ZTSE4532

- Glow Plug Sleeve Installer

## ZTSE4528

- Injector Sleeve Remover

## ZTSE4529

- Injector Sleeve Installer

# SPECIAL TOOLS

## ZTSE4681

- Fuel Pressure Gauge

## ZTSE4525

- Oil Cooler Test Plate / Pressure Adapter

## ZTSE4693

- Relay Breakout Harness

## ZTSE4695

- MAF / IAT Sensor Breakout Harness

## ZTSE4664

- EGR Valve Breakout Harness

## ZTSE4696

- Fuel Pressure Test Adapter

## ZTSE7559

- Vacuum Pump and Gauge

## ZTSE4510

- Crankcase Pressure Test Adapter

## ZTSE4665

- 12-Pin Brakeout Harness

## ZTSE4650

- Injector Connector Remover

## ZTSE4661

- Cylinder Head Lifting Bracket

## ZTSE4680

- Front Seal Installer / Wear Sleeve Installer

## ZTSE4557

- Oil Cooler Reservoir / High-Pressure Pump Magnetic Covers

## ZTSE4526

- Fuel / Oil Pressure Test Coupler

## ZTSE4682

- Intake Manifold Pressure Test Cap

## ZTSE4542

- Fuel Pressure Test Fitting

(used for oil pressure measurement)

## ZTSE4409

- Gauge Bar Tool

## ZTSE4594

- ICP System Test Adapter

# HARD START NO START DIAGNOSTICS

## Hard Start and No Start Diagnostics

VT 275

Technician ______ Kilometers ______ Transmission
Date ______ Miles ______ Manual ____ Auto ____
Hours ______
Unit No. ______ VIN ______ Truck build ______

**WARNING**

To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the "Safety information" section of *Engine Diagnostics Manual* EGES-305 before doing procedures on this form.

**Notes**

See "Hard Start and No Start Diagnostics"- Section 5 in EGES-305. Use figures and additional information to do each test or procedure on this form. Record results on this form.

For starting concerns with ECT temperatures below 16 °C (60 °F), do Tests 14 and 15. Service as necessary. If a problem was found and corrected, it is not necessary to complete the rest of this form - unless a starting concern remains.

Do all tests in sequence unless otherwise stated. Doing a test out of sequence could cause incorrect results.

If a problem was found and corrected, **it is not necessary to complete the rest of the form** unless a starting concern remains.

See Appendix A in EGES-305 for engine specifications.

See Appendix B in EGES-305 or Form CGE 310-1 for Diagnostic Trouble Codes (DTCs).

### 1. Initial Ignition Key On (Do not start)

- ☐ Check for WAIT TO START lamp
- ☐ Check amber WATER IN FUEL lamp
- ☐ Listen for injector precycle. (Duration is temp. dependent.)
- ☐ Listen for hum or buzz from electronic fuel pump.

| Comments |
|---|
| |

### 2. Engine Cranking

- ☐ Does engine crank?
- ☐ Check cranking rpm. (Instrument panel)
- ☐ Check smoke color.

| Check | Spec | Actual |
|---|---|---|
| rpm | | |
| Smoke color | | |

### 3. Diagnostic Trouble Codes

- ☐ Install Electronic Service Tool (EST).
- ☐ Use EST to read DTCs.
- ☐ Use EST to check KOEO values for temperature and pressure sensors.

| | |
|---|---|
| Active DTCs | |
| Inactive DTCs | |
| Abnormal sensor values<br>Suspect sensor/value | ☐ Yes ☐ No |

- Correct problem causing active DTCs before continuing.
- If an EST is not available, see "Standard Test using Cruise Switches" in Section 3.

### 4. KOEO Standard Test

- ☐ Use EST to run KOEO Standard Test

| Active DTCs |
|---|
| |

- Correct problem causing active DTCs before continuing.
- If an EST is not available, see "Standard Test using Cruise Switches" in Section 3.

### 5. KOEO Injector Test

- ☐ Use EST to run KOEO Injector Test.

| Active DTCs |
|---|
| |

- Correct problem causing active DTCs before continuing.

### 6. EST Data List

- ☐ Enter data in the Cranking Spec column.
- ☐ Monitor KOEO values and enter in KOEO column.
- ☐ Crank engine and monitor DATA for 20 seconds.
- ☐ Enter data in the Actual Spec column.

| PID | KOEO | Cranking spec | Actual spec |
|---|---|---|---|
| VBAT | | | |
| RPM | | | |
| ICP | | | |
| EOP | | | |
| EGRP | | | |

- If voltage is below spec, see "ECM Power" in Section 7.
- If no rpm is noted, check DTCs.
- If ICP is below spec, do "Low ICP System Pressure - Test 13.
- If EOP is below spec, see "Engine Symptoms Diagnostics" in Section 4 and "EOP switch" in Section 7.

### 7. Engine Systems

- ☐ Leaks
- ☐ Loose connections

| Fuel | Oil | Coolant | Electrical | Air |
|---|---|---|---|---|
| | | | | |

### 8. Engine Oil

- ☐ Leaks
- ☐ Contaminated oil (fuel or coolant)
- ☐ Oil grade, viscosity, and level
- ☐ Kilometers or Miles and hours on oil

| Comments |
|---|
| |

### 9. Intake and Exhaust Restriction

- ☐ Air inlet and duct
- ☐ Hoses and piping
- ☐ Filter minder
- ☐ Intake and exhaust restriction

| Comments |
|---|
| |

### 10. Fuel Supply System

- ☐ Measure pressure at the secondary fuel filter housing test port.
- ☐ If concerns were not found in test 10.1, do not continue testing fuel system.

| | | | |
|---|---|---|---|
| 10.1 Pressure, quality, and aerated fuel | Fuel in tank | Yes ☐ No ☐ | |
| | Hear FP running | Yes ☐ No ☐ | |
| First sample | Aerated fuel | Yes ☐ No ☐ | |
| | Contaminated fuel | Yes ☐ No ☐ | |
| Second sample (if needed) | Aerated fuel | Yes ☐ No ☐ | |
| | Contaminated fuel | Yes ☐ No ☐ | |
| | Fuel pressure KOEO | Spec | Actual |
| 10.2 Fuel pump discharge pressure | Discharge pressure | Spec | Actual |
| 10.3 Fuel pump inlet restriction | Restriction | Spec | Actual |

- If a hum can not be heard from the HFCM, verify fuel pump is being powered. Repair as necessary.
- If fuel has air bubbles, check for leaks in supply lines - tank to HFCM.
- If fuel is contaminated, correct condition.
- If fuel pressure is low or slow to build, replace both filters and retest.
- If fuel pressure is below specification, do test 10.2.
- If pump discharge pressure is in specification, inspect fuel regulator valve.
- If discharge pressure is low or slow to build, do test 10.3.

| | | |
|---|---|---|
| Ambient temperature ______ | Engine SN ______ | ECM calibration ______ |
| Coolant temperature ______ | Engine HP ______ | IDM calibration ______ |
| | | Injector No. ______ |
| Complaint ______ | Engine Family Rating Code ______ | Turbocharger No. ______ |

### 11. Main Power Relay Voltage to ECM

- ☐ Connect breakout harness between ECM main power relay and distribution box
- ☐ Crank engine and use a DMM to measure voltage to ECM. (Min 130 rpm for 20 seconds)
- ☐ Check voltage between connector Pin 5 and ground

| Instrument | Spec | Actual |
|---|---|---|
| DMM | | |

### 12. Main Power Relay Voltage to IDM

- ☐ Connect 12 - Pin Breakout harness between engine and chassis harness
- ☐ Crank engine and use a DMM to measure voltage to IDM. (Min 130 rpm for 20 seconds)
- ☐ Check voltage between connector Pin 12 and Pin 1.

