SERVICE MANUAL

INTERNATIONAL® DT 466E, 530E, 466, 530, and HT 530

DIESEL ENGINE

Model Year 2000 and Up

EGES-210-1

Printed in the United States of America

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EGES-210-1

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Foreword

This manual is part of a series of publications intended to assist service technicians in maintaining International® diesel engines.

Due to a commitment of continuous research and development, some procedures, specifications, and parts may be altered to improve International® products and introduce technological advances.

Periodic revisions may be made to these publications and mailed automatically to “Revision Service” subscribers. When ordering publications, the latest revision will be supplied.

NOTE: International® diesel engines are installed in many different applications. It is not always possible to illustrate the exact surroundings of the working area in photographs.

When ordering additional copies of this publication or any other International Truck and Engine Corporation publication, refer to the following contact information:

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Technical Service Literature

1171734R7	DT 466E, 1999, 2003 Model Year *Operations and Maintenance Manual*
1171735R5	International 530E, 1999-2003 Model Year *Operations and Maintenance Manual*
EGES 210-1	*Engine Service Manual*
EGES 175-1	*Diagnostic Manual*
EGES 180-1	Hard Starting No Starting Diagnostic Form
EGED 185-1	Electronic Control System Diagnostic Form

Service Diagnosis

Service diagnosis is an investigative procedure that must be followed to locate and correct an engine problem.

The engine is first considered as a complete unit. If it is determined that the problem is application related, see application specific manuals for further diagnostic information.

If the problem is determined to be within the engine, the problem can then be localized to components or systems. Testing procedures will then help analyze the source of the problem.

Prerequisites for effective diagnosis:

- Knowledge of the principles of operation for both engine and application systems.
- Knowledge to perform and understand all procedures in the diagnostic and service publications.
- Availability of and the ability to use diagnostic test equipment, such as gauges.
- Availability of the most current information for the engine application.

Effective service diagnosis requires use of the following references:

- *Engine Service Manual*
- *Engine Diagnostic Manual*
- Diagnostics Forms
- Electronic Control Systems Diagnostics Forms
- Technical Service Information (TSI) letters
- Technical Services Frequently Asked Questions (FAQ)

NOTE: Metric values precede English values for test procedures and reference.

Examples: 96 kPa (14 psi), 20 °C (68 °F)

Safety Information

This manual provides general and specific service procedures 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.

Disregard for warnings, cautions, and instructions can lead to injury, death, or damage to the engine or vehicle.

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

Most accidents that involve operation, maintenance, and repair are caused by failure to observe basic safety rules or precautions. Read and follow OSHA regulations.

SAFETY TERMINOLOGY

Three terms are used to stress your safety and safe operation of the engine: Warning, Caution, and Note

Warning: Signals conditions, hazards, and unsafe practices that can cause injury or death

Caution: Signals conditions and practices that can cause damage to the engine or vehicle

Note: Signals a key point or procedure that must be followed for correct, efficient engine operation.

SAFETY INSTRUCTIONS

Vehicle

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

Work area

The engine and its components must be kept clean during service or maintenance. Contamination of the engine or components will cause premature wear.

- Keep work 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 appropriate protective apparel when working with or around hot liquid, hot engines, or hot engine components
- Wear protective glasses and safety shoes (do not work in bare feet, sandals, or sneakers)
- Wear appropriate hearing protection
- Wear correct work clothing.
- Do not wear rings, watches, or other jewelry.
- Restrain long hair.

Fire prevention

- Make sure charged fire extinguishers are in the work area.
- To prevent fire and hazardous fumes, clean and wipe dry all engine surfaces where fluids may have spilled.

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.
- Use suitable eye protection.
- 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 (30 psi).
- 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, lights, or extension cords.

Fluids under pressure

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

Fuel

- Do not over fill the fuel tank. Over fill creates a fire hazard.
- Do not smoke in the work area.
- Do not fuel 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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Component Location

Front View

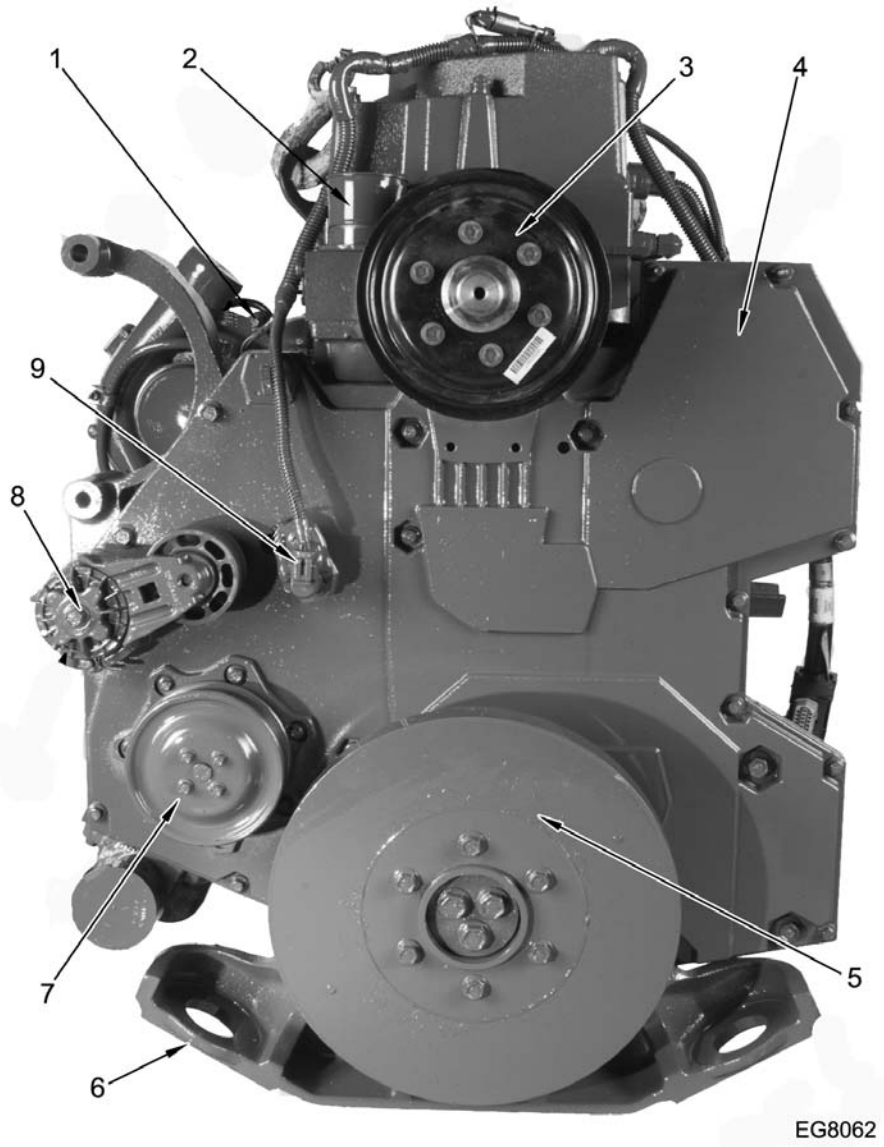

Figure 1 Front

1. Coolant Temperature Sensor
2. Thermostat
3. Fan Pulley
4. Front Cover
5. Vibration Damper
6. Front Engine Mounting Bracket
7. Water Pump Pulley
8. Auto Belt Tensioner
9. CMP Sensor

Left View

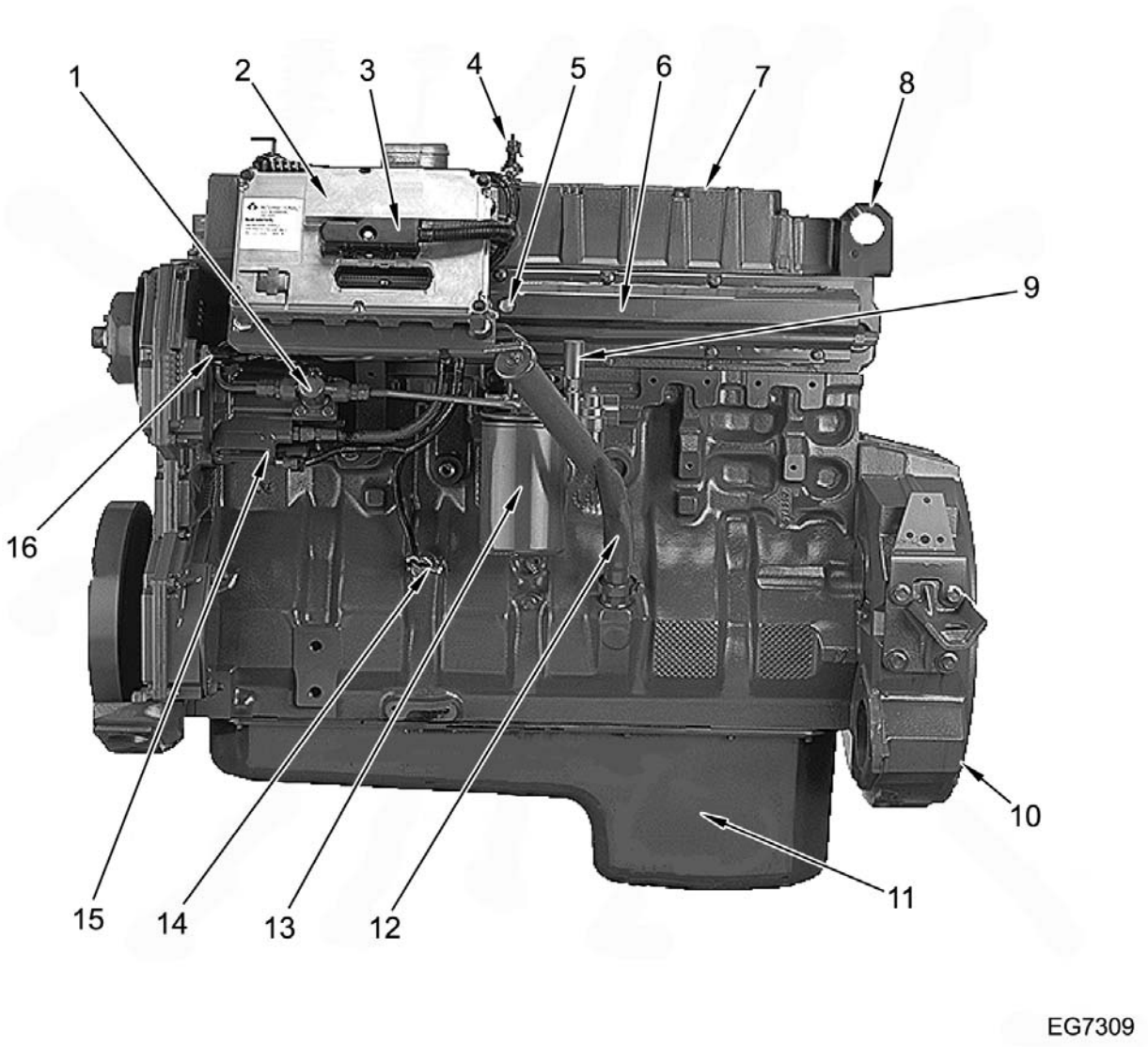

Figure 2 Left

1. Fuel Supply Pump
2. Electronic Control Module (ECM)
3. ECM Connector
4. Manifold Absolute Pressure Sensor (MAP)
5. Injection Control Pressure Sensor (ICP)
6. Supply Manifold
7. Valve Cover and Intake Manifold
8. Lifting Eye (Rear)
9. Hand Primer Pump
10. Flywheel Housing
11. Oil Pan
12. Oil Fill Tube and Oil Level Gauge
13. Fuel Filter
14. Engine Oil Pressure Sensor (EOP)
15. High-pressure Oil Pump
16. Oil Temperature Sensor

Rear View

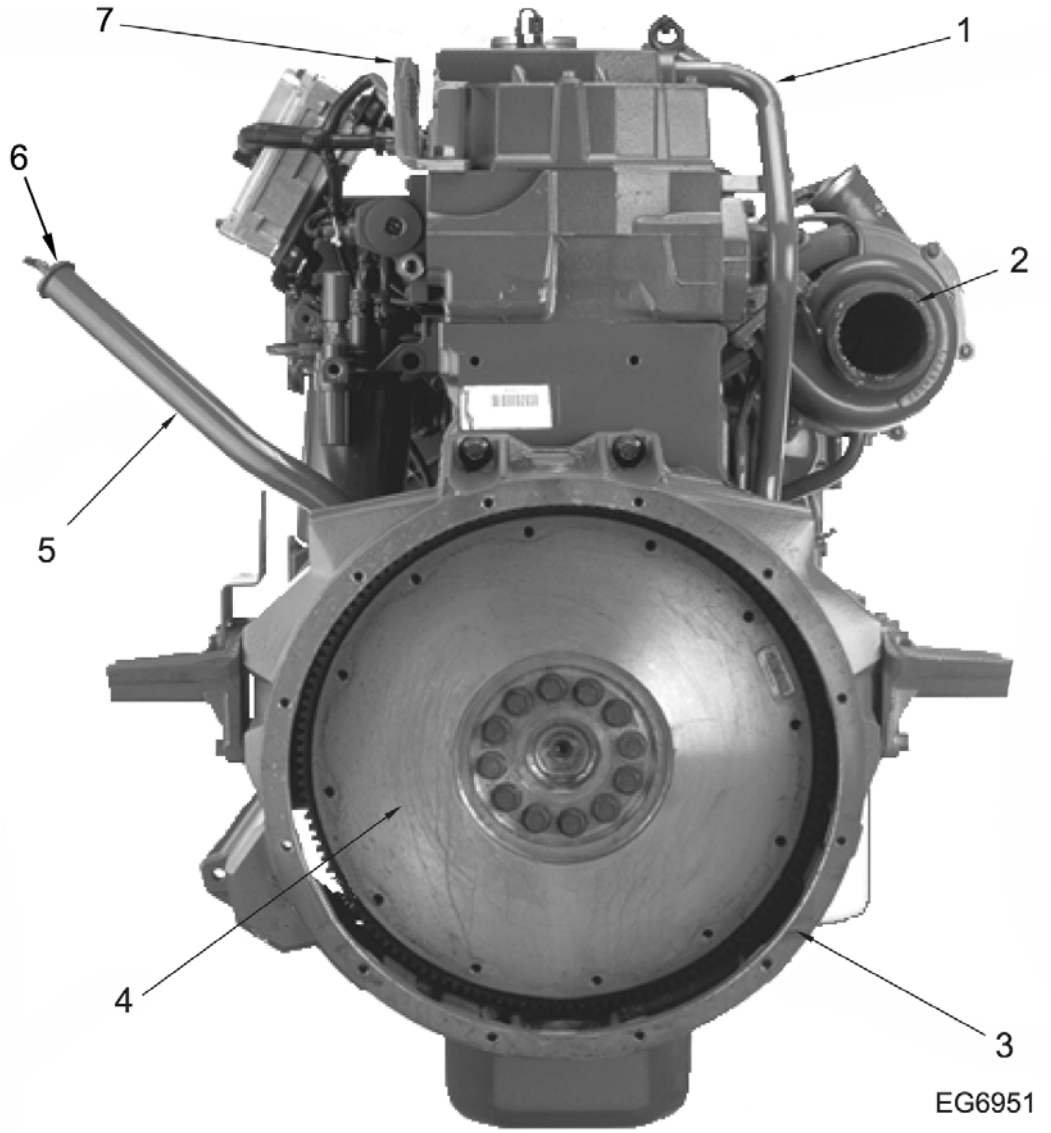

Figure 3 Rear

1. Road Draft Tube
2. Turbocharger Assembly
3. Flywheel Housing
4. Flywheel
5. Oil Fill Tube
6. Oil Level Gauge
7. Lifting Eye (2)

Right View

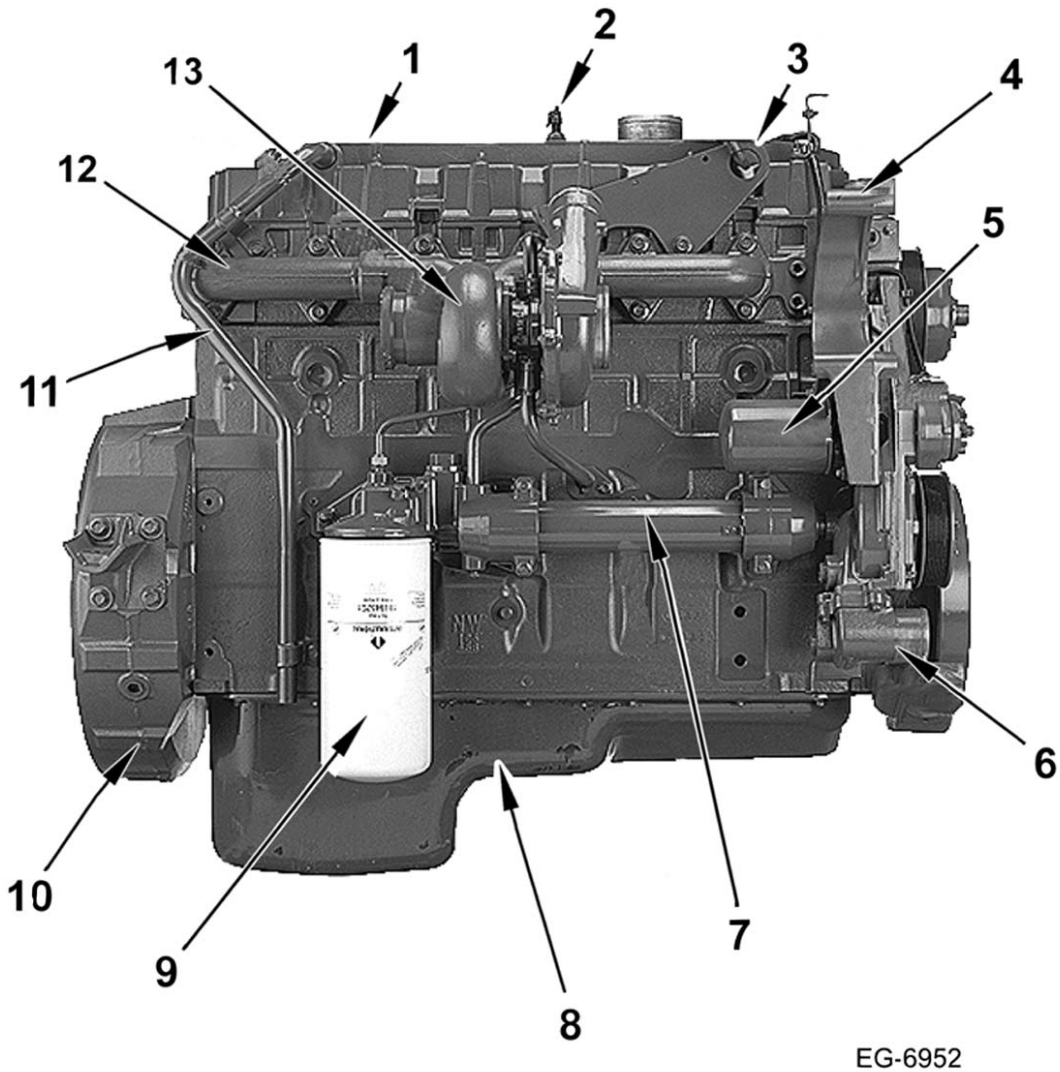

Figure 4 Right

1. Valve Cover and Intake Manifold
2. Manifold Absolute Pressure Sensor (MAP)
3. Lifting Eye (Front)
4. Alternator Bracket
5. Coolant Filter (if equipped)
6. Engine Coolant Inlet
7. Oil Cooler
8. Oil Pan
9. Oil Filter
10. Flywheel Housing
11. Road Draft Tube
12. Exhaust Manifold
13. Turbocharger Assembly

Engine Identification

Engine Serial Numbers

When in need of parts, always specify the engine model and serial number.

The permanent engine serial number is on the machined strip on the right side of engine.

The engine emission label identifies engine model code and year manufactured. This label is located on the top of the valve cover and intake manifold.

Other nameplates are located on the turbocharger and starter. These nameplates show the manufacturer, general specifications, the equipment that is on the engine and its operating conditions.

