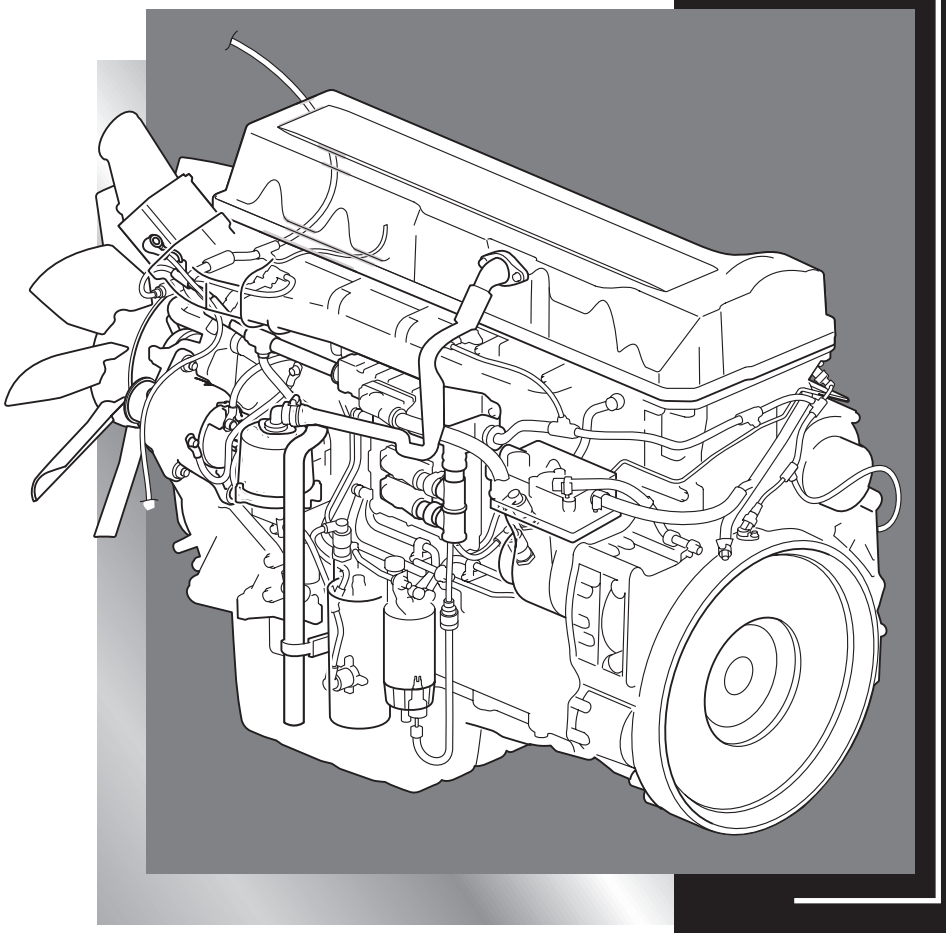


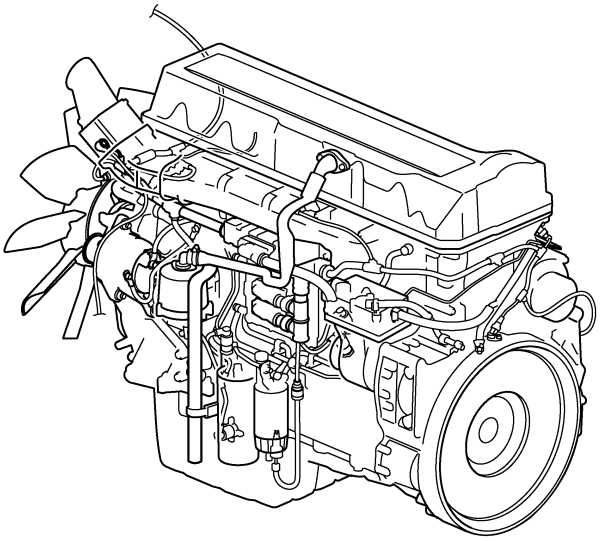
MACK® MP8 DIESEL ENGINE

SERVICE MANUAL

(EURO 3 EMISSIONS REGULATIONS)

JULY 2009
(REVISED)
5-116

MACK® MP8 DIESEL ENGINE SERVICE MANUAL (EURO 3 EMISSIONS REGULATIONS)



JULY 2009
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ATTENTION

The information in this manual is not all inclusive and cannot take into account all unique situations. Note that some illustrations are typical and may not reflect the exact arrangement of every component installed on a specific chassis.

The information, specifications, and illustrations in this publication are based on information that was current at the time of publication. Note that illustrations and instructions are based on information that is subject to change as new engine/chassis development continues.

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INTRODUCTION

SAFETY INFORMATION

Advisory Labels

Cautionary *signal words* (Danger-Warning-Caution) may appear in various locations throughout this manual. Information accented by one of these signal words must be observed to minimize the risk of personal injury to service personnel, or the possibility of improper service methods which may damage the vehicle or cause it to be unsafe. Additional Notes and Service Hints are used to emphasize areas of procedural importance and provide suggestions for ease of repair. The following definitions indicate the use of these advisory labels as they appear throughout the manual:

⚠ DANGER

Danger *indicates an unsafe practice that could result in death or serious personal injury. Serious personal injury is considered to be permanent injury from which full recovery is NOT expected, resulting in a change in life style.*

⚠ WARNING

***Warning* indicates an unsafe practice that could result in personal injury. Personal injury means that the injury is of a temporary nature and that full recovery is expected.**

⚠ CAUTION

***Caution** indicates an unsafe practice that could result in damage to the product.*

NOTE

Note indicates a procedure, practice, or condition that must be followed in order for the vehicle or component to function in the manner intended.

SERVICE HINT

A helpful suggestion that will make it quicker and/or easier to perform a procedure, while possibly reducing service cost.

Service Procedures and Tool Usage

Anyone using a service procedure or tool not recommended in this manual must first satisfy himself thoroughly that neither his safety nor vehicle safety will be jeopardized by the service method he selects. Individuals deviating in any manner from the instructions provided assume all risks of consequential personal injury or damage to equipment involved.

Also note that particular service procedures may require the use of a special tool(s) designed for a specific purpose. These special tools must be used in the manner described, whenever specified in the instructions.

⚠ DANGER

1. ***Before starting a vehicle, always be seated in the driver's seat, place the transmission in neutral, apply the parking brakes, and push in the clutch pedal. Failure to follow these instructions could produce unexpected vehicle movement, which can result in serious personal injury or death.***
2. ***Before working on a vehicle, place the transmission in neutral, set the parking brakes, and block the wheels. Failure to follow these instructions could produce unexpected vehicle movement, which can result in serious personal injury or death.***

⚠ DANGER

Engine-driven components such as Power Take-Off (PTO) units, fans and fan belts, driveshafts and other related rotating assemblies, can be very dangerous. Do not work on or service engine-driven components unless the engine is shut down. Always keep body parts and loose clothing out of range of these powerful components to prevent serious personal injury. Be aware of PTO engagement or nonengagement status. Always disengage the PTO when not in use.

⚠ DANGER

Do not work under a vehicle that is supported only by a hydraulic jack. The hydraulic jack could fail suddenly and unexpectedly, resulting in severe personal injury or death. Always use jackstands of adequate capacity to support the weight of the vehicle.

⚠ CAUTION

Before towing the vehicle, place the transmission in neutral and lift the rear wheels off the ground, or disconnect the driveline to avoid damage to the transmission during towing.

REMEMBER,
SAFETY . . . IS NO ACCIDENT!

Mack Trucks, Inc. cannot anticipate every possible occurrence that may involve a potential hazard. Accidents can be avoided by recognizing potentially hazardous situations and taking necessary precautions. Performing service procedures correctly is critical to technician safety and safe, reliable vehicle operation.

The following list of general shop safety practices can help technicians avoid potentially hazardous situations and reduce the risk of personal injury. DO NOT perform any services, maintenance procedures or lubrications until this manual has been read and understood.

- Perform all service work on a flat, level surface. Block wheels to prevent vehicle from rolling.
- DO NOT wear loose-fitting or torn clothing. Remove any jewelry before servicing vehicle.
- ALWAYS wear safety glasses and protective shoes. Avoid injury by being aware of sharp corners and jagged edges.
- Use hoists or jacks to lift or move heavy objects.
- NEVER run engine indoors unless exhaust fumes are adequately vented to the outside.
- Be aware of hot surfaces. Allow engine to cool sufficiently before performing any service or tests in the vicinity of the engine.
- Keep work area clean and orderly. Clean up any spilled oil, grease, fuel, hydraulic fluid, etc.
- Only use tools that are in good condition, and always use accurately calibrated torque wrenches to tighten all fasteners to specified torques. In instances where procedures require the use of special tools which are designed for a specific purpose, use only in the manner described in the instructions.
- Do not store natural gas powered vehicles indoors for an extended period of time (overnight) without first removing the fuel.
- Never smoke around a natural gas powered vehicle.

EXPLANATION OF NUMERICAL CODE

The organization of MACK service manuals has been upgraded to standardize manual content according to a reference system based on component identification. The new reference system will help link the information contained in this publication with related information included in other MACK service/warranty publications, such as associated service bulletins, warranty manuals, and MACK Service Labor Time Standards.

The system is based on a numerical code, the first **digit** of which identifies the general component grouping as listed here:

GROUP **0**00 — GENERAL DATA

GROUP **1**00 — CHASSIS

GROUP **2**00 — ENGINE

GROUP **3**00 — CLUTCH, TRANSMISSION, TRANSFER CASE AND PTO

GROUP **4**00 — STEERING, AXLES, WHEELS AND TIRES, DRIVELINE

GROUP **5**00 — BRAKES, AUXILIARY SYSTEMS

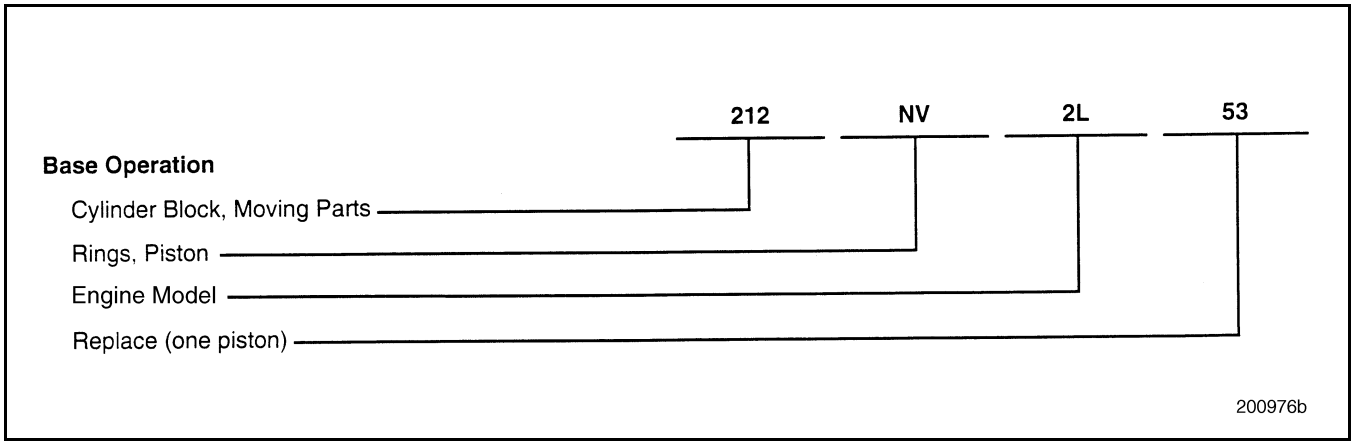
GROUP **6**00 — CAB, TRUCK BODY

GROUP **7**00 — ELECTRICAL

The second two digits of the three-digit code are used to identify the **system, assembly** or **subassembly**, as appropriate, within each of the groupings. The codes applicable to this publication are shown at the beginning of each procedure, as necessary, to guide you to specific component information.

Additionally, a two-character alpha code (i.e., [NV] RINGS, PISTON) may be referenced with each procedure. This alpha code, in combination with the three-digit Group number, identifies the specific assembly, sub-assembly or part, and directly relates to the first five positions of the operation code listed in MACK Service Labor Time Standards.

Example:



Numerical Code

CONVERSION CHART

Conversion Units			Multiply By:
Length Calculations			
Inches (in)	to	Millimeters (mm)	25.40
Inches (in)	to	Centimeters (cm)	2.540
Feet (ft)	to	Centimeters (cm)	30.48
Feet (ft)	to	Meters (m)	0.3048
Yards (yd)	to	Centimeters (cm)	91.44
Yards (yd)	to	Meters (m)	0.9144
Miles	to	Kilometers (km)	1.609
Millimeters (mm)	to	Inches (in)	0.03937
Centimeters (cm)	to	Inches (in)	0.3937
Centimeters (cm)	to	Feet (ft)	0.0328
Centimeters (cm)	to	Yards (yd)	0.0109
Meters (m)	to	Feet (ft)	3.281
Meters (m)	to	Yards (yd)	1.094
Kilometers (km)	to	Miles	0.6214
Area Calculations			
Square Inches (sq-in)	to	Square Millimeters (sq-mm)	645.2
Square Inches (sq-in)	to	Square Centimeters (sq-cm)	6.452
Square Feet (sq-ft)	to	Square Centimeters (sq-cm)	929.0
Square Feet (sq-ft)	to	Square Meters (sq-m)	0.0929
Square Yards (sq-yd)	to	Square Meters (sq-m)	0.8361
Square Miles (sq-miles)	to	Square Kilometers (sq-km)	2.590
Square Millimeters (sq-mm)	to	Square Inches (sq-in)	0.00155
Square Centimeters (sq-cm)	to	Square Inches (sq-in)	0.155
Square Centimeters (sq-cm)	to	Square Feet (sq-ft)	0.001076
Square Meters (sq-m)	to	Square Feet (sq-ft)	10.76
Square Meters (sq-m)	to	Square Yards (sq-yd)	1.196
Square Kilometers (sq-km)	to	Square Miles (sq-miles)	0.3861
Volume Calculations			
Cubic Inches (cu-in)	to	Cubic Centimeters (cu-cm)	16.387
Cubic Inches (cu-in)	to	Liters (L)	0.01639
Quarts (qt)	to	Liters (L)	0.9464
Gallons (gal)	to	Liters (L)	3.7854
Cubic Yards (cu-yd)	to	Cubic Meters (cu-m)	0.7646
Cubic Centimeters (cu-cm)	to	Cubic Inches (cu-in)	0.06102
Liters (L)	to	Cubic Inches (cu-in)	61.024
Liters (L)	to	Quarts (qt)	1.0567
Liters (L)	to	Gallons (gal)	0.2642
Cubic Meters (cu-m)	to	Cubic Yards (cu-yd)	1.308

Conversion Units			Multiply By:
Weight Calculations			
Ounces (oz)	to	Grams (g)	28.5714
Pounds (lb)	to	Kilograms (kg)	0.4536
Pounds (lb)	to	Short Tons (US tons)	0.0005
Pounds (lb)	to	Metric Tons (t)	0.00045
Short Tons (US tons)	to	Pounds (lb)	2000
Short Tons (US tons)	to	Kilograms (kg)	907.18486
Short Tons (US tons)	to	Metric Tons (t)	0.90718
Grams (g)	to	Ounces (oz)	0.035
Kilograms (kg)	to	Pounds (lb)	2.205
Kilograms (kg)	to	Short Tons (US tons)	0.001102
Kilograms (kg)	to	Metric Tons (t)	0.001
Metric Tons (t)	to	Pounds (lb)	2205
Metric Tons (t)	to	Short Tons (US tons)	1.1023
Metric Tons (t)	to	Kilograms (kg)	1000
Force Calculations			
Ounces Force (ozf)	to	Newtons (N)	0.2780
Pounds Force (lbf)	to	Newtons (N)	4.448
Pounds Force (lbf)	to	Kilograms Force (kgf)	0.456
Kilograms Force (kgf)	to	Pounds Force (lbf)	2.2046
Kilograms Force (kgf)	to	Newtons (N)	9.807
Newtons (N)	to	Kilograms Force (kgf)	0.10196
Newtons (N)	to	Ounces Force (ozf)	3.597
Newtons (N)	to	Pounds Force (lbf)	0.2248
Torque Calculations			
Pound Inches (lb-in)	to	Newton Meters (N•m)	0.11298
Pound Feet (lb-ft)	to	Newton Meters (N•m)	1.3558
Pound Feet (lb-ft)	to	Kilograms Force per Meter (kgfm)	0.13825
Newton Meters (N•m)	to	Pound Inches (lb-in)	8.851
Newton Meters (N•m)	to	Pound Feet (lb-ft)	0.7376
Newton Meters (N•m)	to	Kilograms Force per Meter (kgfm)	0.10197
Kilograms Force per Meter (kgfm)	to	Pound Feet (lb-ft)	7.233
Kilograms Force per Meter (kgfm)	to	Newton Meters (N•m)	9.807
Radiator Specific Heat Dissipation Calculations			
British Thermal Unit per Hour (BTU/hr)	to	Kilowatt per Degree Celsius (kW/°C)	0.000293
Kilowatt per Degree Celsius (kW/°C)	to	British Thermal Unit per Hour (BTU/hr)	3414.43
Temperature Calculations			
Degrees Fahrenheit (°F)	to	Degrees Celsius (°C)	(°F – 32) x 0.556
Degrees Celsius (°C)	to	Degrees Fahrenheit (°F)	(1.8 x °C) + 32

Conversion Units			Multiply By:
Pressure Calculations			
Atmospheres (atm)	to	Bars (bar)	1.01325
Atmospheres (atm)	to	Kilopascals (kPa)	101.325
Bars (bar)	to	Atmospheres (atm)	0.98692
Bars (bar)	to	Kilopascals (kPa)	100
Bar (bar)	to	Pounds per Square Inch (psi)	14.5037
Inches of Mercury (in Hg)	to	Kilopascals (kPa)	3.377
Inches of Water (in H2O)	to	Kilopascals (kPa)	0.2491
Pounds per Square Inch (psi)	to	Kilopascals (kPa)	6.895
Pounds per Square Inch (psi)	to	Bar (bar)	0.06895
Kilopascals (kPa)	to	Atmospheres (atm)	0.00987
Kilopascals (kPa)	to	Inches of Mercury (in Hg)	0.29612
Kilopascals (kPa)	to	Inches of Water (in H2O)	4.01445
Kilopascals (kPa)	to	Pounds per Square Inch (psi)	0.145
Power Calculations			
Horsepower (hp)	to	Kilowatts (kW)	0.74627
Kilowatts (kW)	to	Horsepower (hp)	1.34
Fuel Performance Calculations			
Miles per Gallon (mile/gal)	to	Kilometers per Liter (km/L)	0.4251
Kilometers per Liter (km/L)	to	Miles per Gallon (mile/gal)	2.352
Velocity Calculations			
Miles per Hour (mile/hr)	to	Kilometers per Hour (km/hr)	1.609
Kilometers per Hour (km/hr)	to	Miles per Hour (mile/hr)	0.6214
Volume Flow Calculations			
Cubic Feet per Minute (cu-ft/min)	to	Liters per Minute (L/min)	28.32
Liters per Minute (L/min)	to	Cubic Feet per Minute (cu-ft/min)	0.03531

ABOUT THE MACK MP8 (EURO 3) ENGINE [200 EA]

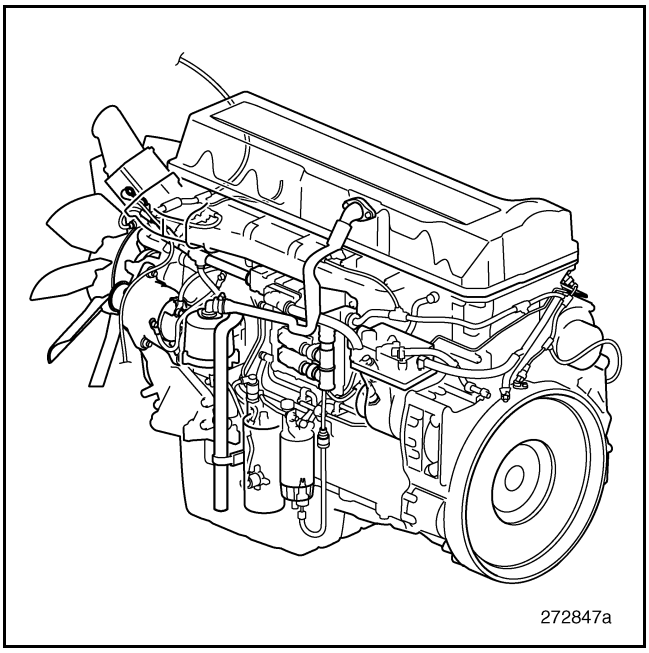


Figure 1 — MACK MP8 Euro 3 Engine

The MACK MP8 (Euro 3) is a 13 liter (800 CID) engine with electronic unit injectors and an exhaust pressure governor (EPG) for engine braking. The optional PowerLeash™ engine compression brake is available in combination with the EPG for increased engine braking performance. The engine conforms to Euro 3 emission requirements.

A wide range of the current transmission offerings, including manual, automated manual and automatic, can be teamed with the MP8.

Diagnostic help can be found in the Premium Tech Tool (PTT). To obtain PTT, contact your local MACK dealer.

The engine weighs approximately 1145 kg (2524 lb.) dry (with air compressor, without oil, coolant, starter, fan, alternator and clutch). Its design includes a one-piece cylinder head, a single overhead camshaft, three or four rocker arms per cylinder, unit injectors and no pushrods. Monosteel™ steel pistons are made in one piece.

⚠ DANGER

Do NOT use starting fluid (ether) on engines equipped with an inlet manifold air heater element. An explosion could occur. Failure to heed this danger may result in severe personal injury or death.

Two optional fan drives are available: On/Off and electronically actuated. The electronically actuated viscous fan drive is precisely controlled by the Engine Electronic Control Unit (EECU).

Timing gears mount on the rear of the MP8 improving the flow of cooling air around the front. Special service instructions apply to the camshaft position sensor. The mounting plate, idler and camshaft gears are marked to facilitate proper installation. The air compressor drive gear meshes with the double idler instead of the auxiliary idler as on the MP7 engine.

Another feature of the MP8 is the rear engine power take-off (REPTO-ready) that is gear driven through the timing gear train. An optional PTO with drive gear, bearing and housing can be added at the factory.

The rocker arm shaft is held in place by camshaft bearing capscrews. There are special instructions for installing the camshaft bearing caps and the rocker arm shaft during service.

A stiffener plate fastens to the bottom of the cylinder block to ensure block strength and rigidity. The engine can be used with axle forward or axle back vehicles by virtue of optional oil pans. The engine fan is mounted high or low depending on vehicle configuration.

The MP8 uses unit injectors. The unit injector incorporates the pump, valve and injector. Its internal solenoids permit fast, precise control of fuel delivery into the cylinder. The unit injectors are encased by the valve cover and not exposed to the heat of exhaust system components.

Fuel passes through two filters, one of which separates water from the fuel. High-pressure fuel in the unit injectors is created via the rocker arms with roller followers in constant, direct contact with the cams.

Replacing injectors requires a specific procedure, and installation requires that the EECU be programmed to recognize replacement injectors. Cleaning injector bores requires a special tool.

Standard equipment on the engine includes the exhaust pressure governor (EPG) which utilizes a shutter in the exhaust pipe after the turbocharger for engine braking. The EPG can be combined with the optional PowerLeash™ engine compression brake for additional assist in deceleration and braking.

There are multiple design variations of the PowerLeash™ engine brake utilizing a 3-rocker valve train or a 4-rocker valve train. The variations require a different camshaft, special exhaust valve rocker arms and yokes (bridges), an oil control valve and wiring harness. Exhaust valve clearance for PowerLeash™ equipped engines is adjusted with shims.

Unique colors and the appearance of the valve cover, filters and logo labels distinguish the MP8 from other engines in the MACK line.

Preventive maintenance is important to get the most from the MACK MP8 engine and to ensure many years of reliable, trouble-free operation. Refer to the current TS494 Maintenance and Lubrication manual for schedules and specifications.

Repair instructions in this manual deal with removal, installation, disassembly, assembly, setup and adjustments of MP8 components.

There are restrictions concerning the reuse of certain fasteners. Refer to current specifications bulletins and the **SPECIFICATIONS** section of this manual for detailed information.

Service Precautions Summary

Following is a summary list of the DO and DON'T issues applying to MP8 engine service.

1. DO NOT machine the cylinder head for clean-up since this will change injector depth, thereby affecting emissions. It will also upset the ability to correctly adjust timing gear backlash.
2. DO NOT grind the injector copper sleeves.
3. Install the crankshaft main bearing caps according to marked assembly number.
4. Connecting rod caps MUST BE mated to their respective connecting rods due to the "fractured manufacturing" process used. Also, the rod caps can be installed only one way because of the difference in spacing between screw holes at each side of the cap.
5. DO NOT use the lifting eye on the flywheel housing when tilting the engine/transmission assembly to an angle greater than 15 degrees.
6. Cylinder head installation requires lowering the head onto the gasket using the alignment screws and washers at the sides of the head and block. The head must be pulled back to the mounting plate using screws inserted through the plate. Pressed bosses in the gasket keep the head from making full contact with the gasket surface and prevent damage to the elastomer sealing rings as the head slides into position.
7. Do NOT use starting fluid (ether) on engines equipped with an inlet manifold air heater element.

⚠ DANGER

The use of starting fluid (ether) on engines equipped with an inlet manifold air heater element is prohibited. An explosion could occur. Failure to heed this danger may result in severe personal injury or death.

8. The MP8 engine uses a number of O-rings for sealing various fluid joints and tubes. It is essential that **new** O-rings of the correct material be used whenever joints are disassembled and reassembled.

VISUAL IDENTIFICATION

MP8 EURO 3 ENGINE MODEL IDENTIFICATION

Engine Information Plate

The engine information plate is located on the top of the cylinder head (valve) cover. This plate includes information concerning the following items.

- Engine model and emissions level
- Prop. version
- Maximum torque
- Rated power
- Rated power speed
- Displacement
- Low idle speed
- Exhaust brake

In addition to the information plate, there is another label on the cylinder head (valve) cover. This additional label lists the chassis number, engine serial number and respective barcodes.

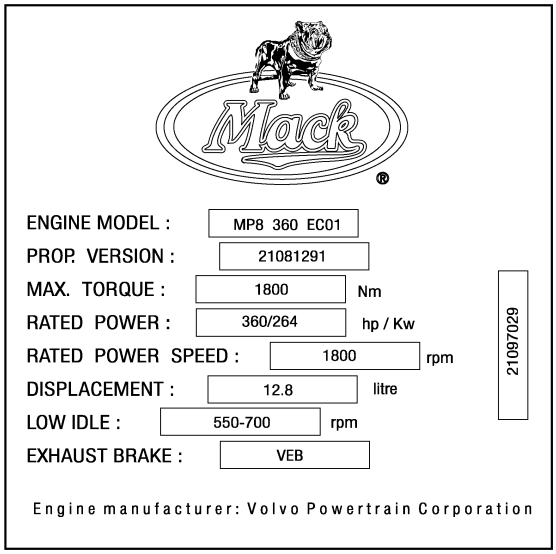


Figure 2 — Engine Information Plate

Engine Serial Number Identification

In addition to the engine information plate on the cylinder head cover, the engine is also identified by the engine serial number stamped into the cylinder block. This serial number is located on the block left side at the front just below the inlet manifold.

DESCRIPTION AND OPERATION

MACK MP8 EURO 3 ENGINE DESIGN FEATURES [200 EA]

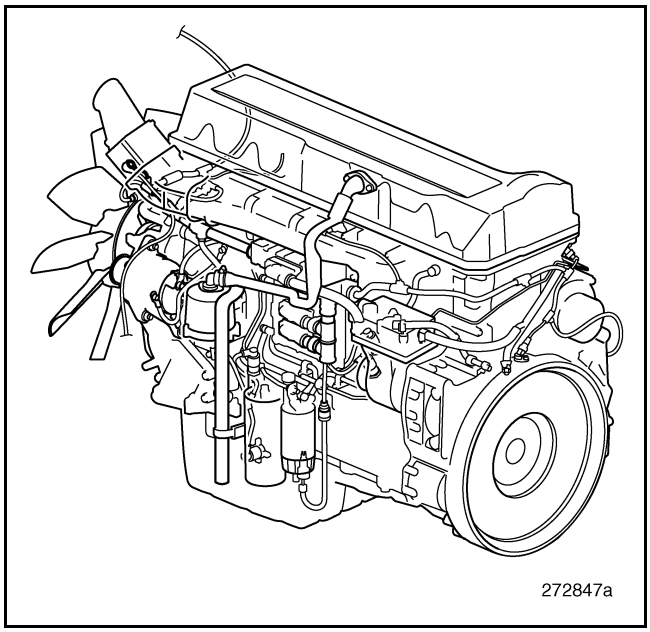


Figure 3 — MACK MP8 Euro 3 Engine

To accommodate the low cab forward design, the inlet manifold is configured differently for the conventional versus the low cab forward chassis. The air inlet from the charge air cooler is at the front of the inlet manifold on the conventional chassis, but near the rear of the manifold on the low cab forward design.