| Instrument | Spec | Actual |
|---|---|---|
| DMM | | |

### 13. Low ICP System Pressure

- ☐ Do only the following tests, if ICP was not to spec during Test 6.
- ☐ Start and continue Test 13.1 System Function, if lube oil pressure is not a concern and terminals on the IPR valve and engine harness are not damaged or corroded.
- ☐ If test result is Yes for 13.1 System Function, **do not do Tests 13.2 through 13.5 for low ICP.**

| Low ICP test | Question | Result | |
|---|---|---|---|
| 13.1 System function | IPR connectors: Corroded, bent or pushed back pins | ☐ Yes | ☐ No |
| | Over 3.45 Mpa (500 psi) (0.82V)? | ☐ Yes | ☐ No |
| 13.2 IPR function | Audible air leak? | Unplugged | B+ applied |
| | | ☐ Yes | ☐ Yes |
| | | ☐ No | ☐ No |
| 13.3 Under valve cover leaks | Audible air leak? | Cylinder Head | |
| | | Left | Right |
| | | ☐ Yes | ☐ Yes |
| | | ☐ No | ☐ No |
| | | Crankcase | |
| | | Left | Right |
| | | ☐ Yes | ☐ Yes |
| | | ☐ No | ☐ No |
| 13.4 Cylinder Head isolation | Audible air leak? | Left | Right |
| | | ☐ Yes | ☐ Yes |
| | | ☐ No | ☐ No |
| 13.5 High-pressure pump | Over 3.45 Mpa (500 psi) (0.82V)? | ☐ Yes | ☐ No |

### 14. Glow Plug System

- ☐ Use EST to do Output State Test for glow plugs. After 40 seconds, measure amperage and check for DTCs.
- ☐ If test results in 14.1 are within specification, **do not continue testing the glow plug system**.

| 14.1 Glow Plug system Amperage | Cylinder Head | Spec | Actual | | | |
|---|---|---|---|---|---|---|
| | Left | 24-42 amps | | | | |
| | Right | 24-42 amps | | | | |
| 14.2 Glow Plug Harness to Ground | Glow plugs LT | | | Glow plugs RT | | |
| | 1 Yellow | 3 Red | 5 White | 2 Yellow | 4 Red | 6 White |
| Spec 0.1 -6 ohmns | | | | | | |
| 14.3 Glow Plug to Ground Spec 0.1 -6 ohmns | | | | | | |
| 14.4 Engine Harness 3-pin to Relay Spec <5 ohmns | | | | | | |
| 14.5 Relay Operation | Terminal | Spec | Actual | | | |
| | Battery feed | B+ | | | | |
| | Relay output | B+ | | | | |

- If results of 14.1 are not within spec, do test 14.2 for all glow plugs out of spec.
- If results of 14.1 are 0 amps for both cylinder heads and DTC 251 was not set, do test 14.5.
- If DTC 251 was set, do GPC (Glow Plug Control) circuit" in Section 7.
- If results of 14.2 are within spec, do test 14.4.
- If results of 14.2 are not within spec, do test 14.3 for all glow plugs out of spec.
- If results of 14.3 are within spec, replace failed glow plug harness
- If results of 14.3 are not within spec, replace the glow plug that was out of spec.

### 15. Inlet Air Heater System

- ☐ Install Amp Clamp around feed wire and use EST to do Output State Test for Inlet Air heater. After 4 seconds, measure amperage for heater wire.
- ☐ If test results in 15.1 are within specification, **do not continue testing the Inlet Air Heater System.**

| Test | Air Heater Wire Spec | Circuit |
|---|---|---|
| 15.1 Amperage draw | 50 +/- 5 amps | |
| 15.2 Voltage at Element | BAT V | |
| 15.3 Resistance or Element | < 5 ohms | |
| 15.4 Wiring harness continuity and resistance | < 5 ohms | |
| 15.5 Relay operation | | |
| Battery feed | B+ | |
| Relay output | B+ | |

## Performance Diagnostics
VT 275

| | | |
|---|---|---|
| Technician ______ | Kilometers ____ | Transmission |
| Date ______ | Miles ______ | Manual ____ Auto ____ |
| | Hours ______ | |
| Unit No. ______ | VIN ______ | Truck build ______ |

**WARNING**

To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the "Safety information" section of *Engine Diagnostics Manual* EGES-305 before doing procedures on this form.

**Notes**

See "Performance Diagnostics"- Section 6 in EGES-305. Use figures and additional information to do each test or procedure on this form. Record results on this form.

Do all checks in sequence unless otherwise stated. Doing a check or test out of sequence could cause incorrect results.

If a problem was found and corrected, **it is not necessary to complete the rest of the form** unless a performance concern remains.

See Appendix A in EGES-305 for engine specifications.

See Appendix B in EGES-305 or Form CGE 310-1 for Diagnostic Trouble Codes (DTCs).

### 1. Diagnostic Trouble Codes

- ☐ Install Electronic Service Tool (EST).
- ☐ Use EST to read DTCs.
- ☐ Use EST to check KOEO values for temperature and pressure sensors.

| | |
|---|---|
| Active DTCs | |
| Inactive DTCs | |
| Abnormal sensor values<br>Suspect sensor/value | Yes ☐ No ☐ |

- Correct problem causing active DTCs before continuing.
- To access DTCs without EST, see “Diagnostic Software Operation” - Section 3.

### 2. KOEO Standard Test

- ☐ Use EST to run KOEO Standard Test

| |
|---|
| Active DTCs |

- Correct problem causing active DTCs before continuing.
- If an EST is not available, see “Standard Test Using Cruise Switches” in Section 3.

### 3. KOEO Injector Test

- ☐ Use EST to run KOEO Injector Test.

| |
|---|
| DTCs found |

- Correct problem causing active DTCs before continuing.

### 4. Engine Oil

- ☐ Leaks
- ☐ Contaminated oil (fuel or coolant)
- ☐ Oil grade, viscosity, and level
- ☐ Kilometers or Miles and hours on oil

| |
|---|
| Comments |

### 5. Fuel Supply System

- ☐ Measure pressure at the secondary fuel filter housing test port.
- ☐ If no concerns are found in test 5.1, do not continue testing fuel system.

| | | | |
|---|---|---|---|
| 5.1. Pressure, quality and aerated fuel | Fuel in tank | Yes ☐ No ☐ | |
| | Hear FP running | Yes ☐ No ☐ | |
| First sample | Aerated fuel | Yes ☐ No ☐ | |
| | Contaminated fuel | Yes ☐ No ☐ | |
| Second sample (if needed) | Aerated fuel | Yes ☐ No ☐ | |
| | Contaminated fuel | Yes ☐ No ☐ | |
| | Fuel pressure KOEO | Spec | Actual |
| | Fuel pressure low idle | Spec | Actual |
| | Fuel pressure high idle | Spec | Actual |
| 5.2. Fuel pump discharge pressure | Discharge pressure | Spec | Actual |
| 5.3. Fuel pump inlet restriction | Restriction | Spec | Actual |

- If a hum can not be heard from the HFCM, verify fuel pump is being powered. Repair as necessary.
- If fuel has air bubbles, check for leaks in supply lines - tank to HFCM.
- If fuel is contaminated, correct condition.
- If fuel pressure is low or slow to build, replace both filters and retest.
- If fuel pressure is still low or slow to build, do test 5.2.
- If pump discharge pressure is in specification, inspect fuel regulator valve.
- If discharge pressure is low or slow to build, do test 5.3.

### 6. Intake and Exhaust Restriction

- ☐ Air inlet and duct
- ☐ Hose and piping
- ☐ Intake and exhaust restriction
- ☐ Measure restriction at high idle, no load.

| Instrument | Spec | Actual |
|---|---|---|
| Magnehelic gauge or Manometer | | |
| Comment | | |

- Correct problem causing out-of-specification values, before continuing.

### 7. KOER Standard Test

**Note:** Engine coolant temperature must be 70 °C (158 °F) or higher.

- ☐ Use EST to run KOER Standard Test.

| |
|---|
| DTCs found |

- Correct problem causing active DTCs before continuing.

### 8. Injection Control Pressure

- ☐ Use EST to monitor ICP and engine speed.

| Condition | Spec | Actual |
|---|---|---|
| Low idle | | |
| High idle - Initial | | |
| High idle - After 2 minutes | | |
| Aerated oil Yes ☐ No ☐ | | |

- If ICP is high or unstable, hold at high idle for 2 minutes. Return to low idle, take oil sample, check for foam, and correct condition if oil is aerated.
- If oil is not aerated, disconnect ICP sensor and check for engine stability.
- If problem is corrected, see Operational Voltage checks for ICP sensor in Section 7 in EGES-305.
- If ICP still high or unstable, replace IPR and retest.

### 9. Injector Disable

- ☐ Use EST to run injector disable diagnostics to identify suspect cylinders.

| Selected cylinder | EOT | Average fuel rate | Deviation | Average engine load | Deviation |
|---|---|---|---|---|---|
| Base Line | | | | | |
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
| Base Line | | | | | |
| Cut-off values: | | Fuel rate | | Engine load | |

- If any cylinder is suspect, do **Test 12**.