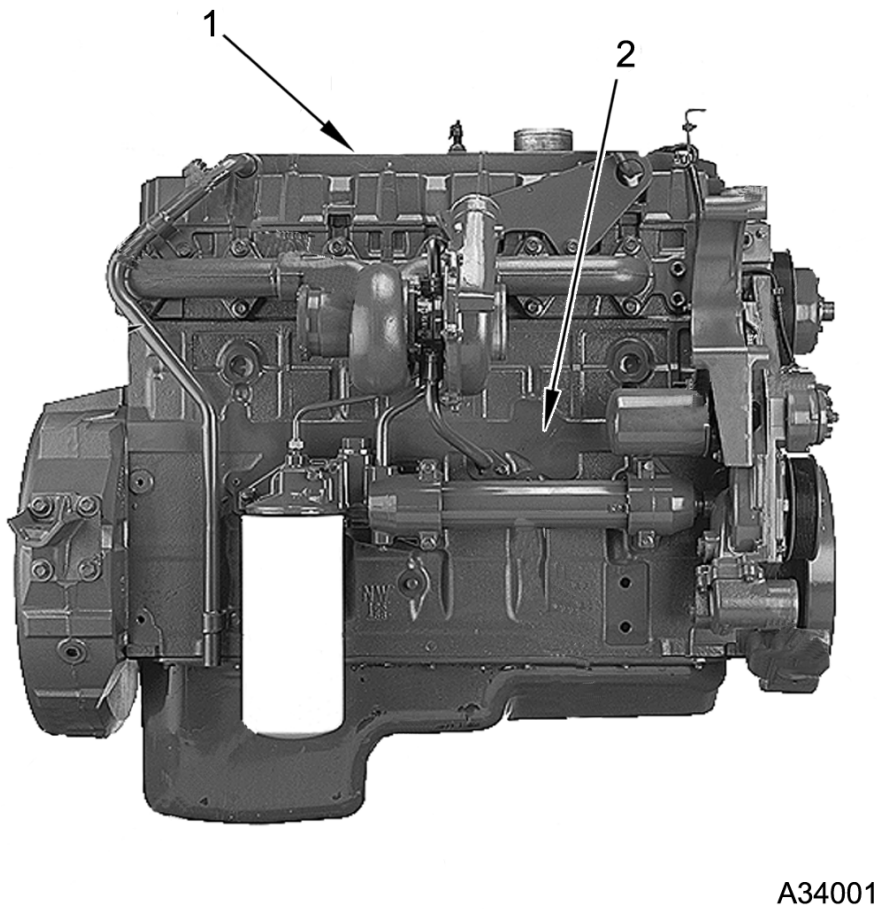

Figure 5 Engine serial number and emission label

1. Engine emission label
2. Engine serial number stamp

Engine Serial Number Chart

Engine Identifying Code	Variation Code	End Use Code	Country of Origin	Serial Sequence Number
531	H	M2	U	0000000*

531 = Engine Identifying Code

H = Diesel, Turbocharged, Air Intercooled and Electronically Controlled

M2 = End Use Code (Truck)

U = Country of Origin - U.S.A.

0000000* = Starting Sequence Number

Engine Component Identification

Turbocharger (Non-Wastegate)

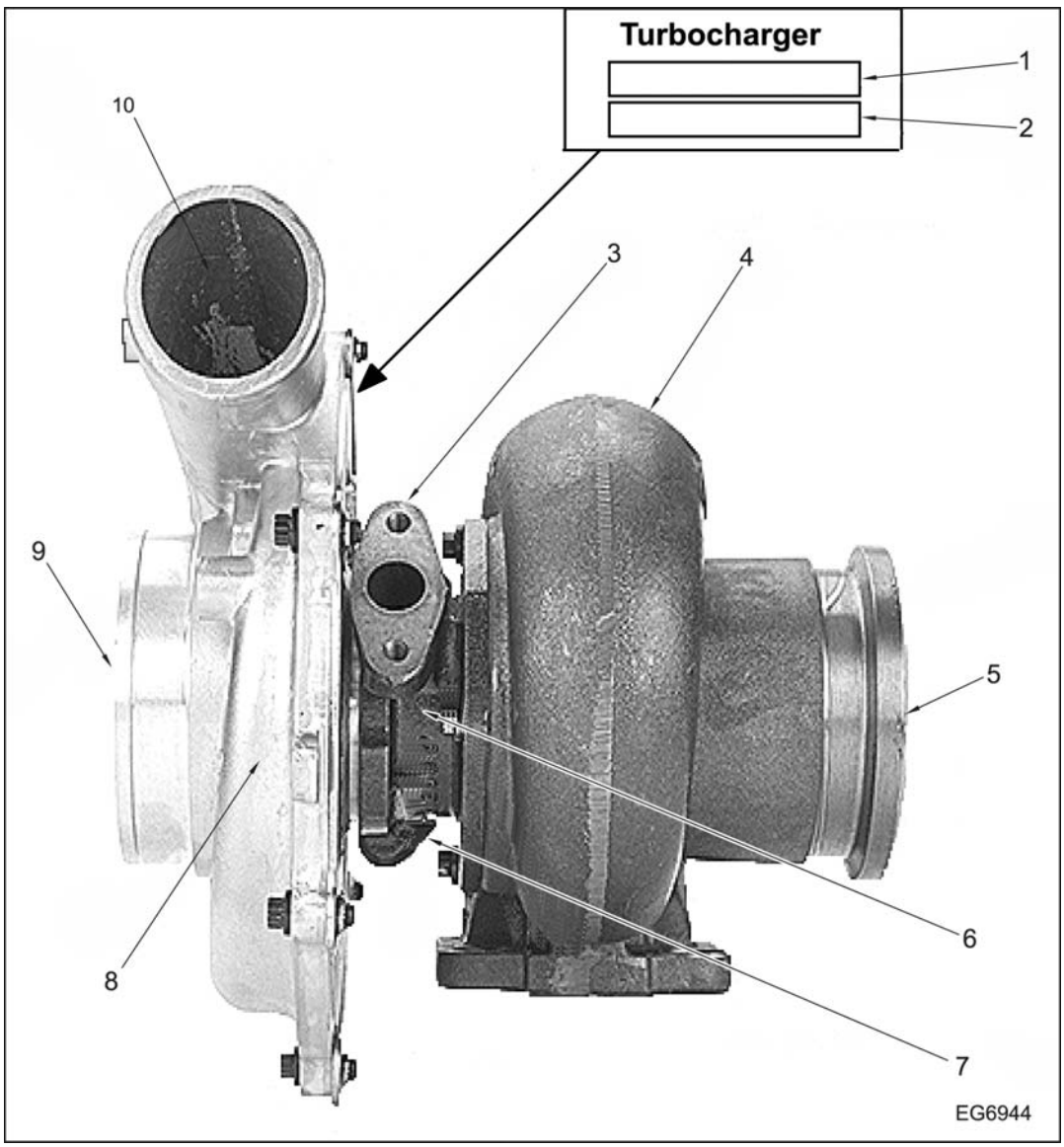

Figure 6 Non-Wastegate Turbocharger

1. International Part Number
2. Turbocharger Serial Number
3. Oil Inlet
4. Turbine Housing
5. Exhaust Outlet
6. Oil Cooled Center Housing
7. Oil Outlet
8. Compressor Housing
9. Air Intake
10. Compressed Air Outlet

Turbocharger (Wastegate)

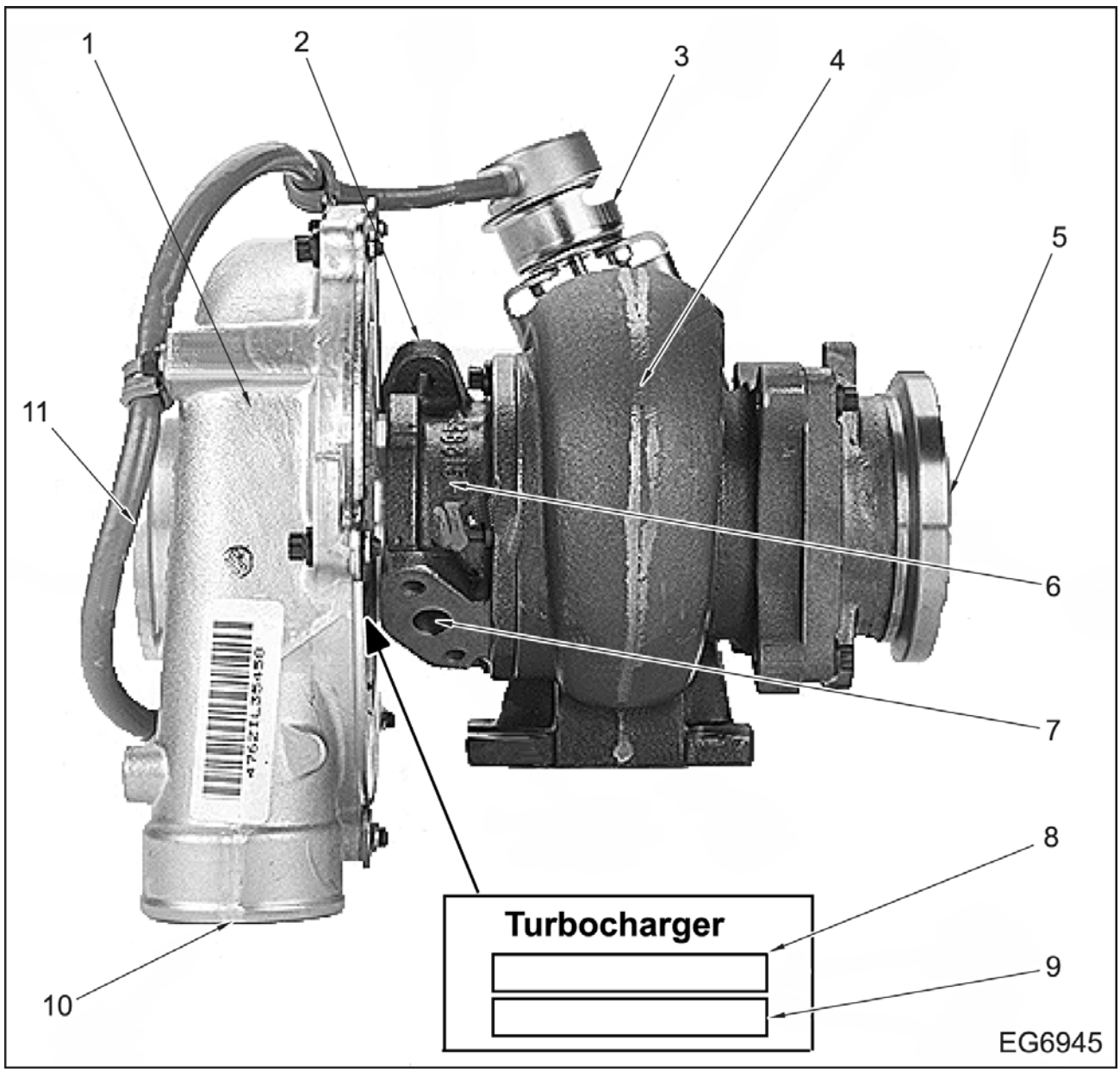

Figure 7 Wastegate Turbocharger

1. Compressor Housing
2. Oil Outlet
3. Wastegate Actuator
4. Turbine Housing
5. Exhaust Outlet
6. Oil Cooled Center Housing
7. Oil Inlet
8. International Part Number
9. Turbocharger Serial Number
10. Compressed Air Outlet
11. Air Intake

Features

General Features

The International® DT 466E and 530E are inline six cylinder, four-cycle, water cooled engines. These engines are equipped with a turbocharger, overhead valves, with replaceable valve guides and valve seats for both intake and exhaust. The engine is fueled by a direct injection fuel system with electronic sensors and Hydraulically actuated Electronically controlled Unit Injectors (HEUI). The firing order is 1-5-3-6-2-4.

The crankcase has been specially designed to withstand the loads of diesel engine operation and has cast water and oil passages. The crankcase also has replaceable wet type cylinder sleeves. Every main bearing web has angled, drilled holes which are fitted with piston jet tubes that direct lube oil, under pressure, to the underside of each piston to help dissipate heat.

Throughout this manual, use of the terms left, right, front and rear must be understood to avoid confusion when following instructions. The left and right sides of the engine are described when facing the flywheel end (rear) of the engine. The front of the engine is the fan drive pulley end.

The crankshaft is forged steel with induction hardened journals and undercut fillets. It is supported on seven precision insert bearings. The camshaft is supported on four pre-reamed bushings and is gear driven from the crankshaft. The end thrust of the camshaft is controlled by a thrust flange located between the front camshaft journal and the cam gear. Valve lifters have roller followers which provide excellent camshaft and lifter durability. This helps minimize engine noise.

There are two types of connecting rods used on this engine for model years 2000 through 2003. The connecting rods are easily identified by the way the connecting rod caps are secured to the connecting rods.

- Forged steel connecting rods are secured to the connecting rod with bolts and nuts.
- Powdered metal forged steel connecting rods are secured with bolts that thread into the connecting rod (no nuts used).

The connecting rod is constructed of forged steel. It is attached to the crankshaft, one per journal. The pistons are cast aluminum alloy or steel crown with an aluminum skirt. All pistons are fitted with two compression rings and one oil ring. The piston pin is a free floating type, permitting the pin to move or float freely in the piston and connecting rod, and is held in place with pin retaining rings.

A gerotor type lube oil pump is mounted to the front cover. The pump is driven directly by the crankshaft at engine speed. All models are equipped with an oil cooler. The oil cooler has a single spin-on type oil filter. There is also a spin-on type coolant filter. The fuel system has a single spin-on type fuel filter and a pre-strainer assembly attached to the fuel filter header. There is no external oil piping with the exception of the air compressor, turbocharger and high-pressure pump piping to cylinder head.

Chassis Features

Chassis-Mounted Charge Air Cooler

The charge air cooler is chassis-mounted in front of or next to the radiator. Air from the turbocharger is pushed through a network of heat exchanger tubes before entering the valve cover and intake manifold. Outside air flowing over the tubes and fins serves to cool the charge air.

The resulting cooler intake air is denser than un-cooled air, which results in additional air entering the cylinders so that additional fuel may be injected to increase output power.

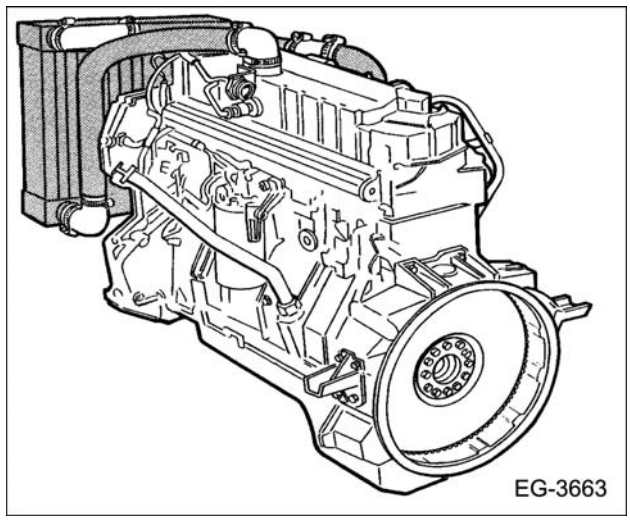

Figure 8 Charge Air Cooler and Piping (Shaded Areas)

Cooling System

Description

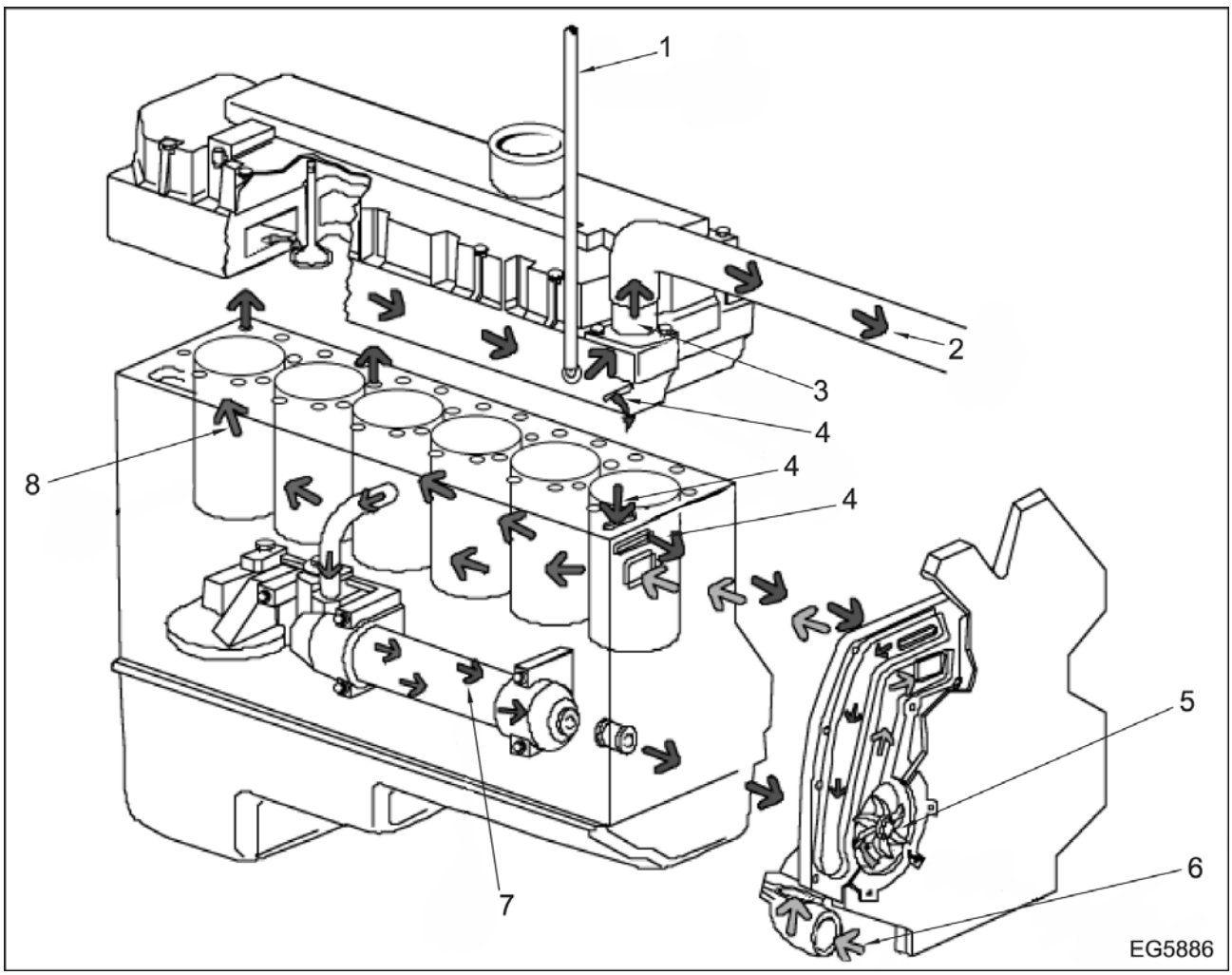

Figure 9 Coolant Flow

1. Line to De-Aeration Tank
2. To Radiator
3. Thermostat
4. By-Pass Passage
5. Water Pump
6. From Radiator
7. Oil Cooler
8. Cylinder Sleeves

The cooling system keeps the engine within a designated temperature range. Major components of cooling systems include a radiator and fan combination with a coolant (water) pump, thermostat, oil cooler, and coolant filter (if equipped). On these engines, the water pump is a belt-driven centrifugal type, which is set into the front cover.

This front cover incorporates two separate passages. One passage to channel coolant to the crankcase from the water pump, the other is a bypass to route coolant back to the water pump when the thermostat is closed. The thermostat starts to open at 88 °C (190 °F) and is fully open at 100 °C (212 °F).

Coolant flows from the bottom of the radiator into the inlet tube of the front cover and into the water pump. The coolant is pushed by the impeller of the water pump, through an internal passage in the front cover and out to the crankcase.