Engine Components

CYLINDER HEAD

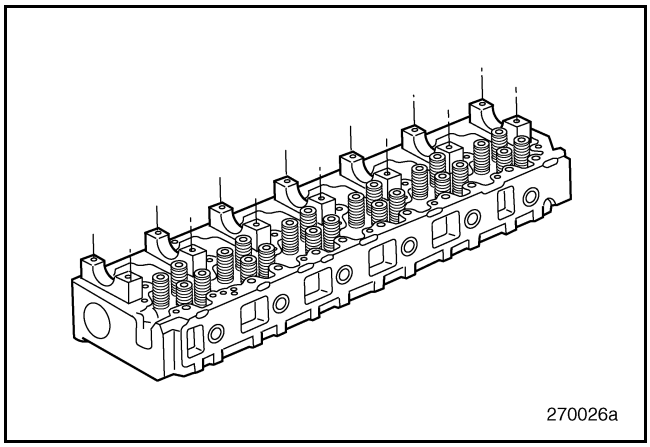


Figure 4 — Cylinder Head with Valves and Camshaft Supports

Main features of the cylinder head are:

- One-piece cast iron
- Integral thermostat housing

Separate chambers for exhaust and inlet at each cylinder make this a “crossflow” design. The fuel channel, drilled from front to rear, connects with grooves machined around each injector opening. A plug at the rear of the cylinder head seals this channel.

CAMSHAFT AND VALVE TRAIN

The engine has an overhead camshaft and rocker arm shaft in support of four valves per cylinder. The camshaft rides on seven journals with a bearing cap and support block (saddle) at each point. The bearing inserts (shells), bearing caps and support blocks are replaceable.

If the engine is equipped with EPG exhaust brake only, there are three cams for each cylinder, including inlet, injection and exhaust. Each valve rocker arm drives two valves via a pinless yoke (or bridge).

On some engines, the EPG exhaust brake is used in combination with the PowerLeash™ engine brake. With this configuration, the engine can have three or four cams for each cylinder depending on the PowerLeash™ variant (3-rocker or 4-rocker).

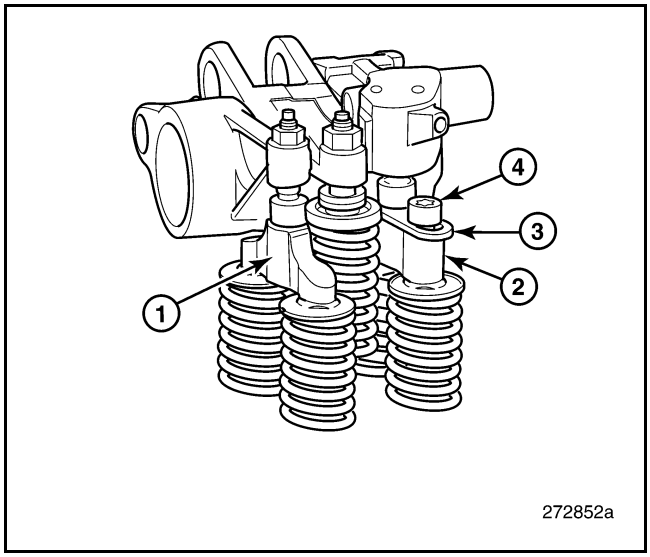


Figure 5 — PowerLeash™ 3-Rocker Valve Train

1. Inlet Valve Yoke (Bridge) 2. PowerLeash™ Exhaust Valve Yoke (Bridge)	3. Adjustment Shim 4. Shim Retaining Screw

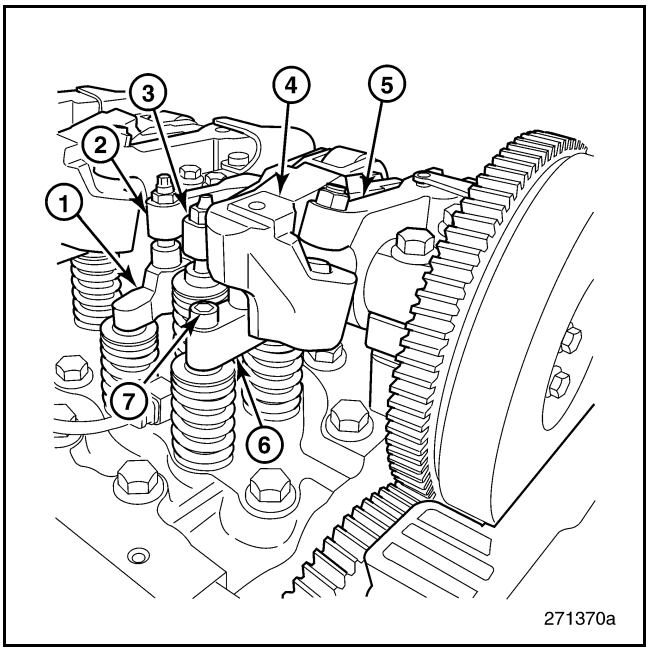


Figure 6 — PowerLeash™ 4-Rocker Valve Train

1. Inlet Valve Yoke (Bridge)	5. PowerLeash™ Brake Rocker Arm
2. Inlet Valve Rocker Arm	6. Exhaust Valve Yoke (Bridge)
3. Injector Rocker Arm	7. Shim Retaining Screw
4. PowerLeash™ Exhaust Valve Rocker Arm	

Exhaust valve yokes include a shim for adjustment. Replaceable valve guides and seats are made of alloyed cast iron and steel respectively. All valve guides have oil seals. Exhaust valves have double valve springs.

Rollers in the ends of the rocker arms contact the cam shaft. The contacts with the yokes have ball sockets for flexibility.

The camshaft is induction-hardened. Timing marks for valve and injector adjustment are located on the flange forward of the No. 1 camshaft journal. These marks are for adjusting valve clearance. They do not apply to camshaft timing.

Camshaft thrust washers are integral on the No. 7 journal bearing. Smooth rotation is ensured by means of a vibration damper on the camshaft gear. Teeth on the damper interact with the camshaft position sensor for input to the EECU.

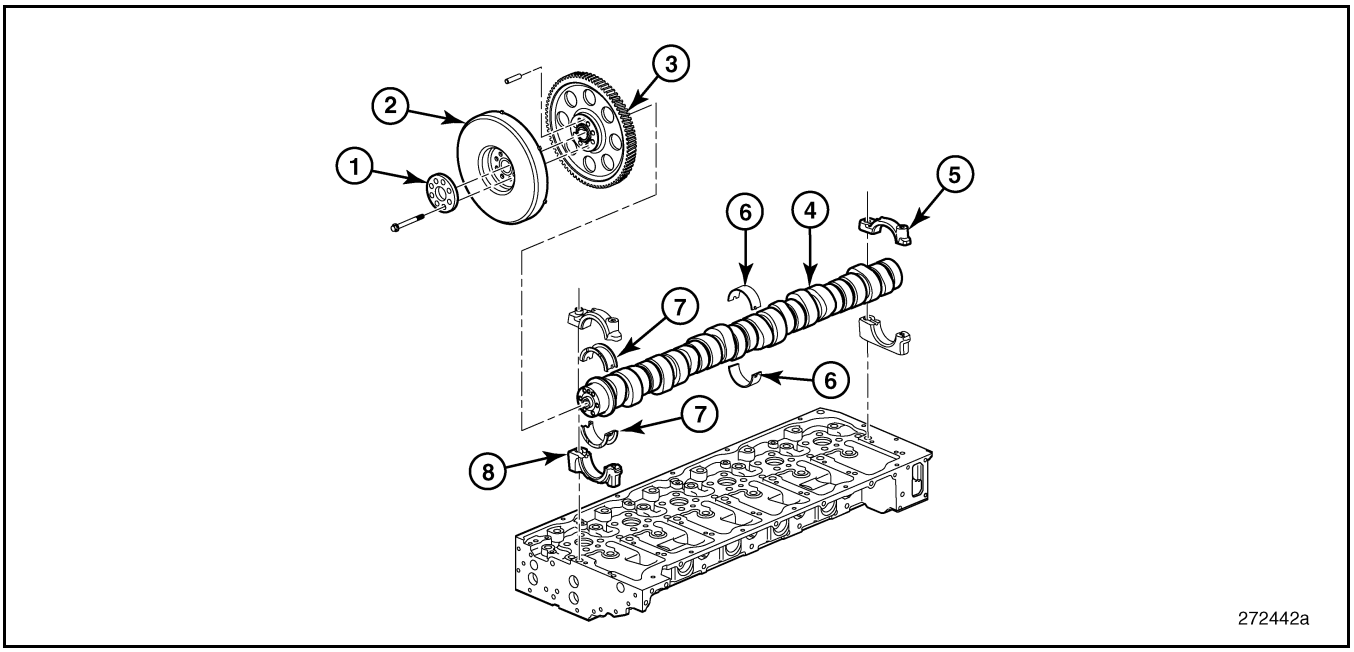


Figure 7 — Camshaft Assembly Components

1. Spacer	5. Upper Bearing Cap
2. Vibration Damper	6. Bearing Inserts
3. Camshaft Gear	7. Thrust Bearing Inserts
4. Camshaft	8. Lower Bearing Cap (Support)

Timing marks on the camshaft provide for valve and injector adjustment. PowerLeash™ includes its own electronic control governed by driver's choice through a switch near the steering wheel. This control mounts on the cylinder head between the No. 3 and No. 4 cylinder rocker arms. The wiring harness includes additional wire leads for PowerLeash™.

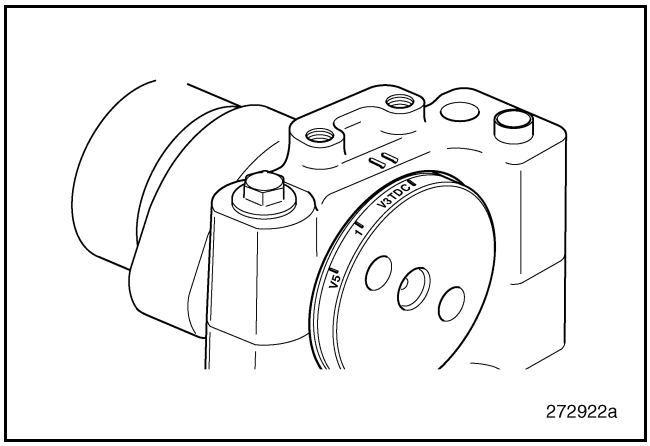


Figure 8 — MP8 Euro 3 Engine Timing Marks — Camshaft Front End

CYLINDER BLOCK

The cylinder block is made of cast iron. For increased cylinder block rigidity and noise and vibration reduction, a steel stiffener plate attaches to the bottom.

The main and piston lubricating channels are drilled longitudinally through the block. These are plugged at the front of the block. The main channel opens into a cast-in channel that supplies oil to the timing gears. The piston cooling channel is covered by the timing gear cover.

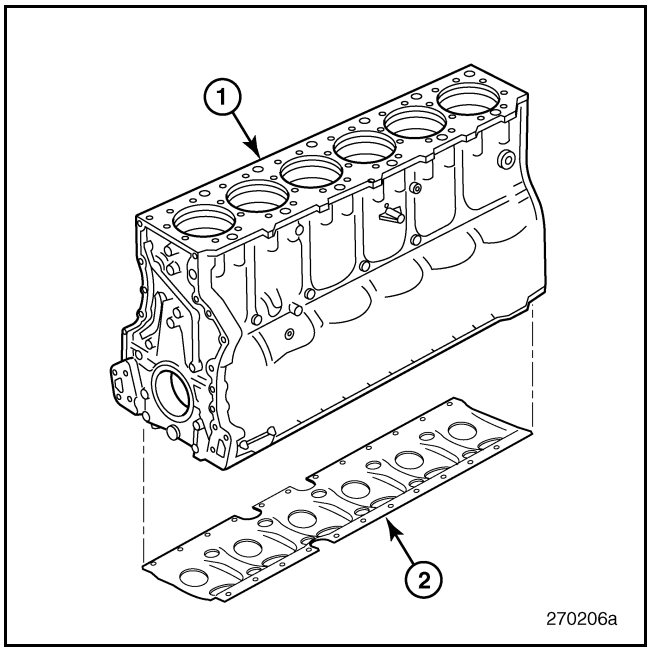


Figure 9 — Cylinder Block and Stiffener Plate

1. Cylinder Block	2. Block Stiffener Plate

Main bearing caps are made of nodular cast iron machined together with the cylinder block. Cast alignment slots in the block and tabs on the caps ensure proper alignment at installation. Each cap is marked with its location beginning with No. 1 at the front. Cap Nos. 4 and 7 are unique and are not numbered.

The block includes cylinder liners that contact the coolant directly (wet liners). The casting shape follows the contours of the cylinders to increase rigidity and reduce noise.

Head to Block Alignment

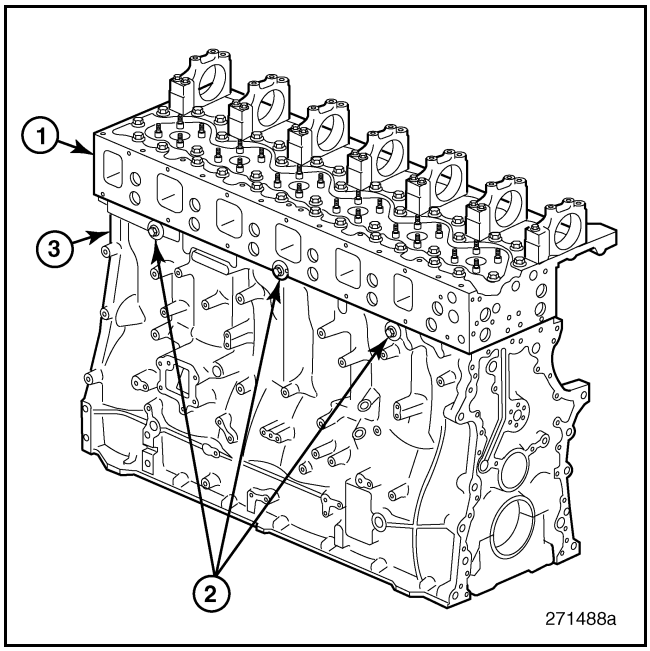


Figure 10 — Head to Block Alignment Screws and Washers

1. Cylinder Head 2. Alignment Screws and Washers	3. Cylinder Block

Three screws and washers installed at the side (two in the block and one in the head) align the head from side to side at assembly. Fore and aft, the head is aligned by contact with the timing gear mounting plate.

⚠ CAUTION

The head is aligned with the timing gear plate by screws passed through the mounting plate into the head and tightened securely. It is extremely important to remove these screws before attempting to remove the cylinder head from the block. Failure to heed this caution may result in severe damage to the timing gear plate and other engine components.

CYLINDER HEAD GASKET

The cylinder head gasket is made of one piece of sheet steel with vulcanized elastomer seals on oil and coolant conduits. The design of the engine and head gasket requires a unique procedure for installation of the cylinder head.

The screws and washers at the side guide the head into side-to-side alignment as it is laid on the gasket and block. Screws passed through the timing gear mounting plate into the head pull the head into alignment fore and aft. Small, stamped bosses on the gasket hold the head clear of the seals and allow it to glide accurately into position against the mounting plate during installation. Tightening the head bolts flattens the bosses on the gasket. For this reason, a new head gasket must be installed whenever the head is removed.

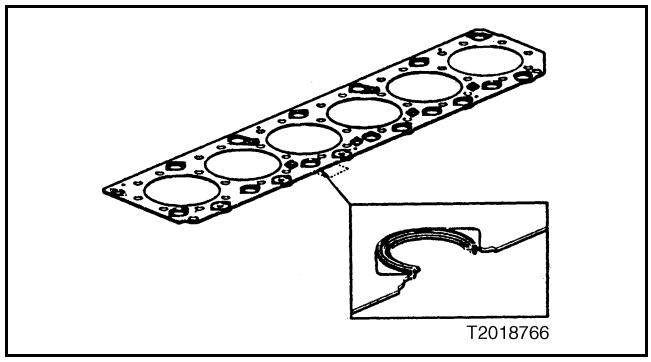


Figure 11 — Cylinder Head Gasket

CYLINDER LINERS

The cylinder block uses replaceable wet cylinder sleeves. The lower end of each sleeve is sealed against the block with three elastomer rings. The upper end is sealed with a ring of EPDM elastomer situated directly under the sleeve collar. This design cools the upper section of the sleeve better because the area of coolant circulation is larger.

The lower seals are fitted in grooves in the cylinder block. The bottom seal is of a different material and fluorescent violet in color to distinguish it from the intermediate seals.

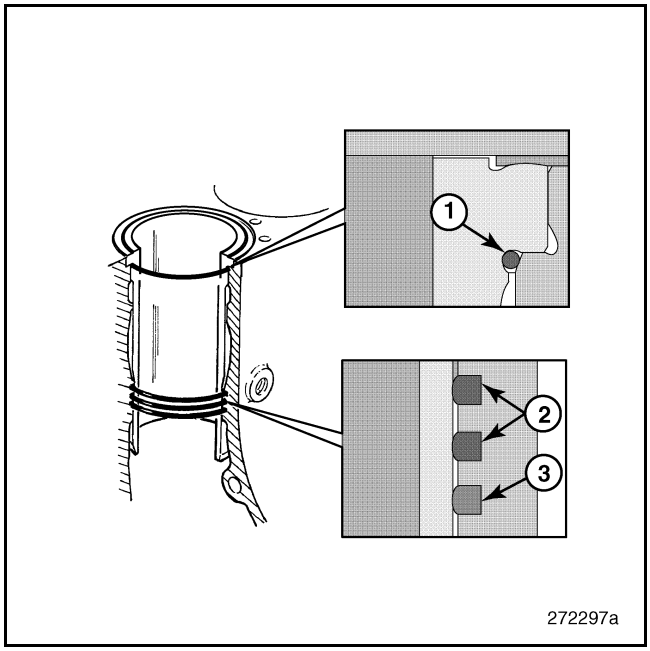


Figure 12 — Cylinder Liner and Seals

1. Upper O-Ring — EPDM (Black) 2. Middle Sealing Rings — EPDM (Black)	3. Lower Sealing Ring — Viton (Purple)

OIL PAN

The oil pan is plastic or steel with a threaded plug for draining. The plastic pan has a groove in the mounting flange which accepts a molded elastomer gasket for a seal. The steel pan is sealed with a gasket on the oil pan flange. Twenty-two spring-loaded screws clamp the pan to the block.

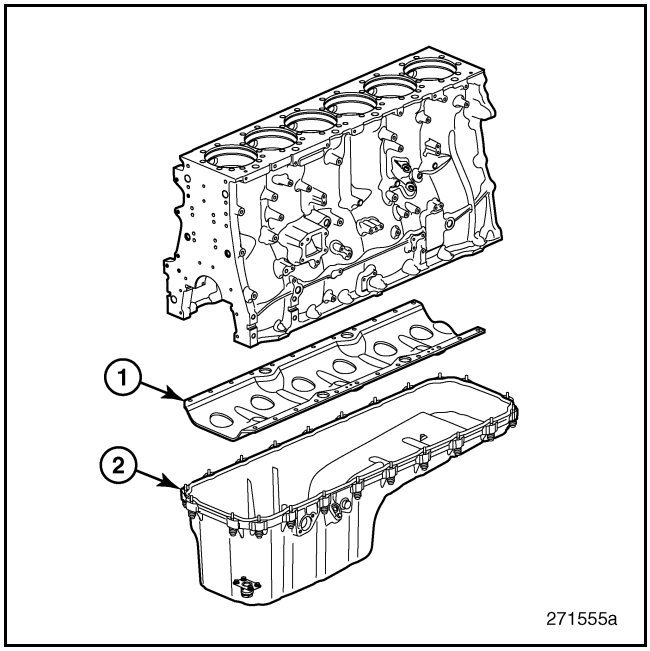


Figure 13 — Oil Pan and Stiffener Plate

1. Block Stiffener Plate	2. Oil Pan with Gasket

The oil pan includes an oil level/temperature sensor with connector. The filler tube and dipstick mounting ports are also components of the oil pan.

NOTE

Oil pans with the sump at the front or at the rear are available to accommodate axle forward or axle back chassis.

CRANKSHAFT

The crankshaft is drop forged steel and induction hardened. It has seven journals with replaceable bearings. Five oversized replacement bearing options are available to accommodate crankshaft regrinding.

The rear main cap (No. 7) includes an attaching point for the lube pump. Thrust washers to control axial movement straddle the central journal (cap No. 4). The remaining caps (Nos. 1–3, 5 and 6) are numbered to facilitate correct assembly.

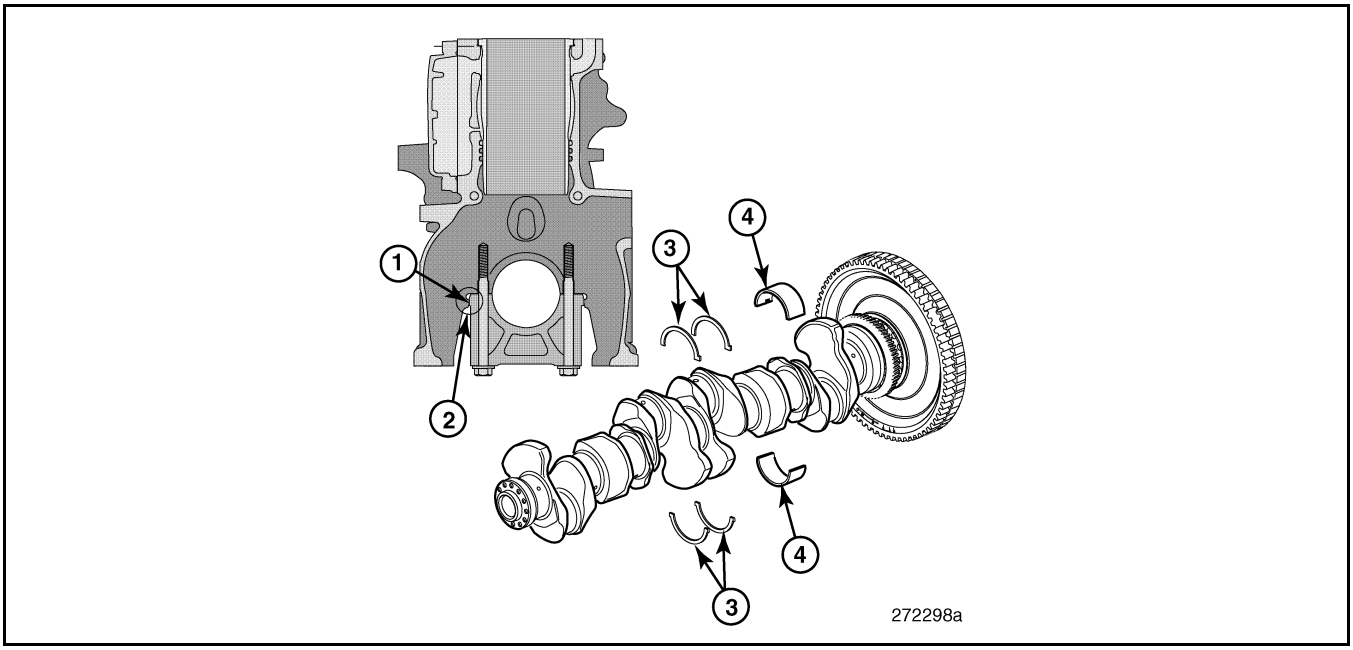


Figure 14 — Crankshaft, Bearings, Thrust Washers and Cap Alignment Tabs

1. Alignment Tab, Block 2. Alignment Tab, Cap	3. Thrust Washers 4. Upper and Lower Bearings

A Teflon® seal bearing directly on the crankshaft flange is used at the front of the crankshaft. The front seal has an outer felt ring which serves as a dust cover. At the rear of the crankshaft is another seal that bears directly on the machined surface of the crankshaft gear. Additionally at the rear, there is a groove in the rear crankshaft flange for an O-ring which forms a seal between the flange and the gear.

NOTE

Whenever the lower main bearing caps are installed in the engine block, ensure the lower main bearing cap is installed in the same location of the engine block as removed. Also, ensure that the aligning mark (boss) on the bearing cap aligns with the mark (boss) on the engine block.

PISTONS AND CONNECTING RODS

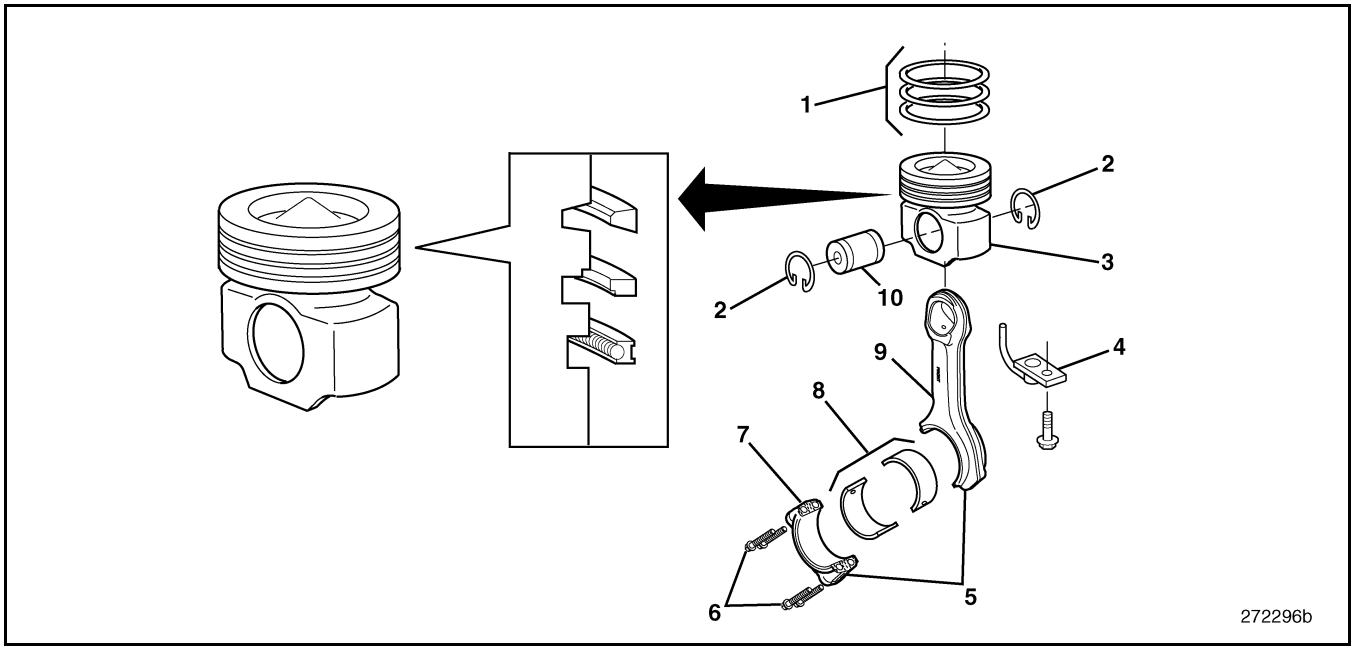


Figure 15 — Piston and Connecting Rod

1. Piston Ring Set 2. Wrist Pin Snap Ring 3. Piston 4. Piston Cooling Nozzle 5. Assembly Matching Marks	6. Connecting Rod Bolts 7. Connecting Rod Bearing Cap 8. Upper and Lower Connecting Rod Bearings 9. Connecting Rod 10. Wrist Pin

Connecting rods are forged steel and are used in combination with one-piece Monosteel™ steel pistons. The bearing caps are attached with four M12 capscrews spaced to prevent misalignment. The rods and caps are made by a “fracture” process that requires a cap be assembled with its original rod. Never attempt to use mismatched rods and caps.

The piston is fitted with three rings. In the top groove is a compression ring with a “keystone” cross section. In the second groove, the compression ring has a rectangular cross section. In the third groove is a spring-loaded oil scraper ring.

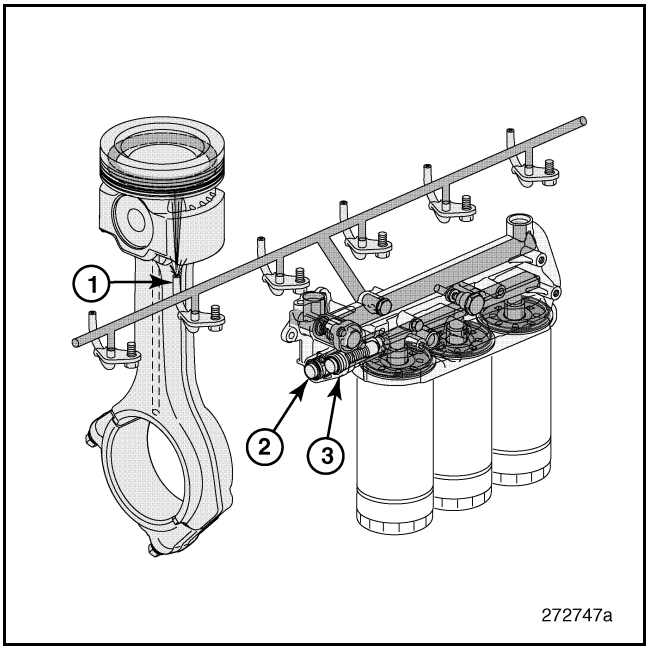


Figure 16 — Piston Cooling

1. Piston Cooling Nozzle 2. Control Valve	3. Opening Valve

Oil flow for the piston cooling system is controlled by two valves. The opening valve supplies oil and the control valve balances the oil flow to the piston cooling channel. The piston cooling nozzle is aligned so that the oil jet hits the underside of the piston crown.

TIMING GEARS

The timing gears are located at the rear of the engine. Backing up the gears is a plate: a 6 mm (1/4 inch) thick steel sheet attached to the cylinder block.

The advantages of this configuration are more precise timing, fewer components and lower noise levels.