### 10. Relative Compression

- ☐ Turn ignition key to ON.
- ☐ Use EST to run Relative Compression Test.
- ☐ Crank engine following EST instructions.

| Relative Compression Test | Value |
|---|---|
| Cylinder 1 Relative Compression | |
| Cylinder 2 Relative Compression | |
| Cylinder 3 Relative Compression | |
| Cylinder 4 Relative Compression | |
| Cylinder 5 Relative Compression | |
| Cylinder 6 Relative Compression | |

- If a Relative Compression Test and Injector Disable Test identify a suspect cylinder, check for a mechanical problem.
- If a Relative Compression Test does not identify a suspect cylinder, but the Injector Disable Test does, replace suspect injector(s).

Ambient temperature ________ Engine SN ________ ECM calibration ________

Coolant temperature ________ Engine HP ________ IDM calibration ________

Injector No. ________

Complaint ________ Engine Family Rating Code ________ Turbocharger No. ________

## 11. Air Management

☐ Use EST to set engine idle speed, monitor engine load, toggle EGR valve and monitor MAF.

| Idle speed | MAF | Load |
|---|---|---|
| EGR close | MAF | Message Set |
| EGR open | MAF | DTC Set |
| EGR close | MAF | DTC Set |

- Correct problem causing messages or DTCs before restarting.

## 12. Boost Control

| | | |
|---|---|---|
| 12.1. Linkage connected | Yes ☐ No ☐ | |
| 12.2. Linkage movement | Yes ☐ No ☐ | |
| Air pressure - Initial movement | Spec | Actual |
| Leaks | Yes ☐ No ☐ | |
| 12.3. Linkage movement | Yes ☐ No ☐ | |
| 12.4. Linkage movement | Yes ☐ No ☐ | |
| Air pressure - Initial movement | Spec | Actual |
| Leaks | Yes ☐ No ☐ | |

## 13. Torque Converter Stall

☐ Set parking brake and apply service brake.

☐ Put transmission in drive.

☐ Push accelerator to the floor, begin timing and monitor tachometer until tachometer stops moving.

☐ Record RPM and time.

| Condition | Spec | Actual |
|---|---|---|
| Stall RPM | | |
| Time (idle to stall in seconds) | | |

- If minimum RPM is reached within specified time, for a launch concern do not continue with performance diagnostics.
- If RPM is low, or was not reached within specified time, continue with performance diagnostics.

## 14. Crankcase Pressure

☐ Measure at oil fill tube with crankcase pressure test adapter.

☐ Clamp off crankcase breather hose.

☐ Measure at high idle, no load.

| Instrument | Spec | Actual |
|---|---|---|
| Magnehelic gauge or Manometer | | |

## 15. Test Drive (Full load, rated speed)

☐ Use EST to monitor **boost pressure** and engine speed.

| Condition | Spec | Spec | Actual |
|---|---|---|---|
| | Engine speed | Boost | EST boost reading |
| Peak HP | | | |
| Peak Torque | | | |

- If boost pressure is not to specification continue performance diagnostics; **if to specification do not continue**.

☐ Use EST to monitor **Mass Air Flow (MAF)** and engine speed.

| Condition | Spec | Spec | Actual |
|---|---|---|---|
| | Engine speed | MAF | EST MAF reading |
| Peak HP | | | |
| Peak Torque | | | |

- If MAF is not to specification continue performance diagnostics; **if to specification do not continue**.

☐ Measure **fuel pressure** at secondary fuel filter fuel pressure test port (full load, rated speed).

| Instrument | Spec | Actual |
|---|---|---|
| 0 - 160 psi gauge | | |

- If fuel pressure is low, perform **Test 5** including measure fuel inlet restriction.

☐ Use EST to monitor **ICP** and engine speed

| Instrument | Spec | Actual |
|---|---|---|
| EST | | |
| Aerated oil Yes ☐ No ☐ After 2 min. ☐ | | |

- Disconnect ICP and test drive vehicle.
- If problem is corrected, see Operational Voltage checks for ICP sensor in Section 7 in EGES-305.
- If still high or unstable, replace IPR and retest.

STOP


## Measure Fuel Pressure

- The engine will not perform correctly with low fuel pressure. Fuel pressure can be measured at the secondary filter housing by removing the fuel pressure test port plug and install the ICP System Test Adapter (ZTSE4594). Connect the Fuel Pressure Gauge (ZTSE4681) to the ICP System Test Adapter. Turn the key switch to the ON position and measure the fuel pressure. The following pressure minimums should be met:

| | |
|---|---|
| Cranking | 20 psi |
| Idle | 50 psi |
| High Idle/No load | 50 psi |
| Full load @ rated speed | 50 psi |

- If fuel pressure does not meet the minimum, verify there is fuel in the tank and the pump is running. Then check for fuel aeration, primary and secondary filter condition, pump inlet restriction, pump deadhead pressure, and pressure regulator operation.

## Check for Fuel Aeration

- The engine will not operate correctly with aerated fuel. Aeration can be checked visually using a clear hose and valve.

- Remove the fuel pressure test port plug. Connect the Fuel Pressure Gauge (ZTSE4681) to the secondary fuel filter housing using the ICP System Test Adapter (ZTSE4594). With the key switch ON, open the valve to allow fuel to flow into a clean container. Observe the fuel flow. Opening the system to install the hose will allow some air to enter the system. This air will be visible in the fuel flow initially but should clear within a few seconds.

- If the fuel continues to show signs of aeration, check the suction side of the system for air leaks.

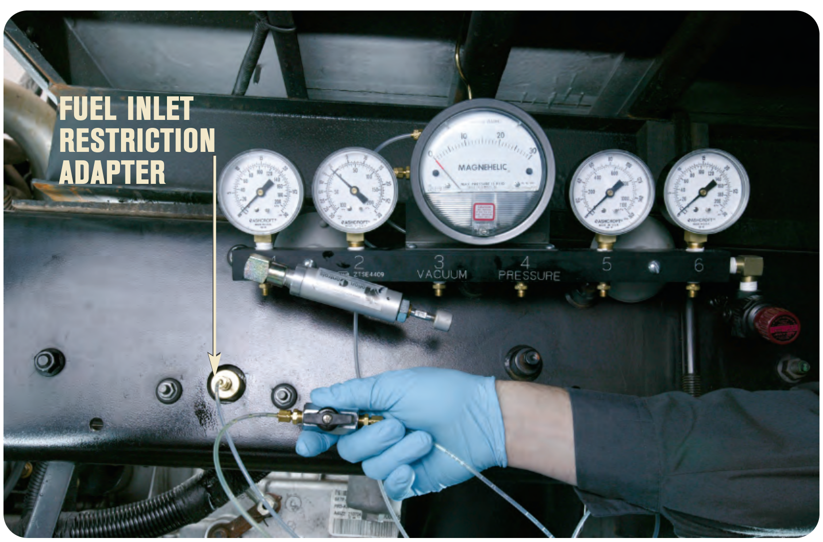
***Consult service literature for latest information before attempting any repairs**

## Measure Fuel Pump Discharge Pressure

- Determine the ability of the fuel pump to develop pressure by isolating the fuel pump from the engine-mounted regulator.

- Remove the banjo bolt on the pressure line at the secondary fuel filter and insert the bolt through the back of the fitting so that the bolt faces away from the engine. Install the Fuel Pressure Test Adapter (ZTSE4696) and tighten the bolt. Attach a 0-160 psi Fuel Pressure Gauge (ZTSE4681) to the test adapter. The fuel pump and its internal pressure regulator are now isolated from the engine-mounted fuel pressure regulator.

- Turn the key switch to the ON position and measure the fuel pressure while the pump is running. Pump discharge pressure should reach 80 psi. If the pressure is low, check for a plugged primary filter and/or high pump inlet restriction.