Thermostat Operation

An internal passageway located in the crankcase directs coolant from front to rear, evenly distributing coolant to the lower sections of the cylinder sleeves. The coolant flow is directed toward each cylinder sleeve on a tangent causing a swirling motion upward towards the cylinder head. This swirling action improves heat dissipation.

Coolant leaves the area around the cylinder sleeves in the following two ways:

1. The coolant is directed to the oil cooler via an exterior tube leading to the rear of the oil cooler header. Coolant flows through passages in the oil cooler and exits at the water pump to be remixed with incoming coolant from the radiator. Coolant is supplied to the rear of the air compressor from the left side of the crankcase. After the coolant exits at the front of the air compressor, it is returned to the crankcase on the left side.
2. Coolant exits from the crankcase, through two cored holes at the top of each side of the cylinder sleeve bore, and is metered for even distribution by holes in the head gasket. Coolant then flows through the cylinder head to the thermostat. The thermostat incorporates two outlets to direct coolant either to the radiator when the engine is at operating temperature, or directly back to the water pump when the engine has not yet reached operating temperature.

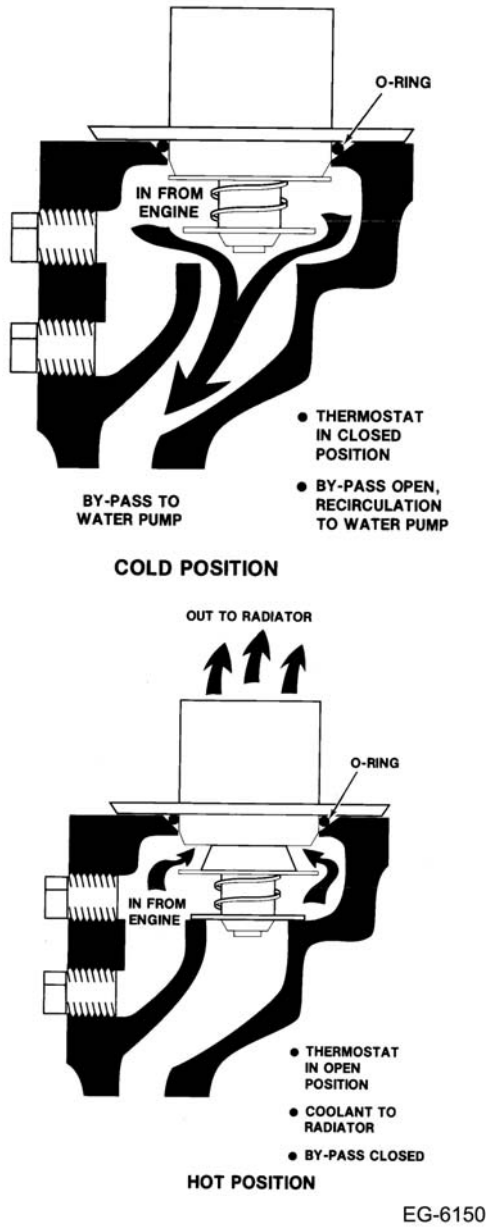

Figure 10 Thermostat Operation

When the engine coolant temperature is below specified thermostat opening temperature, the coolant flows through the bypass passage to the water pump because the radiator outlet port is blocked. As the engine reaches operating temperature, the thermostat opens, directing coolant towards the radiator; this also gradually restricts the bypass opening.

Lubrication System

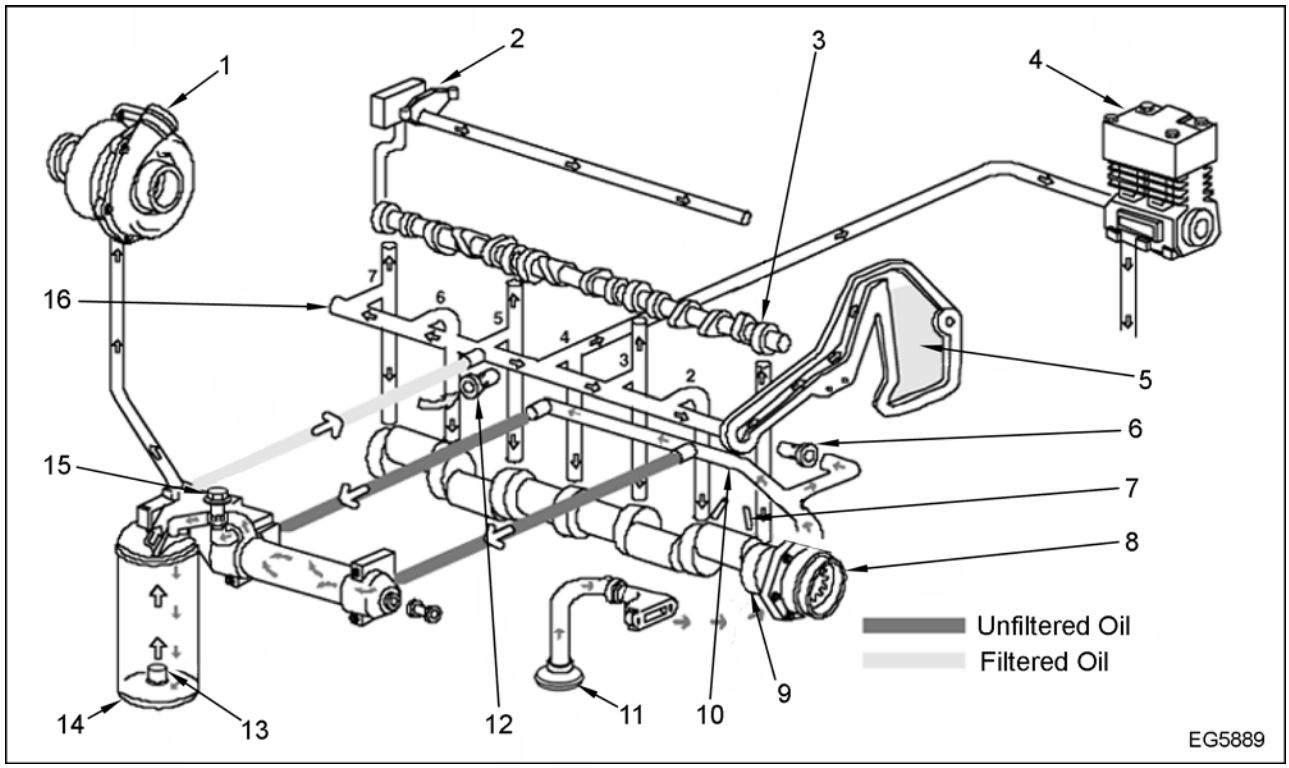

Figure 11 Oil flow

1. Turbocharger
2. Rocker Arm Assembly
3. Cam Bushing Journal
4. Air Compressor
5. Reservoir
6. Pressure Relief Valve
7. Piston Cooling Jets
8. Oil Pump
9. Main Bearing Journal
10. By-Pass Gallery
11. Pick-Up Tube
12. Pressure Regulator
13. By Pass Valve
14. Filter
15. Oil Temperature Control Valve
16. Main Oil Gallery

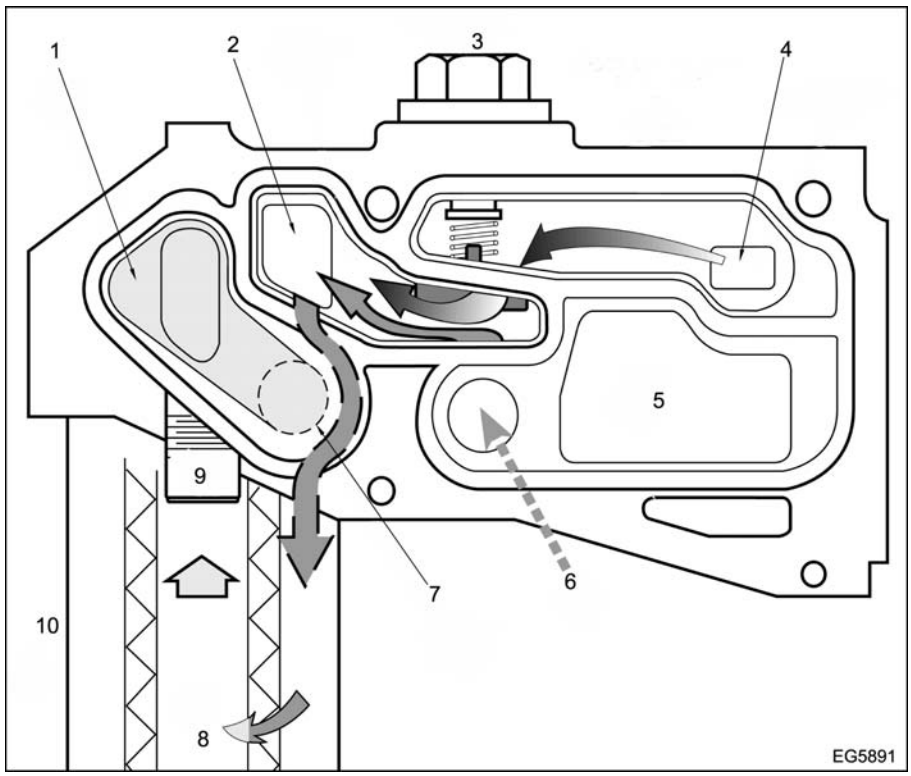

Figure 12 Oil cooler oil flow

1. Filtered Oil to Main Oil Gallery
2. Mixing Chamber
3. Thermostat
4. Oil From Cooler
5. Dead Space
6. From Oil Cooler Bypass Gallery
7. To Pressure Regulator Valve
8. Clean Oil
9. Spud
10. Oil Filter

Description

The lubrication system is pressure regulated, cooled and full flow filtered. In addition to providing engine lubrication, pressurized lube oil is used to control fuel delivery in the hydraulically actuated electronically controlled unit injectors. External oil piping is kept to a minimum to avoid oil leakage.

Location

The right side of the engine has an oil cooler, replaceable full flow oil filter, turbocharger oil supply line, and road draft tube. The left side of the engine has the oil filler tube, oil level gauge, high-pressure pump and oil supply manifold.

Oil Flow

Lube oil is drawn from the oil sump through the pickup screen and tube into the oil pump. The oil pump is of the gerotor type with the inner rotor portion driven directly by the crankshaft. The pump housing is bolted to the front cover. The pump inlet and outlet passages are through ports in the pump plate and front cover. Leaving the oil pump, the unfiltered oil travels (under pressure) back through the front cover assembly, passing the high-pressure oil relief valve and into the crankcase unfiltered oil galley. The relief valve opens and excess oil is dumped back to the oil sump.

NOTE: The oil relief valve controls unfiltered oil pressure at 552 kPa (80 psi) maximum.

There are two oil galleries in the crankcase. The unfiltered oil travels down the unfiltered oil galley on the lower right hand side of the crankcase and the

filtered oil galley runs above it. There are two exit ports in the unfiltered oil galley. One exits to the front header of the oil cooler and one exits to the rear header of the oil cooler. The oil cooler thermostat, located in the rear header, opens or closes by sensing oil temperature in the unfiltered galley. Depending upon the position of the oil thermostat, hot oil flows through the oil cooler core into the rear header and cold unfiltered oil bypasses the oil cooler core and goes directly to the oil filter.

Oil directed from the unfiltered galley to the filter, enters from the outside of the element and exits from the center. The oil filter bypass valve is located within the filter can and operates at a pressure differential of 193 kPa (28 psi). The oil filter element bypass is effected from within the filter can. Clean engine oil flows out of the filter and goes back into the oil cooler header, then out the header and into the crankcase clean oil galley. The clean oil enters the crankcase, passes the oil pressure regulator valve, and is directed through various ports of the crankcase. Excess oil is dumped back into the crankcase by the regulator valve.

NOTE: The oil pressure regulator valve controls filtered oil pressure at 345 kPa (50 psi).

Connecting rod bearings are individually fed through drilled passages in the crankshaft from main to rod journals. The camshaft journals are fed through passages drilled vertically through the main bearing webs.

Oil is fed from the main bearing webs, through angled drilling, providing pressurized lube oil to the piston cooling jets. The valve lever rocker arms are lubricated through an annulus on the inside of the rear camshaft bushing bore of the crankcase. Oil then travels up through the vertical galley in the rear of the engine, through the banana slot in the head gasket and up the cylinder head bolt bore into the rocker arm shaft. Oil continues flowing through drilling located in the shaft of each rocker arm. Oil drains back to sump through push tube openings in the cylinder head.

Oil from the front of the main galley is routed through a cast-in passage located in the front of the crankcase, to the passage in the front cover. Oil then flows to the oil reservoir cast into the front cover, located in front of the high-pressure pump. Oil, as needed, is then drawn by the high-pressure pump through a passage found in the pump housing. High-pressure oil is delivered to the high- pressure supply manifold via an external hose from the high-pressure pump. The high-pressure oil reaches the fuel injectors through drilling in the cylinder head supply manifold which intersect with the injector bores.

The turbocharger receives filtered oil through an external tube connected at the rear oil cooler header. The air compressor (if equipped) also receives oil through a external line which is connected on the left side of the crankcase main filtered oil gallery. This fitting is supplied with oil directly from the main gallery. The front gear train is splash lubricated by oil released by the IPR valve splashing on the gear train and oil from the small bleed shot spraying oil on the gears.

Oil Pressure Regulator Valve and Oil Pressure Relief Valve

The lubricating oil pressure relief valve, 552 kPa (80 psi) located in the front cover and the oil pressure regulating valve [345 kPa (50 psi)], located between the oil filter header and the crankcase, extends the life of the engine because they control the volume and pressure of oil supplied to the engine. The volume of oil supplied by the pump is always in excess of what is needed to lubricate the engine.

The oil pressure relief valve is used to protect the oil cooler and oil filter from extremely high-pressures encountered during cold starts in cold weather. If oil pressure exceeds 552 kPa (80 psi) on the relief valve face, it moves the relief valve inward allowing oil to travel through the relief valve and back to the oil pan, relieving pressure in the lubrication system.

When all points of lubrication within the engine are satisfied, restriction to flow causes pressure to build on the regulator valve causing it to move inward. This action allows excess oil to go directly back to the oil pan, through the ports uncovered by the movement of the regulator valve.

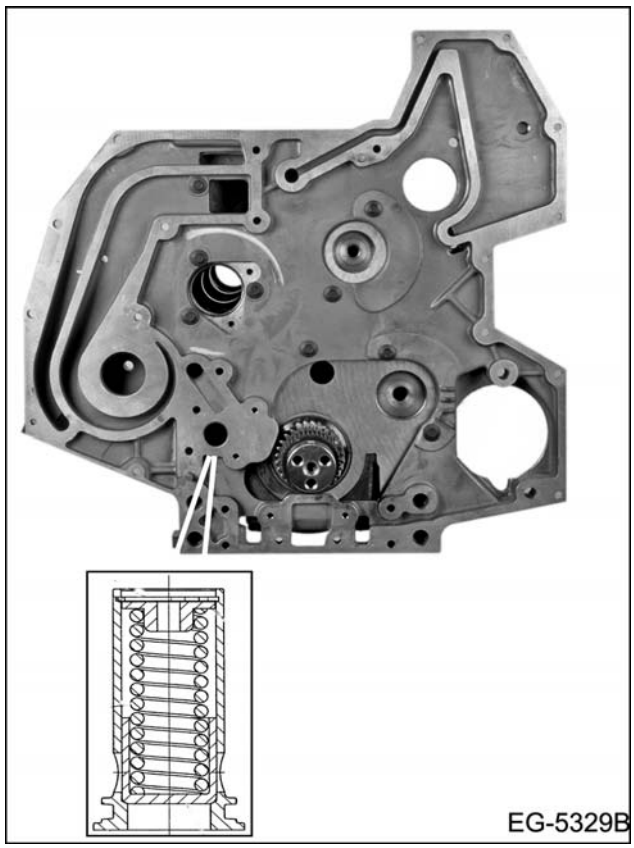

Figure 13 High-pressure relief valve

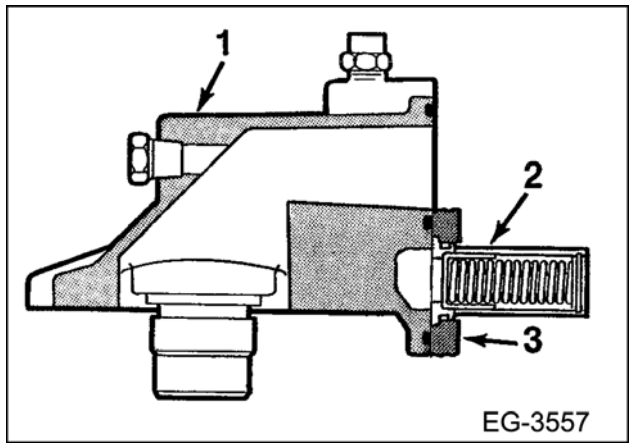

Figure 14 Oil pressure regulating valve

1. Oil Cooler Rear Header
2. Oil Pressure Regulating Valve
3. Crankcase

Air Induction and Exhaust Systems

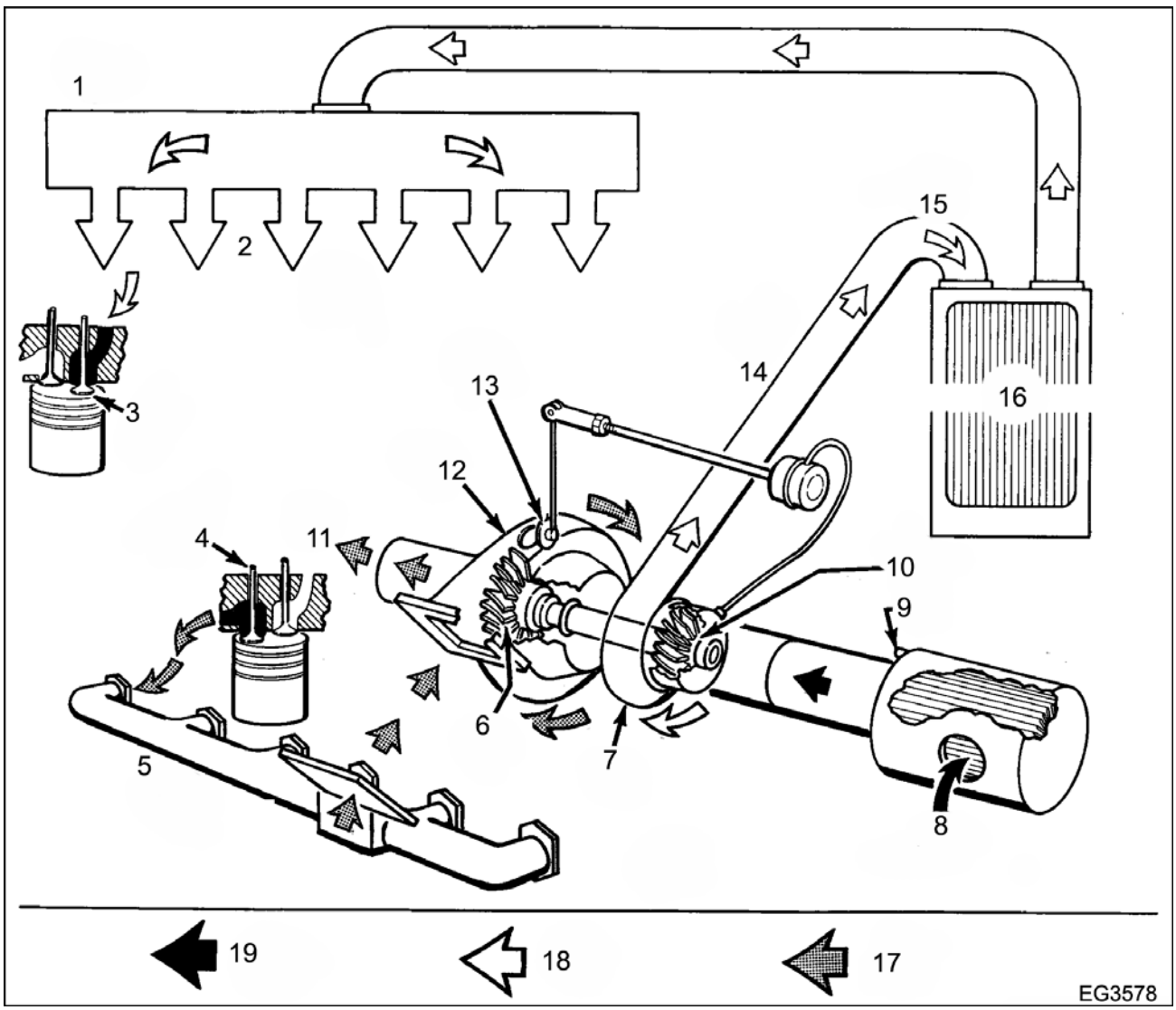

Figure 15 Air induction and exhaust system

1. Engine Intake Manifold And Valve Cover
2. To Engine
3. Intake Valve
4. Exhaust Valve
5. Engine Exhaust Manifold
6. Turbine Wheel
7. Intake Manifold Pressure Port
8. Air Cleaner
9. Restriction Gauge and Indicator Port
10. Compressor Wheel
11. To Exhaust
12. Turbocharger
13. Wastegate (If Equipped)
14. Crossover Pipe
15. Intake Air Pressurized
16. Charge Air Cooler
17. Exhaust Gas from Engine at Pressure
18. Intake Air from Engine at Pressure
19. Intake Air to Engine at Vacuum

Description

The intake and exhaust systems consist of components that flow filtered air to the engine cylinders and exhaust gases to the atmosphere.