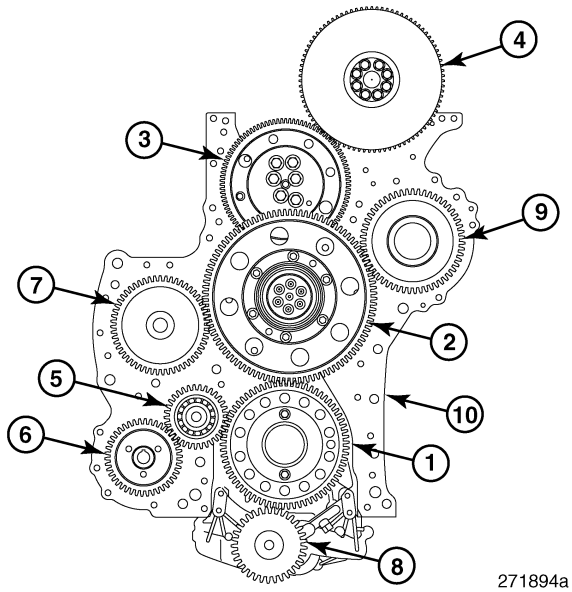


Figure 17 — Timing Gears and Plate

1. Crankshaft Gear	6. Power Steering/Fuel Pump Gear
2. Double Idler Gear	7. Air Compressor Gear
3. Adjustable Idler Gear	8. Oil Pump Gear
4. Camshaft Gear and Damper	9. Power Take-Off Gear (optional)
5. Auxiliary Idler Gear	10. Timing Gear Plate

The power steering/fuel pump gear, the air compressor gear and the PTO gear are not timing gears. The pump and compressor gears fasten to their respective components. The pump gear is driven by the auxiliary idler gear. The compressor gear is driven by the double idler gear.

The double idler drives the adjustable idler and the gear used to drive the power take-off, if so equipped. This is part of the “REPTO-Ready” feature. A PTO unit with drive gear is substituted for a cover on the flywheel housing.

The camshaft gear fastens to the hub on the end of the shaft. A vibration damper also attaches to the hub outboard of the gear. Teeth on the damper actuate the camshaft position sensor. The gear is driven via the adjustable idler.

DRIVE BELTS

This engine can be configured to accommodate either the conventional chassis or the low cab forward (LCF) design. Depending on the vehicle, the fan location may be high or low on the fan bracket.

Two poly-V belts drive the front engine accessories. The outer, primary belt (10 or 12 ribs) drives the coolant pump and fan hub from a pulley on the crankshaft flange nested in the vibration damper. The inner, secondary belt (six ribs), driven by the crankshaft vibration damper, drives the alternator and refrigerant compressor.

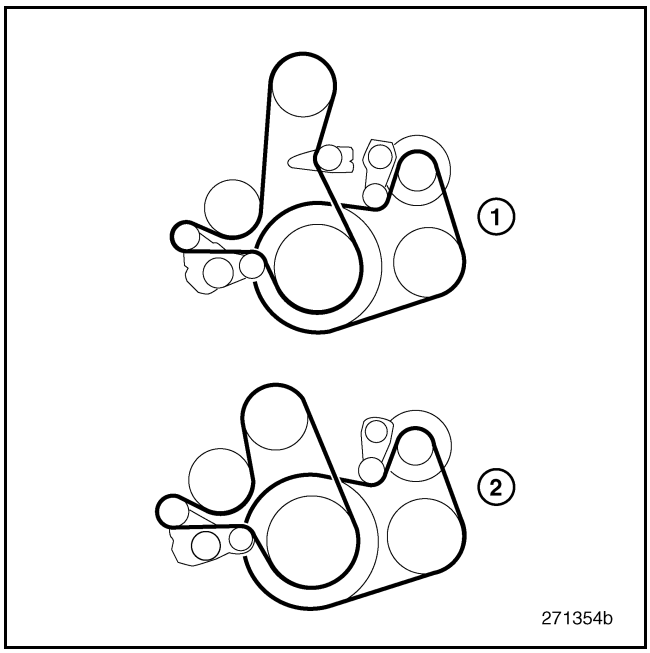


Figure 18 — Drive Belt Routings — Conventional and LCF Chassis

1. Conventional Chassis	2. LCF Chassis

Each belt uses an automatic tensioner. In the high position, view 1 in Figure 18, there are two idler pulleys in the primary loop: one between the coolant pump pulley and the tension idler; the other between the crankshaft pulley and the fan hub.

In the low position, view 2 in Figure 18, the idler between the damper and fan pulleys is omitted.

Lubrication System

A gear-type pump at the rear of the engine, driven by the crankshaft gear, draws lubricant from the oil pan and supplies the system. Oil flows from the pump through the distribution housing to the filters, to a gallery at the right side of the engine serving the crankshaft journals, to a gallery at the left side serving piston lubrication and cooling, to the cylinder head and rocker shaft duct (valve rocker and camshaft) and back to the oil pan. The system includes crankcase ventilation.

Two full-flow filters and a by-pass filter maintain clean lubricant. A sensor in the oil pan monitors fluid level. There is an oil cooler immersed in engine coolant inside the coolant duct cover.

OIL PUMP

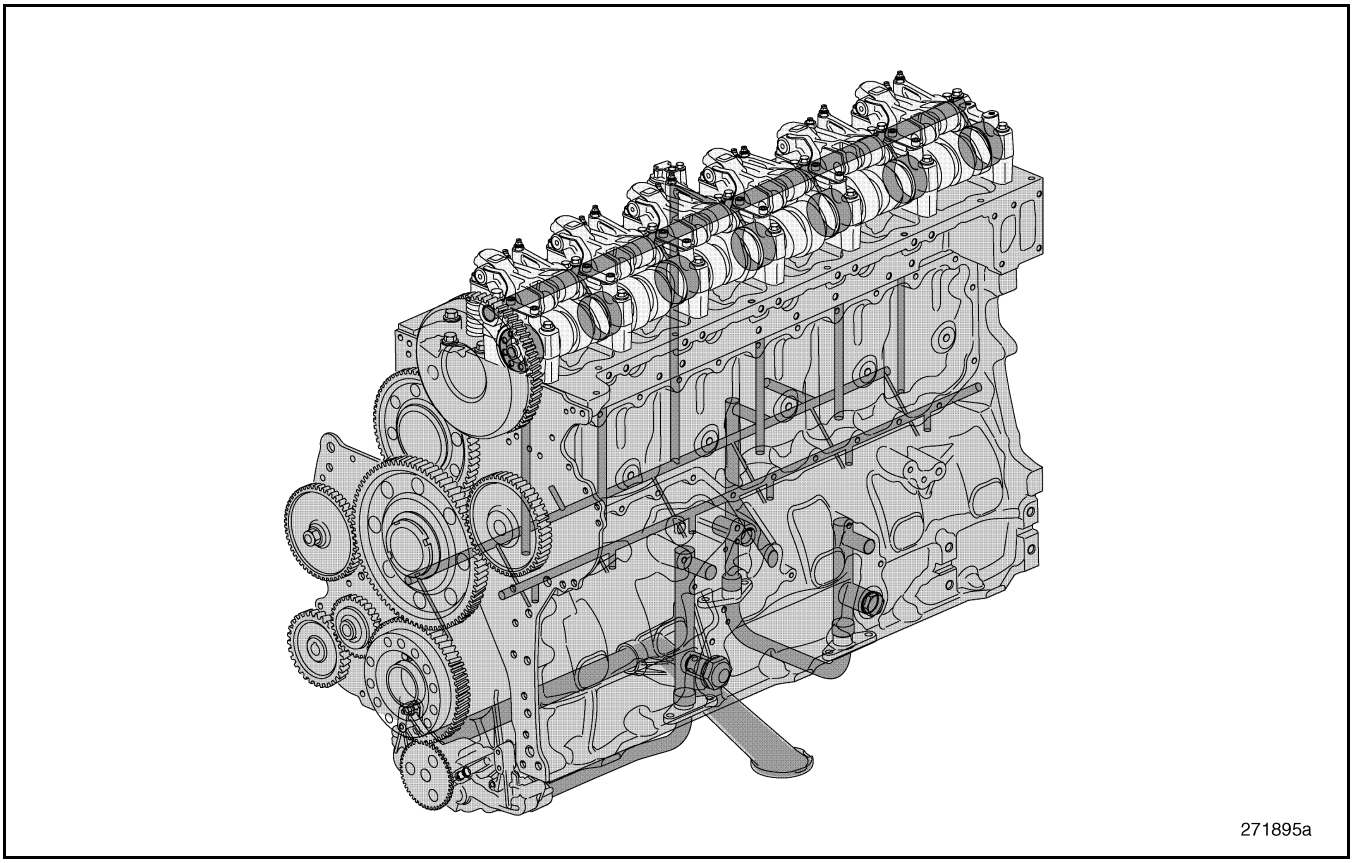


Figure 19 — Lubrication System Diagram

A strainer and pickup tube lead the lubricant into the pump. For the axle forward oil pan, the strainer is mounted on a short tube held in place by a bracket attached to the distribution housing. For the axle back model, a long tube without the bracket is supplied.

OIL FLOW CONTROL AND FILTRATION

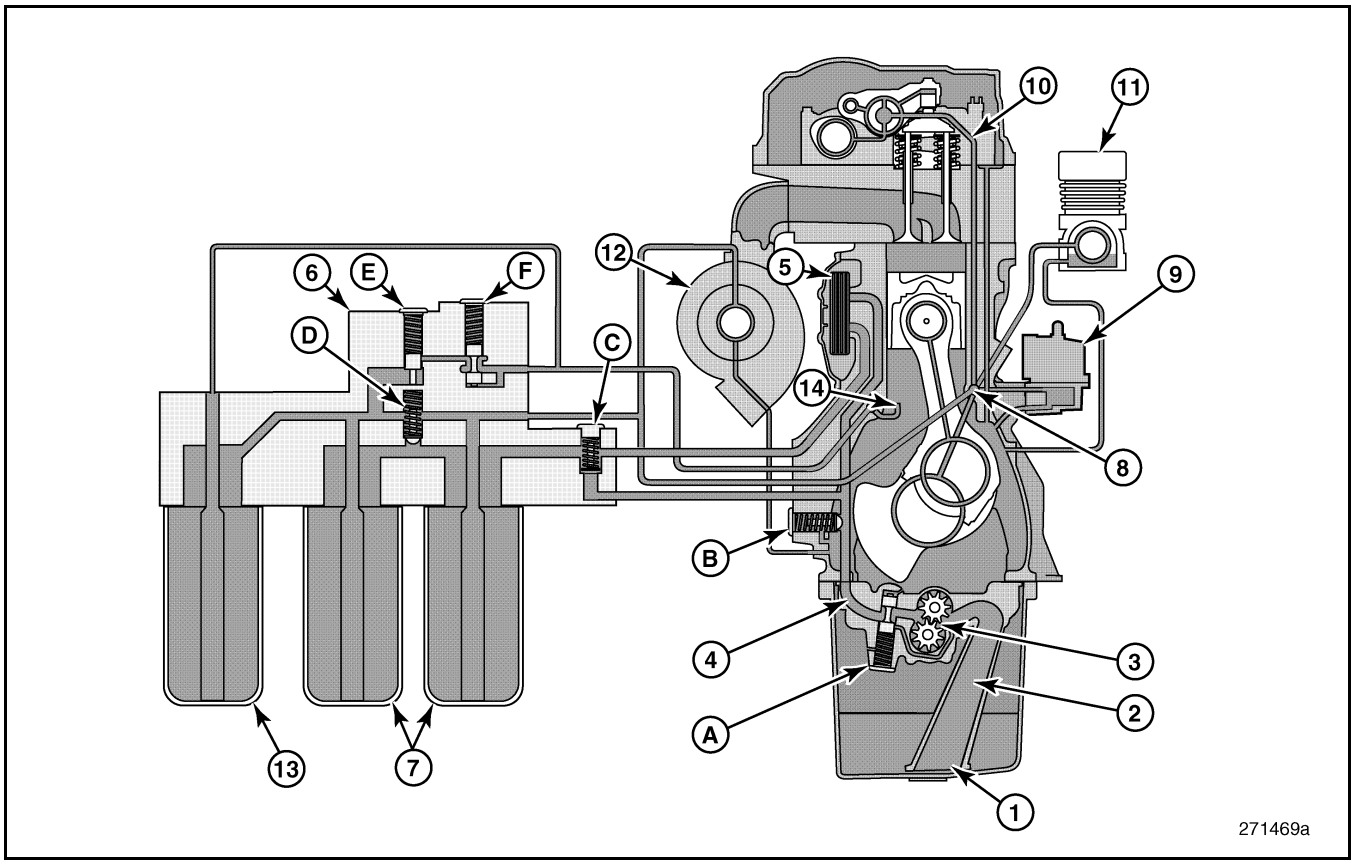


Figure 20 — Lubrication System Flow Diagram

1. Strainer	11. Air Compressor
2. Pickup Tube	12. Turbocharger
3. Oil Pump	13. By-Pass Filter
4. Pressure Pipe	14. Piston Cooling Nozzles
5. Oil Cooler	A. Reducing Valve
6. Filter Housing	B. Safety Valve
7. Full-Flow Filters	C. Oil Cooler Thermostat Valve
8. Main Lubrication Gallery	D. Overflow Valve, Full-Flow Filter
9. CCV Separator	E. Opening Valve, Piston Cooling
10. Exhaust Brake Oil Control Valve	F. Control Valve, Piston Cooling

There are three filters, one by-pass and two full-flow, attached to a housing mounted at the lower right side of the engine. Oil flow through the filters and the lubrication system is controlled by six valves, including:

- Reducing Valve
- Safety Valve
- Oil Cooler Thermostat Valve
- Overflow Valve, Full-Flow Filter
- Opening Valve, Piston Cooling
- Control Valve, Piston Cooling

The reducing valve maintains constant system oil pressure. The safety valve prevents excessive pressure during periods of high viscosity. The oil cooler thermostat valve prevents oil from entering the cooler until it warms to the set point. The overflow valve allows oil to by-pass the filter if it becomes clogged. The opening valve prevents oil from moving to the piston cooling outlets until the system reaches the set pressure. The control valve regulates the oil flow to the piston cooling channels.

Crankcase Ventilation

Lubricant becomes a mist in many areas of the engine as the result of the motion of the parts (e.g., rocker arms, pistons, crankshaft, camshaft and rocker shaft). The mist rides the drafts of air and other gases that circulate in the open spaces in the engine. To prevent pressure buildup, the open spaces are ducted through a pipe that opens to the atmosphere near the bottom of the engine.

The crankcase ventilation (CCV) system separates the oily mist from the gases by centrifugal force. The oil returns to the oil pan. The remainder escapes to the atmosphere.

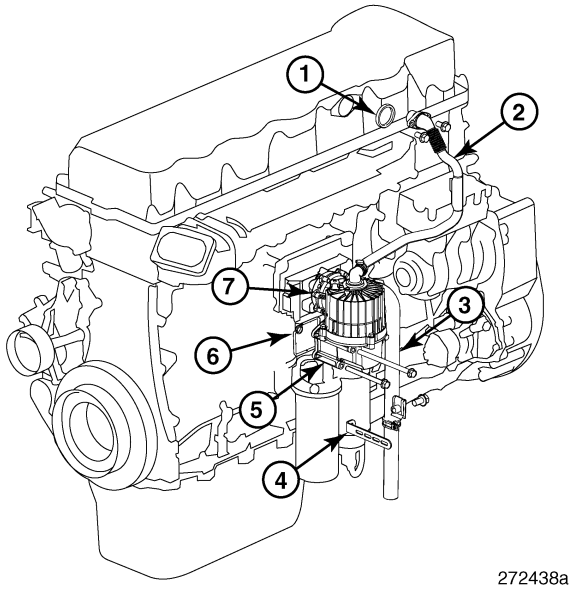


Figure 21 — Crankcase Ventilation System Separator

1. Seal Ring 2. Separator Inlet Hose 3. Separator Vent Tube 4. Vent Tube Bracket	5. Separator Housing 6. Housing Seal 7. Pressure Regulator

A turbine in the CCV separator, driven by a small stream of oil striking its fins, spins at high speed. The mixture of gases and oily mist trapped in the valve cover and the timing gear cover drains onto the top of the center of the turbine and runs down onto several discs rotating with the turbine. Separation occurs as the mixture, flung outward by the turbine, strikes the walls of the CCV. The droplets of mist coalesce into a liquid and drain back into the oil pan along with the oil that drives the turbine. The gases are free to leave via an open port.

The open port connects to a tube leading to the bottom of the engine where road draft draws the gases into the atmosphere.

Fuel System

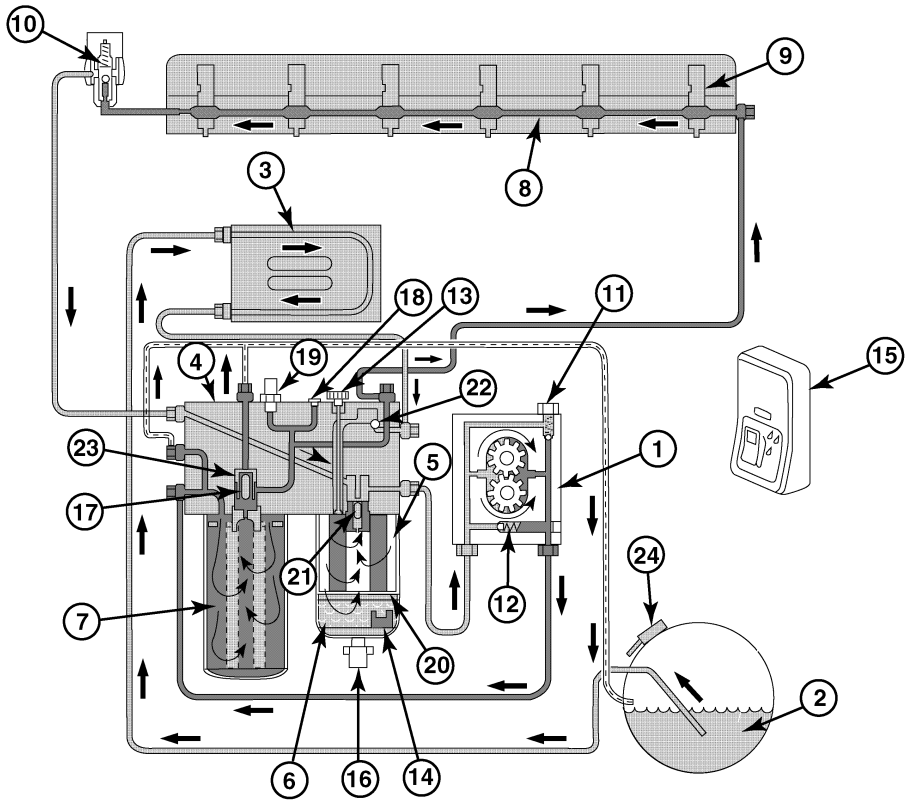


Figure 22 — Fuel System Diagram

1. Fuel Pump	13. Hand Pump Handle
2. Fuel Tank and Inlet Tube	14. Water Level Sensor
3. EECU Cooler	15. Water Discharge Control Switch (Instrument Panel)
4. Fuel Filter Housing	16. Electrical Water Drain Valve
5. Fuel Pre-Filter	17. Automatic Air Bleed Valve (closes when filter removed)
6. Water Cup	18. Service Port (Pressure Gauge)
7. Secondary (Main) Filter	19. Supply Pressure Sensor
8. Fuel Gallery	20. Fuel Heater (Optional)
9. Unit Injector	21. Service Shutoff Valve (closes when filter removed)
10. Pressure Regulator Valve	22. One-Way Valve (Hand Priming)
11. Pump Safety Valve (Pressure Regulator)	23. Automatic Air Bleed Valve
12. One-Way Valve	24. Fuel Tank Breather

The fuel pump attaches with the power steering pump to the flywheel housing at the rear left side. It turns on the same shaft as the power steering pump. The common drive gear meshes with the auxiliary idler driven by the crankshaft gear. At 600 rpm, the pump delivers a minimum 100 kPa (14.5 psi), and at 1200 rpm, 300 kPa (43.5 psi). At 400–550 kPa (58–80 psi), the gallery regulator valve opens to control fuel gallery pressure.

Fuel is drawn by the suction side of the fuel pump from the fuel tank into the ECU cooling plate and enters the fuel filter housing. Fuel passes by the one-way check valve which prevents the bleeding of fuel back to the fuel tank and into the primary fuel filter. The fuel becomes filtered by passing through the filter media from the outside to the center of the primary fuel filter. The fuel leaves the primary filter and passes by a one-way valve located in the threaded nipple of the primary filter. The fuel flows from the filter housing to the suction side of the fuel pump through an external fuel line. Fuel becomes pressurized after leaving the fuel pump and flows back to the filter housing to enter the secondary filter. The fuel becomes filtered by passing through the filter media from the outside to the center of the secondary filter. The fuel leaves the secondary filter and passes by an automatic air bleed valve which is located in the threaded nipple for the secondary filter. Fuel passes by the fuel pressure sensor and then exits the filter housing to enter the rear of the cylinder head through an external fuel line. After fuel enters the cylinder head, it passes through the fuel gallery of the cylinder head to continuously deliver fuel to all six unit injectors. Fuel leaves the cylinder head after passing by the fuel pressure regulator located at the left front corner of the cylinder head. Fuel is routed back from the cylinder head to the filter housing through an external fuel line to deliver some return fuel back into the suction side which goes to the fuel pump. Any excessive fuel not consumed is bled off through the de-aeration valve and then, directed back to the fuel tank.

FUEL FILTRATION

Primary and secondary filter elements attach to the underside of the filter valve housing. The housing, located at the front lower left side of the cylinder block, has an integral hand-priming pump for bleeding the system. The 30 micron pre-filter (primary filter) also separates water from the fuel. Water collects in a cup on the bottom of the pre-filter. There is a sensor to keep track of the water and signal the EECU.

A one-way check valve located in the filter housing prevents fuel from draining back to the fuel tank when the engine is shut down. Also included in the fuel filter housing is the fuel pressure sensor just above the secondary filter.

NOTE

- The collected water can be dumped only while the engine is not running, the key is in the *ON* position and the parking brake is set.
- Some trucks are built with a remote mounted fuel water separator. In this case, the fuel is drawn through the remote mounted filter before it reaches the ECU cooler plate. On the filter base, the mounting location for the standard primary filter is blocked off with a plate.

UNIT INJECTORS

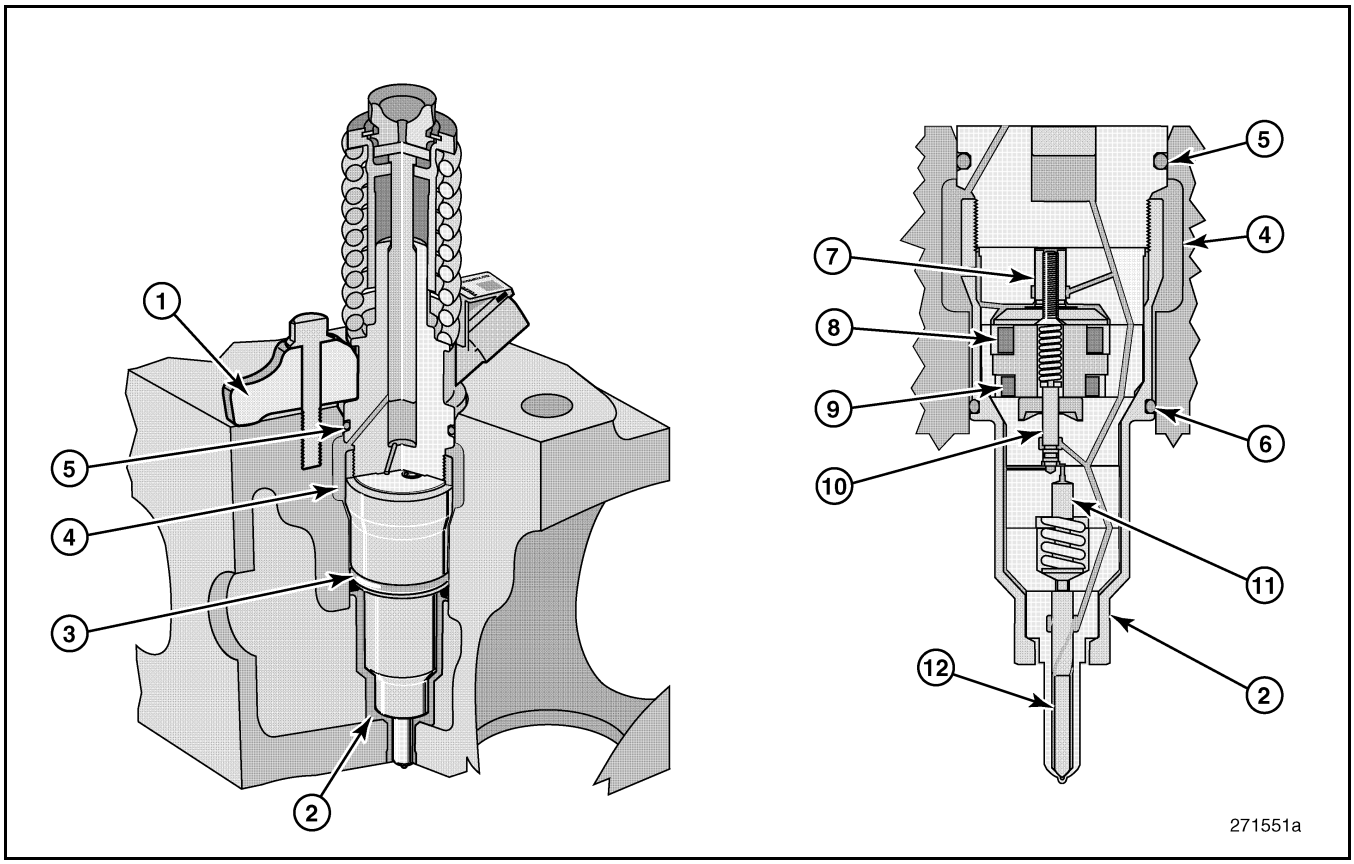


Figure 23 — Unit Injector Diagram

1. Injector Yoke	7. Pressure Relief Valve
2. Copper Sleeve (with bead)	8. Solenoid Coil
3. O-Ring	9. Solenoid Coil
4. Fuel Gallery	10. Injector Valve
5. O-Ring	11. Injector Piston
6. O-Ring	12. Injector Nozzle

This engine uses double solenoid unit injectors. Unlike systems that require separate components for delivering, pressurizing and injecting, this unit injector combines these functions. These injectors precisely control the fuel delivery because of the two solenoids. The solenoids, pump and nozzle are in a single body in close proximity to each other.

The injector is set in a pressurized fuel gallery where the fuel temperature is constant. Uniform fuel temperature means uniform quantity in each injection which means uniform power output from each cylinder.

The fuel pump pressurizes the gallery so that fuel rushes into each injector when it opens. Gallery pressure is regulated by a valve that delivers excess fuel back to the tank.

Copper sleeves, acting as coolant jackets, line the bottoms of the injector bores. Engine coolant circulates around these sleeves aiding the process of controlling injection temperature.

There are four phases to the injector cycle of operation. These include:

- Fill phase
- Spill phase
- Injection phase
- Pressure drop phase

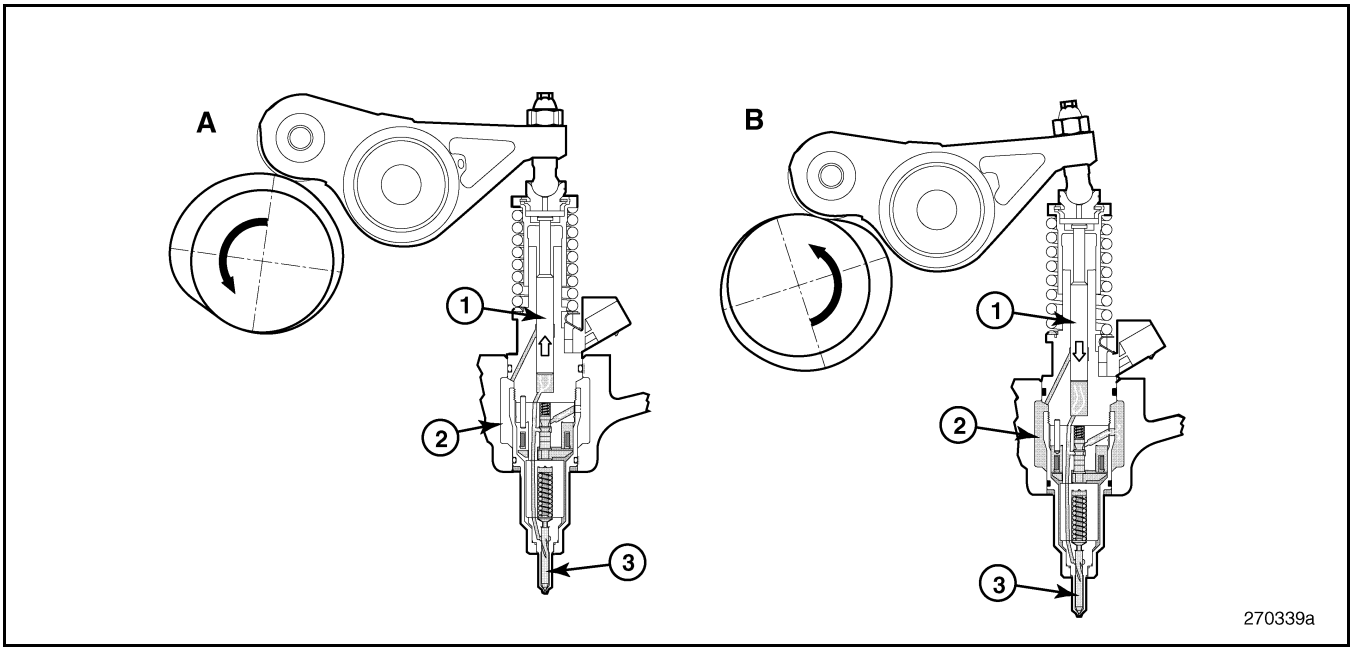


Figure 24 — Unit Injector — Fill and Spill Phases

1. Pump Plunger 2. Fuel Gallery	3. Injector Nozzle

Fill phase (A): During the filling phase, the pump plunger is on its way up, the camshaft lobe is passing its highest point and the rocker arm is on its way toward the camshaft base circle. The fuel valve is open, allowing fuel to flow into the unit injector from the lower fuel gallery. Fuel flows into the cylinder head and the unit injector pump cylinder. Filling continues until the pump plunger reaches its upper position.