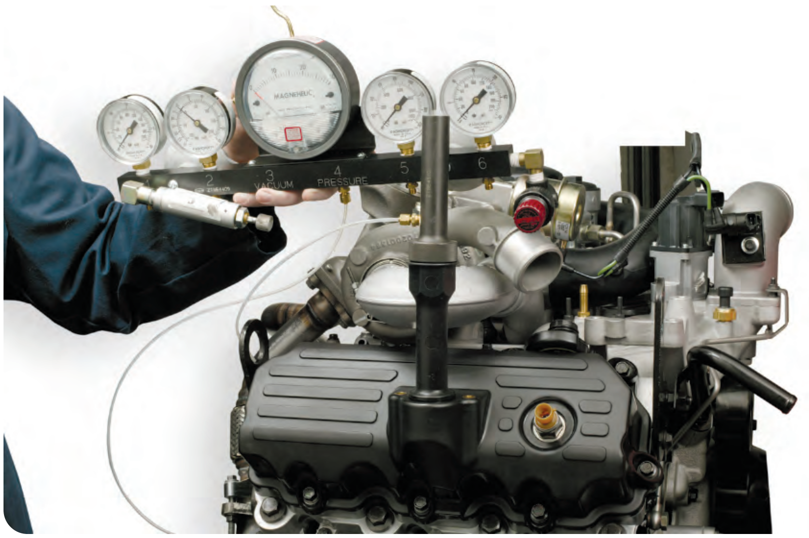

## Measure Fuel Inlet Restriction

- High inlet restriction can starve the suction side of the fuel pump and cause low fuel pressure.

- With the key switch OFF, remove the water drain plug from the fuel pump. Install the Fuel Inlet Restriction Adapter (ZTSE4698) in place of the plug. Connect the 0-30 in/hg pressure gauge to the adapter with a shut off valve in the OFF position between the pump and the Fuel Pressure Gauge (ZTSE4681).

- Turn the key switch ON. With the fuel pump running, open the valve to the 0-30 in/hg pressure gauge and record the restriction.

- If inlet restriction causes a gauge reading of greater than 6 in/Hg, check the lines from the fuel tank to the pump for restrictions.



## Measure Crankcase Pressure

- Crankcase pressure can be used to evaluate the condition of the power cylinders. Remove the oil fill cap and thread the extended Oil Fill Tube (part number 180971C91) into the valve cover fill cap opening. Thread the Crankcase Pressure Test Adapter (ZTSE4510) into the fill adapter.

- Block off the crankcase breather. By blocking the breather, all of the crankcase gasses are forced through the Crankcase Pressure Test Adapter.

- Connect the magnehelic gauge to the Crankcase Pressure Test Adapter. Run the engine to reach normal operating temperature (158°F or higher).

- Run the engine at high idle. Allow the reading to stabilize before taking the reading. Compare the reading with the performance specifications. Use the Injector Disable test and the Relative Compression test to further evaluate high readings.

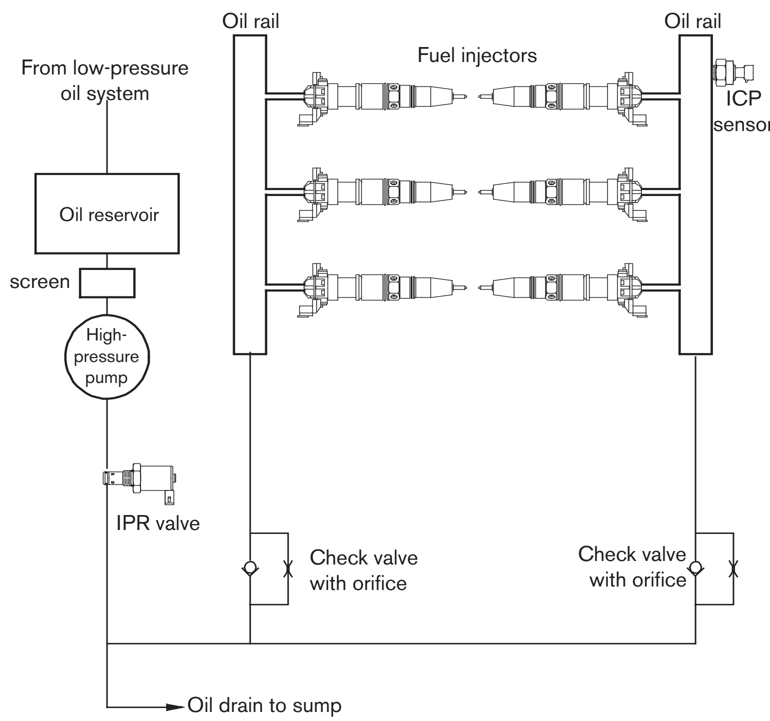
## ICP System Checks

- The Injection Control Pressure system must be able to build a minimum of 500 psi during cranking for the engine to start. The possible causes of low ICP during cranking are:

  -Faulty ICP sensor
  -Low oil level in the reservoir
  -Faulty IPR circuit
  -ECM not controlling the IPR
  -Inoperative IPR
  -Leak in the high-pressure system
  -Inoperative pump

- If the ICP is low while cranking, verify the engine has met the minimum cranking lube oil pressure of 20 psi. Lube oil system pressure is required to maintain the correct level in the reservoir.

- Inspect the IPR connector for corrosion. Perform the KOEO Standard test. The standard test will verify the IPR circuit. If the circuit has a fault, a 241 DTC will be set.

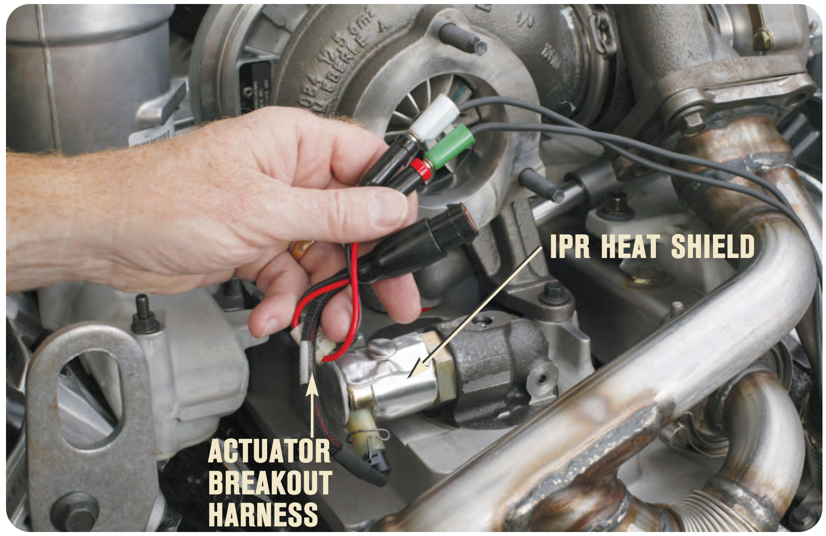


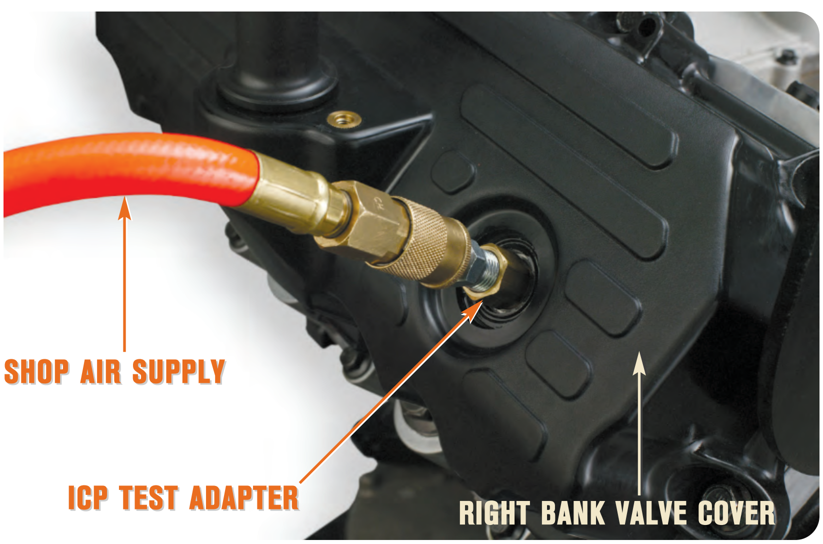
## ICP System Function Test

- The Injection Control Pressure system must be able to build a minimum of 500 psi for the engine to start. During cranking, the ECM must command the IPR valve partially closed to create the pressure required for starting. Test this function by replacing the ECM signal with a direct connection between the IPR and battery power and ground.

- Disconnect the IPR from the engine harness. Install the Actuator Breakout Harness (ZTSE4484) to the IPR only. Use jumper wires to provide power to one lead and a ground to the other. Crank the engine while measuring the injection control pressure. If the engine starts or the pressure now exceeds the minimum cranking pressure, the ECM is not controlling the IPR.

- **Caution:** Do not leave the IPR powered for more than 120 seconds or the IPR may be damaged.