Air Flow

The intake system consists of an air cleaner, air to air cooler, the compressor side of the turbocharger, valve cover and intake manifold and intake valves. During start up, the air is forced through the air cleaner by atmospheric pressure.

The turbocharger is used to increase engine power output by increasing air supply to the engine. It provides uniform performance at various operating altitudes. It is an exhaust driven centrifugal air compressor; that allows filtered air to enter at the center of the compressor housing and forced under pressure to the combustion chamber. After combustion, hot and expanding exhaust gases move through the turbine housing causing the turbine wheel to spin. The turbine wheel drives the compressor wheel through a common shaft. The turbocharger responds directly to engine loads. During heavy load, increased flow of exhaust gases turn the turbine wheel faster causing the compressor impeller to turn faster and supply more air (greater boost) to the intake manifold. Conversely, with light engine load, flow of exhaust gases decreases and less air is pumped into the intake manifold.

The air is cooled by a charge air cooler prior to entering the intake manifold. Air then flows into the combustion chamber where the proper amount of fuel is injected causing combustion to occur. Exhaust gases leave the cylinders through exhaust ports and the exhaust manifold. From the exhaust manifold, the expansion of exhaust gases on the exhaust turbine drive the turbocharger and are released through the exhaust pipe to the atmosphere.

The exhaust system includes exhaust valves, exhaust manifold, exhaust piping and muffler. The turbocharger compressor side is part of the intake system and turbine side is part of the exhaust system.

Fuel System

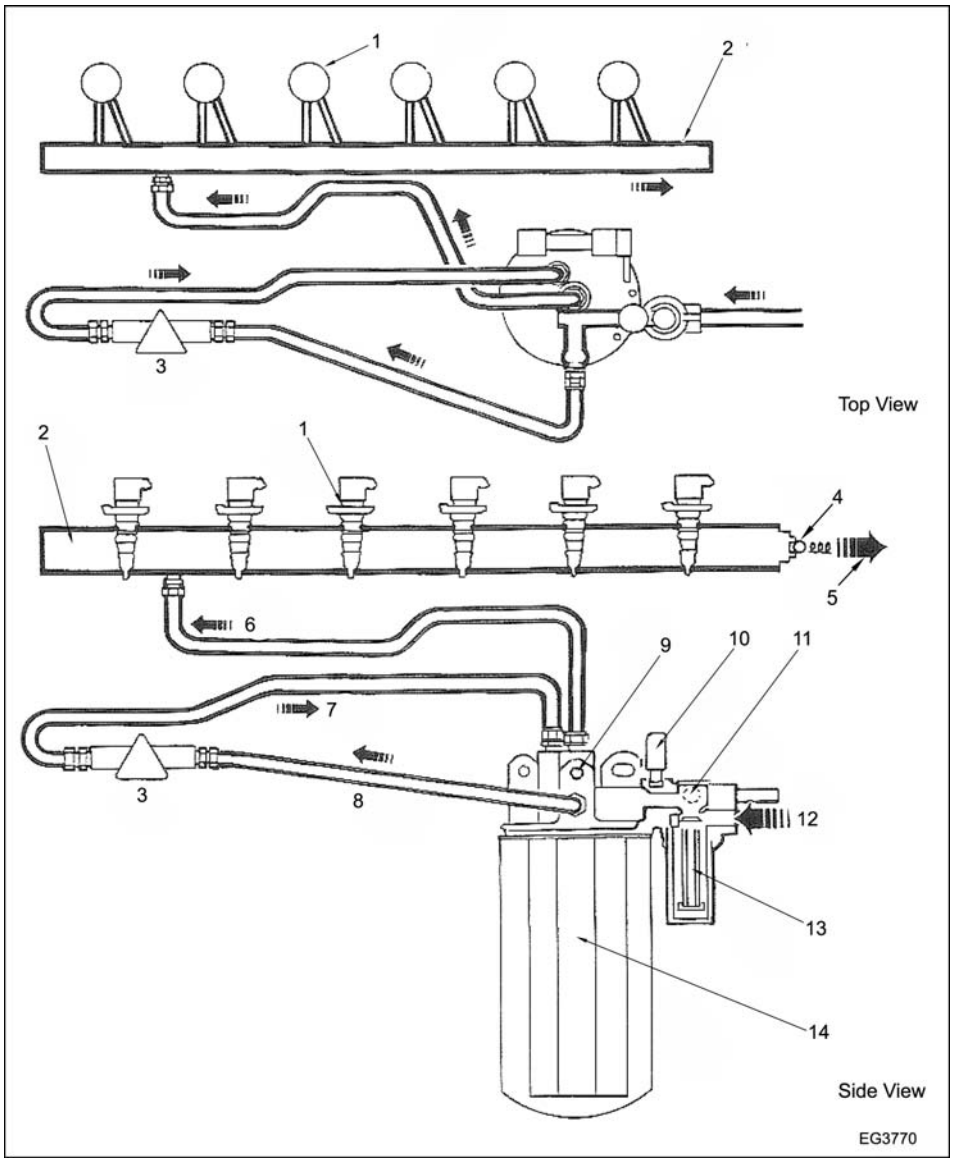

Figure 16 Primer pump fuel system (top mount)

1. Injector
2. Supply Manifold
3. Supply Pump
4. Fuel Pressure Return Valve
5. Return to Tank
6. Filtered Fuel
7. Unfiltered Fuel
8. Fuel Under Negative Pressure (Vacuum)
9. Bleeder Valve
10. Hand Primer
11. Check Ball
12. Fuel Inlet
13. Strainer
14. Filter

Location

The fuel system consists of a chassis mounted fuel tank, fuel filter strainer, hand primer pump, fuel filter, fuel supply pump, supply manifold and fuel injectors. All of these items are located on the left side of engine.

Description

The fuel system provides filtered fuel to the fuel injectors at a regulated pressure. The system also returns warm fuel to the fuel tank during normal engine operation.

Since fuel temperature is dependent on engine temperature, fuel is not warm when the engine is cold.

As fuel travels through the fuel system, it will be under negative pressure (vacuum), supply pump pressure and high-pressure (injection pressure).

Negative Pressure (Vacuum)

When the priming pump is pushed down, the check ball is seated on the fuel strainer. Releasing the priming pump unseats the check ball, draws fuel from the fuel tank to the inlet port of the fuel filter header and into the fuel strainer assembly. Fuel exits the strainer, flows through the internal passage of the fuel filter header, via a fuel line to the fuel supply pump.

Once the engine has been primed, the fuel supply pump keeps the fuel supply header under pressure and the fuel supply line under negative pressure for a constant supply of fuel.

Fuel Supply Pump Pressure

The supply pump produces a regulated pressure of fuel. Fuel flows from the supply pump to the fuel filter header. Fuel then travels through an internal passage into the fuel filter. Fuel passes through the fuel filter, from the outside of the filter element to the filter header spud. Fuel then flows from the filter header through an external hose or line to the fuel supply manifold.

Supply Manifold

Fuel in the supply manifold is delivered to drilling in the cylinder head leading to the injector bores. The fuel is then pressurized by the injectors. Any excess fuel is piped from the rear of the supply manifold to the fuel tank.

Injection Control Pressure (ICP)

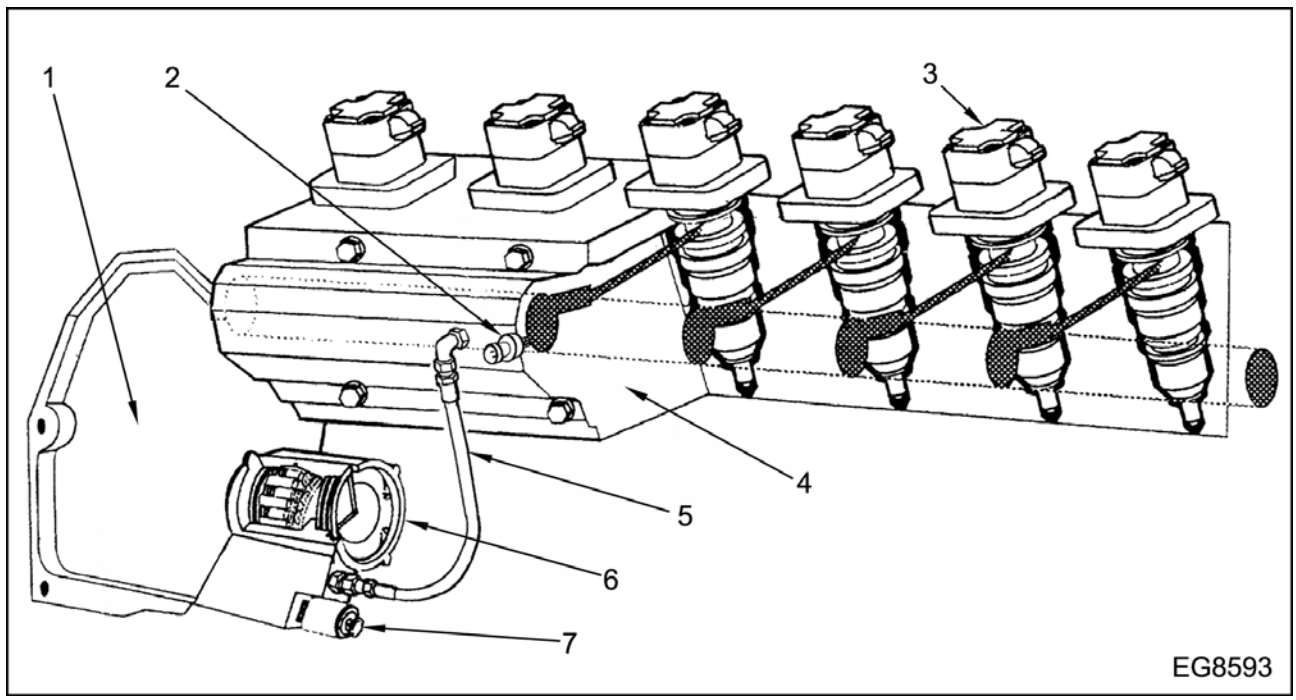

Figure 17 ICP System

1. Oil Reservoir
2. ICP Sensor
3. Injector
4. Supply Manifold
5. High-pressure Hose
6. High-pressure Pump
7. Injection Pressure Regulator (IPR)

The system utilizes hydraulically actuated, electronically controlled injectors to deliver fuel to each cylinder. Engine oil is used as hydraulic fluid to actuate the injectors.

Oil is drawn from the oil pan through the pickup tube by the engine oil pump. The engine oil pump is a gerotor type pump driven by the crankshaft. Oil is fed through passages in the front cover to the oil reservoir.

The reservoir makes available a constant supply of oil to a high-pressure hydraulic pump mounted to the front cover. The high-pressure pump is a gear driven swash plate pump. High-pressure oil is delivered by the high-pressure pump to the supply manifold and into oil passages machined into the cylinder head.

When an injector is energized, a poppet valve is opened by an electronic solenoid mounted on the injector. Oil pressure is allowed to flow into the injector and act on the amplifier piston. When the solenoid is disengaged the oil pressure on top of the amplifier piston is vented by the poppet valve through the top portion of the injector.

Pressure control in the Injection Control Pressure System is a closed loop system. It is controlled by the Injection Pressure Regulator (IPR) valve, the Injection Control Pressure (ICP) sensor and the strategy in the Electronic Control Module (ECM).

ICP pressure ranges from 3.5 to 21 MPa (500 to 3000 psi). The regulator valve is mounted in the high-pressure pump and achieves injection control pressure regulation by dumping excess oil into the front cover and back to sump.

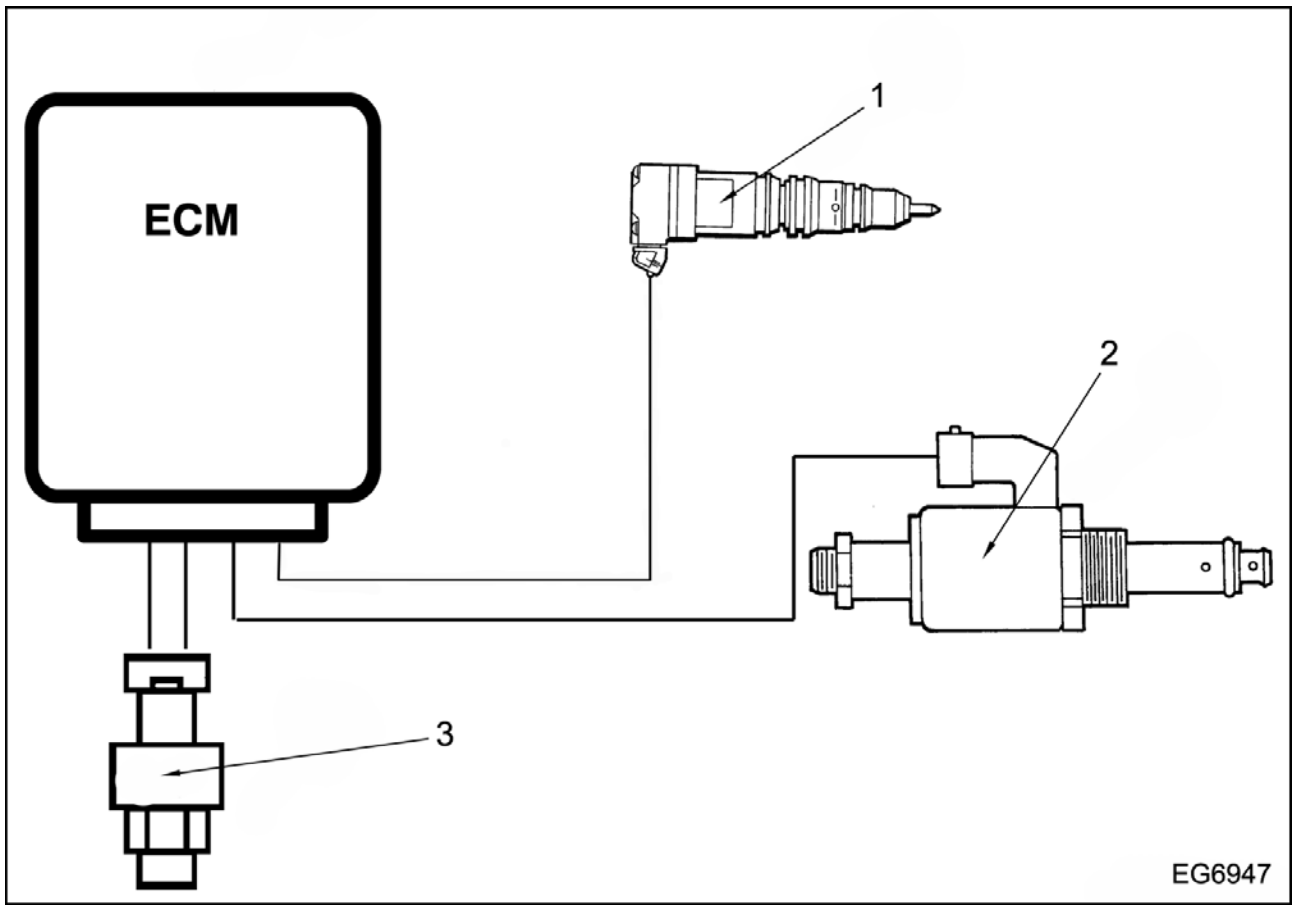

Figure 18 Electronic Control Module (ECM) system (engine mounted)

1. Fuel Injector
2. IPR
3. ICP Sensor

For engine mounted ECM systems (Figure 18), the ECM controls the IPR valve. Desired pressure control is a variable function of the engine control strategy and the calibration that has been programmed into the ECM.

The ICP sensor is mounted on the supply manifold and provides the feedback signal for the closed loop control system. The ICP sensor is a ceramic disk type pressure sensor that converts pressure into a 0 to 5 volt analog signal that the ECM uses to determine ICP pressure.

A spring and piston pop-off valve is installed internal to the high-pressure pump and is set to dump oil pressure into the front cover in the event ICP pressure exceeds 27.6 MPa (4000 psi).

Fuel Injector Assembly

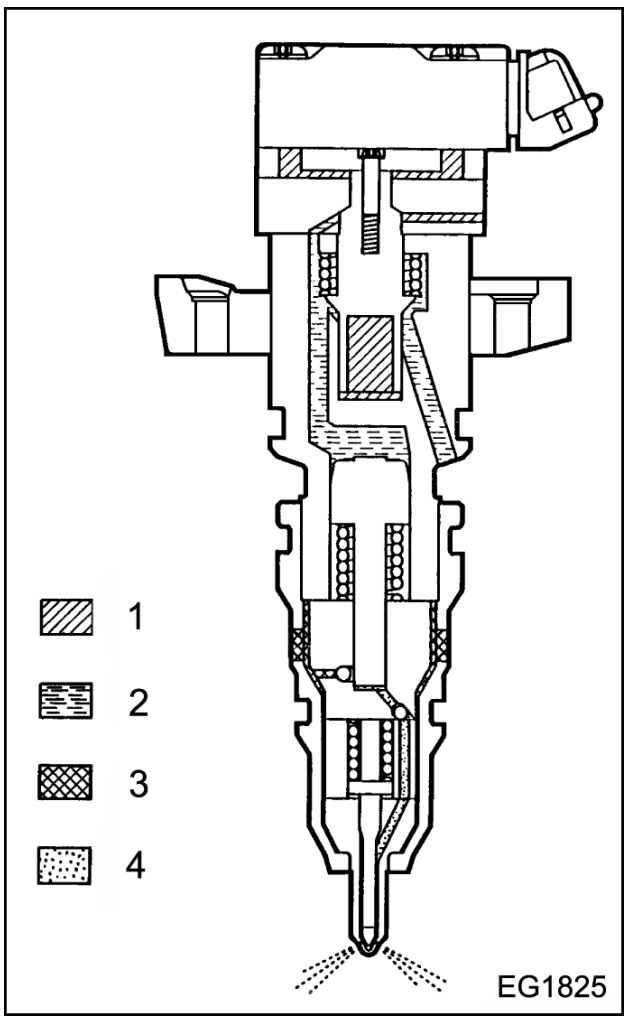

Figure 19 Fuel Injector flow

1. Atmospheric Pressure
2. Gallery Pressure (Oil)
3. Fuel Supply Pressure
4. Injection Pressure

The fuel injector assembly consists of four major components:

- Solenoid
- Poppet Valve
- Intensifier Piston and Plunger
- Nozzle Assembly

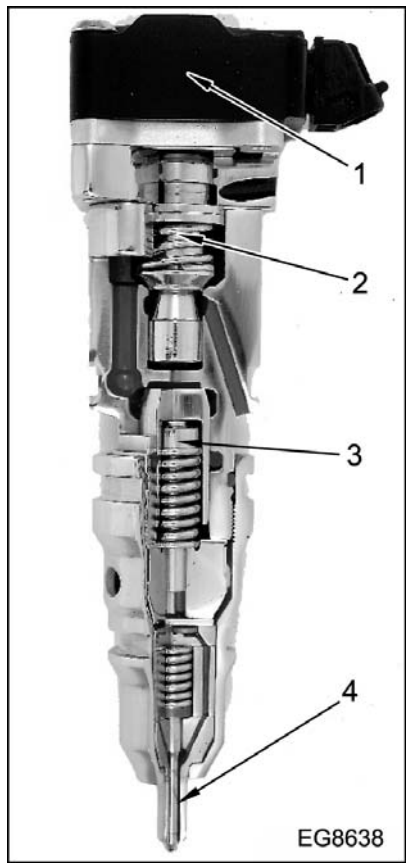

Figure 20 Fuel Injector Assembly

1. Solenoid
2. Poppet Valve
3. Intensifier Piston and Plunger
4. Nozzle Assembly

Description

The fuel injector is a unitized fuel injector that is hydraulically actuated and electronically controlled.