Spill phase (B): The spill phase begins when the camshaft lobe forces the rocker arm to push the pump plunger down. The fuel can now flow through the fuel valve, through the holes in the unit injector and out through the fuel gallery. The spill phase continues as long as the fuel valve is open.

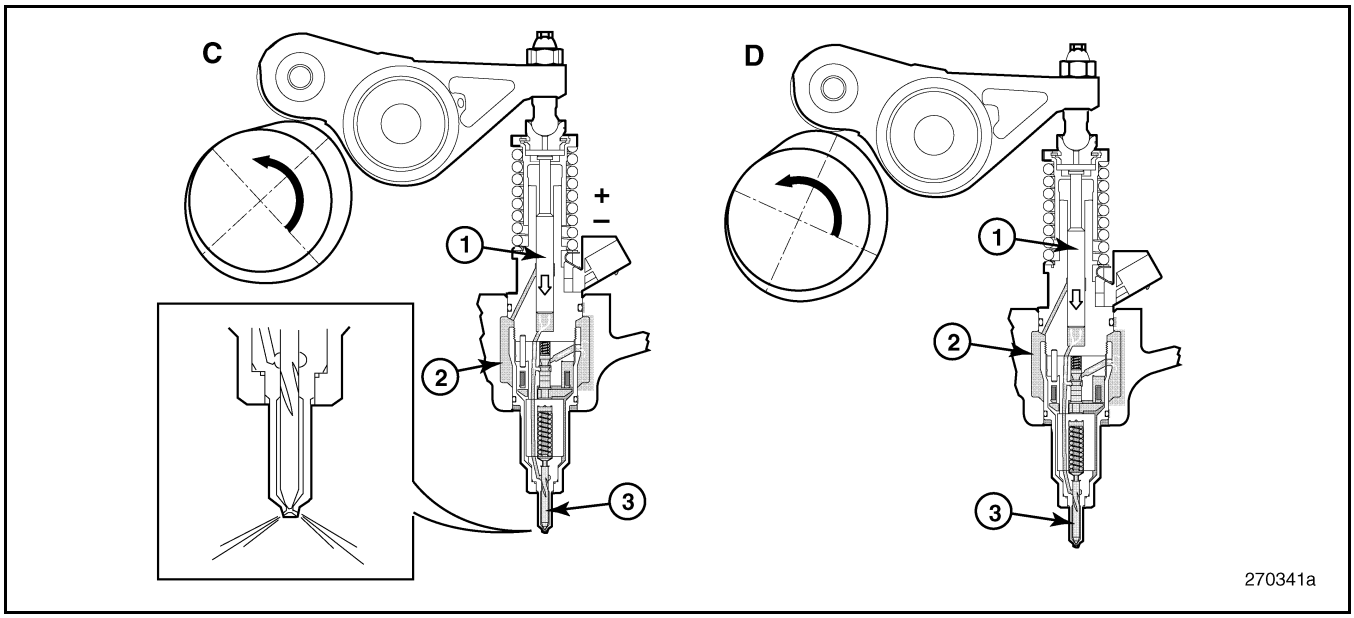


Figure 25 — Unit Injector — Injection and Pressure Drop Phases

1. Pump Plunger 2. Fuel Gallery	3. Injector Nozzle

Injection phase (C): The injection phase begins when the fuel valve closes. The camshaft lobe and rocker arm continue to press down on the pump plunger and injection occurs as the path through the fuel valve closes. The injection phase continues as long as the fuel valve is closed.

Pressure drop phase (D): The injection phase ends when the fuel valve opens and pressure in the unit injector drops below the nozzle opening pressure. The fuel flows through the open fuel valve, through the unit injector holes and out through the fuel gallery. Note that the fuel valve position (closed or open) determines when the injection phase begins and ends. The time during which the fuel valve is closed determines the amount of fuel injected at each pump stroke.

Unit injectors are categorized and coded with regard to tolerances. Whenever a unit injector is replaced, the replacement injector **MUST** be programmed for the cylinder in which it is installed. This is done by programming EECU parameters using the VCADS *pro* or the Premium Tech Tool (PTT) to set *Injector Trim* parameters with the trim codes marked on the injectors.

NOTE

The dimension by which the injector nozzle extends from the head is critical. This means that machining the head in any way that changes this nozzle extension is not permitted.

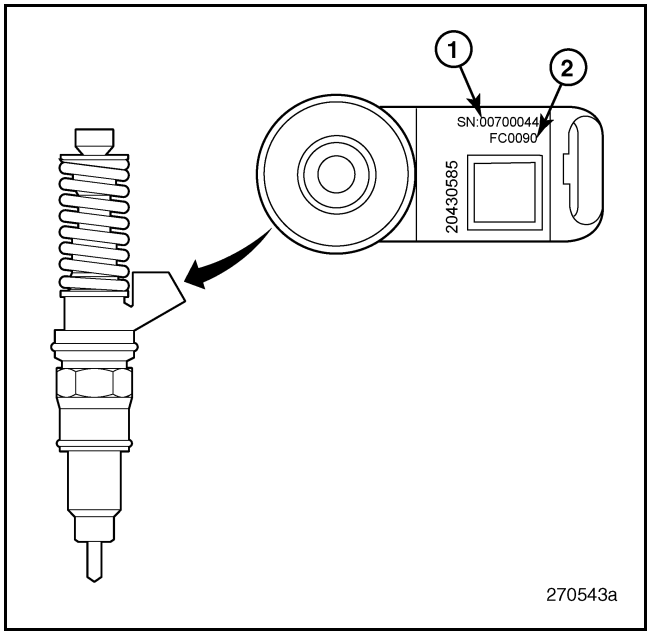


Figure 26 — Injector Coding

1. Serial No.	2. Unit Calibration No.

Exhaust Pressure Governor (EPG) System

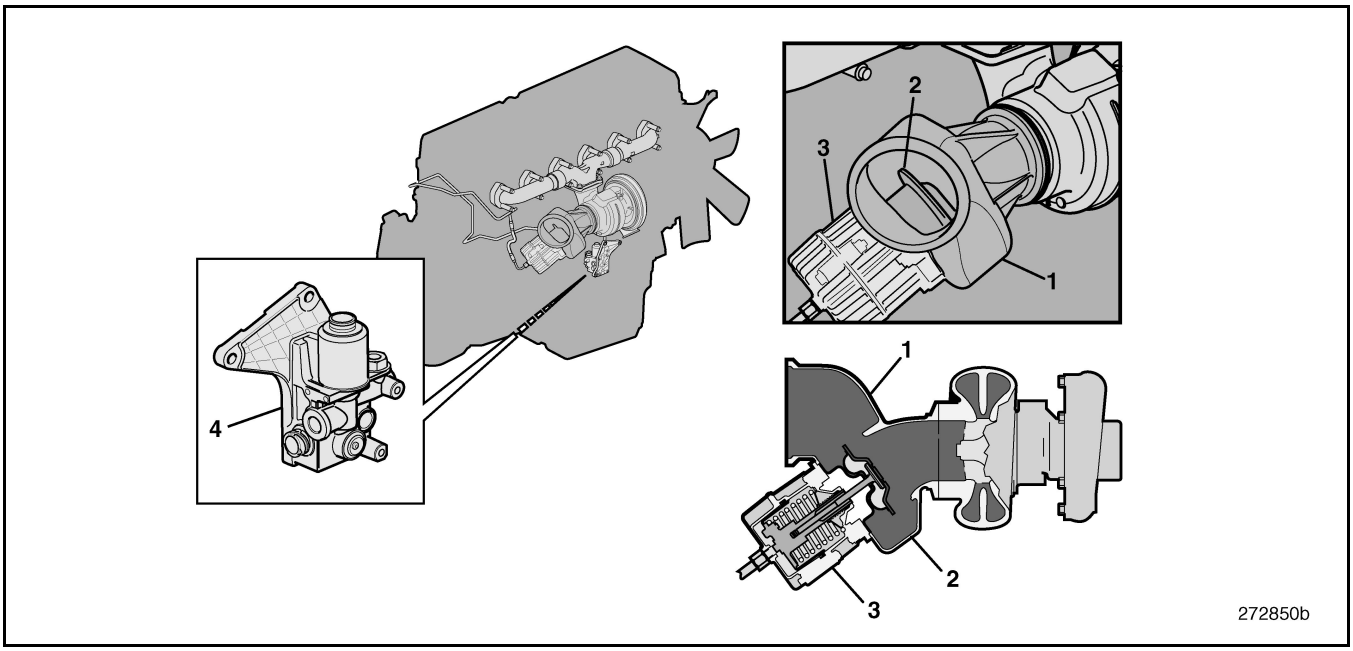


Figure 27 — Exhaust Pressure Governor (EPG) System

1. EPG Shutter Housing 2. Shutter	3. Air Cylinder 4. Air Valve Unit

The exhaust pressure regulator (EPG) is placed in direct connection with the turbine housing of the turbocharger, and has two tasks:

- When idling, the engine is kept warm by creating a back pressure in the exhaust manifold.
- When the accelerator pedal is released, it acts as an exhaust brake.

The exhaust pressure regulator consists of a shutter housing (1), a shutter (2) and a pneumatic cylinder (3) as shown in Figure 27. Compressed air is taken from the vehicle air system and controlled by an air valve unit (AVU), which is available in two variants — for turbochargers with or without waste gates (actuators) respectively. The AVU valve consists basically of a solenoid valve, an air valve and a printed circuit board. It regulates the pressure steplessly within the 0.5 to 7.5 bar range. The valve has a built-in reducing valve, which releases different pressures for the respective amounts of braking.

To meet the varying control air needs of the exhaust brake, the engine electronic control unit sends a Pulse Width Modulated (PWM) signal to the AVU valve, where the signal pulse width (as a percentage) determines the output air pressure to the pressure cylinder.

Figure 27 shows the situation during normal driving. When the AVU valve is not receiving electric current, the shutter (2) is completely open and the exhaust is free to pass.

PowerLeash™ Engine Brake

The engine can be equipped with a PowerLeash™ engine brake system to assist in slowing the vehicle when necessary. The system includes:

- Wiring harness
- Camshaft
- Oil control valve
- Exhaust rocker arm or exhaust and brake rocker arms
- Exhaust valve yokes (bridges)

There are multiple design variations of the PowerLeash™ engine brake utilizing a 3-rocker valve train or a 4-rocker valve train.

POWERLEASH™ (3-ROCKER)

With the 3-rocker PowerLeash™ design, the exhaust rocker arms contain a power piston and non-return valve to actuate the exhaust valves for engine braking. The three rocker arms are positioned on the shaft (front to back) in the order of inlet, injector and exhaust. Both the inlet and exhaust rocker arms each drive the valve pairs via a pinless yoke (bridge).

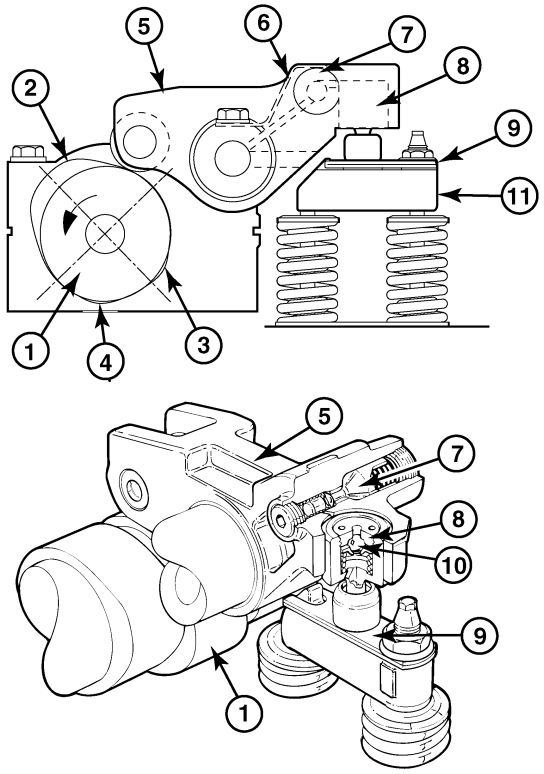


Figure 28 — PowerLeash™ (3-Rocker) Components

1. Camshaft	7. Non-Return Valve
2. Exhaust Lobe	8. Power Piston
3. Charging Lobe	9. Adjustment Shim
4. Decompression Lobe	10. Pressure Relief Valve
5. Exhaust Rocker Arm	11. Yoke, Exhaust Valve
6. Blade Spring	

There are two small lobes on each of the exhaust cams in addition to the regular lobe. Their locations are timed to open the exhaust valves at the end of the induction stroke and immediately before TDC on the compression stroke when engine braking is activated.

The exhaust rocker arms are sturdier than standard and are equipped with blade springs to maintain clearance between the roller and the two small extra lobes when PowerLeash™ is not activated. Valve clearance adjustment is accomplished through the use of shims attached to the top of the valve yoke.

POWERLEASH™ (4-ROCKER)

With the 4-rocker design, the exhaust rocker arms contain a pump piston in addition to the power piston and non-return valve. An additional “brake” rocker arm, working in combination with the exhaust rocker arm, drives the pump piston for engine braking.

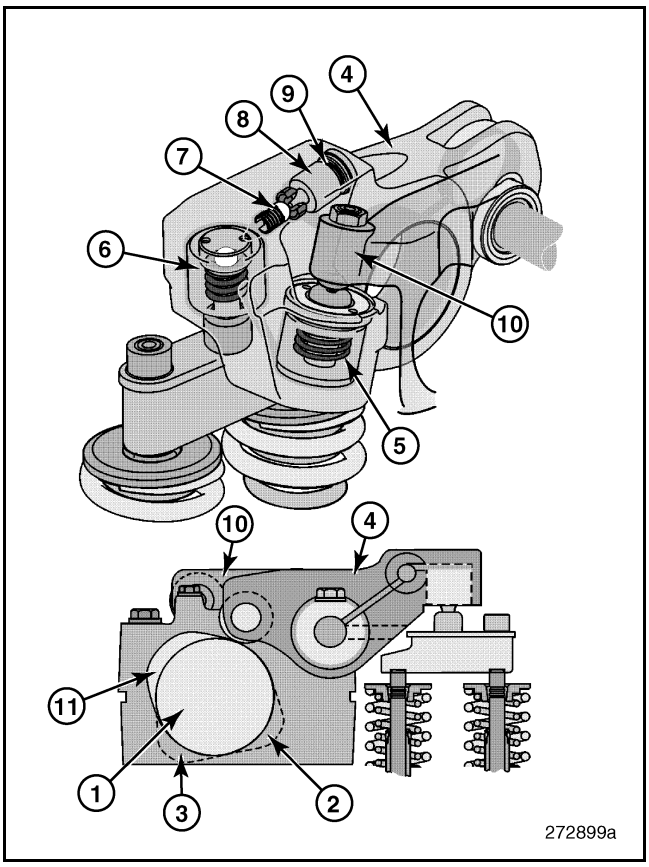


Figure 29 — PowerLeash™ (3-Rocker) Components

1. Camshaft	7. Non-Return Valve
2. Charging Lobe	8. Piston
3. Decompression Lobe	9. Spring
4. Exhaust Rocker Arm	10. Brake Rocker Arm
5. Pump Piston	11. Exhaust Lobe
6. Power Piston	

At each cylinder, there is a fourth cam to drive the brake rocker arm. This cam contains the charging and decompression lobes which are timed to open the exhaust valves at the end of the induction stroke and immediately before TDC on the compression stroke when engine braking is activated.

With the 4-rocker design, it is the engine brake rocker arm that is equipped with a blade spring. Here, the purpose is to keep the roller in contact with the fourth “brake” cam.

OPERATION (3-ROCKER AND 4-ROCKER)

PowerLeash™ operation depends on all of the following conditions which must exist simultaneously.

- Accelerator pedal released
- Engine speed above 1000 rpm
- Clutch pedal released
- Road speed above 5 km/h (3.1 mph)
- ABS inactive
- Transmission in gear
- Oil temperature above 60°C (140°F)
- Charge air pressure below 50 kPa (7.25 psi)

On the cylinder head, the oil control valve connects the oil passages in the head and rocker shaft. The control valve reduces the oil pressure in the rocker shaft to 100 kPa (14.5 psi) when PowerLeash™ is not activated.

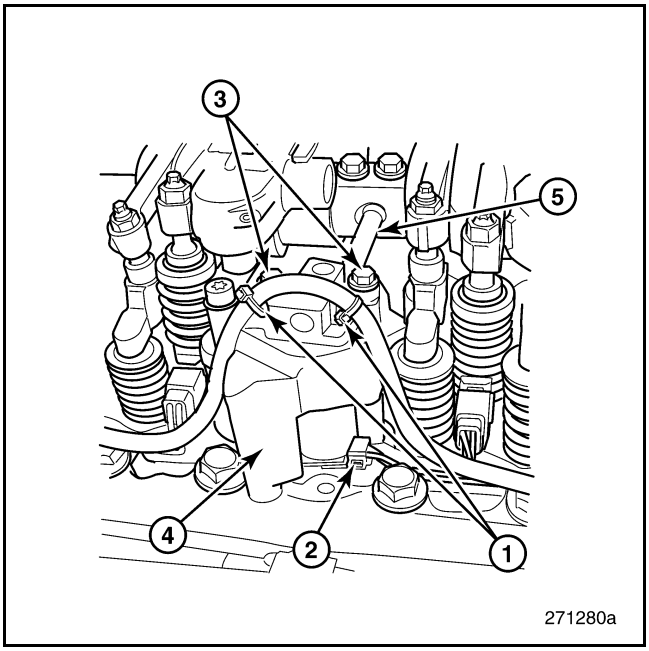


Figure 30 — PowerLeash™ Oil Control Valve — Location

1. Tie Wraps	4. Control Valve
2. Electrical Connector	5. Tube — Valve to Shaft
3. Attaching Screws	

When the accelerator pedal is released (and the PowerLeash™ switch is *ON*), the solenoid opens allowing some oil to escape through a small port. Reduced spring pressure moves the piston, opens the passage to the rocker shaft and increases the oil pressure. The system opens the exhaust valve during induction and again immediately before TDC on the compression stroke.

The engine slows because the extra volume under compression takes more power to compress, and escaping pressure in the combustion stroke reduces the power output. A switch on the instrument panel allows the driver to engage or disengage PowerLeash™.

If the ABS system becomes active, it automatically disables PowerLeash™. If the oil temperature goes below 55°C (131°F), PowerLeash™ cannot be activated. A warning lamp on the instrument panel flashes if the driver attempts to activate it under this condition.

A port in the cylinder head allows access to the oil passageway. The plug can be removed and a gauge and hose assembly inserted for use during diagnostic procedures.

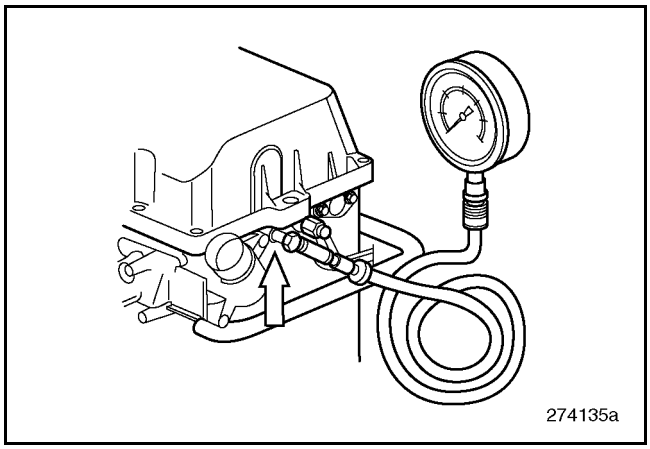


Figure 31 — Cylinder Head Oil Pressure Access Port

System Oil Pressure		
Engine Speed/RPM	**Temperature**	**Pressure**
600	90–110°C (195–230°F)	>250 kPa (>36 psi)
>1100	90–110°C (195–230°F)	300–550 kPa (44–80 psi)
>1100	Cold Engine	650 kPa (95 psi)

Rocker Shaft Oil Pressure		
Engine Brake	**Engine Speed/RPM**	**Pressure**
Active	1000–2300	>220 kPa (>32 psi)
Inactive	—	80–120 kPa (12–17 psi)

Air Intake System

Fresh air enters the intake above the back of the cab. Plastic duct work leads the air to the filter assembly mounted on the bulkhead under the hood. An impregnated paper filter prevents foreign particles from passing through. The assembly design permits the addition of a second filter if needed in extreme environments.

A combination pressure/temperature sensor mounted on the pipe between the filter housing and the turbocharger alerts the driver if the filters need replacement before the scheduled service. The brake system air compressor also draws fresh, clean air from this same pipe.

Turbocharger

The turbocharger is of Map Width Enhancement design, which means that the air intake is divided into two areas (an inner and an outer area) connected by a ring-shaped gap. This turbocharger design ensures efficiency at both low and high rotation speeds.

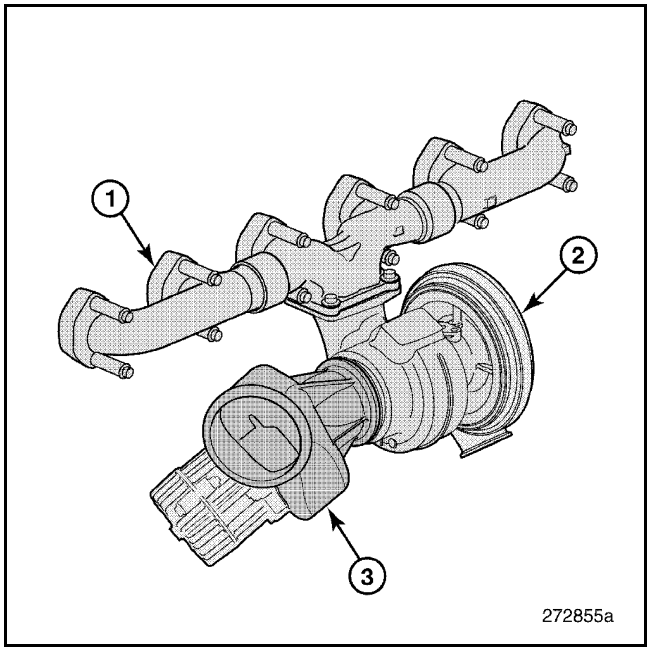


Figure 32 — Turbocharger

1. Exhaust Manifold 2. Turbocharger	3. Exhaust Pressure Governor (EPG)

Cooling System

The cooling system incorporates a belt-driven coolant pump mounted on the front of the engine on the right. It also uses a piston-type thermostat housed in the front of the cylinder head and a fan with viscous or air-operated drive mounted above the crankshaft pulley. A coolant conditioner (filter) attached to the pump housing filters impurities from the coolant and releases supplemental coolant additives for system protection.

COOLANT PUMP

The back of the coolant (water) pump, with its ducts for distributing coolant, is a separate casting attached to the cylinder block.

A housing containing an impeller, shaft seals, bearing and pulley attaches to the mounting plate. The bearing is a permanently lubricated combination roller and ball bearing. Between the shaft seals and the bearing, there is a ventilated space which leads into a duct behind the pulley. This allows internal leaks to be detected.

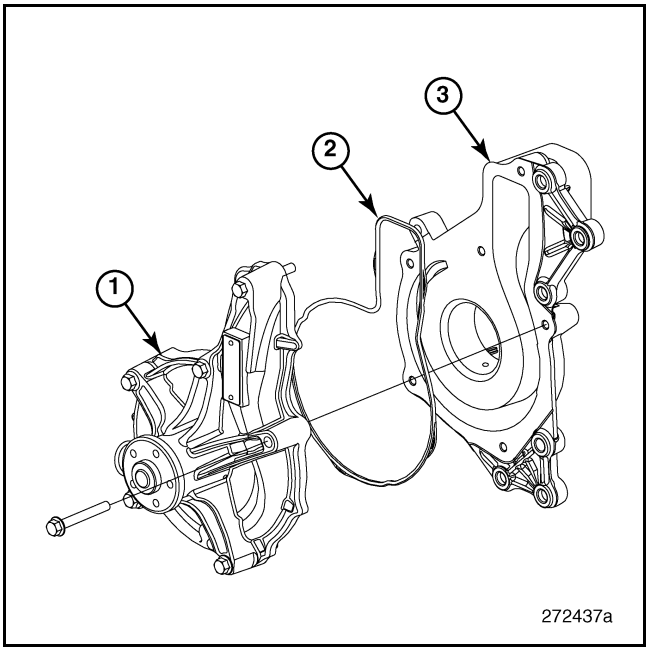


Figure 33 — Coolant (Water) System Components

1. Impeller Housing 2. Coolant Pump Seal	3. Coolant Pump Mounting Plate

THERMOSTAT

This is a piston-type, full-flow thermostat with piston, bulb, seal and housing in a single assembly. Coolant flows continuously, either back to the pump, or to the radiator and back to the pump. It has lower pressure drop compared to other types. The thermostat is mounted on the front of the cylinder head.

ENGINE COOLING FAN

The cooling fan (Figure 34) runs via a viscous or air-operated drive through which fan speed is electronically controlled by the EECU. With precise EECU control, fan speed is continuously adjusted in response to several interrelated influences. This makes for efficient cooling with low fuel consumption.

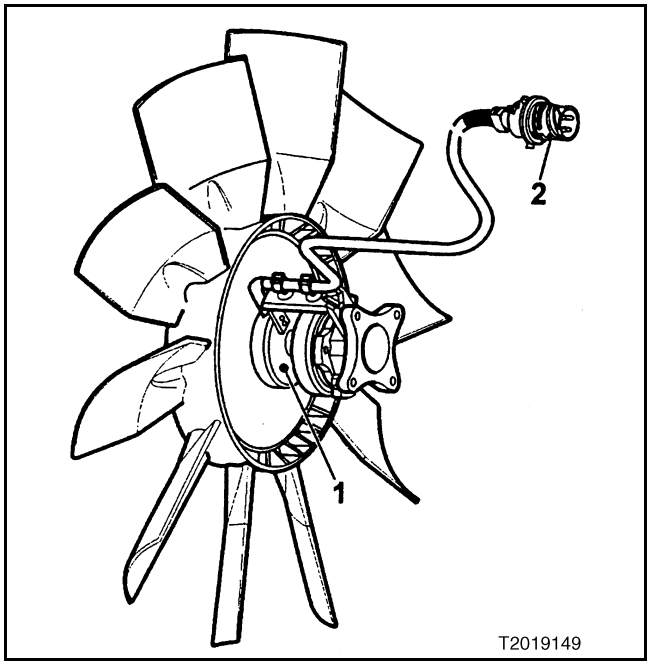


Figure 34 — Viscous Drive Engine Cooling Fan

1. Solenoid Valve and Speed Sensor	2. Connector (to EECU)

Other fan drive options include On/Off Fan Clutches and Electronically Modulated Fan Drives. Refer to Engine Cooling Service Manual, 7-002, for a complete description of all available fan drive systems.

Engine Management System

ENGINE ELECTRONIC CONTROL UNIT (EECU)

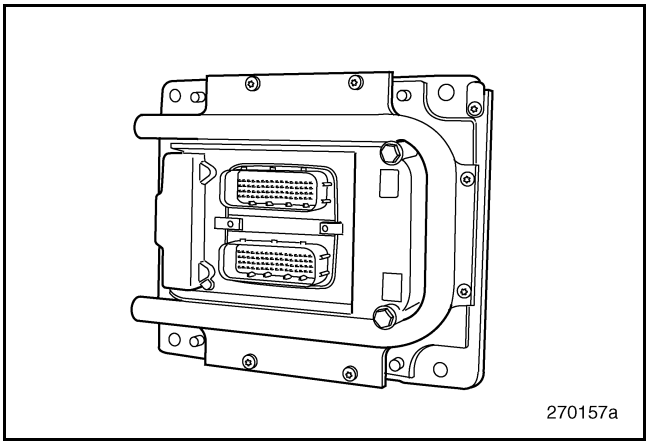


Figure 35 — EECU and Cooler

The engine management system module, also known as the Engine Electronic Control Unit (EECU), is located on the left side of the engine just below the inlet manifold. The EECU is cooled by fuel circulating through a plate attached to the cover of the unit. The fuel comes from the tank on its way to the fuel pump.

Algorithms, called *maps*, are programmed in the EECU so that it can translate sensor data into action. These maps enable the EECU to receive status information from the sensors and send functional data to the actuators so they can simultaneously assume the proper posture for the safest, most efficient operation of the engine in any given instant.

Due to the EECU self-learning capability, it is necessary to reset the learned EECU parameters after servicing some engine-related components. This allows the EECU to learn the new component's behavior. After servicing is complete, perform the “Learned Data Reset” located in the Function Group 1 menu on the PC tool.

SENSORS AND ACTUATORS

Sensors on the engine provide for electronic control. The figures that follow show the locations of the devices on the left and right sides of the engine, respectively.