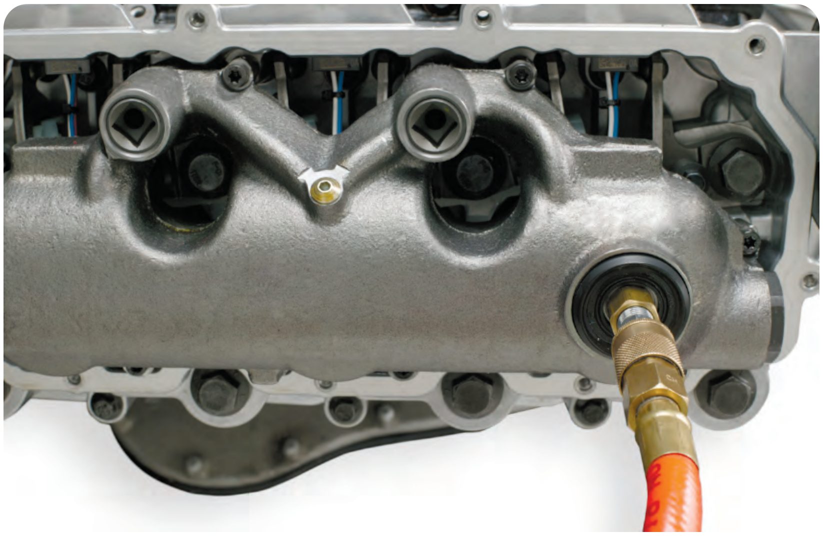



## IPR Function Test

- The IPR must function for the ICP system to build sufficient pressure to start. Remove the ICP sensor from the right bank valve cover. Install the ICP System Test Adapter (ZTSE4594) with an air fitting in place of the sensor. Remove the oil fill cap and attach shop air pressure to the air fitting.

- Listen at the opening of the oil fill cap for air leaking into the crankcase from the IPR. Allow five minutes for the air to displace the oil through the system (cold oil may take longer). If there is a massive air leak in the crankcase when the air is connected, go to the Under Valve Cover Leak test. If there is a faint leak, install the Actuator Breakout Harness (ZTSE4484) to the IPR only. Provide power to one breakout harness lead and a ground to the other. The faint air leak in the crankcase should stop when power is applied. This verifies the ECM signal can operate the IPR valve internally. If the faint air leak stops when the IPR is given power and ground, perform the pump test.



## Under Valve Cover Leak Test

- If the IPR function test reveals a massive air leak, remove the valve covers and apply shop air pressure to the ICP System Test Adapter (ZTSE4594). Attempt to isolate the location of the leak. The possible leak points are:

  -Rail to injector O-rings
  -Rail fittings
  -Case-to-head tube and port plug O-rings
  -Branch tube assembly
  -Pump housing

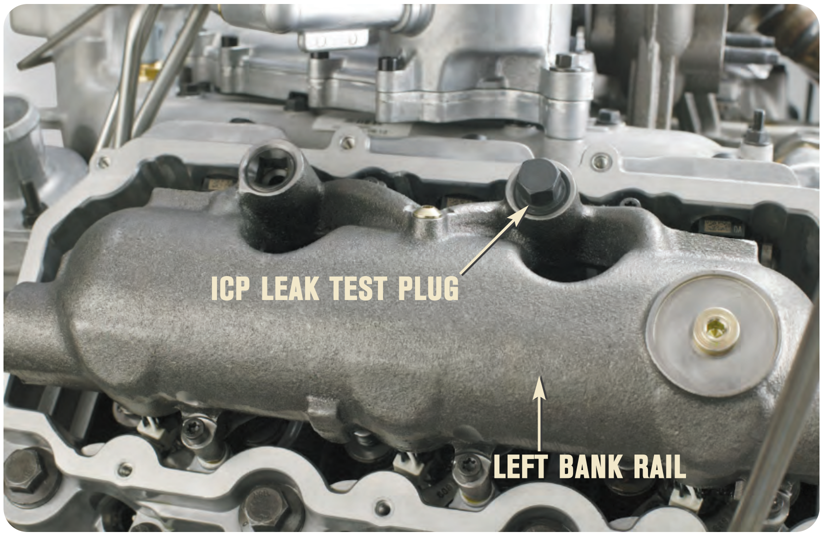
- If the air leak is in the valve cover area, use a short length of rubber hose as a stethoscope to locate the air leak.

- If the air leak is from the crankcase (not the valve cover area), remove the case-to-head tubes and inspect the lower O-rings. If the O-rings are good, remove the high-pressure pump cover and listen for the air leak at the pump-to-branch tube connections.

## Cylinder Head Isolation

- If an air leak is heard, but the location cannot be detected, isolate each bank, one at a time, and test. To test the left bank, remove the left bank rear port plug and install the ICP Leak Test Plug (ZTSE4690) in place of the port plug. Leave the valve covers off, but connect the ICP sensor. Crank the engine while measuring ICP pressure. If the engine starts or ICP pressure exceeds 500 psi, the leak causing the low ICP is in the left bank.

- To test the right bank, install the ICP Sensor Adapter (ZTSE4690) in place of the rear right bank port plug. Install the ICP sensor in the top of the adapter and connect the ICP sensor to the harness using the three-wire Pressure Sensor Breakout Harness (ZTSE4347) as an extension, if needed. Leave the valve covers off. Crank the engine while measuring ICP pressure. If the engine starts or ICP pressure exceeds 500 psi, the leak causing the low ICP is in the right bank.

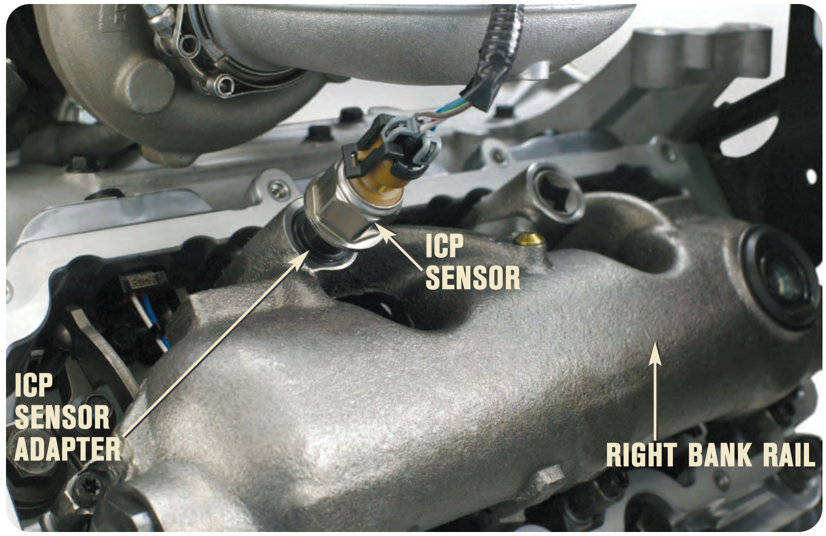


## High Pressure Pump Test

- The pump can be deadheaded by installing the ICP Leak Test Plug (ZTSE4690) in place of the rear left bank port plug, and the ICP Sensor Adapter ( also ZTSE4690) in place of the rear right bank port plug. Install the ICP sensor in the top of the ICP Sensor Adapter and connect the ICP sensor to the harness using the three-wire Pressure Sensor Breakout Harness (ZTSE4347) as an extension, if needed. Leave the valve covers off. Crank the engine while measuring ICP pressure.

- If the ICP pressure exceeds 500 psi, the pump is not at fault and there is a leak in the system.

- If the pressure is below the minimum cranking pressure, and there are no leaks around the pump, remove the pump from the crankcase. Oil should come up from the pump feed port in the crankcase indicating that the reservoir has oil. If the reservoir had oil, the pump is inoperative.




| ICP Diagnostic Test | Purpose |
|---|---|
| KOEO Standard Test | Verifies the IPR Circuit |
| ICP System Function Test | Verifies that the ECM can control the IPR |
| IPR Function Test | Verifies the IPR is working |
| Under the Valve Cover Leak Test | Locates leaks under the valve cover |
| Cylinder Head Isolation | Identifies which bank of cylinders has a high pressure leak |
| High Pressure Pump Test | Verifies the pump’s operation |

## ICP Diagnostics

- If there is lube oil pressure while cranking, the IPR functions, and there are no leaks in the hydraulic lines or rails, then either the pump is not getting oil from the reservoir, the pump is not turning with the crankshaft, or the pump is defective.