Hydraulic actuation is accomplished when the injector solenoid is energized opening a poppet valve and allowing ICP pressure to flow on top of the amplifier and accumulator piston.

Fuel is supplied to the injector by passages drilled through the cylinder head that intersect with fill ports in the injector. The area under the plunger is filled with fuel from pressure supplied by the supply pump. As the plunger moves down the increased pressure closes the fuel inlet check ball. Pressure continues to rise opening the nozzle valve, fuel is pressurized

through the nozzle orifices and injected into the combustion chamber.

Injection is terminated when the solenoid is de-energized and ICP pressure is released.

Solenoid

The solenoid is a very fast acting electromagnet, which when energized, pulls the poppet valve off its seat.

Poppet Valve

The poppet valve is held on its seat by a spring. In this closed position, high-pressure inlet oil is blocked and the intensifier cavity is opened to drain. When the solenoid is energized, the poppet is quickly lifted off its seat. The path to drain is closed and the inlet for high-pressure oil is opened.

Intensifier Piston and Plunger

When the poppet valve opens the inlet port, high-pressure oil enters the injector and acts on the top of the intensifier piston. Pressure builds on the intensifier, pushing it and the plunger down. The intensifier is seven times larger on the International® DT 466E, and six times larger on the International® 530E, in surface area than the plunger; providing an equal multiplication of force. The downward movement of the plunger pressurizes the fuel in the plunger cavity, causing the nozzle to open.

Nozzle Assembly

The nozzle assembly is of conventional design with the exception of the fill check. This check ball seats and seals during the downward stroke of the plunger to prevent leakage of the high-pressure fuel. During the return stroke, it unseats allowing the plunger cavity to fill. The nozzle valve is an inwardly opening type which lifts off its seat when pressure overcomes the spring force. Fuel is then atomized at high-pressure through the nozzle tip.

Fuel Injector Operation

There are three stages the fuel injector goes through during operation. They are:

1. Fill cycle
2. Injection
3. End of injection

Fill Cycle

During pre-injection all internal components have returned to their spring loaded positions. The poppet valve is blocking high-pressure oil from entering the injector. The plunger and intensifier are at the top of their bore and the plunger cavity is full of fuel. Fuel pressure in the plunger cavity is the same as fuel gallery pressure.

Injection

When the ECM determines that the injector should be fired, the following sequence of events occurs:

1. The ECM turns the injector solenoid on.
2. Solenoid is fully energized almost instantly creating a strong magnetic pull on the armature.
3. Magnetic pull of the solenoid overcomes spring tension holding the poppet closed.
4. Poppet is quickly raised off its seat.
5. Upper poppet land closes off path to drain.
6. Lower land opens poppet chamber to incoming high-pressure oil.
7. High-pressure oil flows around poppet to the top of intensifier piston.

Pressure on top of intensifier forces it down along with plunger. Downward movement of plunger pressurizes fuel in the plunger cavity and nozzle. When the fuel pressure reaches Valve Opening Pressure (VOP) the nozzle valve lifts off its seat and injection begins.

Injection pressures may be as high as 124 MPa (18,000 psi) depending on engine requirements.

NOTE: Fuel injection pressure is directly dependent on Injection Control Pressure (ICP).

End Of Injection - Drain Cycle

The end of the injection cycle begins when the ECM terminates the fuel delivery command signal to the Injector solenoid. The following events occur:

1. The magnetic field of the solenoid collapses and is no longer able to overcome poppet spring tension to hold the poppet off its seat.
2. The poppet closes, shutting off high-pressure oil from entering the injector.
3. When the poppet is seated, the upper land of the poppet opens the poppet cavity to drain.
4. Pressurized oil in the intensifier chamber and poppet chamber flows upward around the poppet seat, through the vent holes in the poppet sleeve and out the adapter drain hole.
5. The pressure of the fuel and spring in the plunger cavity exerts an upward force on the plunger and intensifier. As the pressure of the pressurized oil above the intensifier drops, so does the downward force on the intensifier.
6. The upward force from the pressurized fuel almost instantly becomes greater than the downward force on the intensifier so the downward motion of the intensifier and plunger stops.
7. When the plunger stops, fuel flow also stops.
8. With the check still open, the remaining pressure on the fuel pushes a tiny amount of additional fuel out the orifice holes. This causes a large pressure drop and fuel nozzle pressure drops below the VOP. Spring tension on the nozzle valve now resets it, and injection stops.

Table of Contents

Engine Preparation

Clean Engine

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 this manual.

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set, and wheels are blocked before doing diagnostic or service procedures on engine or vehicle.

WARNING: To avoid serious personal injury or possible death, wear safety glasses with side shields when using compressed air for cleaning to reduce the danger from flying debris. Limit the air pressure to 207 kPa (30 psi).

NOTE: Do not use a caustic solution on engine or related components.

1. Cap all openings to prevent water and de-greasing agents from entering any engine components internally.
2. Cover any exposed electrical pin connectors and ECM and IDM modules using plastic and duct tape.
3. Use an appropriate detergent mixed in the correct amount of water and apply to engine using a hot water pressure washer or similar cleaning equipment.
4. Remove oil pan drain plug and O-ring gasket. Drain engine oil and discard the O-ring gasket. Dispose of rags, containers, and engine fluids according to local regulations.
5. Install oil pan drain plug with new O-ring gasket. Tighten drain plug to "Special Torque (page 37)."

Remove Turbocharger

Remove turbocharger. See "Remove Turbocharger (page 45)" in the "Turbocharger" section of this manual.

Remove Oil Filter

Remove oil filter cartridge. See "Remove Oil Filter and Header (page 249)" in the "Lubricating Oil Pump, Oil Filter and Cooler" section of this manual.

Remove Coolant Filter (If Equipped)

Remove coolant filter. See "Coolant Filter (If Equipped) (page 265)" in the "Water Pump and Thermostat" section of this manual.

Remove Oil Cooler Assembly

Remove oil cooler assembly. See "Remove Oil Filter and Header (page 249)" in the "Lubricating Oil Pump, Oil Filter and Cooler" section of this manual.

Remove Road Draft Tube

Remove road draft tube. See "Road Draft Tube (page 63)" in the "Manifolds" section of this manual.

Mount Engine

CAUTION: To avoid engine damage, whenever mounting an engine on a repair stand, see instructions included with mounting stand and its corresponding adapter plates for specific directions on safe use. Use only metric 10.9 (Grade 8) bolts when mounting the engine on an engine stand.

1. Cap all openings to prevent debris from entering engine.
2. Install recommended Adapter Plate (ZTSE4151) (page 37) as directed. See instructions included with Engine Stand (OEM4137) (page 37). Mount adapter plate on side of engine.

NOTE: The adapter plate must be mounted to engine before installing the engine on the engine stand. Locating Guide Pins are recommended to assist in aligning and holding adapter plate.

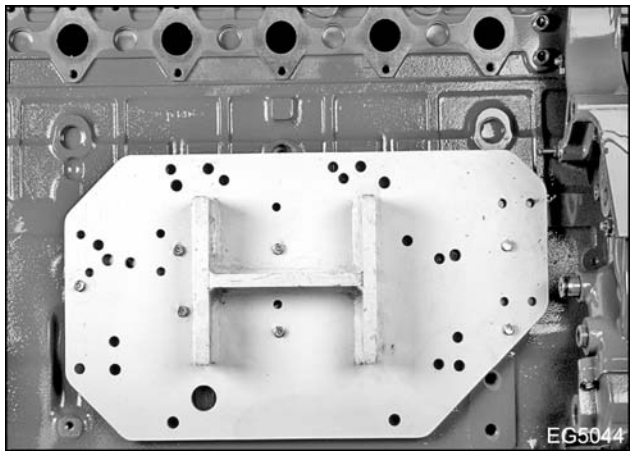

Figure 21 Attach adapter plate

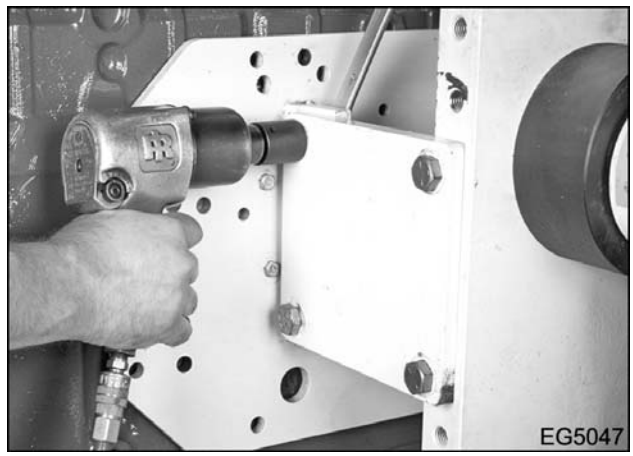

Figure 22 Attach engine stand

⚠ WARNING: To avoid serious personal injury, possible death, and damage to engine, be careful when hoisting engine to engine stand to avoid damage to valve cover and intake manifold. Use safety catch on hoist hook when lifting engine by lifting eyes.

3. Attach engine stand to adapter plate. Fasten with eight hardened [10.9 (grade 8)] bolts and nuts. Tighten bolts to “Standard Torque (page 343).”
4. Attach safety chain to lifting eyes.
5. Raise engine to approximate height of engine stand.
6. Align engine stand and adapter plate to engine, rotating stand or raising engine to match adapter plate. Attach one bolt and rotate stand if necessary to thread remaining bolts.
7. Use metric grade 10.9 (grade 8) bolts to fasten engine to adapter plate. Tighten bolts to “Standard Torque (page 343).” Remove safety chain hooks from engine lifting eyes.

Special Information

Specifications

No specifications required for this section.

Special Torque

Oil Pan Drain Plug	68 N·m (50 lbf·ft)

Special Service Tools

Adapter Plate	ZTSE4151
Engine Stand	OEM4137
Guide Pins	Obtain locally

Table of Contents

Exploded Views

Turbocharger Piping (Non-Wastegate)

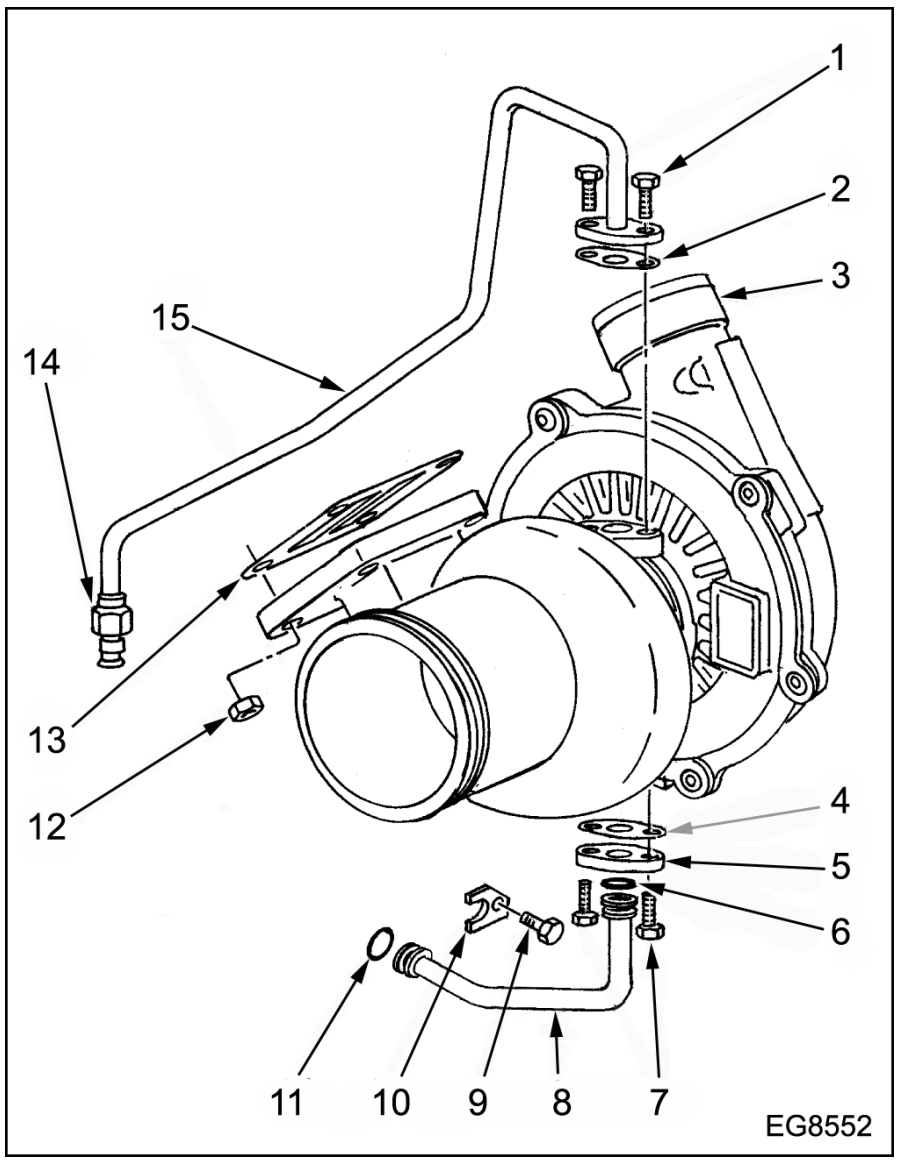

Figure 23 Turbocharger piping (Non-Wastegate)

1. Turbocharger Oil Inlet Tube Flange Bolt (2)
2. Turbocharger Oil Inlet Tube Flange Gasket
3. Turbocharger Assembly
4. Turbocharger Oil Drain Tube Flange Gasket
5. Turbocharger Oil Drain Tube Flange
6. Turbocharger Oil Drain Tube O-ring
7. Turbocharger Oil Drain Tube Flange Bolt (2)
8. Turbocharger Oil Drain Tube
9. Turbocharger Oil Drain Tube Retaining Bracket Mounting Bolt
10. Turbocharger Oil Drain Tube Retaining Bracket
11. Turbocharger Oil Drain Tube O-ring
12. Turbocharger Assembly Mounting Nut (4)
13. Turbocharger Assembly Gasket
14. Tube Mounting Nut
15. Turbocharger Oil Inlet Tube Assembly

Turbocharger Piping (Wastegate)

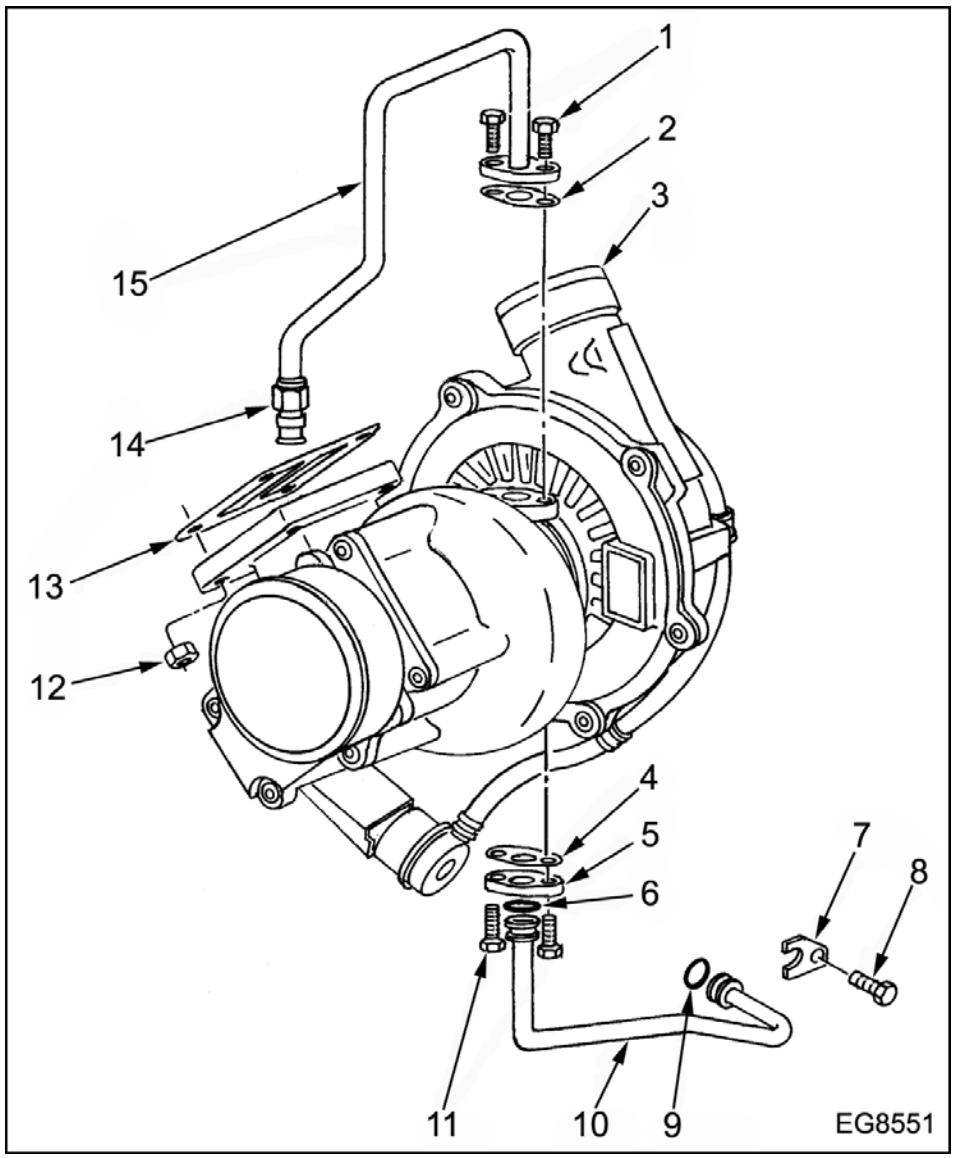

Figure 24 Turbocharger piping (Wastegate)

1. Turbocharger Oil Inlet Tube Flange Bolt (2)
2. Turbocharger Oil Inlet Tube Flange Gasket
3. Turbocharger Assembly
4. Turbocharger Oil Drain Tube Flange Gasket
5. Turbocharger Oil Drain Tube Flange
6. Turbocharger Oil Drain Tube Flange O-ring
7. Turbocharger Oil Drain Tube Retaining Bracket
8. Turbocharger Oil Drain Tube Retaining Bracket Mounting Bolt
9. Turbocharger Oil Drain Tube O-ring
10. Turbocharger Oil Drain Tube
11. Turbocharger Oil Drain Tube Flange Mounting Bolt (2)
12. Turbocharger Assembly Mounting Nuts (4)
13. Turbocharger Assembly Gasket
14. Tube Mounting Nut
15. Turbocharger Oil Inlet Tube Assembly

EVRT® Electronically Controlled Turbocharger (HT 530)