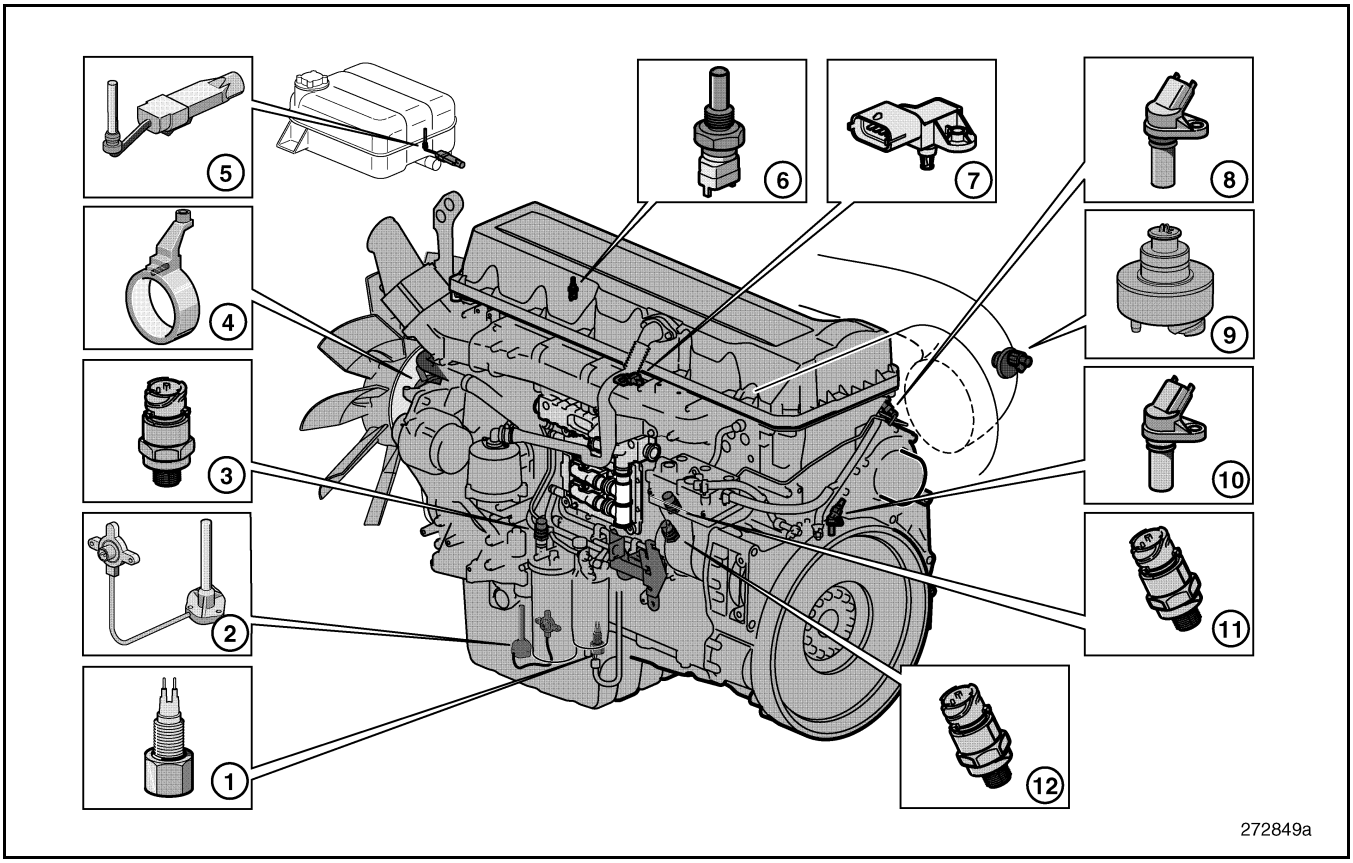


Figure 36 — MP8 Euro 3 Engine Sensors

1. Water Level (in fuel/water separator)	7. Charge Air Pressure/Temperature
2. Oil Level/Temperature	8. Camshaft Position
3. Fuel Pressure	9. Inlet Air Pressure
4. Fan Speed (only if equipped with viscous fan)	10. Engine Position/Speed
5. Coolant Level Sensor (in expansion tank)	11. Oil Pressure
6. Coolant Temperature (at front edge of cylinder head)	12. Crankcase Pressure

GLOSSARY OF TERMS

Carbon Monoxide (CO)

An odorless, colorless gas resulting from incomplete combustion of hydrocarbons; found in diesel truck exhaust; poisonous to humans and animals.

Electronic Unit Injector (EUI)

Controlled electronically by the EECU, there is one electronic unit injector for each cylinder of an engine. A unit injector incorporates the pump, the injector nozzle and two solenoids in a single body. Actuated by the camshaft via rocker arms with roller followers, electronic unit injectors offer precise fuel metering using a process called “rate shaping.”

Engine Electronic Control Unit (EECU)

A microprocessor-based controller usually mounted on the engine block. On the MP8 engine, a cooling plate mounts on the surface of the module. A tube on the plate conducts fuel drawn from the tank on its way to the pump before being pressurized. The fuel acts as the coolant. With the MACK V-MAC® IV system, the EECU controls fuel timing and delivery, fan operation, engine protection functions and engine brake operation.

Hydrocarbons (HC)

Chemical compounds composed only of carbon and hydrogen. Gasoline, diesel fuel and motor oil are all examples of a very large group of hydrocarbons. The largest source of hydrocarbons is petroleum.

Idler Gear

A gear running between a driving and a driven gear to make the driven gear rotate in the same direction as the driving gear.

Idler Tensioner

A belt tensioning device designed to maintain optimum tension under varying engine speeds and load.

Intake Air Temperature and Humidity Sensor

Mounted in the air intake between the air cleaner and the turbo compressor housing, detects outside air temperature and humidity and relays these values to the EECU.

Oxides of Nitrogen (NOx)

High temperatures and pressures of combustion produce oxides of nitrogen (NOx). When combustion temperature exceeds 1372°C (2,500°F), oxygen and nitrogen combine in large quantities to form NOx. By themselves, NOx emissions are no great hazard; however, when mixed with the right amount of HC in the air, NOx will combine in the presence of sunlight to form smog.

Poly-V Belt

A multi-ribbed belt design incorporated into the accessory drive belt and pulley arrangement at the front of the engine.

Roller Follower

A type of rocker arm with an axle-mounted roller that rides on (or follows) a camshaft lobe. The rolling motion of this design provides increased load capacity with less friction than the flat-faced rocker arm design. Roller followers provide the rocker arm lifting action for the electronic unit injector, intake and exhaust valves and exhaust brake.

Vehicle Electronic Control Unit (VECU)

A microprocessor-based controller, sometimes referred to as a module, mounted in the cab, inside the passenger-side dash panel. With the MACK V-MAC IV system, the VECU controls engine speed, cruise control, accessory relay controls, idle shutdown and trip recorder functions.

COMPONENT LOCATOR

MP8 EURO 3 ENGINE COMPONENT LOCATION VIEWS [200 EA]

The locations of primary component assemblies of the MP8 engine are identified in the illustrations contained in this section.

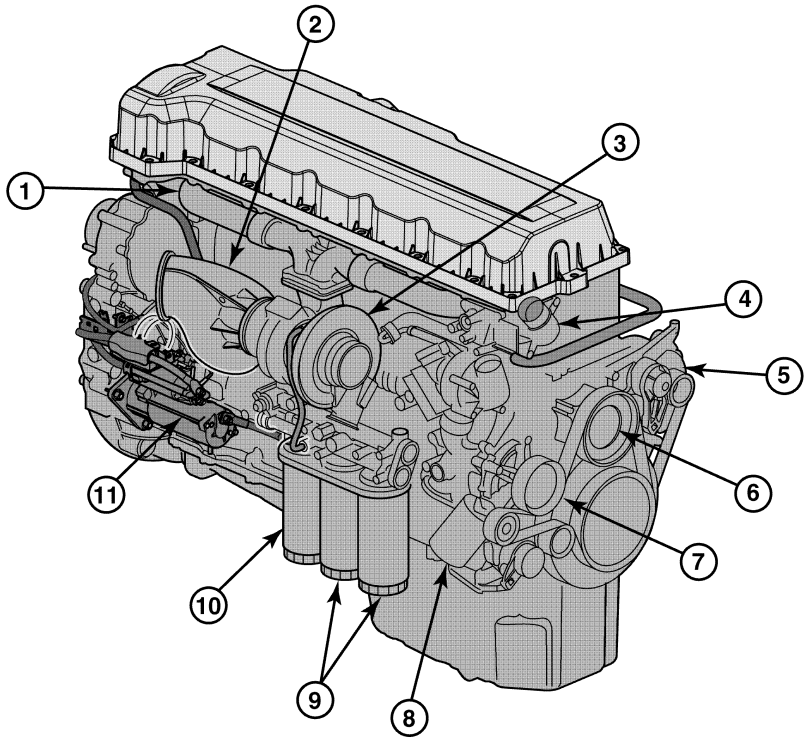


Figure 37 — MACK MP8 Euro 3 Engine, Right-Side View (Front >)

1. Exhaust Manifold 2. Exhaust Pressure Governor (EPG) 3. Turbocharger 4. Thermostat 5. Alternator 6. Fan Hub	7. Coolant Pump 8. Coolant Conditioner 9. Full Flow Oil Filters 10. Bypass Oil Filter 11. Starter

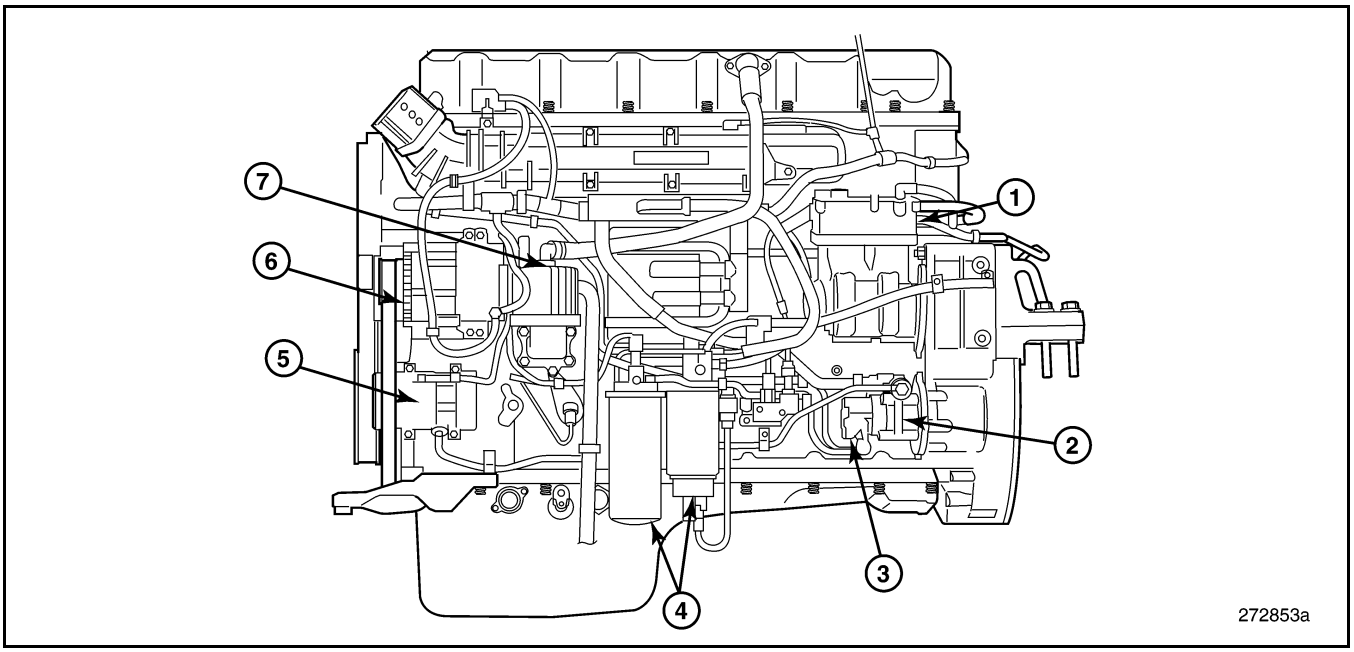


Figure 38 — MACK MP8 Euro 3 Engine, Left-Side View (< Front), Conventional Chassis Configuration Shown

1. Air Compressor 2. Power Steering Pump 3. Low Pressure Fuel Pump 4. Fuel Filters	5. Refrigerant Compressor (Pad Mount) 6. Alternator (Pad Mount) 7. CCV Separator

NOTE

For the conventional chassis, the air inlet is at the front of the inlet manifold which is the configuration shown in Figure 38. For the low cab forward (LCF) chassis, the air inlet is located near the rear of the manifold.

TROUBLESHOOTING

ENGINE SYMPTOM DIAGNOSIS [200 EA]

The Vehicle Management and Control (V-MAC IV) system monitors engine function and displays a code when a fault is detected. The code can be observed on the instrument panel or through an electronic diagnostic tool. An explanation of the fault codes can be found in VCADS, Guided Diagnostics or the Fault Code Manual, 8-218. Guided Diagnostics also includes symptom-based troubleshooting. To obtain Tech Tool, contact your local MACK dealer.

The Tech Tool provides complete system diagnostics. For more information, see manual 8-371 or the Tech Tool web site. Repair information is available in the respective engine service manuals and from the MACK Electronic Information System (EIS). EIS is easily accessed with Tech Tool.

Troubleshooting Technique

Talk to the vehicle operator. Learn how the engine operated before it failed. Ask about the maintenance schedule and the fuel, coolant and lubricant used. Begin by attempting to determine whether anything has happened recently that could point to the electrical system, but which is not related to the electronic control system.

Depending on the vehicle configuration, a problem may be caused, or influenced, by malfunctions in other vehicle components. Be sure to inspect for unusual conditions among the batteries, tires, axles, trailer, bodybuilder adaptations and other possibilities. Consult specific service information resources according to the conditions observed. Fuel waxing, for example, can cause symptoms easily mistaken for other engine problems.

If possible, recreate the problem in an environment similar to that described by the vehicle operator. Run the engine at the temperature at which the symptom occurred.

Engine problems can be electrical, mechanical or a combination of the two. Electrical and electronic problems will, for the most part, cause fault codes to be set in the V-MAC system.

Before Troubleshooting Begins

Before troubleshooting begins, observe all shop safety procedures.

Noise and Vibration

NORMAL VERSUS ABNORMAL

Noise is the name we give to vibration that irritates us through our ears. *Vibration* can be felt without being heard. Engine operation can cause vibration and noise throughout a vehicle that we regard as “normal.”

Abnormal noises and vibrations suggest that something is not working properly or is not assembled properly. A damaged driveshaft can cause abnormal vibration. A loose fastener allows two surfaces to rub or slap together causing unusual noise in response to the vibration.

Be sure to discuss noise and vibration issues with the driver. It is important to discover under what conditions these occur. Maybe a test drive will be necessary to familiarize yourself with the details of the driver's story. Even so, it will probably be necessary to start the diagnostic process with a guess as to the nature of the difficulty.

The table below affords an opportunity to make note of various influences discovered while investigating the problem and organize thoughts. It is made for you to use as you see fit.

The noise or vibration occurs:	Yes	No	Remarks
When the vehicle is stationary			
At idle			Engine Speed =
When power take-off is engaged			Engine Speed =
Other items of interest			
When the vehicle is in motion			
With a particular superstructure			
At a particular weight			
At a particular speed			
On a particular type of road			
Driving without cruise control			
Driving with cruise control			
Driving using the speed governor			
At full load			
In a particular gear			
When freewheeling (clutch disengaged)			
Vehicle information			
Type of chassis suspension (air?)			
Type of cab suspension (air?)			
Type of driver's seat (make and model)			
Other items of interest			
Notes:			

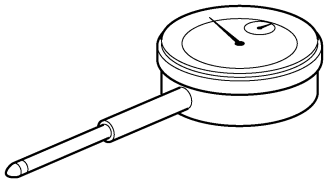
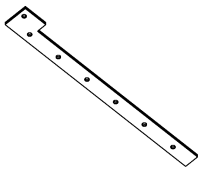
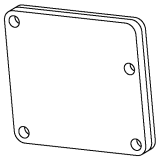
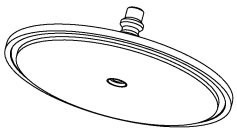
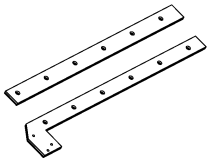
If the solution does not become evident in the course of completing the check list above, use Tech Tool to investigate further.

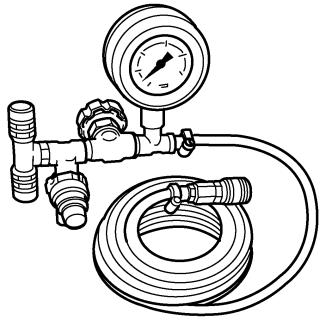
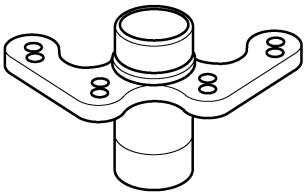
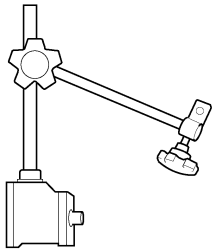
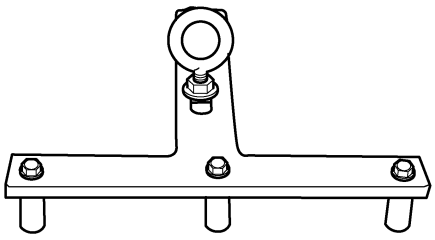
ENGINE CHECKS AND TESTS

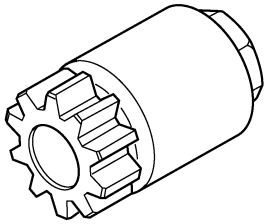
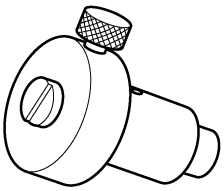
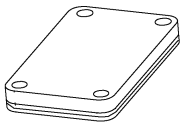
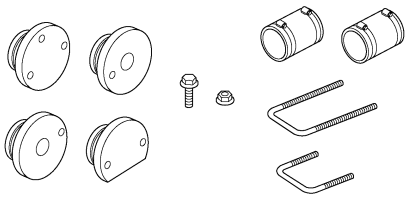
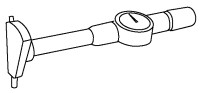
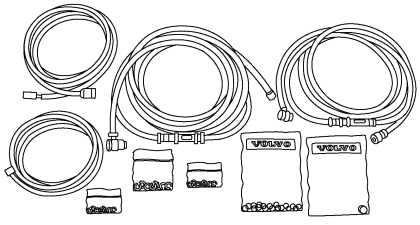
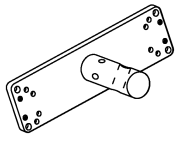
Included in this section are the following engine checks and tests:

- Camshaft Sensor Depth, Check
- Camshaft Timing, Check
- Crankcase Ventilation, Check
- Cylinder Head, Pressure Test
- Cylinder Liner and Piston Wear, Check
- EGR Cooler, Pressure Test
- Engine Compression, Test
- Flywheel Housing Runout, Check
- Oil Cooler, Pressure Test
- Rocker Arm, Check
- Thermostat, Check
- Valve Guide Wear, Check

Special Tools

Tool No.	Description	Image
9989876	Dial Indicator (Available)	 006899a
9990105	Sealing Plate for MP7 Cylinder Head	 274113a
9990106	Sealing Plate for MP7, MP8 and MP10 Cylinder Heads	 274114a
9990107	Connection Disc for MP7, MP8 and MP10 Cylinder Heads	 274115a
9990164	Sealing Plate for MP10 Cylinder Head	 274116a

Tool No.	Description	Image
9996662	Pressure Gauge and Hoses (Available)	 006793a
9996956	Flywheel Turning Tool for MP7 Engine (Essential)	 006795a
9999683	Sweep Dial Indicator (Essential)	006948a
9999696	Magnetic Stand (Available)	 006900a
85109036	Cylinder Head Lifting Tool (Essential)	 006769a

Tool No.	Description	Image
88800014	Flywheel Turning Tool for MP8 and MP10 Engines (Essential)	 271485a
88800031	Camshaft Sensor Depth Gauge (Available)	 006804a
88800215	Sealing Plate	 007157a
88800216	EGR Cooler Test Kit	 007002c
J 5347-B	Dial Bore Gauge	 000615b
J 42753	Fuel Line Kit	 007158a
J 47364	Cylinder Head Adapter Plate	 007117a

Camshaft Sensor Depth, Check

The signal from the camshaft sensor must exceed 0.5 volt in order to start the engine. If the signal is low, check the depth setting of the sensor following this procedure.

1. Remove the plug from the flywheel housing and install the appropriate flywheel turning tool, 9996956 (MP7) or 88800014 (MP8 and MP10).
2. Check for proper camshaft position sensor clearance using the sensor depth gauge, 88800031, to determine if shims are required for sensor depth.

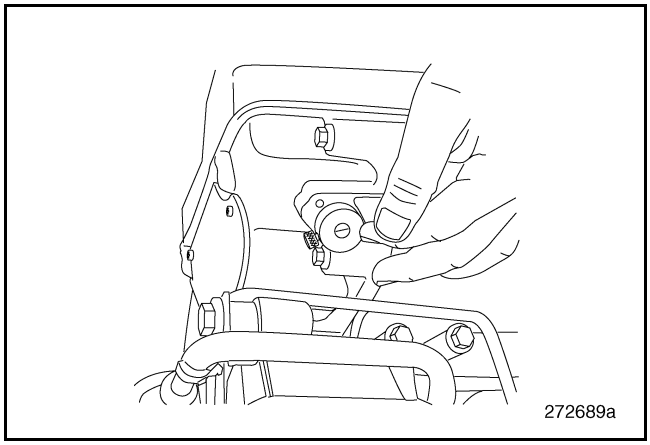


Figure 39 — Using Gauge at Camshaft Sensor Location

   a. Rotate the engine until a tooth of the camshaft toothed wheel is aligned with the sensor bore.
   b. Insert the depth gauge into the sensor bore until the outer part of the gauge is fully seated against the timing gear cover.
   c. Loosen the thumb screw of the gauge and push the inner part of the gauge in until it contacts a tooth of the toothed wheel.
   d. Tighten the thumb screw to secure the inner part of the gauge.
   e. Carefully remove the gauge from the camshaft sensor bore and observe the location of steps between the inner and outer portions of the gauge (Figure 40):
      - Both steps below the surface of the gauge = no shims required.
      - One step below the surface of the gauge = one shim required.
      - Both steps above the surface of the gauge = two shims required.

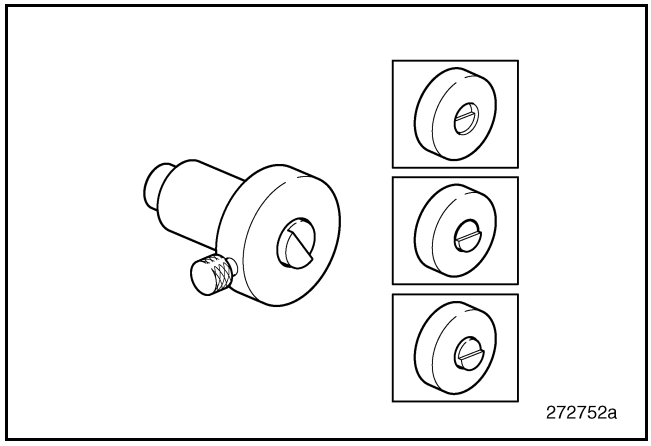


Figure 40 — Depth Gauge

3. Install the camshaft position sensor with the appropriate shim(s) and **new** O-ring. Secure the sensor with a bolt and plug in the harness connector.

Camshaft Timing, Check

1. Remove the cylinder head (valve) cover.
2. Check the camshaft vibration damper for damage to the pulse wheel pins.
3. Check the pulse wheel mounting for secure, square attachment.
4. Turn the engine crankshaft so that the TDC mark on the camshaft corresponds to the marks on the camshaft bearing cap No. 7 (MP7) or camshaft bearing cap No. 1 (MP8 and MP10) and the flywheel TDC mark “0” is opposite the pointer on the flywheel housing.
5. To ensure that the camshaft is correctly installed, complete a valve lift check on the intake valves of cylinder No. 1.
   - Temporarily adjust the No. 1 inlet rocker arm, at the valve yoke, to zero lash.
   - Position a dial indicator at the inlet valve yoke for the No. 1 cylinder.
   - Preload the dial indicator and reset the dial to align with zero.
   - Turn the engine in the normal direction of engine rotation one full rotation to “0” and past to the mark 6 degrees (after TDC) on the flywheel.
   - The dial indicator travel reading should be approximately 1.6 ±0.03 mm (0.06 ±0.01 inch) for MP7 and MP8 or 1.4 ±0.03 mm (0.05 ±0.01 inch) for MP10. This reading indicates a correctly timed camshaft.
   - Readjust the cylinder No. 1 inlet valves and yoke.

NOTE

If the camshaft is one tooth out of time, the dial indicator reading will be approximately 0.762 mm (0.030 inch) out of specification and should experience a fault code for the camshaft sensor.

6. Install the cylinder head (valve) cover.

Crankcase Ventilation, Check

1. Check the inlet pipe to the CCV separator for oil film, oil residue and particles. Remove any accumulated oil and dirt particles from the pipe.

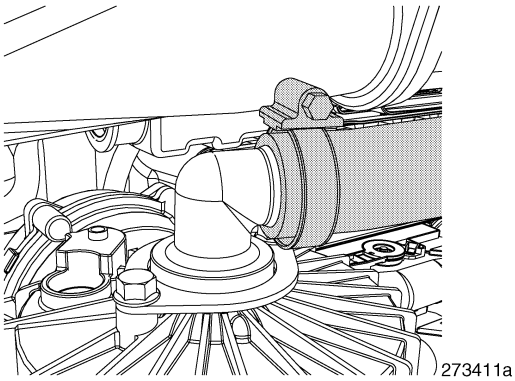


Figure 41 — CCV Inlet Pipe Connection

2. Remove the CCV separator from the engine.
3. With the separator removed, rotate the turbine by hand. It should rotate easily. If it does not rotate easily, replace the separator unit.

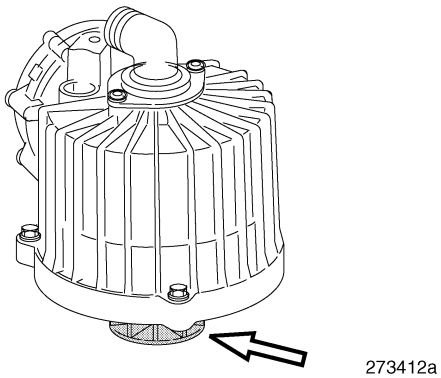


Figure 42 — CCV Separator Turbine Wheel

4. Check the oil nozzle in the CCV base for dirt and any accumulated oily deposits. Clean the nozzle as required. If unable to clean the nozzle sufficiently, replace the complete CCV separator assembly.

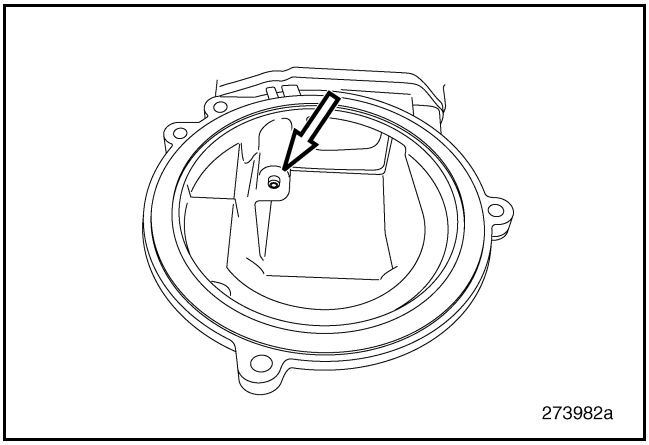


Figure 43 — Oil Nozzle (Separator Base)

NOTE

If the oil nozzle becomes clogged, the oil pressure is reduced and the turbine does not rotate as it should.

Cylinder Head, Pressure Test (Cylinder Head Removed)

The following procedure applies for MACK MP7, MP8 and MP10 engine cylinder heads. While the procedure is typical, the sealing tools required will be different for each MP engine series.

1. Clean the contact surfaces on the cylinder head. Install the:
   - Sealing plates, 9990105 (MP7), 9809696 and 9998266 (MP8) or 9990164 (MP10), onto the cylinder head coolant ports using cylinder head bolts and M16 nuts
   - Connection disc, 9990107, in position on the thermostat housing bore
   - Plug, M12x1.5, in the temperature sensor hole
   - Sealing plate, 88800215, on the side of the cylinder head

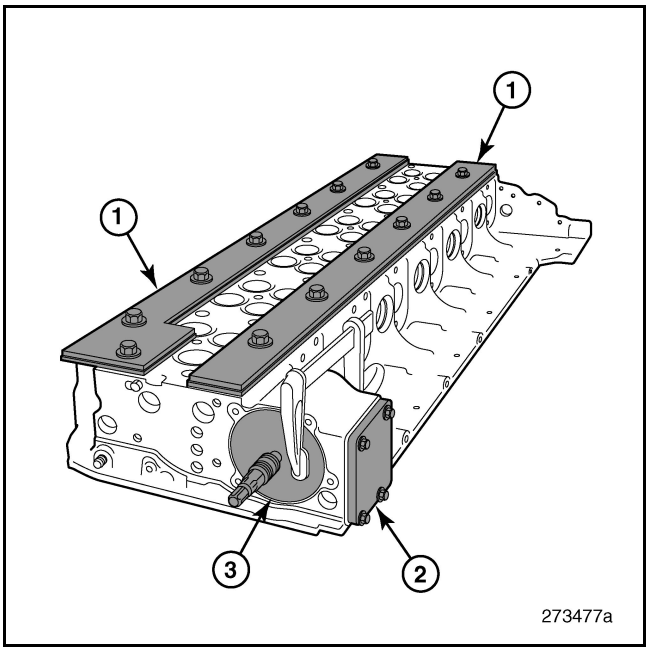


Figure 44 — Sealing Plates Installed (Typical)

1. Sealing Plates (Cooling Ports) 2. Sealing Plate (By-Pass Port)	3. Connection Disc (Thermostat Housing)

2. Connect the pressure gauge, 9996662, to a suitable air supply. Connect the pressure gauge hose to the connection disc on the cylinder head. Adjust the pressure to 100 kPa (14.5 psi) using the control valve. Close the stop valve for two minutes. The pressure should not fall.
3. Lower the pressure in the cylinder head by adjusting the knob on the pressure gauge control valve.