- Rotation can be verified by removing the high-pressure pump cover and cranking the engine while observing the pump gear. Oil in the reservoir can be verified by removing the pump and observing the oil flow from the pump feed passage in the crankcase. Oil should come up from the pump passage indicating that the reservoir has oil. If the reservoir had oil, the pump is inoperative.

# DIAGNOSTIC TROUBLE CODES

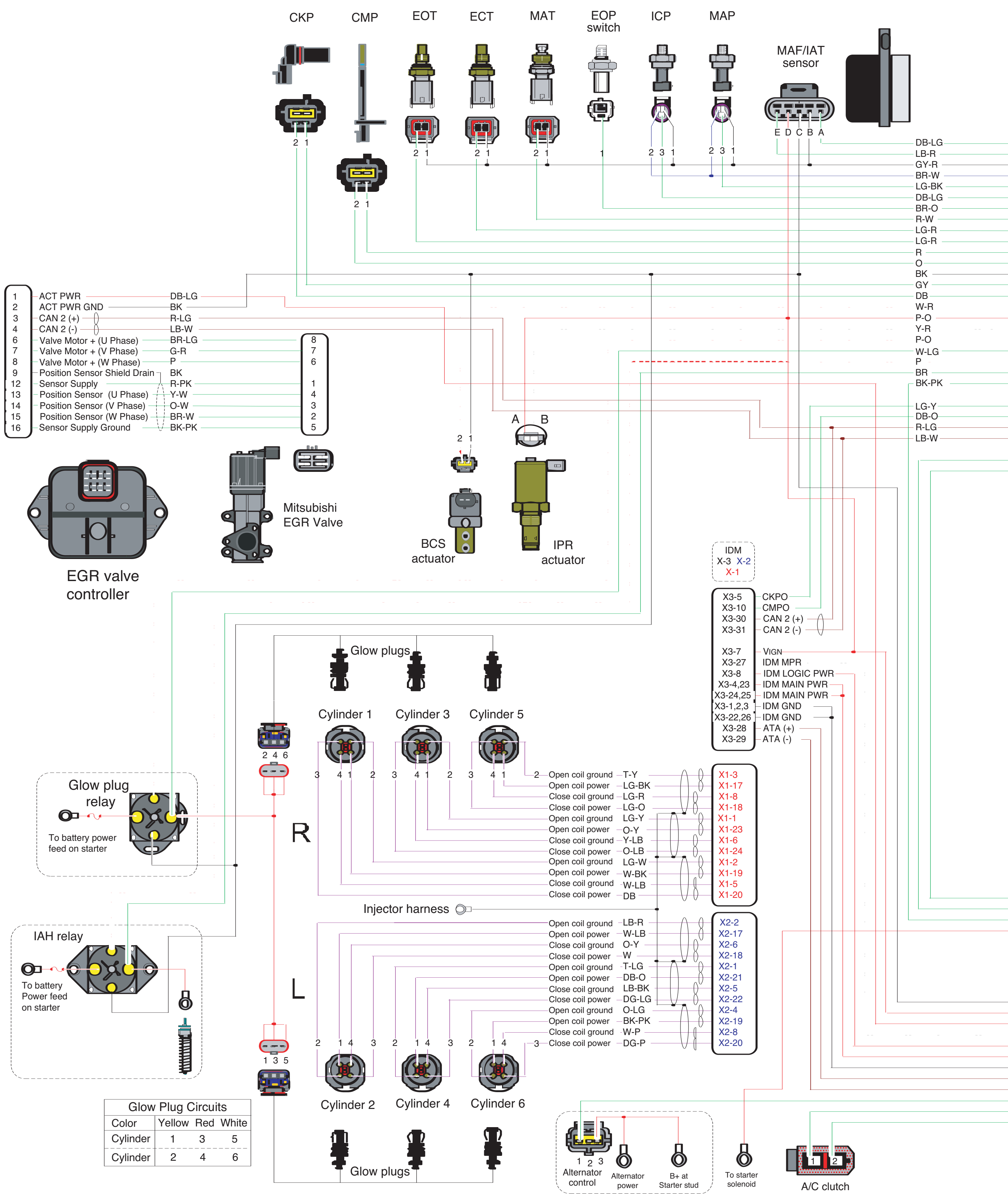
**Consult service literature for latest information before attempting any repairs**

| CODE NUMBER | CIRCUIT NAME | CONDITION DESCRIPTION |
|---|---|---|
| 111 | ECM | No errors detected - flash code only |
| 112 | ECM PWR | Electrical system voltage B+ out of range high |
| 113 | ECM PWR | Electrical system voltage B+ out of range low |
| 114* | ECT | Engine Coolant Temperature signal out of range low |
| 115* | ECT | Engine Coolant Temperature signal out of range high |
| 121* | MAP | Manifold Absolute Pressure signal out of range high |
| 122* | MAP | Manifold Absolute Pressure signal out of range low |
| 123* | MAP | Manifold Absolute Pressure signal in-range fault |
| 124* | ICP | Injection Control Pressure signal out of range low |
| 125* | ICP | Injection Control Pressure signal out of range high |
| 131* | APS / IVS | APS signal out of range low |
| 132* | APS / IVS | APS signal out of range high |
| 133* | APS / IVS | APS signal in-range fault |
| 134* | APS / IVS | APS signal and IVS disagree |
| 135* | APS / IVS | Idle Validation Switch circuit fault |
| 143 | CMP | Incorrect CMP signal signature |
| 145 | CMP | CMP signal inactive |
| 146 | CKP | CKP signal inactive |
| 147 | CKP | Incorrect CKP signal signature |
| 148* | MAF | Mass Air Flow signal frequency out of range high |
| 149* | MAF | Mass Air Flow signal frequency out of range high |
| 152* | BAP | Barometric Absolute Pressure signal out of range low |
| 154* | IAT | Air Inlet Temperature signal out of range low |
| 155* | IAT | Air Inlet Temperature Signal out of range high |
| 161* | MAT | Manifold Air Temperature Signal out of range low |
| 162* | MAT | Manifold Air Temperature Signal out of range high |
| 163* | EGR | Exhaust Gas Recirculation Valve Position Signal out of range low |
| 221 | SCCS | Cruise-PTO control switch circuit fault |
| 222 | BRAKE | Brake switch circuit fault |
| 225 | EOP | EOP sensor signal in range fault |
| 231 | ATA | ATA data communication link error |
| 237 | FPC | Fuel Pump Control OCC self-test failed |
| 238 | IAH | Inlet Air Heater Control OCC self-test failed |
| 241 | IPR | Injection Pressure Regulator OCC self-test failed |
| 251 | GPC | Glow Plug Control OCC self-test failed |
| 268 | ACC | AC Clutch Control Relay OCC self-test failed |
| 311* | EOT | Engine Oil Temperature signal out of range low |
| 312* | EOT | Engine Oil Temperature signal out of range high |
| 313** | EOPS | Engine Oil Pressure below warning level |
| 315* | EWPS | Engine speed above warning level |

*indicates amber ENGINE lamp on when DTC is set
** indicates red ENGINE lamp on when Engine Warning Protection System is enabled and a DTC is set