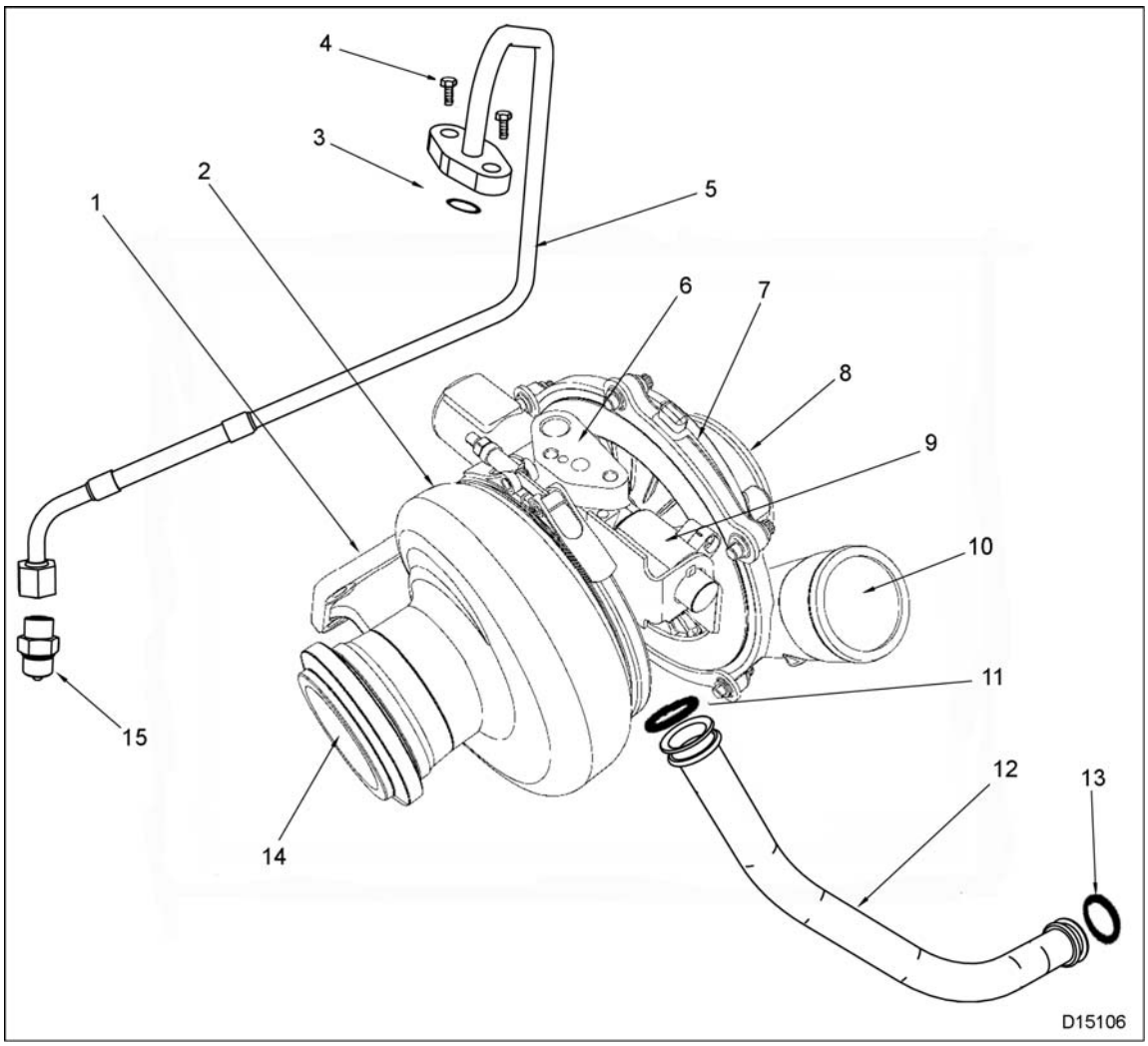

Figure 25 EVRT® electronically controlled turbocharger components

1. Exhaust inlet
2. Turbine housing
3. O-ring (size 111)
4. M8 x 1.25 x 20 hex flange bolt (2)
5. Turbo Oil Supply Tube Assembly
6. Oil supply
7. Compressor housing
8. Air inlet
9. Control valve assembly
10. Compressed air outlet
11. O-ring (size 210)
12. Turbo Oil Drain Tube
13. O-ring (size 210)
14. Exhaust outlet
15. Turbo Oil Supply Fitting Assembly

General Description

General Operation

The EVRT® Electronically Controlled Turbocharger features actuated turbine vanes. These vanes modify the flow characteristics of exhaust gases that pass through the turbine housing. Among the advantages of the EVRT® is its ability to precisely alter the boost pressure necessary to accommodate various engine speed and load conditions. The EVRT® also allows for lower emissions.

NOTE: The control valve and solenoid assembly is the only serviceable component on the EVRT® Electronically Controlled Turbocharger. When a failure is isolated to components other than the control valve and solenoid assembly, the complete EVRT® assembly must be replaced.

The EVRT® is a closed loop system that uses the Manifold Air Pressure (MAP) sensor to provide input to the Electronic Control Module (ECM). The ECM provides the required duty cycle to control the EVRT® in response to engine speed and load. Continuous monitoring and evaluation of these variables allows for optimal duty cycle adjustment to match engine requirements.

The solenoid receives a pulse width modulated signal (duty cycle) that indicates the amount of time the control valve is energized. This is also referred to as the on/off time. The control valve and solenoid assembly regulate the engine oil pressure from the filter header. The control valve directs oil flow to both sides of the piston within the center housing.

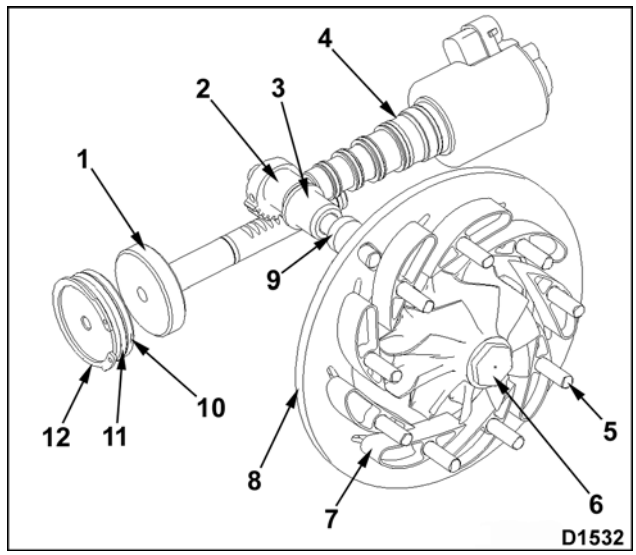

Figure 26 EVRT® Vane Components

1. Piston
2. Cam and gear
3. Bushing
4. Control valve
5. Vane pin
6. Turbine wheel
7. Vane
8. Unison ring
9. Crankshaft
10. End cap
11. O-ring
12. Snap ring

The unison ring links all of the turbine vanes and controls vane position. When the unison ring moves, each vane moves accordingly. The actuated vanes are mounted around the internal circumference of the turbine housing. Redirection of the oil to different sides of the piston will result in movement of the unison ring. This will result in the desired increase or decrease in manifold pressure.

Remove

The turbocharger is removed prior to mounting the engine on a stand.

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 this manual.

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set, and wheels are blocked before doing diagnostic or service procedures on engine or vehicle.

WARNING: To avoid serious personal injury, possible death, or damage to the engine, make sure that the engine and turbocharger have cooled down sufficiently.

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure to disconnect the battery cable from the battery. Failure to remove the battery ground cable could cause an electrical arc while removing the turbocharger.

Turbocharger

Remove Turbocharger (Non EVRT®)

1. Remove oil feed supply tube nut located on top of oil filter header. Remove and discard tube nut O-ring.

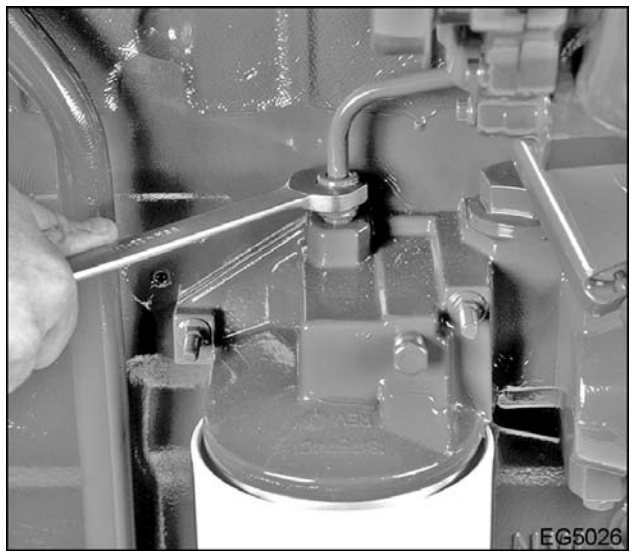

Figure 27 Remove oil feed supply tube nut

2. Remove two oil feed supply tube cap screws on top of turbocharger housing.

Figure 28 Remove oil feed supply tube cap screws

3. Remove oil feed supply tube and tube flange gasket from turbocharger assembly. Discard flange gasket.
4. Cap oil feed supply tube fitting located on filter header.
5. Loosen turbocharger oil drain tube retaining plate cap screw from crankcase. Remove retaining plate and cap screw.
6. Remove two turbocharger oil drain tube cap screws at bottom of turbocharger housing.

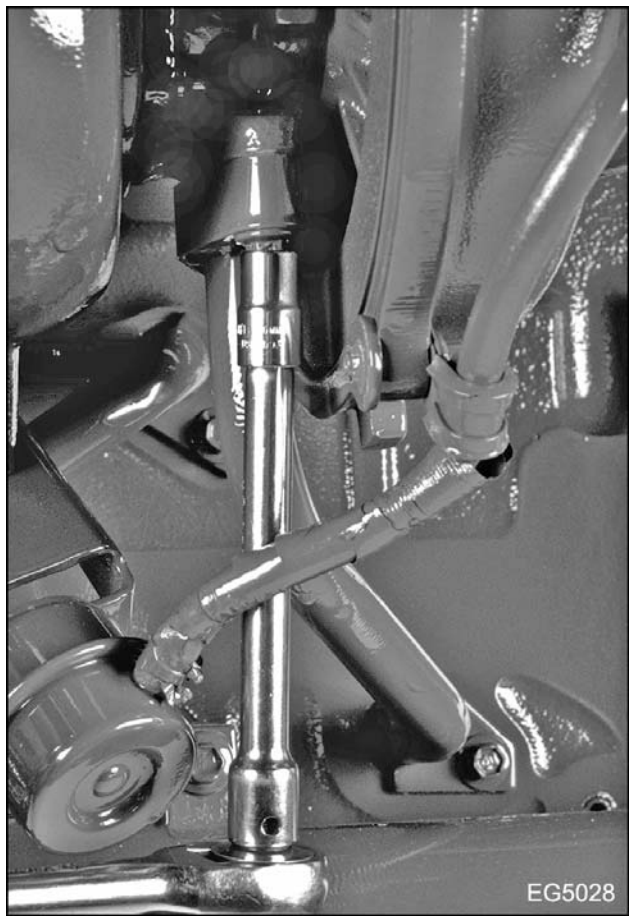

Figure 29 Remove turbocharger oil drain tube

7. Remove turbocharger oil drain tube retaining plate together with turbocharger oil drain tube, tube flange, two tube O-rings, and tube flange gasket from bottom of turbocharger assembly. Discard both drain tube O-rings (one on each end of drain tube) and flange gasket.
8. Cap all openings on turbocharger assembly. Use Turbocharger Intake Cap Set (ZTSE4296) (page 57).

   NOTE: If plastic caps are not available, use duct tape to cover openings.
9. Remove four nuts holding turbocharger assembly on exhaust manifold flange.

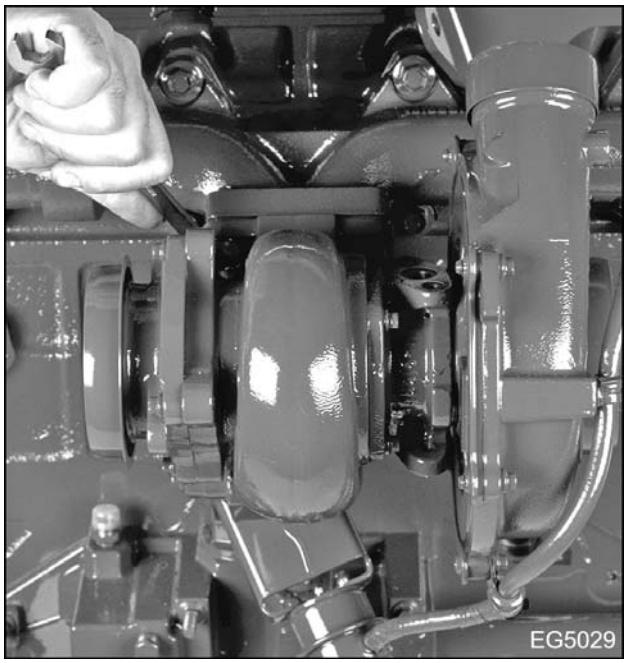

Figure 30 Remove turbocharger

CAUTION: To avoid possible engine or turbocharger damage, support turbocharger during removal and installation. Fasteners, turbocharger, and mounting plates could be bent or damaged.

10. Remove turbocharger assembly and gasket from engine. Discard gasket.

Remove Turbocharger (EVRT®)

CAUTION: To avoid engine damage, do not operate engine without heat shield. Heat shield should not be removed for turbocharger replacement.

NOTE: Special reusable locking flange nuts are used on the EVRT®. If lost or damaged, they must be replaced with the same locking nuts.

1. Disconnect control valve connector.
2. Remove oil feed supply tube nut located on top of oil filter header. Remove and discard tube nut O-ring.
3. Remove turbocharger oil supply line. Discard old O-rings. New O-rings should be used for reassembly.
4. Remove air inlet and exhaust outlet, clamps, and piping.
5. Remove EVRT® assembly, by removing four flange nuts. Remove oil drain line at this time. Discard old O-rings.

Clean, Inspect, and Test

WARNING: To avoid serious personal injury or possible death, wear safety glasses with side shields when using compressed air for cleaning to reduce the danger from flying debris. Limit the air pressure to 207 kPa (30 psi).

NOTE: Do not use a caustic solution on turbocharger or related components.

Clean

1. Use soap and water to thoroughly clean piping that connects air cleaner to turbocharger. Dry with filtered compressed air.
2. Remove vehicle mounted air cleaner. Clean inside air cleaner element housing. This helps to prevent turbocharger or engine failure.
3. Clean air inlet piping and connecting hoses with filtered compressed air.
4. Inspect oil inlet tube and oil drain tube for restrictions. Clean with a suitable solvent and a nylon brush. Dry with filtered compressed air. Replace any damaged tubes.
5. Clean off any remaining gasket material from the turbine housing and exhaust manifold mounting surfaces.

Inspect

CAUTION: To avoid possible engine or turbocharger damage, do not attempt to straighten bent turbocharger wheel blades. This weakens or damages the wheels.

Pre-Disassembly Inspection

Make the following inspections. If the turbocharger meets these requirements, it can be considered satisfactory and may be reinstalled on the engine. If it does not meet the requirements, it must be replaced or rebuilt.

Inspect Turbocharger Wheels and Housings

1. Inspect compressor impeller and turbine wheel. If there are deposits on blades or any blades are bent, broken or eroded, replace turbocharger assembly.

NOTE: Compressor impeller and turbine wheel deposits can be caused by the following:

- High Air Inlet Restriction: allows oil to transfer from the turbocharger center housing, resulting in oil deposits.
- Excessive Oil Consumption: resulting in turbine wheel carbon deposits.
- Engine Over Fueling: can result in excessive operating temperatures which can cause aluminum components to melt. Such deposits may be found on the turbine wheel if such a failure occurs.

Inspect Turbocharger for Free Rotation

1. Stand turbocharger on bench with shaft in a horizontal position.
2. Inspect turbine and compressor housing for any contact.
3. Turn shaft by hand and check for wheel rub in each housing.

   The wheels must rotate freely. If there is any rubbing or interference, replace turbocharger assembly.

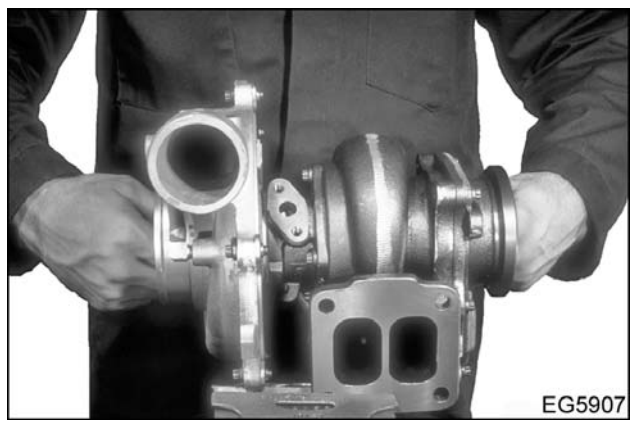

Figure 31 Inspect turbine and compressor wheel

Inspect Turbocharger (All) for Axial End Play

1. Place turbocharger assembly on clean workbench.
2. Clamp turbocharger mounting flange in a vise and position Dial Indicator with Magnetic Base (page 57) on frame of vise. Place tip of Dial Indicator on turbine end of shaft.

3. Move shaft back and forth by hand.
4. If shaft movement exceeds “Specifications (page 57)” for any type of turbocharger, turbocharger must be replaced.

Measure Actuator Movement

Measure Wastegate Actuator Movement (If Equipped)

1. Clamp turbocharger mounting flange in a vise and position Dial Indicator with Magnetic Base (page 57) on frame of the vise. Place tip of Dial Indicator on actuator lever.
2. Connect air hose to 207 kPa (30 psi) pressure regulator.
3. Using hose, connect pressure regulator, note rod location (scribe mark). Gradually apply 197 kPa (29 psi) to the wastegate actuator. Measure actuator rod travel, compare to “Specification (page 57),” for actuator movement tolerance.

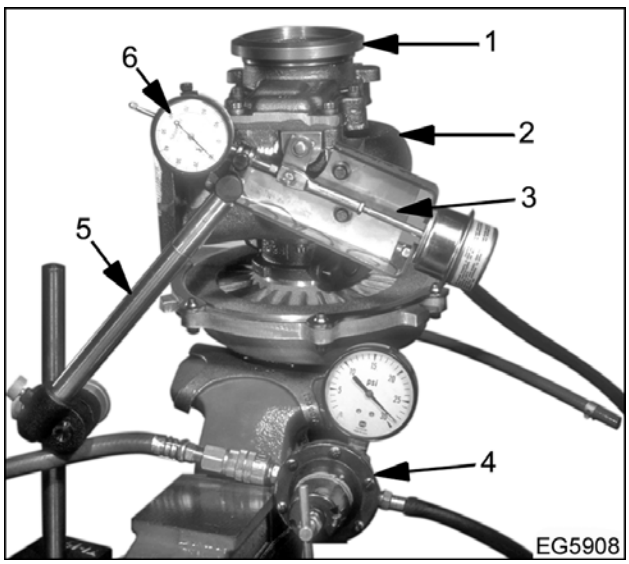

Figure 32 Measure Wastegate actuator movement

1. Wastegate housing
2. Turbine housing
3. Wastegate actuator shaft
4. Air pressure regulator
5. Dial indicator magnetic base
6. Dial indicator

Diagnosing Possible EVRT® Damage

Should you suspect trouble with the EVRT®, note that there are several diagnostic procedures that must be followed in order to determine whether or not there is a problem with the EVRT®. These steps include completing the appended EGED-260 EVRT® Warranty Checklist, and the Performance Diagnostics side of EGED-220 Mechanical Diagnostics form.

NOTE: Prior approval is required from International® Technical Services before turbocharger replacement under warranty. In order to be considered for warranty reimbursement, a completed EVRT® Warranty Checklist must be attached to the EVRT® when it is returned to International Truck and Engine Corporation.

Measure EVRT® Actuator Movement

1. Orient EVRT® turbocharger assembly so that actuator linkage can be easily accessed and viewed.
2. Move the actuator shaft through its entire travel.
3. The actuator shaft should rotate 90° and return under spring tension.

Disassemble

NOTE: EVRT® turbochargers are not repairable, do not disassemble.

Disassemble Wastegate and Non-Wastegate Turbochargers

CAUTION: To avoid engine damage, do not attempt reorientation of compressor housing, this will damage the compressor housing O-ring.

NOTE: Disassembly procedure is same for wastegate and non-wastegate turbochargers except where noted.