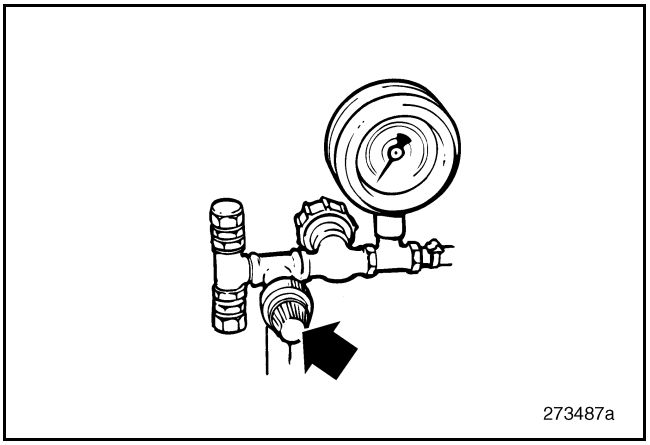


Figure 45 — Pressure Gauge Adjustment Knob

4. Attach the cylinder head lifting tool, 85109036, to the cylinder head.
5. Using a hoist, lower the cylinder head into a container suitable for the pressure test. Fill the container with 70°C (158°F) water.

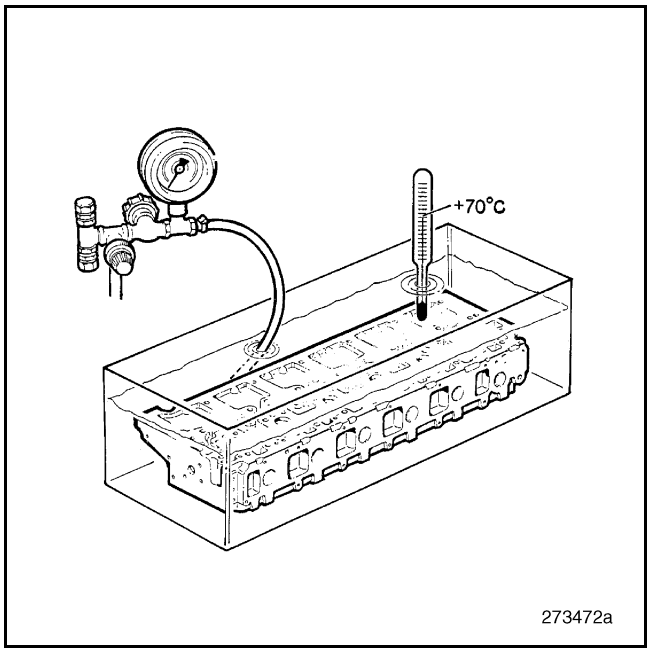


Figure 46 — Testing for Air Leaks

6. With the pressure gauge connected to an air supply and the connection disc on the cylinder head, carefully open the gauge control valve.
7. Set the pressure to 50 kPa (7.25 psi) and hold the pressure for one minute.
8. Raise the pressure to 150 kPa (21.8 psi) and close the stop valve. After two minutes, check for a drop in pressure and for any air bubbles forming around the cylinder head.

NOTE

A drop in pressure and the appearance of air bubbles indicates a leak(s) in the coolant, fuel or oil passages. The source of the leak(s) must be found and the cylinder head repaired or replaced as required.

9. Lower the pressure in the cylinder head by adjusting the knob on the pressure gauge control valve.
10. Using a hoist, remove the cylinder head from the water container.
11. Remove the sealing plates and connection disc from the cylinder head. Using compressed air, blow the water off the cylinder head and out of all threaded holes.

⚠ CAUTION

Use care with the fuel passages to make sure that no dirt enters the fuel channels. Dirt can cause the unit injectors to be damaged.

Cylinder Liner and Piston Wear, Check

Thoroughly clean the cylinder liners and pistons before inspecting and measuring. To thoroughly check for cracks, remove the cylinder liner from the cylinder block. Mark the position of the cylinder liner in the cylinder block before removing it so it can be installed in the same position during assembly.

CYLINDER LINER

1. Check the cylinder liner for cracks, paying special attention to the liner flange. The standard dye penetrant or Magnaflux® method can be used for checking.
2. Measure the cylinder liner wear with a cylinder bore gauge. The original bore size of the cylinder liner can be used as a reference measurement.

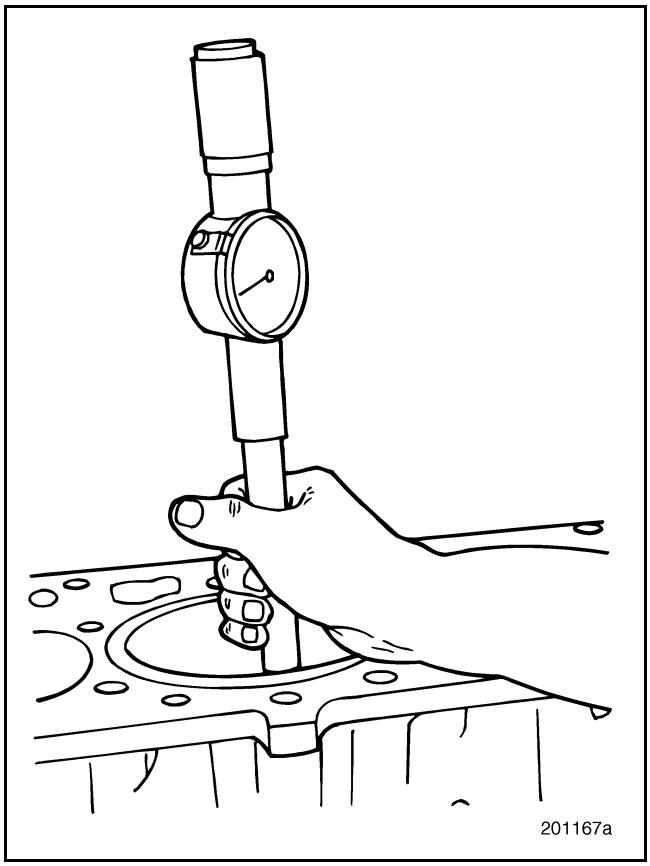


Figure 47 — Measuring Cylinder Liner Wear

3. Measure the cylinder liner at Top Dead Center (TDC), at Bottom Dead Center (BDC) and at a couple of positions in between. At each point, measure in two directions — engine crosswise and engine lengthwise.

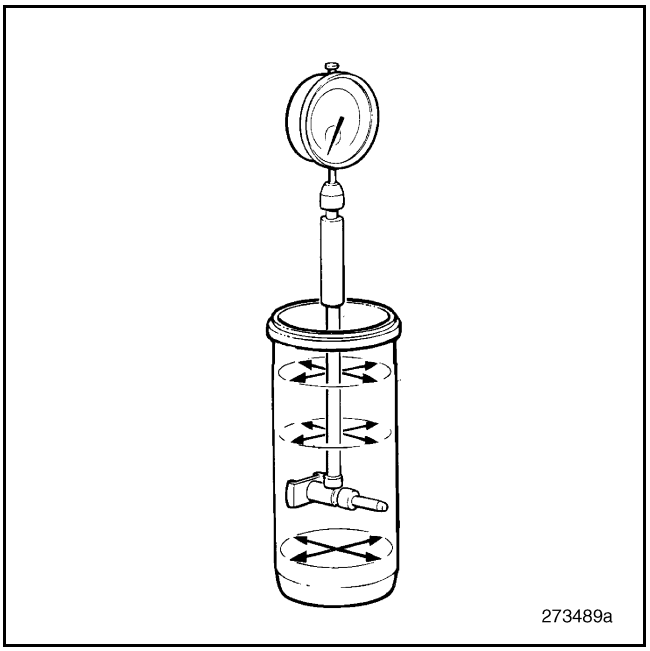


Figure 48 — Measurement Locations

4. If wear is greater than 0.05–0.10 mm (0.002–0.004 inch), use a complete liner kit (cylinder liner, piston, piston rings, piston pin and cylinder liner seals). Also consider engine oil consumption to determine when to replace the cylinder liner.

NOTE

Pistons and cylinder liners are available from stock only as matched pairs and should not be mixed.

PISTON

Inspect the piston ring grooves, lands, skirt and combustion bowl for wear, scuff marks, deep scratches, cracks and blow-by. Pistons are NOT repairable. Discard worn or damaged pistons.

⚠ CAUTION

Do not stamp or engrave on the TOP of the piston. Failure to heed this caution may result in severe engine damage.

To ensure that pistons are reinstalled into the same cylinders, the pistons must be tagged with the corresponding cylinder number when removed during disassembly.

EGR Cooler, Pressure Test

(Not Applicable for MP8 Euro 3 Engine)

1. Check inside the gas inlet port. If build-up of soot is seen, perform the EGR cooler cleaning procedure before checking for leaks.
2. Lubricate the O-rings on the coolant inlet and outlet port plugs with a suitable O-ring lubricant. Install the plugs and cap on the EGR cooler. Install the plugs on the EGR cooler coolant inlet and outlet ports. Install the coupler on the plug and connect the gauge to the coupler.

⚠ CAUTION

Do NOT over-tighten the fasteners on the plugs and cap.

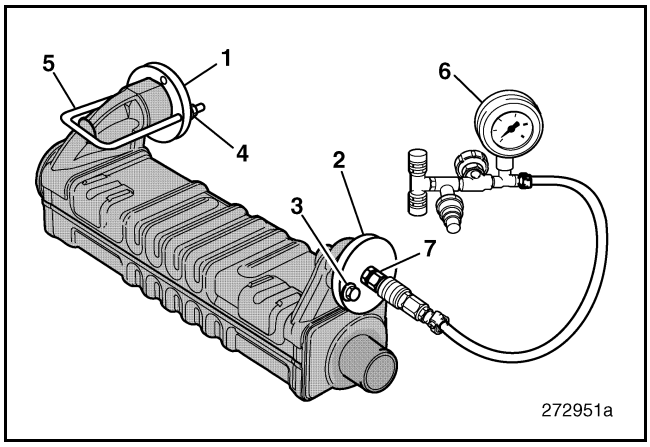


Figure 49 — Installation of Leak Test Kit on Cooler

1. 88800216-1 2. 88800216-2 3. Flange Capscrew 4. Flange Nut	5. U-Bolt 6. 9996662 7. 9998333

3. Fill a container with enough water to cover the EGR cooler.
4. Lower the EGR cooler into the container of water at room temperature (or fill the cooler core with water — see NOTE).

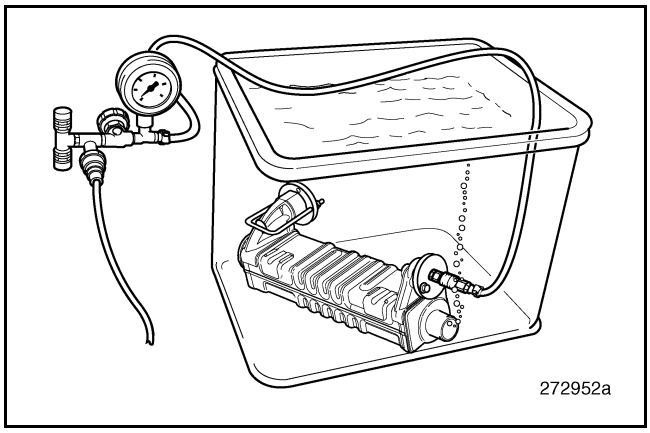


Figure 50 — Conducting Pressure Test

NOTE

If a large enough container cannot be obtained, the EGR cooler can be tested without being immersed in water by using the test plugs included with the kit, 88800216-5, to seal the gas outlet port. The EGR cooler core can then be filled with water and tested by applying air pressure to the coolant outlet port as shown in Figure 51. When using this technique, the cooler must be tested in the upright position.

To ease the installation of the test plug, coat the inside of the hose with a suitable O-ring lubricant.

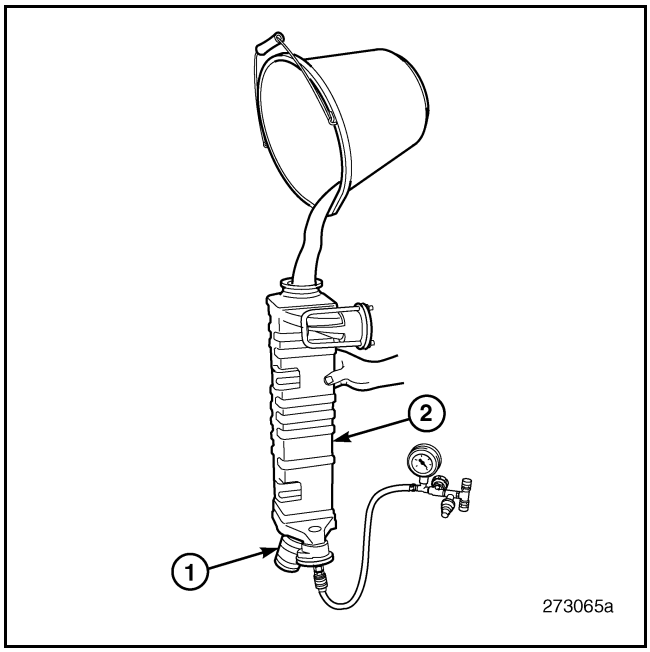


Figure 51 — Test with EGR Gas Outlet Port Plugged

1. Test Plug, 88800216-5	2. EGR Cooler

5. Apply air pressure (240 kPa [35 psi]) to the EGR cooler. Maintain the pressure for 15 minutes. If the EGR cooler is leaking internally, there will be a steady stream of bubbles coming from the gas inlet or outlet openings. If a steady stream of bubbles appears, replace the EGR cooler.

NOTE

If the cooler is being tested without being immersed in water, look inside the gas inlet port. If bubbles are seen, the cooler is leaking internally and must be replaced.

NOTE

A stream of bubbles seen coming from around the plugs in either of the coolant ports indicates that the O-rings may be damaged. If this is the case, remove the plugs, inspect the O-rings and replace as required.

6. Lift the EGR cooler out of the container and remove the pressure testing equipment.
7. Dump the water from inside the EGR cooler and then use compressed air to remove any remaining water from the cooler core and outer cover.

Engine Compression, Test (on Vehicle)

Verify suspected leaks in the cylinder head or block by pressure testing before replacing these. Do not use Magnaflux® inspections alone as replacement criteria.

Before proceeding with the tests, look for coolant stains around the sealing plugs on the cylinder head. Check that the plugs are installed properly and in good condition.

1. Remove the cylinder head (valve) cover.

⚠ CAUTION

On engines fitted with PowerLeash™, secure the pistons in the rocker arms with rubber bands or tie straps so the pistons do not drop out when the rocker assembly is lifted. Pistons and rockers are matched together. Failure to heed this caution may result in severe component damage.

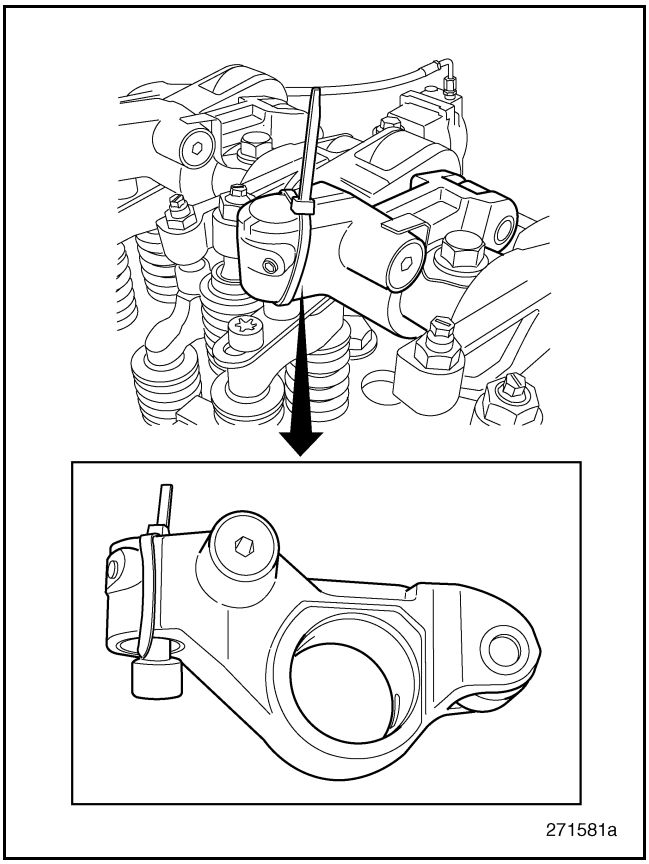


Figure 52 — Tie Strap Holding Engine Brake Piston (MP7 Shown)

2. Remove the PowerLeash™ (engine brake) control valve if so equipped.

⚠ CAUTION

It is very important to loosen the rocker arm shaft assembly uniformly across the complete shaft. Loosening the rocker shaft assembly unevenly can cause damage.

3. Install the appropriate lifting tool, 85109050 (MP7), 85109250 (MP8) or 85109035 (MP10), on the rocker arm assembly. Loosen the rocker arm shaft uniformly across the complete shaft. Remove the rocker arm assembly.
4. Remove the unit injectors and clean the copper sleeves if necessary.
5. Install an adapter, J 47363, in each of the unit injector ports.
6. Refit the rocker arm assembly to the engine.
7. Install the PowerLeash™ control valve and oil tube between the valve and the rocker arm shaft as follows:
   - Lubricate and assemble the seals on each end of the oil tube.
   - Insert the larger end of the oil tube in the rocker shaft.
   - Make sure the oil seal is in place at the bottom of the valve assembly.
   - Position the valve assembly on the mounting plate and insert the free end of the oil tube.
   - Using a torque wrench, tighten the attaching screws according to specification.

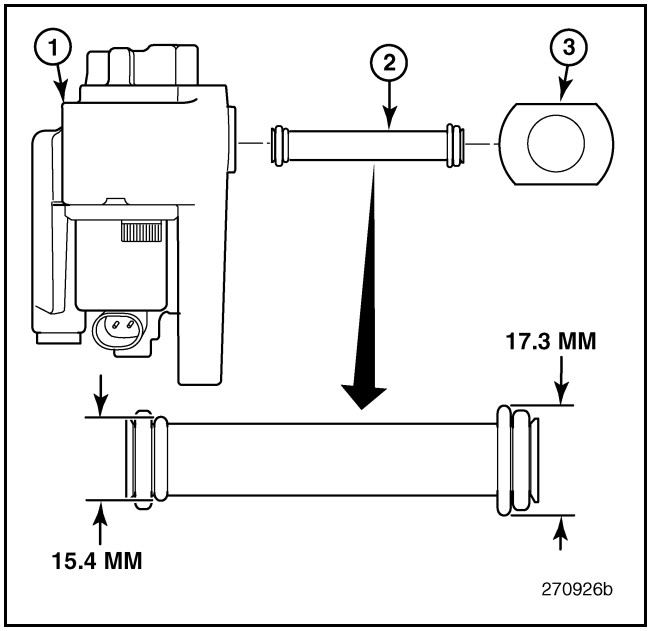


Figure 53 — Engine Brake Control Valve Oil Tube Orientation (MP7 Only)

1. Control Valve 2. Oil Tube	3. Rocker Arm Shaft

8. Connect a remote starter switch to the starter.

⚠ CAUTION

Do not run the starter motor for longer than 15 seconds at a time. Wait 60 seconds before trying again.

9. Connect the compression gauge, J 6692-B, to the adapter on the first cylinder. Crank the engine with the remote starter switch until the needle on the compression gauge stops moving (maximum compression). Record and repeat for all remaining cylinders.
10. Remove the screws for the PowerLeash™ control valve.
11. Remove the control valve and the oil tube between the valve and the rocker arm shaft.
12. Install the lifting tool, 85109050 (MP7), 85109250 (MP8) or 85109035 (MP10), on the rocker arm assembly. Loosen the rocker arm shaft uniformly across the complete shaft. Remove the rocker arm shaft assembly.
13. Remove the J 47363 adapters from all of the cylinders.
14. Install the unit injectors using **new** O-rings and **new** sealing washers.
15. Connect the wiring harness to the unit injectors.
16. Carefully lower the rocker arm shaft assembly onto the head.
17. Remove the lifting tool from the rocker arm shaft.

⚠ CAUTION

It is very important to tighten the rocker arm shaft assembly uniformly across the complete shaft. Tightening unevenly can cause damage to the rocker arm shaft assembly.

18. Tighten the rocker arm shaft screws in the sequence specified.
19. Install the PowerLeash™ control valve and oil tube between the valve and the rocker arm shaft making sure the sealing rings are correctly positioned before tightening the screws.

⚠ CAUTION

If the oil tube is installed incorrectly with the large end in the control valve and the small end in the rocker arm shaft, oil leaks will occur. This may cause oil starvation in the rocker arms which can result in engine failure.

20. Tighten the control valve screws according to specification and then connect the wiring harness to the valve assembly.
21. Adjust the valve and the unit injector rockers.
22. Install the cylinder head cover.
23. Bleed the fuel system.

Flywheel Housing Runout, Check (Clutch Removed)

CHECKING AXIAL AND RADIAL RUNOUT

1. Clean the flywheel and flywheel housing.
2. Remove the plug from the flywheel housing and install the appropriate flywheel turning tool, 9996956 (MP7) or 88800014 (MP8, MP10).

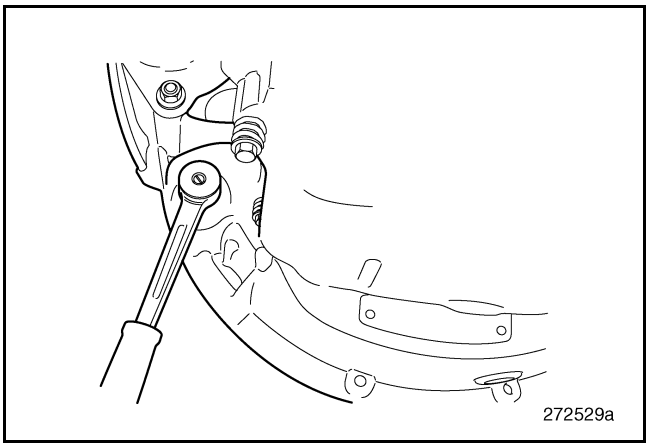


Figure 54 — Turning Flywheel (MP8 Shown, Typical)

3. To check **axial runout**, attach the dial gauge to the flywheel using the magnetic base and position its tip against the outer flange (transmission mounting surface) of the flywheel housing. Set the dial gauge to zero.
4. Rotate the flywheel and note the indicated runout at a minimum of four locations around the outer flange of the housing. Compare the noted runout with the specified axial runout tolerance.

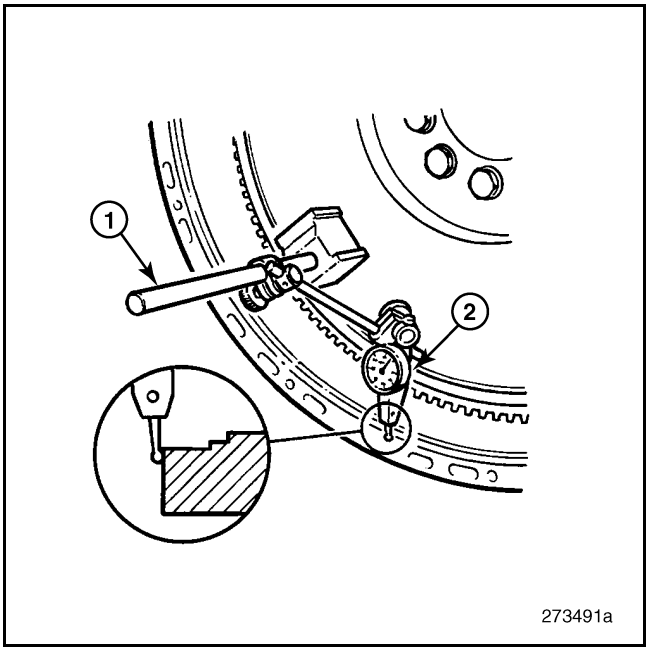


Figure 55 — Checking Axial Runout

1. Magnetic Stand, 9999696	2. Sweep Dial Indicator, 9999683

5. To check **radial runout**, position the tip of the dial gauge against the inner flange of the flywheel housing. Rotate the flywheel and note the indicated runout, again at a minimum of four locations around the inner flange of the housing. Compare the noted runout with the specified radial runout tolerance.

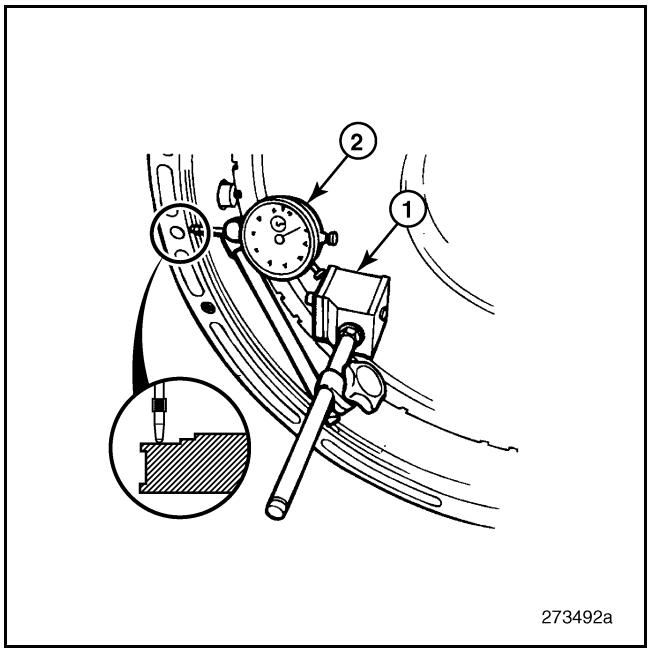


Figure 56 — Checking Radial Runout

1. Dial Gauge, 9989876	2. Magnetic Stand, 9999696

6. If the runout values are out of specification, check the mating surface for the flywheel housing against the engine block and the mating surface for the flywheel on the crankshaft. Do this before replacing the flywheel housing.
7. Remove the flywheel turning tool and reinstall the plug in the flywheel housing.

Oil Cooler, Pressure Test

1. Clean the coolant side of the oil cooler with a water-soluble degreasing fluid. Flush the oil side of the cooler with degreasing solvent.
2. Install the clamp tools, 9996845, making sure they are properly seated.

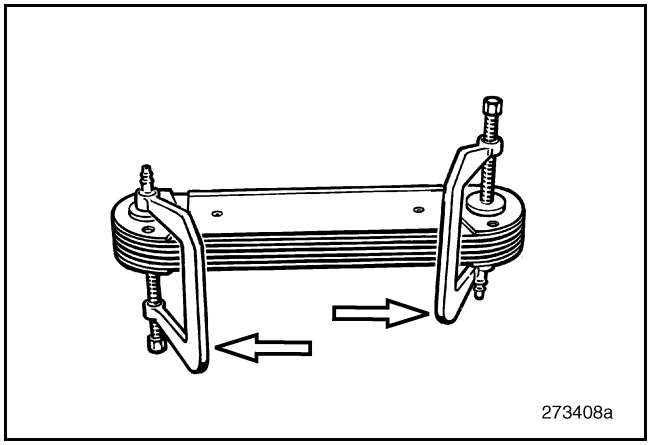


Figure 57 — Clamp Tools, Installed

3. Adjust the pressure gauge reduction valve knob until the pressure gauge needle is at zero.
4. Connect the pressure gauge assembly to the fitting on the clamp. Lower the oil cooler into a bath of water. The water temperature should be at approximately 70°C (160°F).

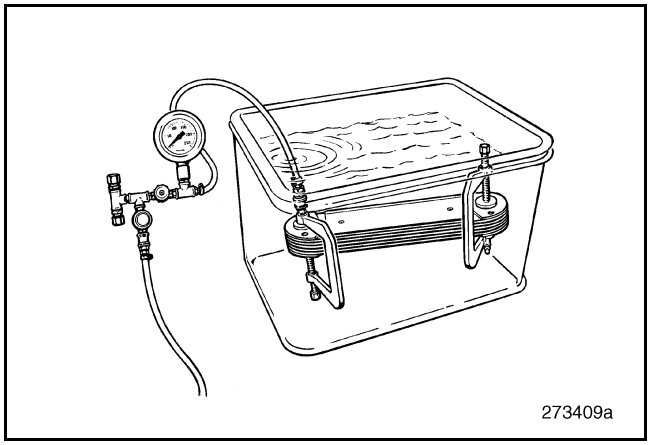


Figure 58 — Testing Oil Cooler

5. Increase the pressure to 250 kPa (35 psi) using the reduction valve knob and check for air bubbles emerging from the oil cooler. The test period should last for at least one minute.

NOTE

Air bubbles emerging from the oil cooler indicate a leak. The oil cooler should be replaced.

Rocker Arm, Check

NOTE

Make sure there is clearance between the rocker arm rollers and the camshaft when performing the following rocker arm bushing and roller bushing checks.

ROCKER ARM BUSHINGS

1. Install the appropriate flywheel turning tool, 9996956 (MP7) or 88800014 (MP8 and MP10), and turn the engine until the camshaft is in a position where the rocker arm roller being checked is on the base circle of the camshaft lobe. Make sure that there is clearance between the roller and camshaft.