| CODE NUMBER | CIRCUIT NAME | CONDITION DESCRIPTION |
|---|---|---|
| 316 | EWPS | Engine Coolant Temperature unable to reach commanded set point |
| 321** | EWPS | Engine Coolant Temperature above warning level |
| 322** | EWPS | Engine Coolant Temperature above critical level |
| 324** | IST | Idle Shutdown Timer enabled engine shutdown |
| 325 | EWPS | Power reduced, matched to cooling system performance |
| 331* | ICP | Injection Control Pressure above system working range |
| 332* | ICP | Injection Control Pressure above specification with engine not running |
| 333* | ICP sys | Injection Control Pressure above / below desired level |
| 334 | ICP sys | ICP unable to achieve setpoint in time (poor performance) |
| 335 | ICP sys | ICP unable to build pressure during cranking |
| 346 | AMS | Faults detected during EGR portion of the AMS test |
| 365* | EGR | EGR valve position above / below desired level |
| 368* | EGR | EGR drive module / ECM2 communication fault |
| 373 | IAH | Inlet Air Heater relay circuit fault |
| 374 | FPC | Fuel Pump Relay Circuit fault |
| 375 | GPC | Glow Plug Relay Circuit fault |
| 421-426 | INJ | High side to low side open (cylinder number indicated) |
| 431-436 | INJ | High side shorted to low side (cylinder number indicated) |
| 451-456 | INJ | High side short to ground or VBAT (cylinder number indicated) |
| 523 | IDM | IDM VIGN voltage low |
| 525* | IDM | IDM fault |
| 533 | IDM | IDM relay voltage high |
| 534 | IDM | IDM relay voltage low |
| 543* | ECM / IDM | ECM / IDM communications fault |
| 551 | ECM / IDM | IDM / CMPO signal inactive |
| 552 | ECM / IDM | IDM incorrect CKPO signal signature |
| 553 | ECM / IDM | IDM CKPO signal inactive |
| 554 | ECM / IDM | IDM incorrect CKPO signal signature |
| 613* | ECM | ECM / IDM software not compatible |
| 614* | ECM | EFRC / ECM configuration mismatch |
| 621* | ECM | Engine using mfg. default rating |
| 622* | ECM | Engine using field default rating |
| 623* | ECM | Invalid Engine Family Rating Code (EFRC) |
| 624 | ECM | Field default active |
| 626 | ECM PWR | Unexpected reset fault |
| 631 | ECM | Read Only Memory (ROM) self test fault |
| 632 | ECM | Random Access Memory (RAM) - CPU self test fault |
| 655 | ECM | Programmable parameter list level incompatible |
| 661 | ECM | RAM programmable parameter list corrupt |
| 664 | ECM | Calibration level incompatible |
| 665 | ECM | Programmable parameter memory content corrupt |

*indicates amber ENGINE lamp on when DTC is set
** indicates red ENGINE lamp on when Engine Warning Protection System is enabled and a DTC is set




| Glow Plug Circuits | | | |
|---|---|---|---|
| Color | Yellow | Red | White |
| Cylinder | 1 | 3 | 5 |
| Cylinder | 2 | 4 | 6 |

## ELECTRONIC CONTROL SYSTEM DIAGNOSTICS

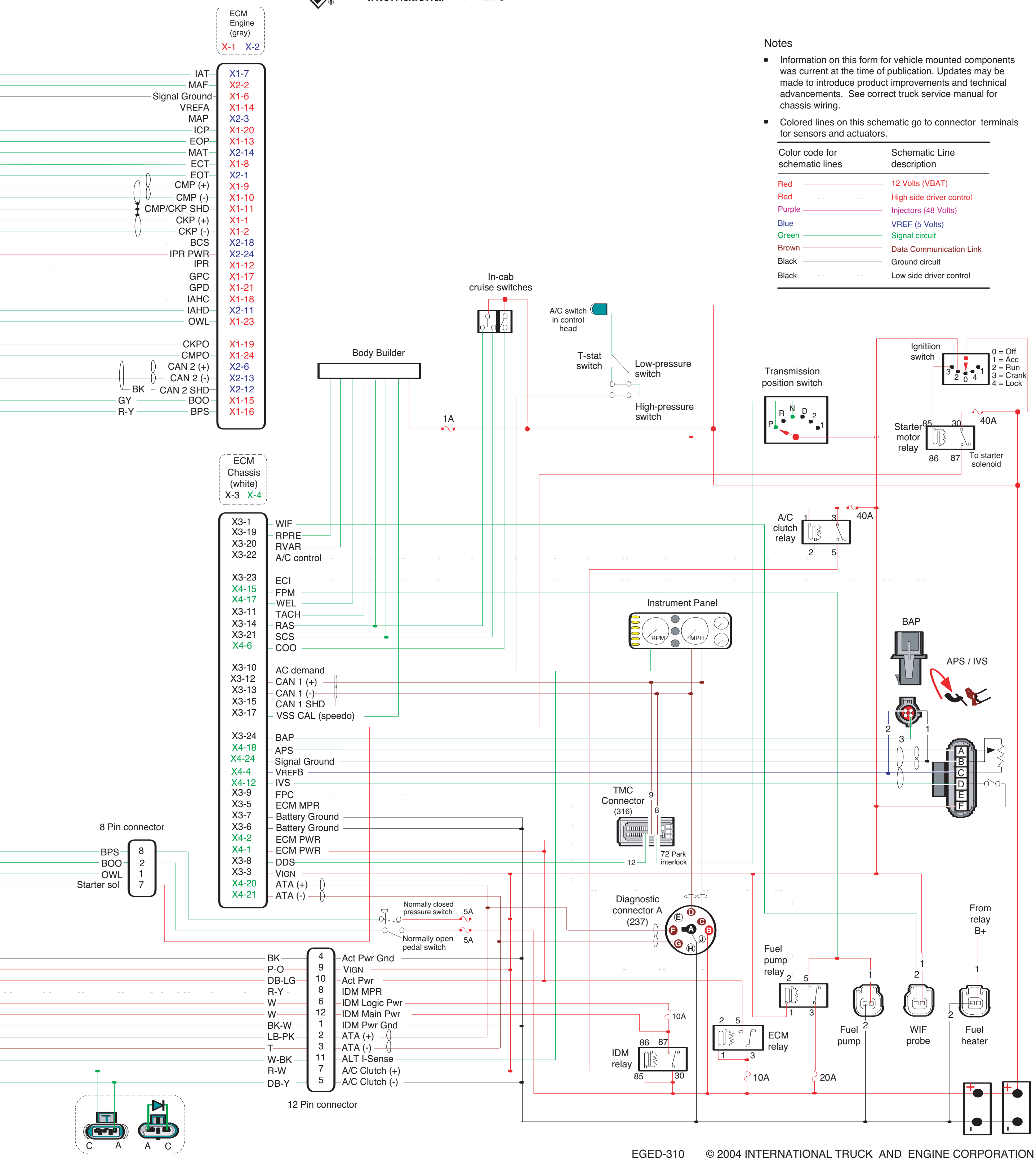
International® VT 275

**WARNING**

Notes

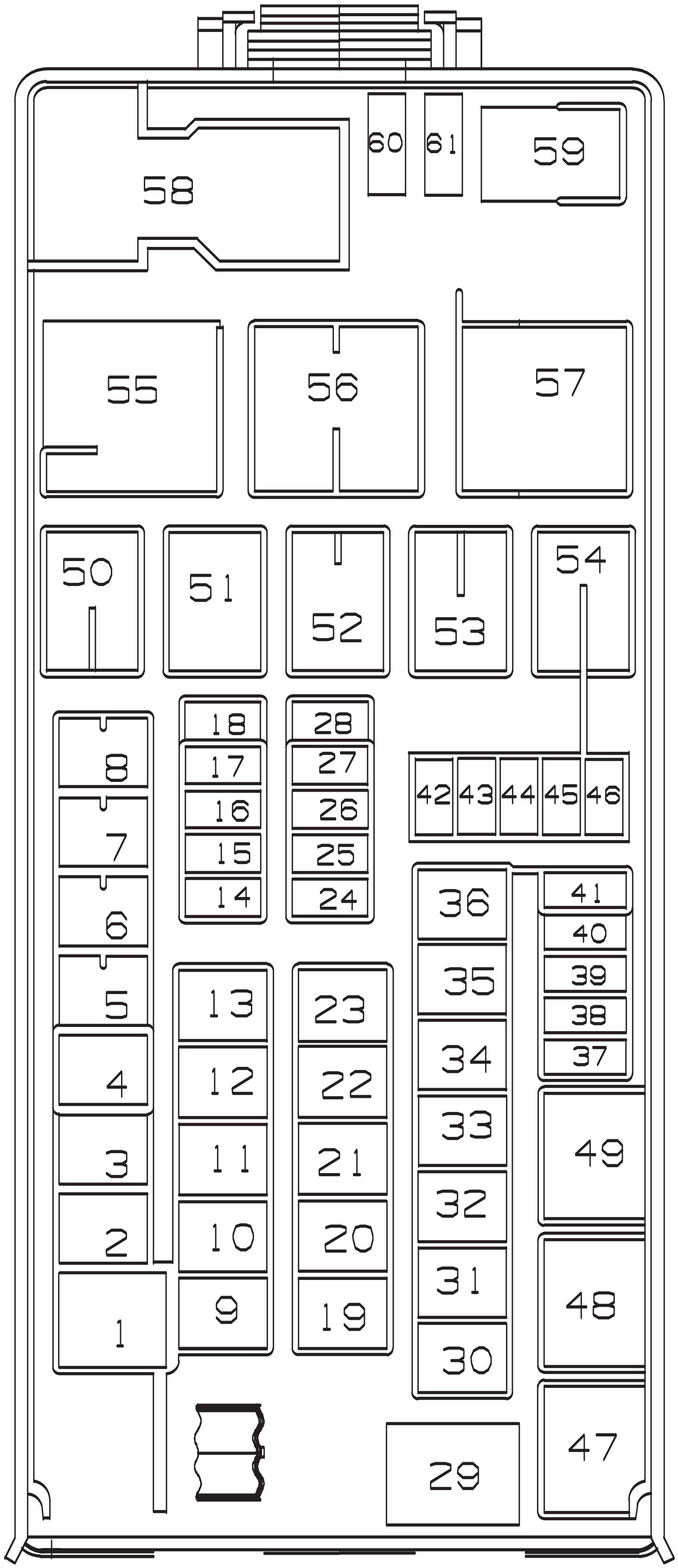
- Information on this form for vehicle mounted components was current at the time of publication. Updates may be made to introduce product improvements and technical advancements. See correct truck service manual for chassis wiring.
- Colored lines on this schematic go to connector terminals for sensors and actuators.