1. Mark compressor housing location to back plate to aid in reassembly.

Figure 33 Mark compressor

2. (Wastegate turbocharger) remove two hose clamps on hose connecting turbine side to wastegate actuator. Remove hose from wastegate actuator.

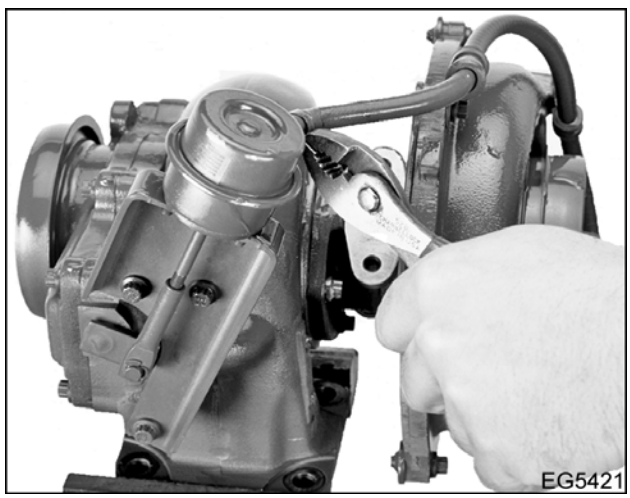

Figure 34 Remove hose clamp

3. (Wastegate turbocharger) remove wastegate actuator arm retaining clip to disengage arm.

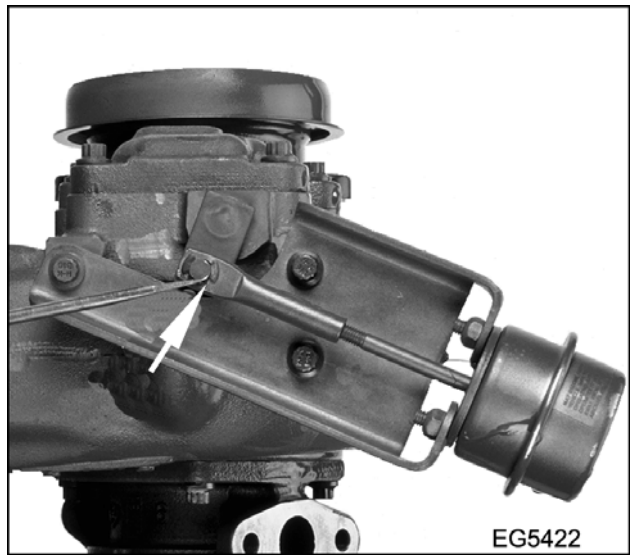

Figure 35 Remove retaining clip

1. Retaining clip

4. (Wastegate turbocharger) remove three bolts holding wastegate actuator bracket arm to center housing. Remove actuator bracket arm.
5. Remove six bolts holding compressor housing to back plate. Remove clamps. Remove compressor housing.

Figure 36 Remove compressor housing

6. Remove O-ring from back plate and discard.

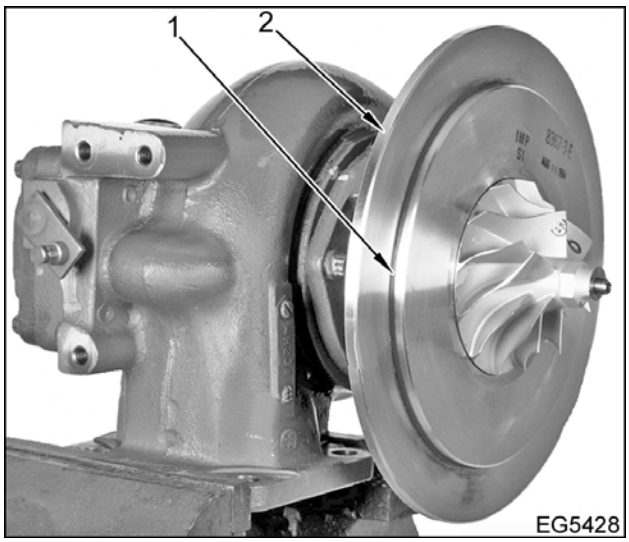

Figure 37 Remove back plate O-ring

1. O-ring
2. Back plate

7. Mark turbine and center housing.

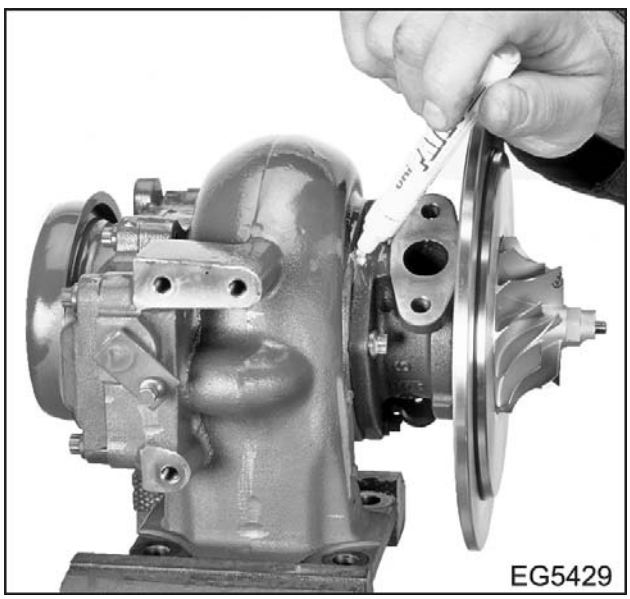

Figure 38 Mark turbine and center housing

8. Remove four bolts holding center housing to turbine housing.

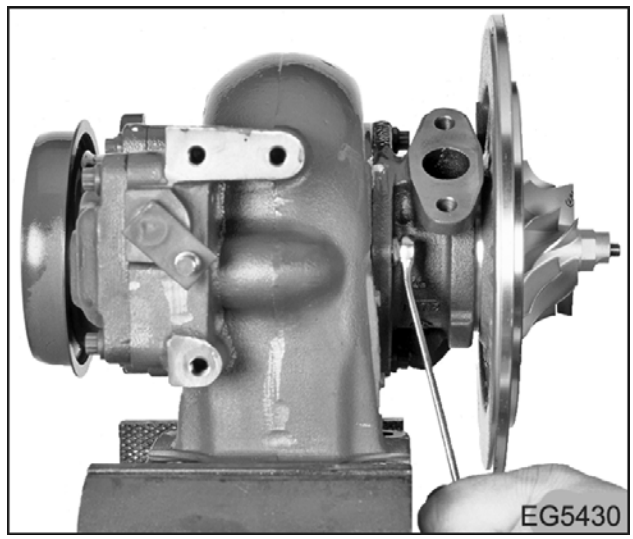

Figure 39 Remove turbine housing

9. (Wastegate turbocharger) mark wastegate housing and turbine housing. Remove six bolts holding wastegate housing to turbine housing. Remove housing.

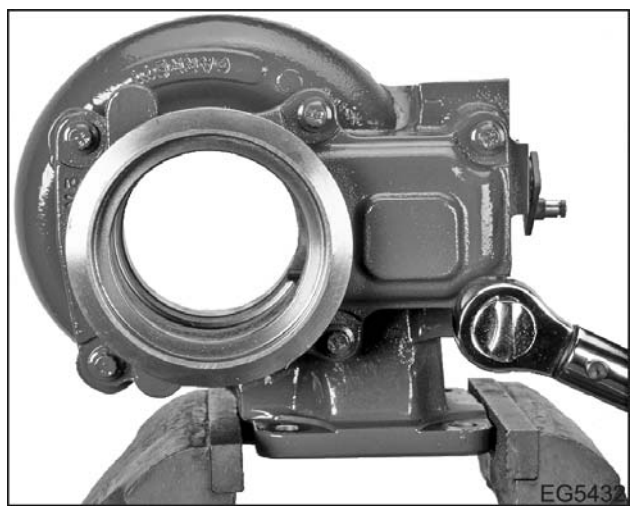

Figure 40 Remove wastegate housing

10. (Wastegate Turbocharger) flip actuator arm, inspect check valves for cracks or wear.

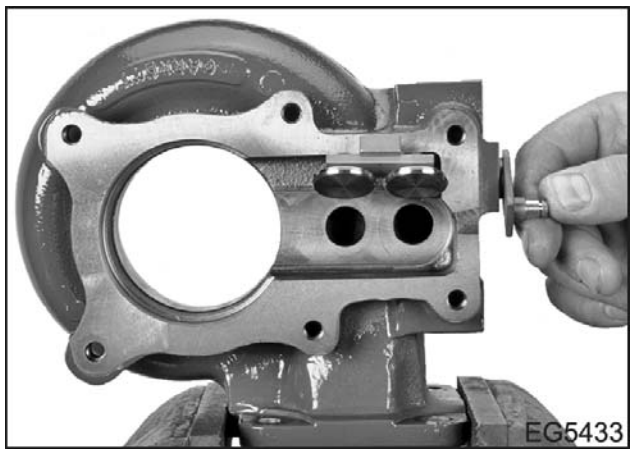

Figure 41 Inspect wastegate check valves

CAUTION: To avoid engine damage, compressor turbine wheel and wheel shaft assemblies are balanced as an assembly. Removal and reassembly of compressor wheel may result in excessive noise as well as imbalance and turbocharger failure.

Control Valve Replacement (EVRT®)

1. Remove control valve retaining bolt, bracket, and solenoid. Have a shop towel and a container handy for draining oil.
2. Inspect valve and center housing bore for pieces of or missing O-rings.
3. Position new bracket on new control valve solenoid.

CAUTION: To avoid engine damage, make certain control valve has been seated by hand. Do not to draw the control valve into place with retaining bolt. When the control valve is seated correctly, a sharp "snap" will be heard and felt. If this "snap" is not felt or heard, remove control valve and inspect for damaged O-rings.

4. Coat new control valve O-rings with clean engine oil and position on control valve solenoid. Push solenoid in turbocharger center housing until fully seated.
5. Install retaining bolt and tighten to the standard torque value of 31 N·m (23 lbf·ft).

Reassemble

NOTE: EVRT® turbochargers are not repairable, do not disassemble.

Reassemble Turbocharger

1. Install a new O-ring on back plate. Align marks of compressor housing to back plate. Attach compressor housing to back plate. Tighten six bolts finger tight.
2. (Wastegate turbocharger) install wastegate actuator bracket with actuator arm and diaphragm attached, to center housing. Fasten bracket with three bolts. Tighten bolts to “Standard Torque (page 343).”

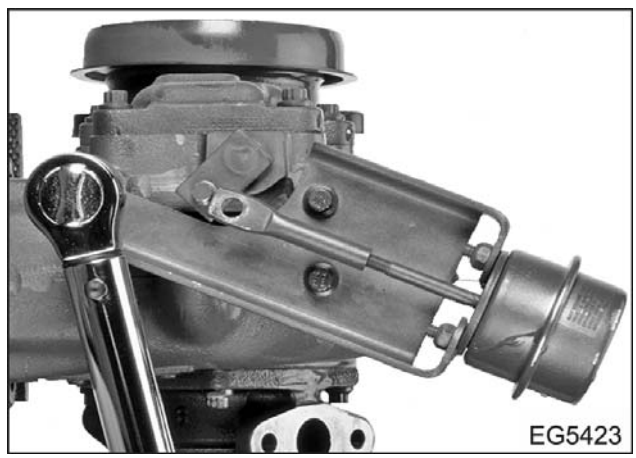

Figure 42 Install wastegate actuator bracket

3. (Wastegate turbocharger) connect wastegate actuator arm to wastegate. Install retaining clip.
4. (Wastegate turbocharger) align marks of the wastegate and turbine housing. Attach wastegate housing to turbine housing with six bolts. Tighten bolts to “Special Torque (page 57).”

Figure 43 Install wastegate housing

5. Align marks on the turbine and center housing. Attach turbine housing to center housing with four bolts. Tighten bolts to “Special Torque (page 57).”

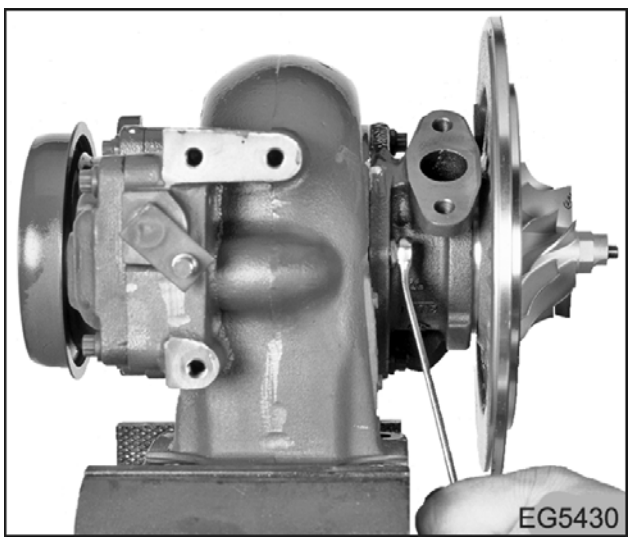

Figure 44 Install turbine housing

6. Fasten compressor housing to back plate with six bolts and three clamps. Tighten bolts to “Special Torque (page 57).”

Figure 45 Install compressor housing

NOTE: Use a new actuator hose when reassembling wastegate turbocharger.

7. (Wastegate turbocharger) attach hose from the compressor side of turbocharger to wastegate actuator with two hose clamps.

Install

NOTE: Turbocharger can only be installed if engine is not on engine stand.

Install Turbocharger (Non EVRT®)

1. Install new gasket on exhaust manifold flange.
2. Attach turbocharger assembly on exhaust manifold flange and tighten nuts to the “Special Torque (page 57).”

Figure 46 Install turbocharger

3. Remove protective caps from oil inlet port at turbocharger and from oil feed supply tube fitting located on oil filter header.
4. Pour five ounces of clean engine oil in oil inlet opening of turbocharger. This provides sufficient lubrication for turbocharger bearings until engine oil pressure is obtained.
5. Position new gasket on turbocharger oil inlet port.
6. Install oil feed supply tube to turbocharger and fasten with two mounting cap screws.

Figure 47 Install oil feed tube

7. Install new rubber seal ring in oil feed supply tube connector nut.
8. Install oil feed supply tube on tube fitting with connector nut.

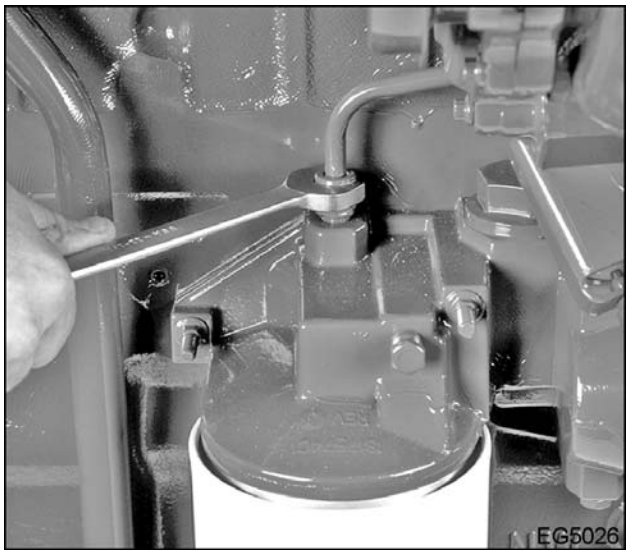

Figure 48 Install oil feed tube

9. Remove protective cap from oil drain port on turbocharger.
10. Lubricate two new O-rings with engine oil, install one on each end of turbocharger oil drain tube.
11. Position turbocharger oil drain tube with new O-rings, tube flange and flange gasket on turbocharger oil drain port.
12. Fasten turbocharger oil drain tube to turbocharger and tighten nuts.

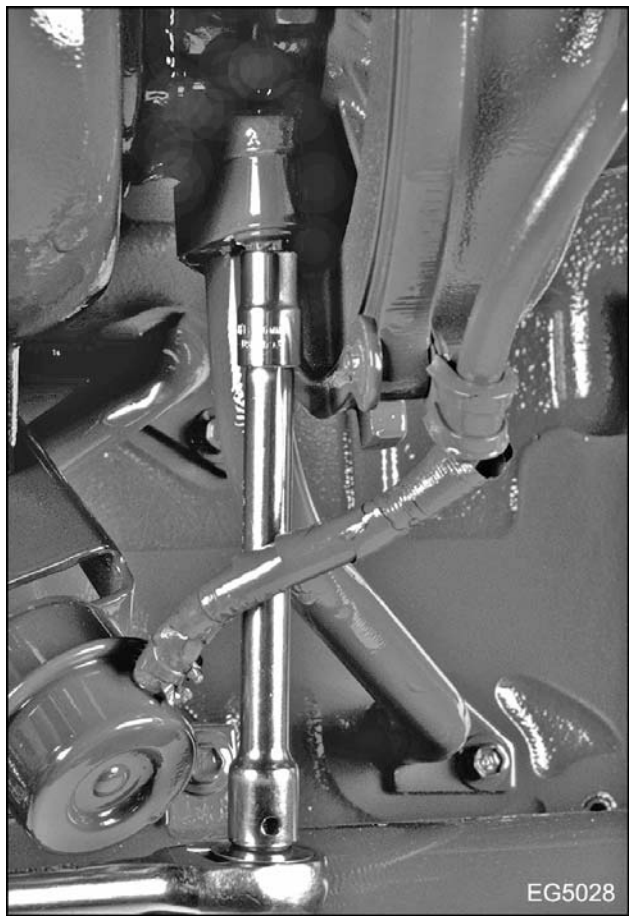

Figure 49 Install oil drain tube

13. Install loose end of turbocharger oil drain tube in crankcase with retaining plate and one cap screw.

Install Turbocharger (EVRT®)

New parts listed in the following table are necessary for installation of the EVRT®.

Parts Required for EVRT® Installation

Quantity	Part
2	O-rings for turbocharger oil drain tube
2	O-rings for turbocharger oil inlet tube
1	Turbocharger flange gasket

1. Install EVRT® assembly with new flange gasket, using four flange nuts.

2. Install oil line drain. Use new O-rings. Torque nut to special torque of 17 N·m (52 ft·lb).
3. Install air inlet and exhaust outlet, clamps, and piping.
4. Before installing supply line, fill oil supply inlet cavity of the center housing with oil.
5. Install turbocharger oil supply line using new O-rings.

CAUTION: To avoid engine damage, be careful not to twist or crimp the flexible section of the oil supply line.

6. Install oil feed supply tube on tube fitting with connector nut.
7. Connect control valve connector to solenoid.

Special Information

Specifications

Turbine shaft axial end play	0.02 to 0.10 mm (0.001 to 0.004 in)
Turbine shaft radial movement (play)	0.08 to 0.15 mm (0.003 to 0.006 in)
Wastegate actuator movement	0.37 mm at 196 kPa (0.015 in at 29 psi)
EVRT®	
Turbine shaft axial end play	0.05 to 0.13 mm (0.002 to 0.005 in)
Turbine shaft radial movement (play)	0.52 to 0.74 mm (0.020 to 0.029 in)
EVRT® axial linkage shaft	Must strike open and closed stops in actuator, 90° rotation

Special Torque

Center Housing-to-Turbine Housing Cap screws	13 N·m (115 lb·in)
Wastegate housing to turbine housing cap screws	21 - 24 N·m (185 - 215 lbf·in)
Center Housing-to-Compressor Housing Cap screws	21 - 24 N·m (185 - 215 lbf·in)
Compressor housing to back plate	21 - 24 N·m (185 - 215 lbf·in)
Turbocharger Mounting Nuts	71 N·m (52 lbf·ft)
EVRT® Turbocharger mounting studs and nuts	71 N·m (52 lbf·ft)

NOTE: Apply clean engine oil to all threads.