NOTE

To check the injector, the rocker arm roller must be on the base circle of the camshaft lobe and the injector adjusting screw backed off (preload must be readjusted).

2. Position the magnetic stand, 9999696, and dial indicator, 9989876, so that the tip of the indicator is on top of the rocker arm above the middle of the rocker arm shaft bushing area.

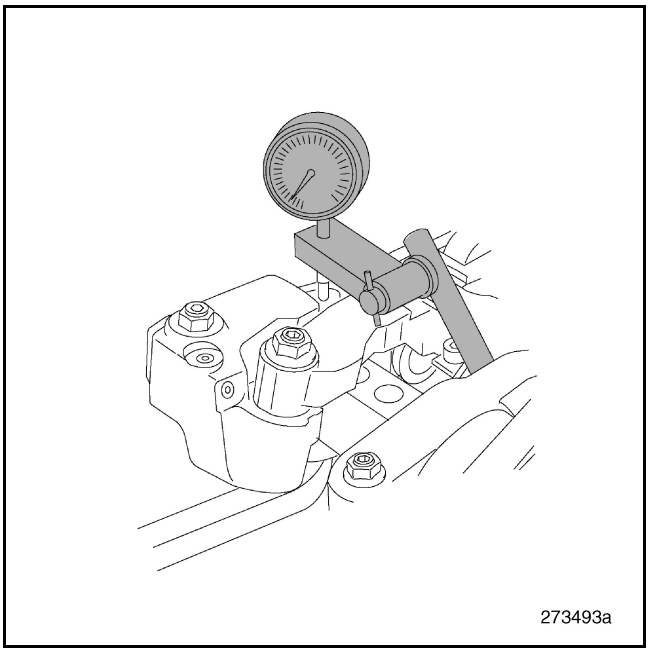


Figure 59 — Dial Indicator Positioning

3. Push down on the rocker arm so that any oil film is forced out of the upper side of the rocker arm shaft.
4. Set the dial indicator to zero.
5. Position a pry bar directly under the rocker arm in the shaft area. Pry the rocker arm up and note the reading on the dial indicator. The maximum clearance allowed between the rocker arm and shaft is 0.1 mm (0.0039 inch). If the clearance is greater, replace the rocker arm and check the shaft for wear.

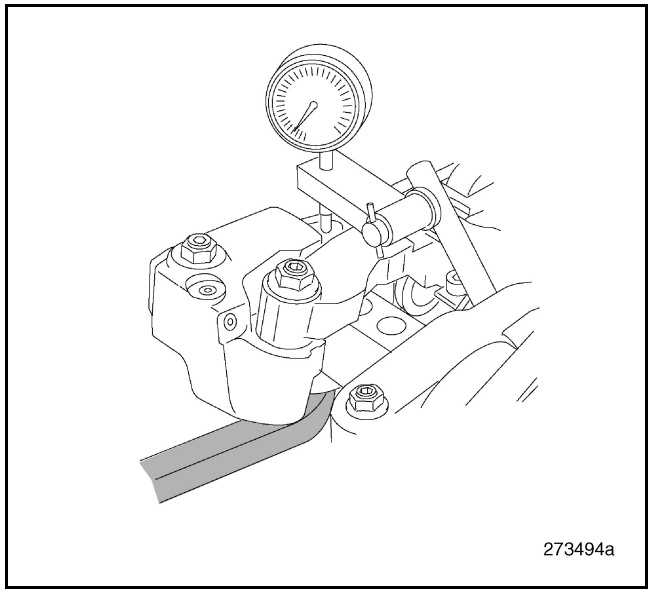


Figure 60 — Prying Rocker Arm Up

6. Repeat the check on all other rocker arm bushings.

ROCKER ARM ROLLER BUSHINGS

1. Using the flywheel turning tool, 9996956 (MP7) or 88800014 (MP8 and MP10), turn the engine until the camshaft is in a position where the rocker arm roller being checked is on the base circle of the camshaft lobe.
2. Make sure there is clearance between the rocker arm roller and the camshaft lobe.

NOTE

To check the injector, the rocker arm roller must be on the base circle of the camshaft lobe and the injector adjusting screw backed off (preload must be readjusted).

3. Rotate the roller a few turns so that the oil film between the roller bushing and shaft is forced out. If the roller jams, is sticky or rough, the rocker arm should be replaced.

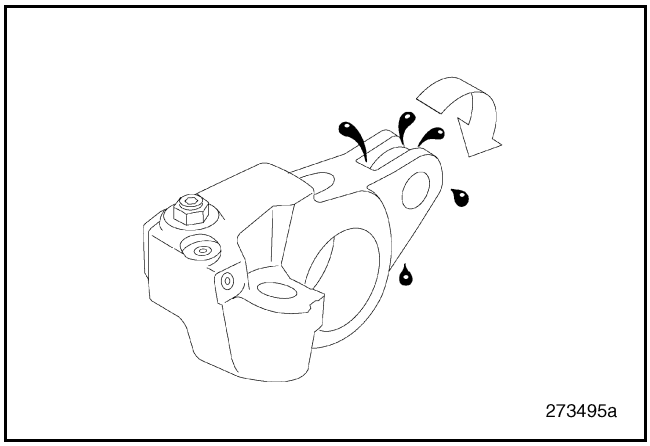


Figure 61 — Forcing Oil from Roller

4. Place the dial indicator, 9989876, into the magnetic stand, 9999696, and position the magnetic stand as level as possible on the rocker arm.

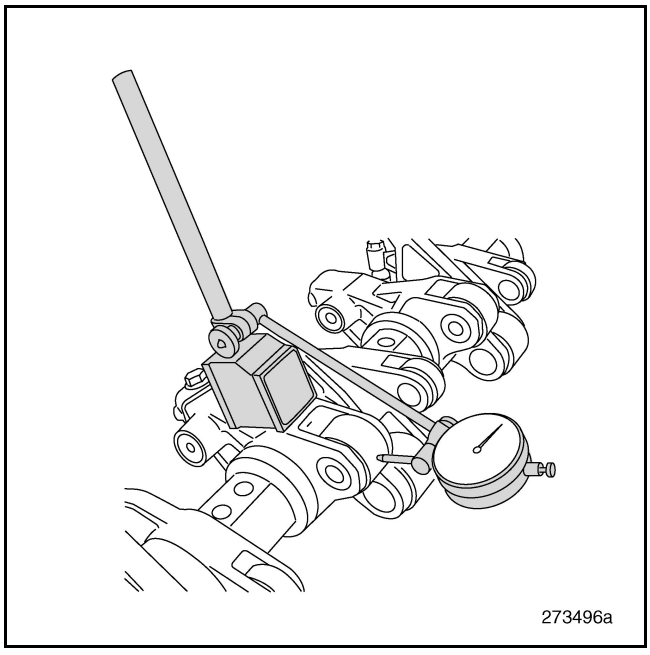


Figure 62 — Dial Indicator Positioning

5. Adjust the tip of the dial indicator so that it is horizontal to the center of the roller. Zero the dial indicator.

NOTE

Check that the tip of the dial indicator is pre-tensioned and can move in both directions.

6. Place a screwdriver between the rocker arm and the roller. Carefully pry the roller out as far as possible and note the value on the dial indicator.

⚠ CAUTION

Use care when prying or pressing on the roller to avoid damage to the surface of the roller.

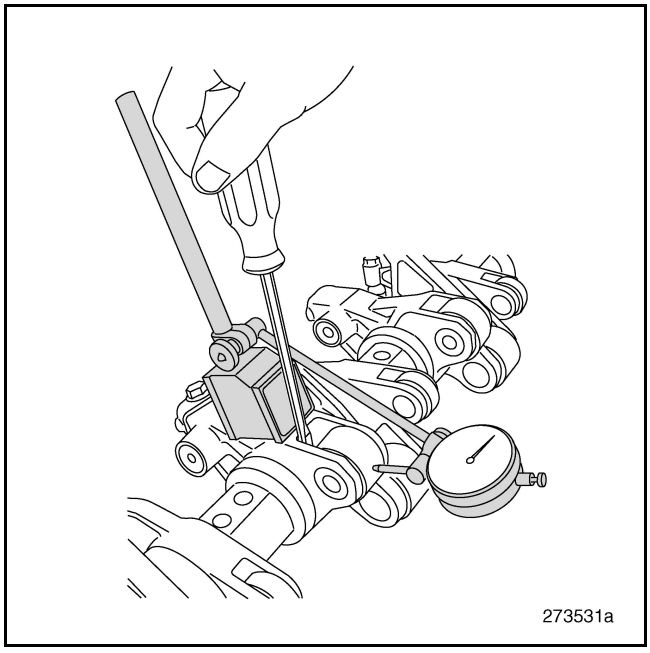


Figure 63 — Prying Roller Out

7. Using a blunt object, press the roller in as far as possible. Note the reading on the dial indicator. The maximum clearance allowed between the roller bushing and shaft is 0.1 mm (0.0039 inch). If the clearance is greater than this, replace the rocker arm.

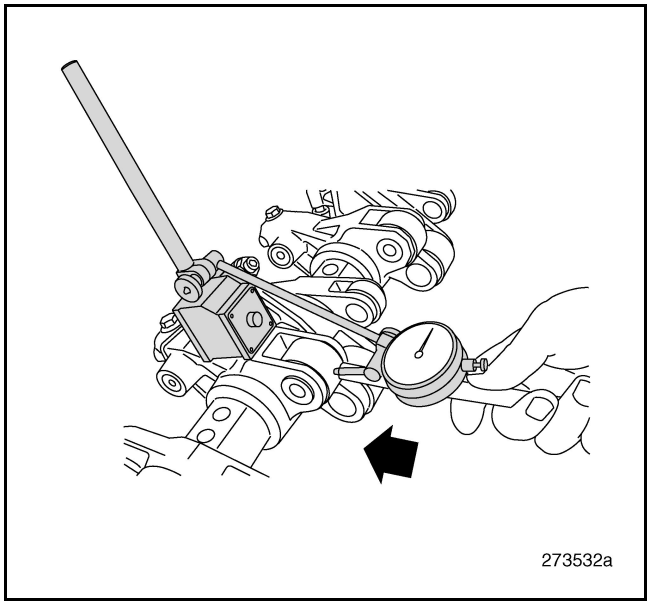


Figure 64 — Pressing Roller In

8. When replacing a rocker arm, lubricate the **new** rocker arm roller bushing with clean engine oil. Use an oil can and insert the nozzle into the oil channel passage. Rotate the roller while lubricating and check that oil comes out on both sides of the roller.

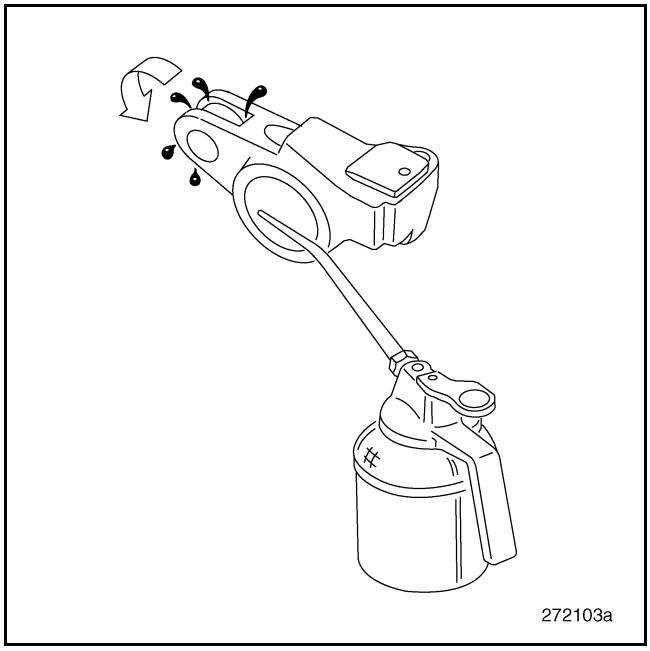


Figure 65 — Lubricating Rocker

9. Repeat the check on all other rocker arm roller bushings as necessary.

Thermostat, Check

With the thermostat removed from the engine, check its operation as follows:

1. Check to be sure that the thermostat closes fully. This can be done by holding it up to the light to verify that there is no visible gap at the opening point. If the thermostat does not close properly, replace it.
2. Add water to a suitable container and warm the water to 75°C (167°F). With the water warmed, immerse the thermostat in the water. Use a piece of wire attached to the thermostat.

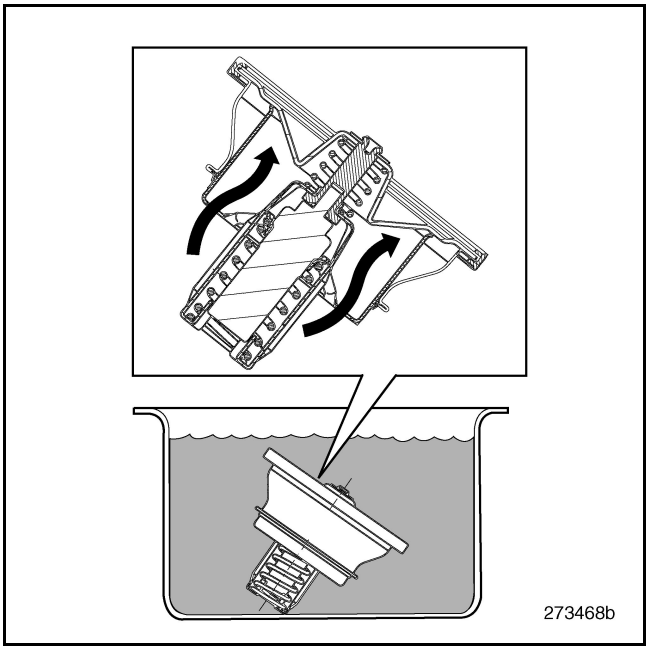


Figure 66 — Thermostat Closed

3. After at least 30 seconds, check that the thermostat is still closed.

4. Now warm the water to 100°C (212°F). After at least 30 seconds at the boiling point, check that the thermostat has opened approximately 16 mm (0.63 inch). If the thermostat has not opened, it must be replaced. A good thermostat starts to close at approximately 92°C (198°F) and is fully closed at approximately 82°C (180°F).

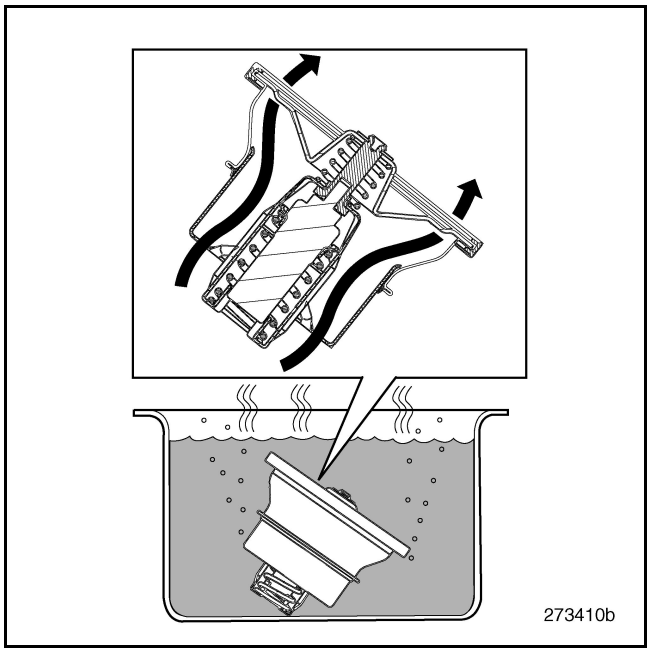


Figure 67 — Thermostat Open

Valve Guide Wear, Check

WEAR CHECK

1. Remove the oil seals from the valve guides.
2. Mount the cylinder head on a suitable engine stand using the cylinder head adapter plate J 47364.
3. Install a **new** valve into the guide so that the end of the valve stem is even with the valve guide edge.
4. Using the dial indicator 9989876 and holder 9999696, place the tip of the dial indicator against the edge of the valve disc. Move the valve back and forth laterally in the direction of the intake/exhaust ports. Note the measured value and compare it with the acceptable wear limit specified for the engine.

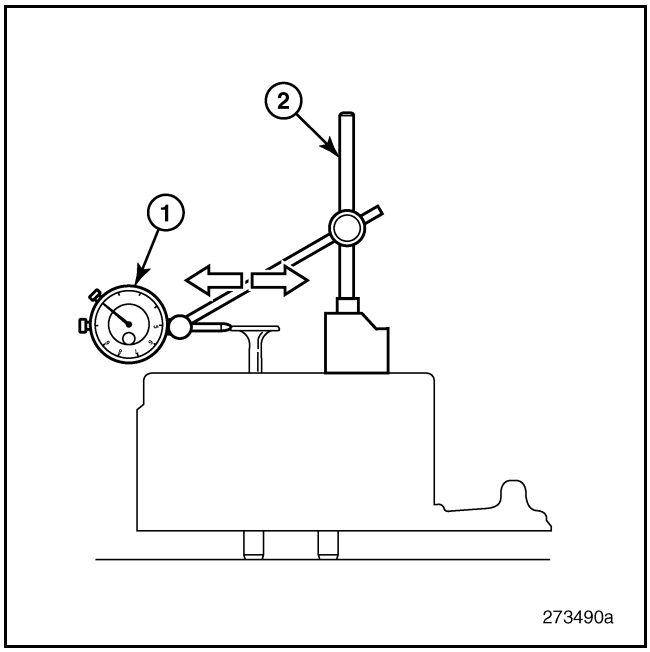


Figure 68 — Measuring Valve Guide Wear

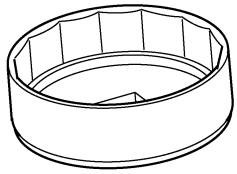
1. Dial Indicator, 9989876	2. Magnetic Stand, 9999696

5. Repeat Step 4 to check all valve guides. Replace the valve guides if the measured values exceed the acceptable wear limit.

MAINTENANCE

LUBRICATION SYSTEM MAINTENANCE

Special Tool

Tool No.	Description	Image
9998487	Oil Filter Wrench (Available)	 006845a

Oil Level Check

When checking oil levels, the vehicle must be parked on level ground. Components must be filled to the correct level. DO NOT OVERFILL.

The best time to check oil level is while the engine is COLD (prior to starting at the beginning of the work day, or after the vehicle has sat approximately 2 hours). At normal operating temperature (engine oil temperature above 80°C [175°F]), oil level can be checked 15 minutes after shut down.

⚠ CAUTION

Failure to wait a sufficient amount of time (2 hours if engine oil temperature is below 80°C [175°F]) or 15 minutes if oil temperature is above 80°C [175°F]) will result in an inaccurate dipstick reading.

For accurate oil level readings, the dipstick must be inserted fully into the dipstick tube. The level must be close to the FULL line (at least between the LOW and FULL lines) on the dipstick, but must NOT exceed the FULL line.

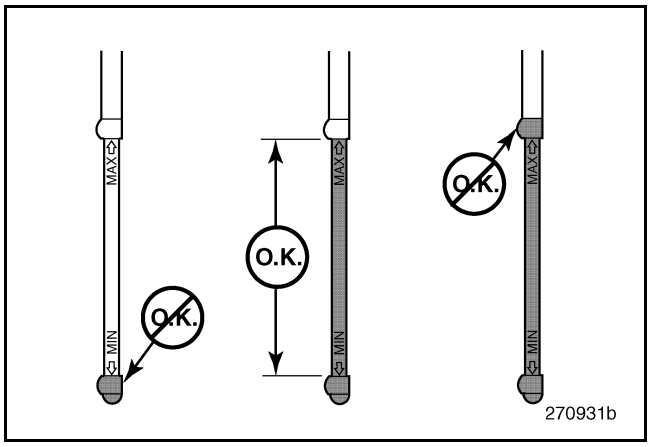


Figure 69 — Oil Level Check

Oil and Filter Change Procedure [219 EV]

This engine is equipped with improved spin-on type oil filters.

DISPOSABLE SPIN-ON OIL FILTER REPLACEMENT

Change oil and replace oil filters using the following procedure:

1. Run the engine until normal operating temperature is reached. Then, shut off the engine and drain the oil before the engine cools.
2. Thoroughly clean the area around the filters before removing.
3. Using filter wrench 9998487 or equivalent, remove the spin-on filters and wipe the filter mounting base clean.
4. Fill each filter with 1.9 liters (2 quarts) of the specified engine oil. DO NOT allow any contaminants to enter the filters while filling.
5. Apply a film of clean engine oil to the sealing gasket on each new filter.
6. Install the filters and tighten 3/4 to 1 turn after the gasket contacts the base.
7. Fill the crankcase with the recommended engine oil. If the engine is equipped with a REPTO unit, add one additional quart.
8. Start the engine and check for leaks. Run the engine for approximately five minutes, then shut it off and recheck the oil level. Add oil if necessary.

NOTE

Use of anything other than genuine MACK filters may cause damage and void the engine warranty. Change filters according to the recommended maintenance schedule.

Crankcase Ventilation System

The crankcase ventilation (CCV) system separator is not repairable. If there is apparently faulty operation, perform these inspections before replacing the separator.

1. Inspect the separator inlet hose and connectors at the valve cover and at the separator. Remove any obstruction, oil film, residue and particles.
2. Inspect the separator outlet hose and connector. Remove any obstruction, oil film, residue and particles.
3. Remove the separator and attempt to turn the turbine manually. If it does not turn easily, replace the separator.
4. If the turbine turns easily, inspect and clean the oil jet nozzle.
5. Reassemble the separator and the hoses.
6. If faulty operation continues, continue fault tracing with Guided Diagnostics.

FUEL FILTER REPLACEMENT

Fuel Filter Change

[231 BA]

FILTER DESCRIPTION

Two filters ensure that clean, waterless fuel reaches the electronic unit injectors. One is a full-flow filter, the other is a water separating pre-filter with a transparent cup to collect and drain the water. A water-in-fuel sensor informs the driver of excessive accumulation in the cup. The water separating pre-filter is in the “suction side” of the fuel circuit. It is a spin-on type with one end of its casing threaded to receive the cup.

The full-flow main filter is on the “pressure side” of the circuit. It is also an easily replaced spin-on filter. The casing completely encloses the filter element. This filter is rated at 3–5 microns.

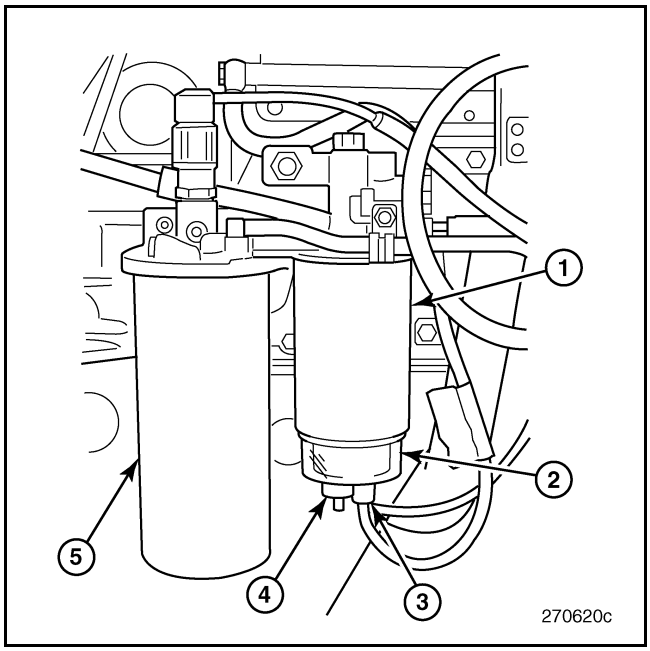


Figure 70 — Fuel Filters

1. Water Separating Pre-Filter 2. Water Separator Bowl 3. Water-in-Fuel Sensor Harness	4. Drain Assembly 5. Full-Flow Main Filter

FUEL FILTER REPLACEMENT

NOTE

Because of ice buildup or fuel waxing which can clog fuel filters, it may be necessary during extremely cold weather to reduce the time or mileage interval between fuel filter changes.

Be careful to prevent foreign matter of any kind from entering the filters during service.

Install **new** fuel filters dry.

Water Separating Pre-Filter Replacement

To replace the water separating pre-filter:

1. Disconnect the electrical cable.
2. Make sure the filter casing is thoroughly cleaned. If not already done, wash the area around the filter mounting adapter with a suitable solvent and blow dry with compressed air.
3. With a suitable container in place to collect spillage, open the fitting and drain the filter.
4. Unscrew and remove the water cup.
5. Using a filter wrench, remove the filter from the mounting bracket and discard it safely.
6. Apply a thin film of clean engine oil to the sealing gasket of the new filter.
7. Screw the **new** dry filter in place and tighten an additional 3/4 to 1 turn by hand after the gasket contacts the base.

NOTE

After filter installation, operate the hand primer to fill the fuel filters before attempting to start the engine.

8. Screw the water cup into the filter casing.

NOTE

There is a new-style pre-filter with a stepped-down diameter at the bottom of the filter. The earlier-style filter has straight sides with a larger bottom diameter which requires an adapter to attach the fuel/water separator bowl to the filter. When replacing the previous straight-sided filter with the current stepped-down version, the adapter is not used. However, do not discard the adapter as it can be used should inventory of the earlier-style filter still be available.

9. If necessary, replace the full-flow main filter. See the following instructions.
10. Connect the electrical cable.
11. Start the engine and run at idle for five minutes to fill the filter with fuel.
12. Check for leaks.

Full-Flow Main Filter Replacement

To replace the full-flow main filter:

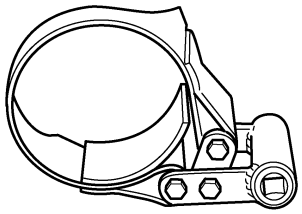
1. Make sure the filter casing is thoroughly cleaned. If not already done, wash the area around the filter mounting adapter with a suitable solvent and blow dry with compressed air.
2. Put a suitable container in place to collect spillage.
3. Using a filter wrench, remove the filter casing from the mounting bracket and discard it.
4. Apply a thin film of clean engine oil to the sealing gasket of the new filter.
5. Screw the **new** dry filter in place and tighten an additional 3/4 to 1 turn by hand after the gasket contacts the base.
6. If necessary, replace the water separating pre-filter. See the preceding instructions.
7. Start the engine and run at idle for five minutes to fill the filter with fuel.
8. Check for leaks.

⚠ CAUTION

Severe engine damage may be caused by attempting to prime the fuel system using an auxiliary pump or by applying air pressure in the fuel tank. These techniques may destroy seals that prevent fuel from leaking into the crankcase.

COOLING SYSTEM MAINTENANCE

Special Tool

Tool No.	Description	Image
J 48061	Coolant Filter Wrench (Available)	 006807a

Coolant Drain Outlets

Extra outlets provide convenient drain sites for use during maintenance and other procedures involving coolant.

Coolant Filter

The coolant filter attaches to the back of the coolant pump housing. It resembles a spin-on oil filter. The filter element and casing are replaced as a unit.

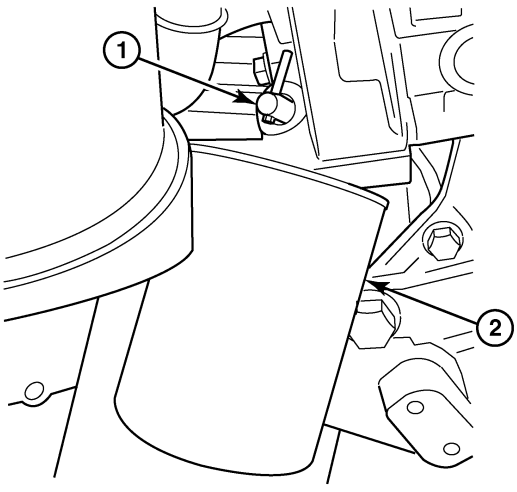


Figure 71 — Coolant Filter

1. Shut-Off Valve	2. Coolant Filter

NOTE

For Australia, engines are not equipped with the coolant filter. VCS coolant is used to protect the cooling system.

REMOVE AND REPLACE

1. Close the shut-off valve on the coolant pump housing.

NOTE

In the closed position, the pin on the shut-off valve should be horizontal.

2. Place a suitable container below the filter to collect spilled coolant.
3. Using filter wrench J 48061 or equivalent, unscrew the filter and discard it safely.
4. Apply a light film of coolant on the face of the **new** filter gasket.
5. Screw the **new** filter on the threaded nipple extending from the mounting flange.
6. Using the filter wrench, tighten the filter one full turn after the gasket contacts the base.
7. Open the shut-off valve on the coolant pump housing.
8. Check for any coolant leaks.

DRIVE BELT REPLACEMENT AND TENSIONING [216 AA]

General Information

The service life of the multi-groove belts is considerably improved over other systems and allows the use of higher horsepower cooling fans. All MP8 engines are equipped with multi-groove belt systems.

MP8 Engine

In the dual multi-groove drive belt arrangement, the fan drive and coolant pump are driven directly from the crankshaft pulley by a 10- or 12-rib multi-groove belt. The alternator and the air conditioning compressor (if equipped) are driven off the crankshaft pulley by a six-rib multi-groove belt (Figure 72). Two automatic tensioners are used, one for the fan drive and one for the accessory drive.