| Color code for schematic lines | Schematic Line description |
| --- | --- |
| Red | 12 Volts (VBAT) |
| Red | High side driver control |
| Purple | Injectors (48 Volts) |
| Blue | VREF (5 Volts) |
| Green | Signal circuit |
| Brown | Data Communication Link |
| Black | Ground circuit |
| Black | Low side driver control |




EGED-310 

**Consult service literature for latest information before attempting any repairs**



| | | |
|---|---|---|
| 1 | BLANK | |
| **2*** | **30A** | **STARTER** |
| 3 | 20A | PARK LAMPS |
| **4*** | **30A** | **IDM / ECM** |
| 5 | 30A | HEAD LAMPS |
| 6 | 40A | BLOWER MOTOR |
| 7 | 25A | WIPER |
| 8 | 30A | ELECTRIC BRAKE |
| 9 | 20A | DOOR LOCK |
| 10 | 20A | STOP LAMPS |
| **11*** | **20A** | **FUEL PUMP** |
| 12 | 20A | RUN / ACC FEED |
| 13 | 20A | RUN / START FEED |
| 14 | 15A | HORN |
| 15 | 10A | CLUSTER BATT |
| 16 | 15A | B/U LAMPS |
| 17 | 15A | FOG LAMPS |
| 18 | 15A | TRANS |
| **19*** | **20A** | **FUEL HEATER** |
| 20 | 60A | ABS MODULE |
| 21 | 30A | CONJOINER 1 |
| 22 | 30A | CONJOINER 2 |
| 23 | 40A | TRAILER BATT |
| 24 | 20A | CIGAR LIGHTER |
| 25 | 20A | HAZARD |
| 26 | 15A | KEYLESS |
| 27 | 10A | RADIO |
| 28 | 10A | DOME |
| 29 | BLANK | |
| 30 | 60A | ABS PUMP |
| 31 | BLANK | |
| 32 | 40A | PWR WINDOW |
| 33 | 25A | BODY BUILDER |
| **34*** | **20A** | **A/C CLUTCH** |
| 35 | 20A | CLUSTER |
| 36 | 20A | FUEL XFER PUMP |
| 37 | 10A | TURN |
| 38 | BLANK | |
| 39 | 10A | CORNERING LAMPS |
| **40*** | **10A** | **IDM LOGIC PWR** |
| **41*** | **10A** | **ECM PWR** |
| 42 | 10A | RADIO |
| 43 | BLANK | |
| 44 | BLANK | |
| 45 | BLANK | |
| **46*** | **5A** | **ECM KEY PWR** |
| 47 | BODY BUILDER | |
| **48*** | **FUEL PUMP RELAY** | |
| 49 | B/U LAMPS | |
| **50*** | **ECM RELAY** | |
| **51*** | **FUEL HEATER RELAY** | |
| 52 | TRANS | |
| **53*** | **A/C CLUTCH RELAY** | |
| 54 | FOG LAMPS | |
| **55*** | **IDM RELAY** | |
| 56 | WIPER | |
| **57*** | **STARTER RELAY** | |
| 58 | BLANK | |
| 59 | PARK LAMPS | |
| 60 | TRANS RELAY DIODE | |
| 61 | BLANK | |

*indicates engine related fuse

# GLOSSARY

**Accelerator Position Sensor (APS)**
A potentiometer sensor that indicates the position of the throttle pedal.

**Actuator**
A device that performs work in response to an electrical input signal.

**Aeration**
The entrainment of gas (air or combustion gas) in the coolant or lubricant.

**Ambient Temperature**
The environmental air temperature in which a unit is operating.

**American Trucking Association (ATA) Datalink**
A serial datalink specified by the American Trucking Association and the SAE.

**Analog Signal**
A continuously variable voltage.

**Barometric Absolute Pressure (BAP) Sensor**
A variable capacitance sensor which, when supplied with a 5 volt reference signal from the ECM, produces a linear analog voltage signal indicating atmospheric pressure.

**Boost Pressure**
The pressure of the charge air leaving the turbocharger.

**Camshaft Position (CMP) Sensor**
A magnetic pickup sensor that indicates engine speed and camshaft position.

**CAN 1**
A data link between the vehicle modules and ECM.

**CAN 2**
The private link between the ECM and IDM.

**Catalytic Converter**
An antipollution device in the exhaust system that contains a catalyst for chemically converting some pollutants in the exhaust gases (carbon monoxide, unburned hydrocarbons, and oxides of nitrogen) into harmless compounds.

**Charge Air**
Dense, pressurized, heated air discharged from the turbocharger.

**Controller Area Network (CAN)**
A J1939 high speed communication link.

**Coolant**
A fluid used to transport heat from the engine to the radiator.

**Crankcase**
The housing that encloses the crankshaft, connecting rods, and associated parts.

**Crankshaft Position (CKP) Sensor**
A magnetic pickup sensor that determines crankshaft position and speed.

**Duty Cycle**
A control signal that has a controlled on/off time measurement from 0 to 100%. Normally used to control solenoids.

**Electronic Control Module (ECM)**
An electronic processor that monitors and controls the engine.

**EGR Cooler**
A cooler that allows heat to dissipate from the exhaust gasses before they enter the EGR Valve.

**EGR Valve**
A valve that regulates the flow of exhaust gasses into the intake manifold.

**Engine Oil Pressure Switch (EOPS)**
A switch that senses oil pressure.

**Engine Oil Temperature (EOT) Sensor**
A thermistor sensor that senses engine oil temperature.

**Exhaust Gas Recirculation**
A system used to recirculate a portion of the exhaust gases into the intake air charge in order to reduce oxides of nitrogen (NOx).

**Injection Control Pressure (ICP)**
High lube oil pressure generated by a high pressure pump/pressure regulator used to hydraulically actuate the fuel injectors.

**Injection Control Pressure (ICP) Sensor**
A sensor that measures injection control pressure.

**Injection Pressure Regulator (IPR)**
An ECM regulated valve that varies injection control pressure.

**Injector Drive Module (IDM)**
An electronic processor that calculates injection timing and fuel quantity and is the power supply for the injectors.

**Intake Air Temperature (IAT) Sensor**
A thermistor sensor that senses intake air temperature.

**Manifold Absolute Pressure (MAP)**
Boost pressure in the manifold that is a result of the turbocharger.

**Manifold Absolute Pressure (MAP) Sensor**
A variable capacitance sensor that measures boost pressure.

**Manifold Air Temperature (MAT) Sensor**
A thermistor style sensor used to indicate air temperature in the intake manifold.

**Mass Air Flow (MAF) Sensor**
A sensor that measures the air flow into the engine.

**Magnehelic Gauge**
A gauge that measures pressure in inches of water (in $H_2O$).

**Magnetic Pickup Sensor**
A sensor that creates an alternating current current voltage when a magnetic field is broken.

**Oxides of Nitrogen (NOx)**
Oxides of nitrogen form by a reaction between nitrogen and oxygen at high temperatures.

**Potentiometer**
An electro-mechanical device that senses the position of a mechanical component.

**Reference Voltage (VREF)**
A 5 volt reference supplied by the ECM to operate the engine sensors.

**Thermistor**
A semiconductor device that changes resistance as temperature changes.

**Turbocharger**
A turbine driven compressor mounted to the exhaust manifold. The turbocharger increases the pressure, temperature and density of the intake air.

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# NOTES




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