Special Service Tools

Dial Indicator with Magnetic Base	Obtain locally
Turbo Intake Cap Set	ZTSE4296
Turbocharger Intake Shield	ZTSE4293

Table of Contents

Exploded View, Flow, and Identification

Exploded View

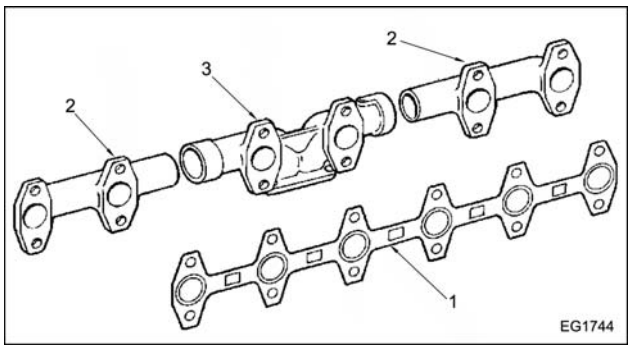

Figure 50 Exhaust manifold

1. Exhaust manifold gasket
2. End exhaust manifold
3. Center exhaust manifold

Piping and Flow

NOTE: The intercooler and connecting hardware is chassis mounted. See the appropriate chassis manual for detailed information.

Identification

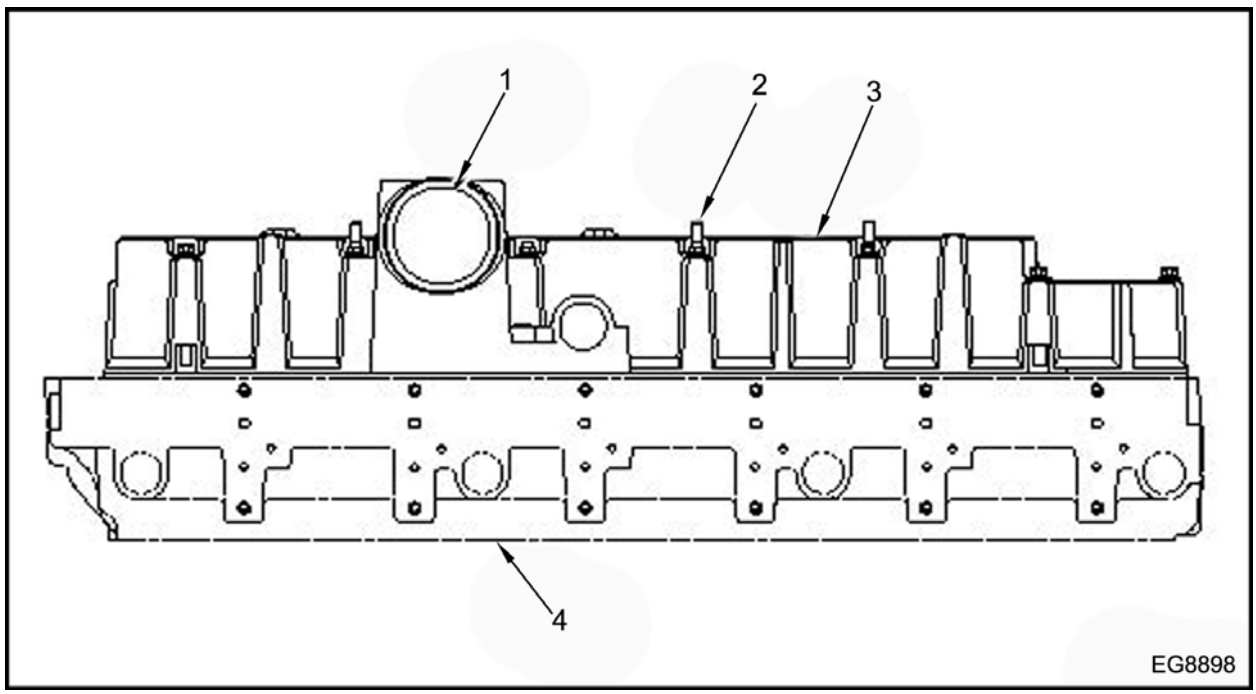

Figure 51 Valve cover intake manifold with side air inlet

1. Side air inlet
2. Stud bolts (quantity and locations vary)
3. Valve cover intake manifold
4. Cylinder head

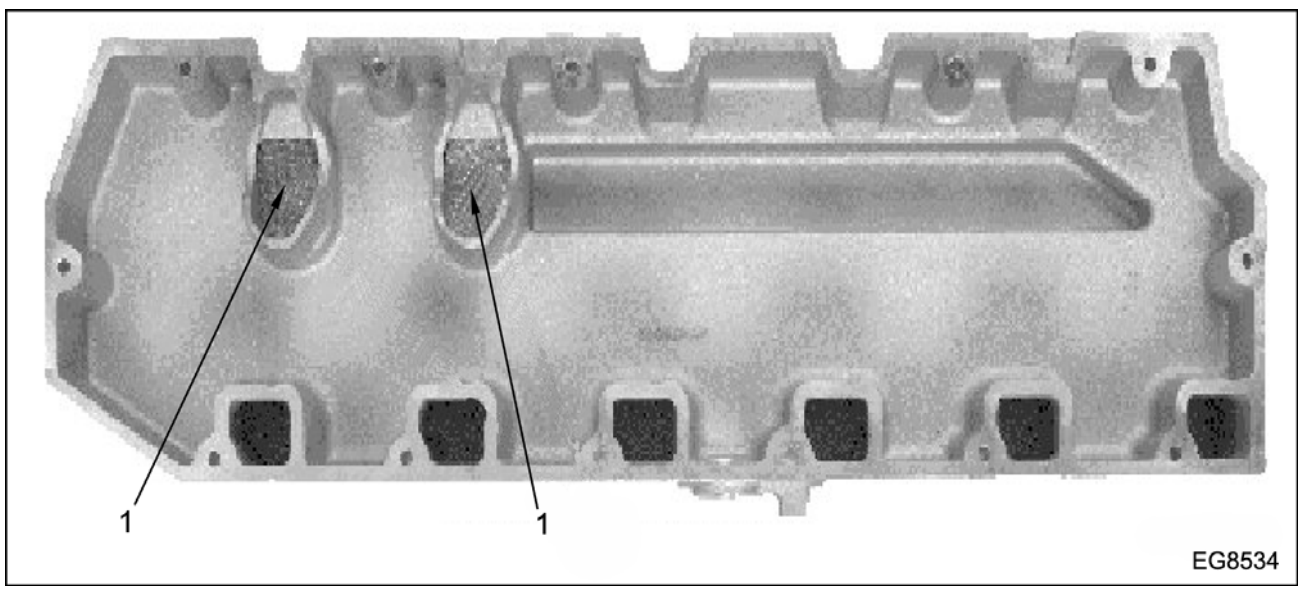

Figure 52 Underside of valve cover and intake manifold

1. Breather elements

Remove

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 this manual.

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral or park, parking brake is set, and wheels are blocked before doing diagnostic or service procedures on engine or vehicle.

Miscellaneous

Refer to the appropriate section for removal of these components as required:

Turbocharger and turbocharger support components

Electronic Control Module (ECM) unit and mounting bracket, if equipped

Engine wiring harness

Road Draft Tube

The road draft tube is removed prior to mounting the engine on a stand.

1. Remove two road draft tube bolts connecting it to crankcase.
2. Pull road draft tube out of valve cover and intake manifold and the crankcase.

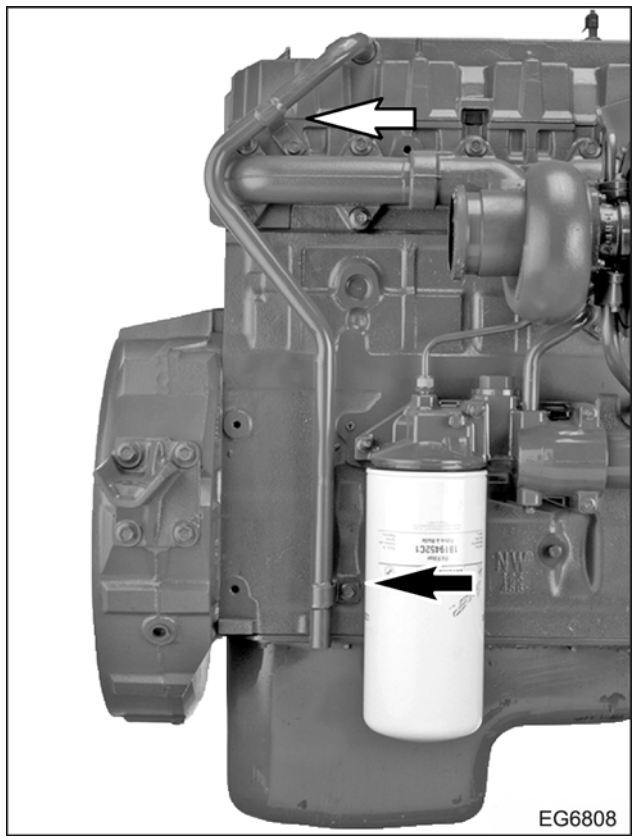

Figure 53 Road draft tube

Exhaust Manifold

1. Remove twelve mounting bolts holding three exhaust manifold sections to cylinder head.
2. Remove exhaust manifold and discard one-piece gasket.

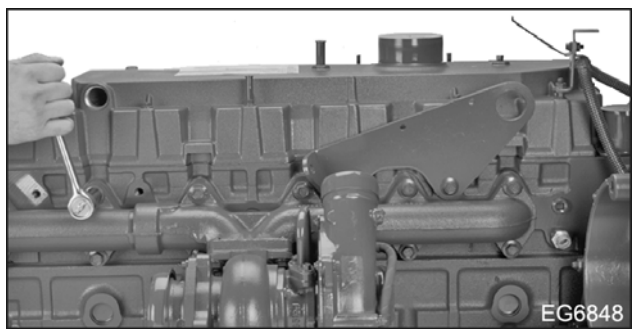

Figure 54 Remove exhaust manifold

Valve Cover and Intake Manifold

NOTE: Make sure the road draft tube has been removed from valve cover and intake manifold.

See ”Remove ECM (page 284)” in the “Engine Electrical” section for procedures to remove wiring harnesses, ECM, and ECM mounting bracket.

1. Record the locations of the stud bolts and brackets, with orientation, related to the valve cover intake manifold mounting. Locations and quantity may vary depending on the particular application. Save the information for reassembly.
2. Disconnect the wiring harness connector from valve cover and intake manifold. For engines equipped with an engine mounted ECM, disconnect the wiring harness.
3. Release the retaining tabs of the wiring harness connector. Push the connector body toward the inside of the valve cover and intake manifold.

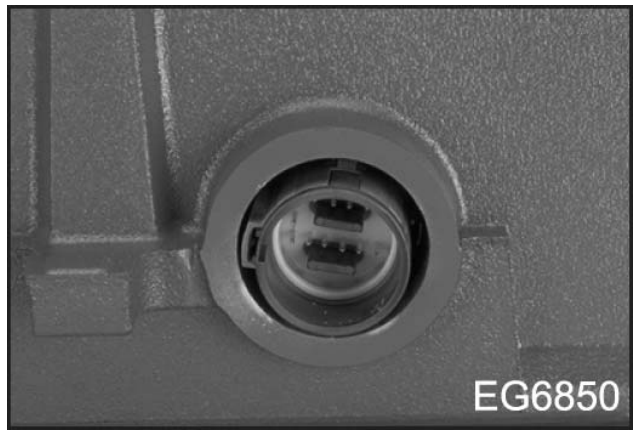

Figure 55 Push wiring harness connector inside

4. Remove the thirteen valve cover and intake manifold mounting bolts. Remove the valve cover and intake manifold and gasket from the cylinder head.

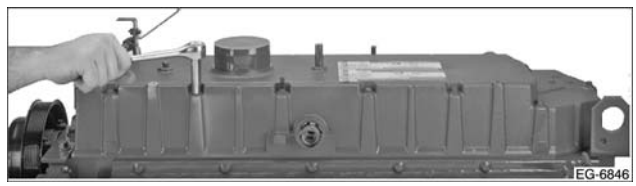

Figure 56 Remove valve cover and intake manifold

Clean and Inspect

WARNING: To avoid serious personal injury or possible death, wear safety glasses with side shields when using compressed air for cleaning to reduce the danger from flying debris. Limit the air pressure to 207 kPa (30 psi).

NOTE: Do not use a caustic solution on engine or related components.

Exhaust Manifold

Clean Exhaust Manifold

1. Clean exhaust manifold with steam or a suitable non-caustic solvent.
2. After cleaning, use filtered compressed air to dry the manifold sections.

Inspect Exhaust Manifold

1. Inspect exhaust manifold sections for cracks. Replace as required.
2. Inspect for warping as follows:
   a. Install exhaust manifold on cylinder head without the gasket. Tighten the bolts to the special torque value (page 68).
   b. Use a 0.25 mm (0.010 in) Feeler Gauge (page 68) to measure the gap between the bolts at the manifold flange and the cylinder head mating surface.
   c. If the Feeler Gauge passes through, the exhaust manifold requires resurfacing.

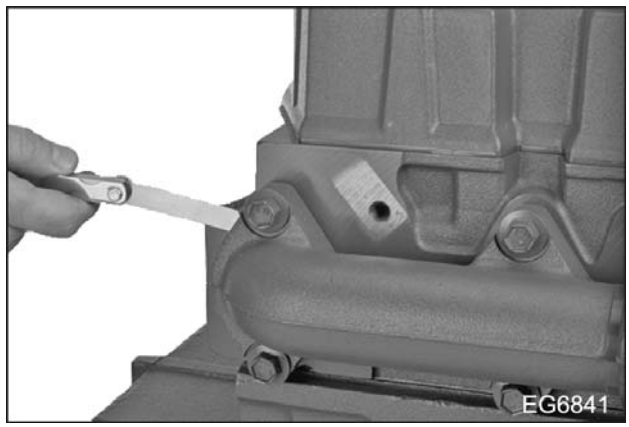

Figure 57 Inspect exhaust manifold

NOTE: A maximum of 0.64 mm (0.025 in) of material can be ground off to correct warping.

NOTE: It may be necessary to resurface all manifold section surfaces to correct warping.

3. If warping cannot be corrected by resurfacing, replace the exhaust manifold.

Valve Cover and Intake Manifold

Clean Valve Cover and Intake Manifold

1. Use a suitable non-caustic solvent to clean the valve cover and intake manifold and breather.
2. Use filtered compressed air to dry the breather.

Inspect Valve Cover and Intake Manifold

Inspect the valve cover and intake manifold for any damage. Replace as required.

Install

Valve Cover and Intake Manifold

NOTE: If valve cover and intake manifold gasket is not damaged and in good condition, it can be reused.

1. Place the gasket on the cylinder head.
2. Hold the valve cover and intake manifold over the engine. Place a new O-ring in the wiring harness connector port and push the connector in until the tabs lock.
3. Install the valve cover and intake manifold on the cylinder head.

   NOTE: Make sure the valve cover and intake manifold and gasket are aligned properly.

Figure 58 Install valve cover and intake manifold bolts

4. Install the thirteen mounting bolts that secure the valve cover and intake manifold to the cylinder head. Tighten the bolts to “Special Torque (page 68).”

Install Exhaust Manifold

1. Install the assembled exhaust manifold with a new gasket on the cylinder head.
2. If the twelve exhaust manifold bolts are being reused, apply Never-Seez™ to the bolts.
3. Ensure gasket is aligned with the bolt holes and install the twelve exhaust manifold bolts.

NOTE: Make sure the exhaust manifold gasket and exhaust manifold are aligned before tightening bolts.

4. Tighten the bolts to “Special Torque (page 68).”

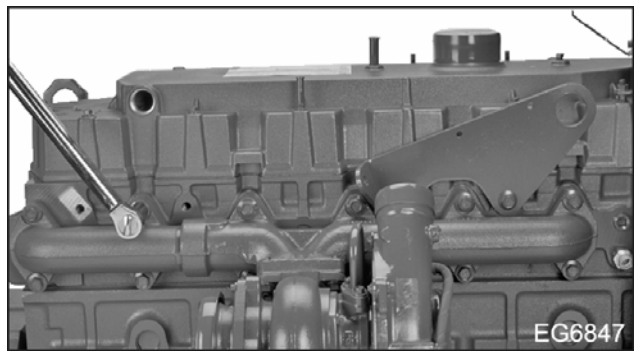

Figure 59 Install exhaust manifold

Install Road Draft Tube

The road draft tube can only be installed if the engine is off the stand.

1. Lubricate and install new O-ring on road draft tube.

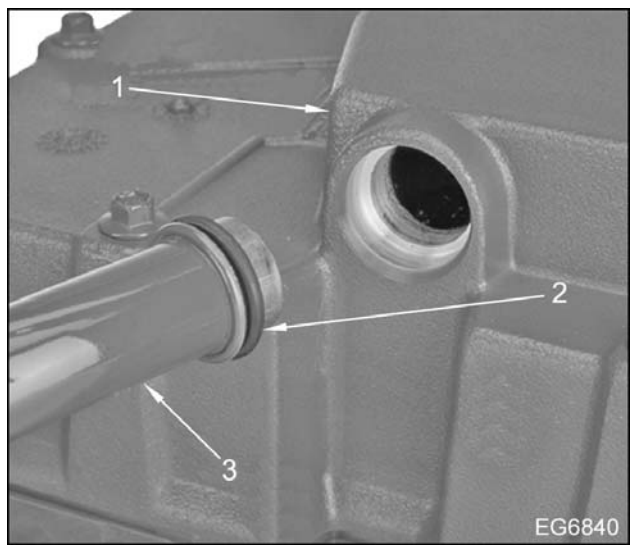

Figure 60 Install road draft tube

1. Valve cover and intake manifold
2. O-ring
3. Road draft tube

2. Insert road draft tube in the bore on the rear right side of the valve cover and intake manifold. Fasten the road draft tube to the crankcase with two mounting bolts. Tighten the bolts to “Special Torque (page 68).”

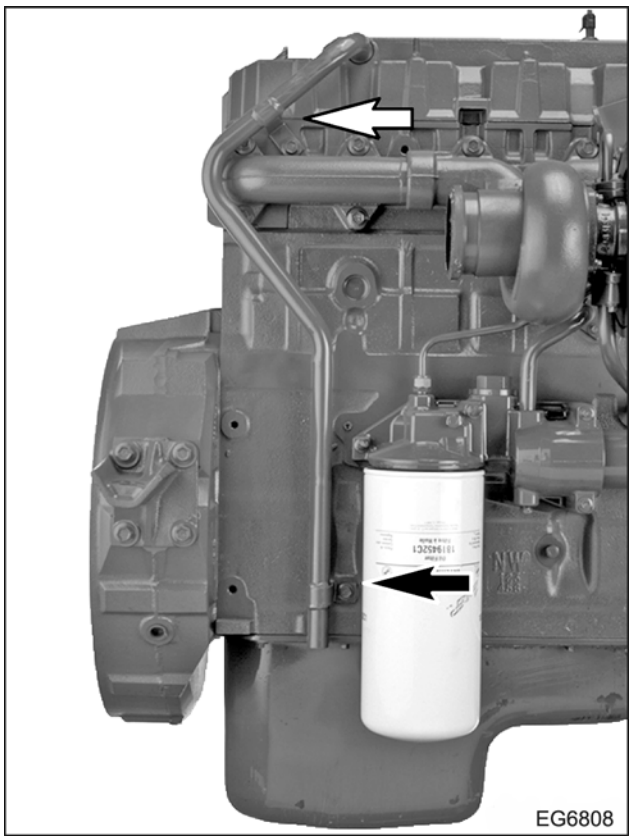

Figure 61 Road draft tube

Miscellaneous

Refer to appropriate sections for proper installation procedures:

Turbocharger, if removed

Turbocharger oil supply tube, if removed

Turbocharger oil drain tube, if removed

Engine mounted ECM unit and mounting bracket, if equipped

Engine wiring harness

Special Information

Specifications

Maximum allowable warping (intake manifold)	0.254 mm (0.010 in)
Maximum allowable warping (exhaust manifold)	0.254 mm (0.010 in)
Maximum allowable removal of material	0.635 mm (0.025 in)
Minimum flange thickness	18.41 mm (0.725 in)

Special Torque Values

Exhaust manifold bolts	81 N·m (60 lbf·ft)
Valve cover and intake manifold bolts	18 N·m (13 lbf·ft)
Road draft tube mounting bolts	49 N·m (36 lbf·ft)

Special Service Tools

Feeler Gauge	Obtain locally