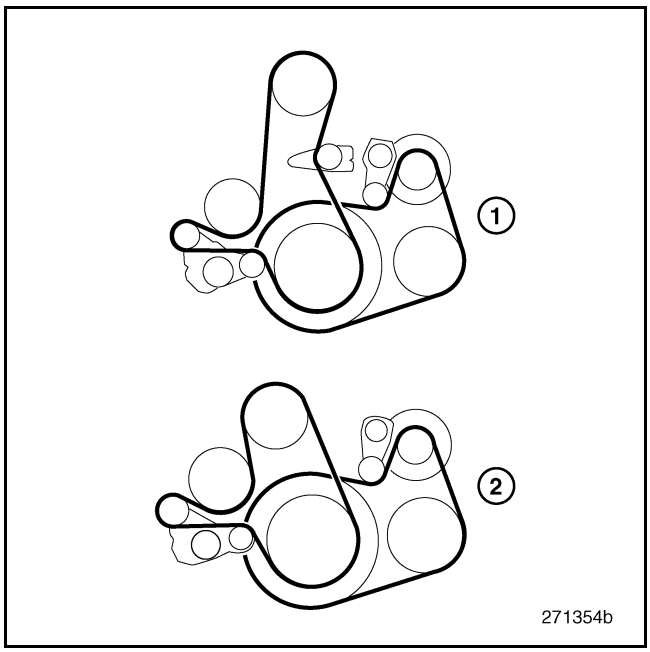


Figure 72 — Belt-Drive Arrangement

1. Conventional	2. LCF (N/A Australia)

The lower tensioner for the fan and coolant pump is mounted on the coolant pump housing. This tensioner applies its load *counterclockwise*. The upper tensioner for the alternator (and refrigerant compressor if so equipped) is mounted on the alternator bracket. The tensioner applies its load in a *counterclockwise* direction.

Automatically Tensioned System

INSTALLATION

Swing the tensioner to the fully sprung position and without force, using belt tensioner tool, J 44392, place the belt over the pulleys. Do not allow the tensioner to snap against its stops. Do not pry the belt over a pulley.

TENSIONING

No tensioning adjustment is required. Once the tensioner is released against the belt, the belt is tightened to optimum tension automatically at all speeds and loads.

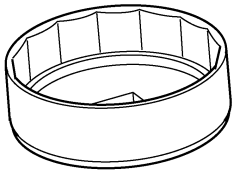
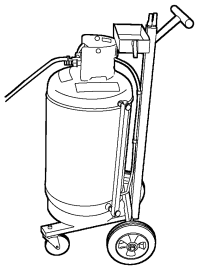
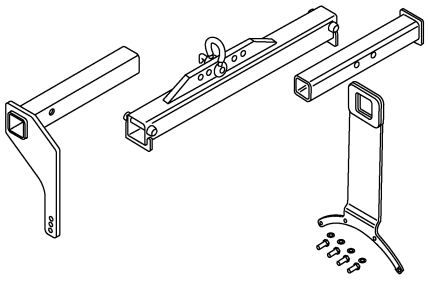
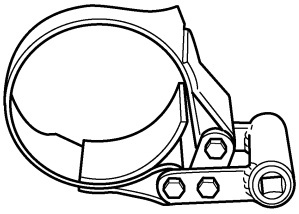
MAINTENANCE

The condition of the belt and tensioner should be checked when performing preventive maintenance inspections. Belt tension levels need not be checked as long as the tensioner is in good condition and there is no evidence of a loose belt.

REPAIR INSTRUCTIONS, PART 1

ENGINE REMOVAL

Special Tools

Tool No.	Description	Image
9998487	Oil Filter Wrench (Available)	 006845a
DBT2V700	Coolant Extractor/Injector	 006940a
J 47038-3 J 47038-4 J 47038-6 J 47038-8	Engine Lifting Tool Set	 006927b
J 48061	Coolant Conditioner Filter Wrench	 006807a

General Instructions

NOTE

Before removing the engine, make sure tools and equipment are inspected for safety and available for use.

NOTE

- It is good practice to steam clean the engine to remove road grime, grease and oil before starting work. Steam cleaning the engine and engine area allows more detailed inspection and improved workmanship.
- Prevent moisture from entering the air intake system. If moisture enters the system, make sure it is removed (dried) before the engine is reinstalled.
- Prevent the steam cleaning nozzle from spraying directly on any electronic components and connections.
- Avoid the use of any caustic or corrosive cleaning detergents.

1. Position the vehicle on a flat, level surface with ample work space around the vehicle.
2. Apply the parking brake and block the wheels to prevent the vehicle from moving. Observe all safety precautions.
3. Disconnect the battery negative (ground) cable.
4. Drain the air tanks.

Removal

1. Remove the hood. On cab over engine models, tilt the cab.
2. Place suitable containers beneath the engine and drain the oil and coolant. Open the coolant drain valves in the block and the radiator.

NOTE

If available, use the coolant extractor, DBT2V700, to remove coolant from the engine.

3. Using the oil filter wrench, 9998487 or equivalent, remove the oil filters.
4. Using a suitable filter wrench, remove the fuel filters.
5. Using the coolant filter wrench, J 48061 or equivalent, remove the coolant filter.
6. Disconnect the inlet air heater if present.
7. If the vehicle is equipped with air conditioning:
   a. Using A/C refrigerant recovery and recycling equipment, recover the refrigerant.
   b. Disconnect the A/C compressor discharge hose at the connection near the radiator support.
   c. Disconnect the A/C line at the receiver/dryer.
   d. Locate and disengage the electrical connector from the binary pressure switch on the receiver/dryer.
   e. Locate and disengage the electrical connector from the low-pressure cutout switch in the A/C refrigerant line.
8. Disconnect and remove the upper radiator tube from the engine.
9. Disconnect the cab heater and fuel heater coolant return lines from the radiator lower tube (if applicable).
10. Disconnect and remove the lower radiator tube.
11. Remove the charge air cooler inlet tube and hoses.
12. Remove the charge air cooler outlet tube and hoses.
13. Disconnect the radiator fan if electronically controlled.

NOTE

The radiator and intercooler assembly is heavy and difficult to handle. Provide a suitable lifting device and a helper to support it safely during removal.

14. Remove the radiator and charge air cooler assembly.

NOTE

The fan assembly is heavy and difficult to handle. Obtain assistance to support it safely during removal.

15. Remove the fan assembly.

NOTE

To prevent fluid leaking from the fan assembly, store it horizontally face down (hub flange up) or vertically as shown.

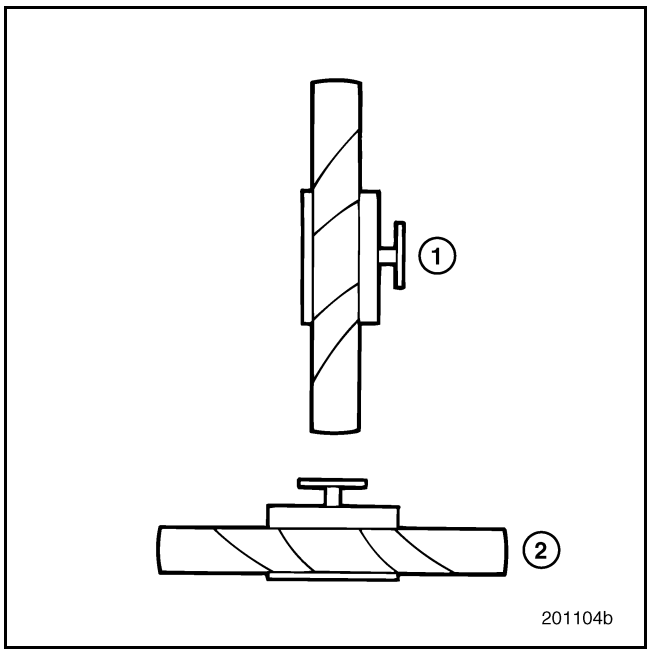


Figure 73 — Viscous Fan Drive Assembly Storage

1. OK to Store with Fan Blade in Vertical Position.	2. OK to Store with Fan Blade in Horizontal Position and Mounting Flange Up. Do Not Store with Mounting Flange Down.

16. If equipped, remove the exhaust bracket from the flywheel housing.

NOTE

Provide a container to collect power steering fluid.

17. Remove the power steering hoses.
18. Disconnect the exhaust system from the turbocharger.
19. Disconnect electrical cables or wires connected to the starter.
20. Disconnect or remove all other items attached to the frame or cab that would prevent engine removal, such as:
    a. Clutch linkage
    b. Ground straps
    c. Electrical wiring
    d. Coolant tubing
    e. Air lines
    f. Fuel lines
    g. Hydraulic hoses or tubing
21. Remove the valve cover.

⚠ CAUTION

Cover the valve mechanism and gear train with a suitable cloth or similar covering to prevent dirt and debris from entering the engine.

NOTE

Provide a transmission jack to support the transmission when disconnected from the engine.

22. With transmission jack in place, remove the screws attaching the transmission to the engine.
    a. If a manual transmission, make certain the clutch linkage and brackets have been removed.
    b. If an automatic transmission, make certain the torque converter access panel and the torque converter have been removed.

⚠ CAUTION

Obtain a helper and provide a lifting device, such as engine lifting tool, J 47038, to support the engine safely during removal.

23. Attach the engine lifting tool, J 47038, to the engine. Secure the engine lifting tool to the front of the cylinder head and to the rear at the flywheel housing.

⚠ DANGER

Ensure all bolts and pins in the lifting tool are correctly positioned prior to removing the engine from the chassis. Failure to properly install all bolts and pins of the engine lifting tool can result in personal injury or death.

24. Remove the screws that secure the rear engine support brackets to the frame brackets.
25. Remove the bolts that secure the front engine support to the frame crossmember.

⚠ CAUTION

While removing the engine, watch for obstructions that may interfere, such as engine and chassis components, brackets, clamps and other parts still attached to the engine. Failure to heed this caution may result in severe damage to the engine and other components.

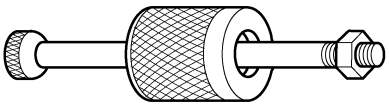
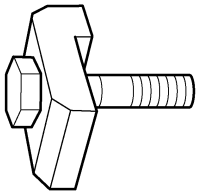
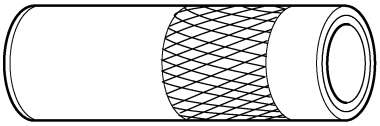
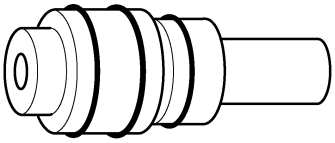
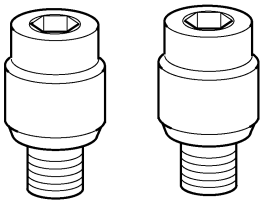
26. Using the lifting device and the aid of the helper, remove the engine from the vehicle.

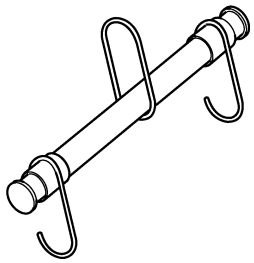
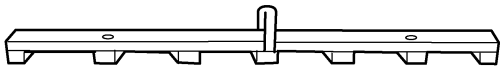
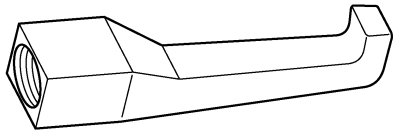
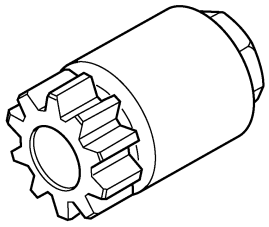
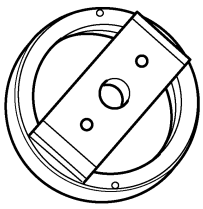
⚠ CAUTION

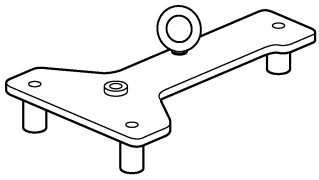
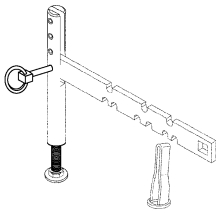
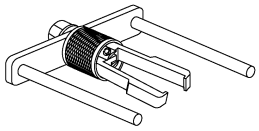
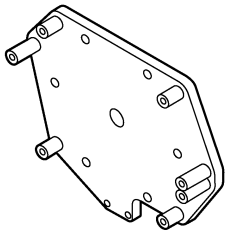
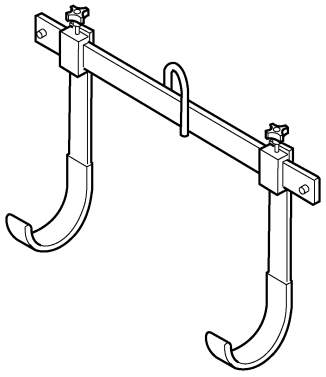
Before attempting to remove the cylinder head from the block, ensure that the screws holding the head against the timing gear mounting plate have been removed. Failure to heed this caution may result in severe damage to the engine and other components.

ENGINE DISASSEMBLY
MACK MP8 Euro 3 Engine
[200 EA]

Special Tools

Tool No.	Description	Image
9990013	Slide Hammer	 006779a
9991821	Slide Hammer for Pilot Bearing Removal and other various uses (Available)	006784a
9996966	Liner Hold-Down Tools (Essential)	 006796a
9998249	Unit Injector Protection Sleeves (Essential)	 006798a
9998251	Unit Injector Bore Sealing Plug (Essential)	 006800b
9998267	Dowels (Locating Tools for the Timing Gear Mounting Plate)	 006887a

Tool No.	Description	Image
9998511	Lever	007121a
85109034	Camshaft Lifting Bar (Essential)	 006835a
85109250	Rocker Shaft Assembly Lifting Tool (Essential)	 006770a
85109980	Cam Cap Removal Tool, use with slide hammer, 9990013	 006886a
88800014	Engine Barring Tool (Essential)	 271485a
88800021	Front Main Seal Remover/Installer (Essential)	 006774a

Tool No.	Description	Image
88800188	Cylinder Head Lifting Tool (Essential)	 006923a
J 41989-A	Valve Spring Compressor	 007122a
J 48922	Heavy-Duty Unit Injector Puller	 007000b
J 48662	Engine Stand Adapter Plate (Available)	 006925a
J 49002	Crankshaft Lifting Tool (Essential)	 007089a

General Instructions

[210 EN]

This section includes step-by-step procedures for disassembly of the engine. After cleaning components, store them where they will remain clean until needed for reassembly.

The sequence in which components are removed from the engine may vary depending on the type of engine repair stand used. The repair stand identified for this procedure uses a mounting plate attached to the left side of the engine which requires the removal of certain left side components to provide space for attachment of the mounting plate. This must be done prior to mounting the engine on the repair stand.

⚠ W A R N I N G

Failure to follow the sequence of operations may result in damage to components or personal injury.

Mounting the Engine on a Repair Stand

[200 EB]

If the engine is to be mounted on a repair stand by means of a mounting plate attached to its left side, the mounting surfaces must be clear of obstruction.

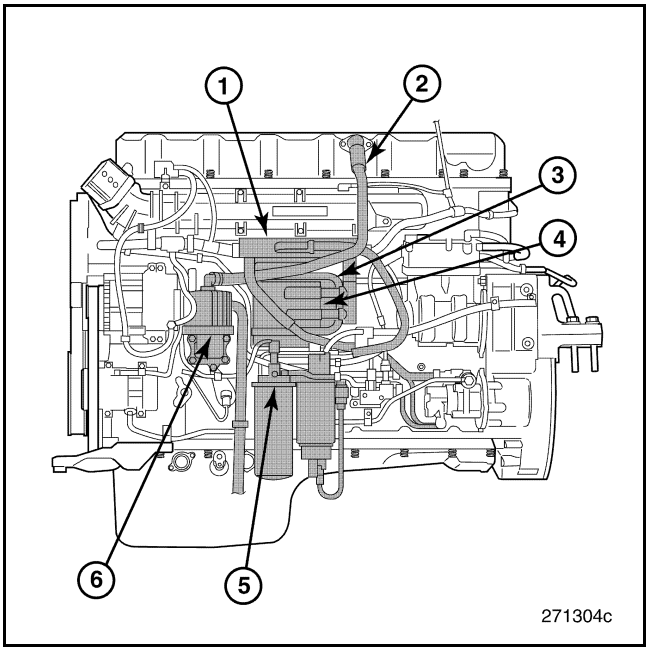


Figure 74 — Components to be Removed Before Mounting on a Repair Stand — Conventional Chassis, Typical

1. Wiring Harness Block 2. CCV Tubing 3. EECU Cooling Plate	4. EECU 5. Fuel Filter Housing Assembly 6. CCV Separator Assembly

In order to attach the mounting plate, J 48662, to the left side of the engine, the following components must also be removed if present.

1. Remove the dipstick and oil fill pipe.
2. Remove the crankcase ventilation (CCV) separator and tubing.
3. Tag the electrical connectors on the left side of the engine to facilitate reconnection upon reassembly.
4. Unlock and remove the harness end connectors attached to the EECU. Remove the screws from the harness retainer clamps. Then, push the connector locks inward and rotate outward to disconnect both wiring harnesses from the EECU.

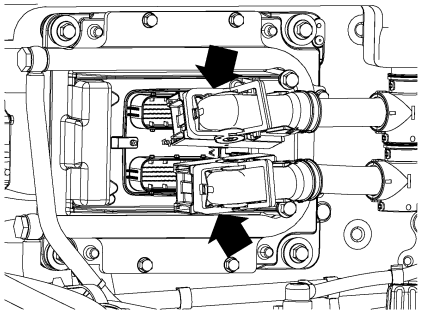


Figure 75 — EECU Harness Connectors

⚠ CAUTION

Use care to avoid damaging the terminal pins.

5. Unlock and separate the external wiring harness connectors at the various junctions and sensors.
6. Remove the clamps holding the harness to the cylinder block.
7. Remove the fasteners securing the wiring harness block to the cylinder block. Position the harness block and leads out-of-way.

NOTE

Provide suitable rags and containers for collecting fuel and coolant drainage at each of the following steps.

8. Loosen the fuel line banjo fittings. Remove the banjo fittings, clamps and the following fuel lines from the side of the engine.
   - Fuel return line — EECU cooling plate-to-filter valve housing
   - Fuel return line — cylinder head (at front)-to-filter valve housing
   - Fuel supply line — filter valve housing-to-cylinder head (at rear)
   - Fuel supply and return lines — fuel pump-to-filter valve housing
9. Remove the filter housing assembly.
10. Remove the cooling plate and the EECU from the cylinder block.
11. Attach the engine mounting plate, J 48662, to the left side of the engine.
12. Using a suitable hoist and the appropriate lifting device, attach the engine to the repair stand.

Cylinder Head (Valve) Cover Removal

[211 JB]

1. Remove the fasteners and remove the crankcase ventilation pipe.

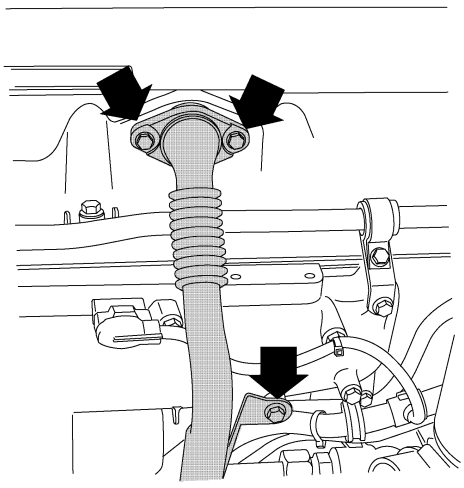


Figure 76 — Crankcase Ventilation Pipe

2. Remove and set aside the spring-loaded screws attaching the cylinder head (valve) cover to the cylinder head.

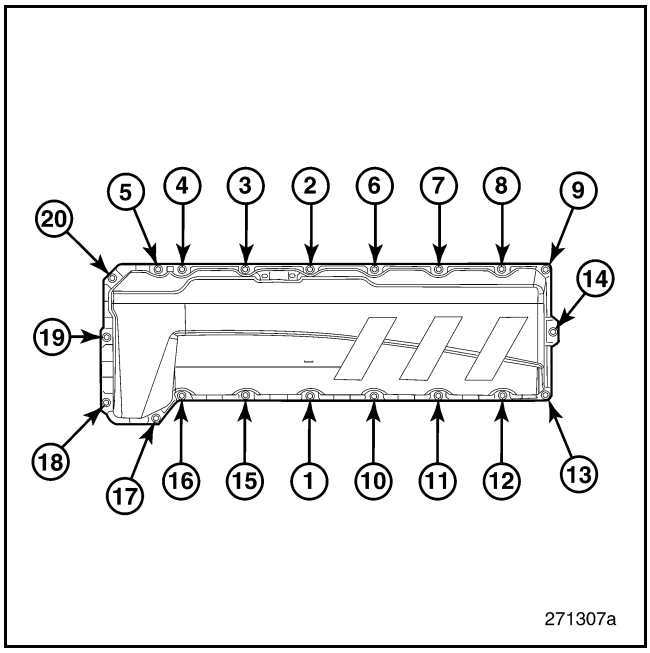


Figure 77 — Cylinder Head Cover

3. Remove the cover from the cylinder head.

Engine Wiring Harness Removal

[723 KA]

1. To facilitate connection at reassembly, tag all harness connectors to the various engine sensors and components prior to disconnecting them. Also, note the routing of the harness and leads for proper installation at reassembly.
2. If not already done, unlock and remove the harness end connectors attached to the EECU.
3. Unlock and separate the connectors at the various sensors, engine components and harness junctions.
4. Remove the clamps holding the harness to the cylinder head and block.
5. At the top of the cylinder head, disconnect the wiring harness at each unit injector.

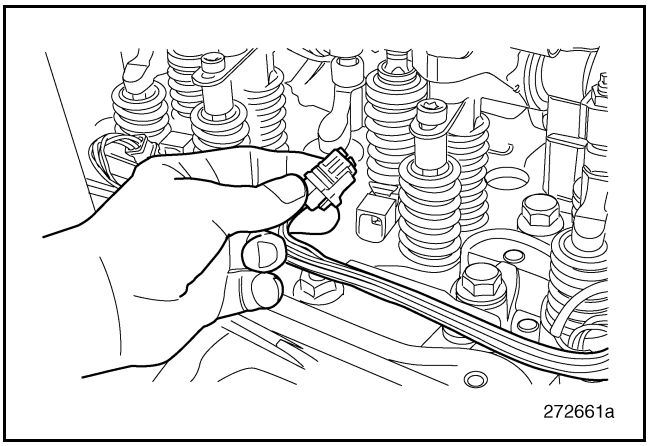


Figure 78 — Disconnecting Harness at Unit Injector

6. If so equipped, disconnect the harness from the engine brake control valve.

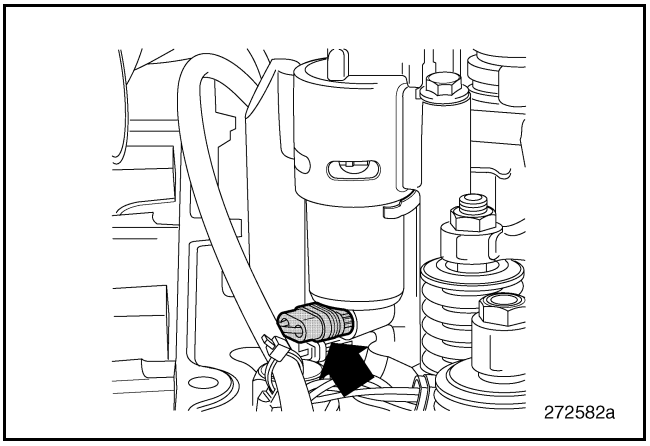


Figure 79 — Engine Brake Control Valve Terminal

7. Cut the cable ties holding the harness to the cylinder head and the engine brake control valve.
8. Carefully pull the harness through the hole at the front of the cylinder head and remove the harness from the engine.

Timing Gear Cover Removal

[211 AA]

1. Remove the mounting fastener and remove the camshaft position sensor from the timing gear cover.
2. Remove all straps, P-clamps and other retainers used to restrain harnesses, oil lines and coolant tubes to the rear of the engine. This will allow the support bracket at the rear of the engine to be removed.

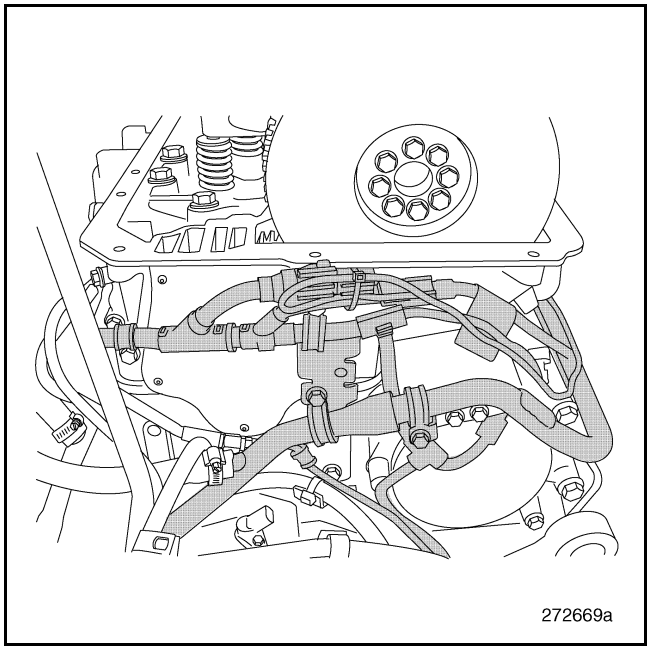


Figure 80 — Harness, Oil and Coolant Lines

3. Remove the support bracket fasteners and remove the rear support bracket.
4. Remove the screws attaching the timing gear cover to the timing gear mounting plate and cylinder head (Figure 81).

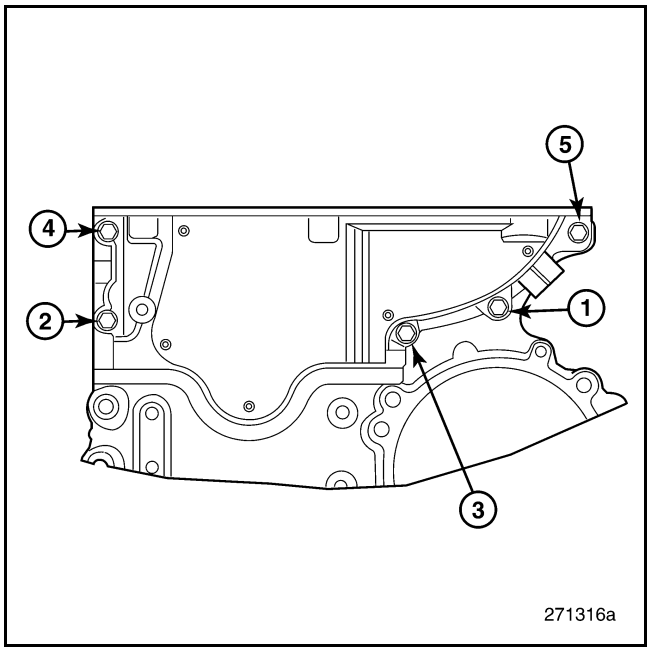


Figure 81 — Timing Gear Cover Fasteners Torque Sequence

5. Remove the cover from the engine.
6. Remove and discard the elastomer seals.

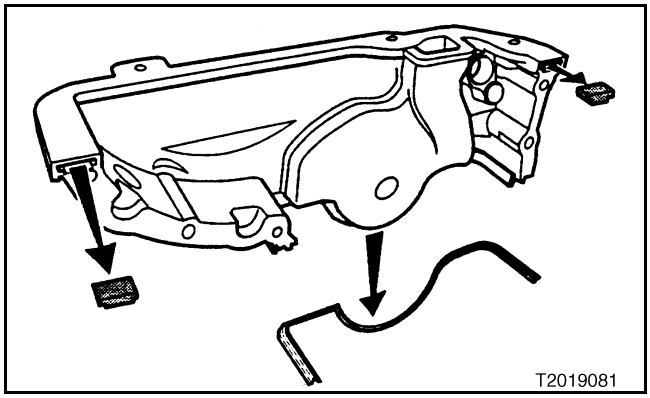


Figure 82 — Timing Gear Cover Seals

Camshaft Gear and Vibration Damper Removal

[213 DE]

NOTE

If the engine is not being completely disassembled for overhaul and only the camshaft is to be removed, crank the engine manually (using the engine turning tool, 88800014) so that the camshaft is positioned at top dead center (TDC) by aligning the TDC mark on the camshaft with the timing marks on the No. 1 camshaft bearing cap (Figure 83).

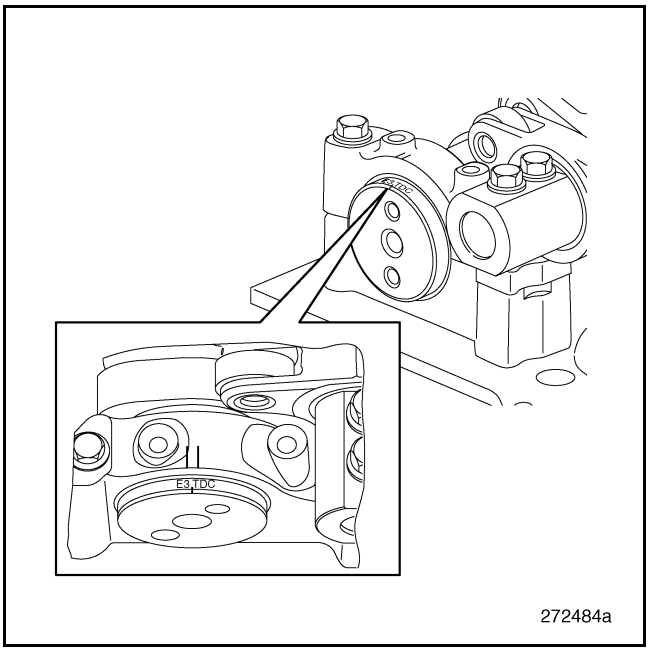


Figure 83 — Camshaft Timing Marks

1. Remove the fasteners securing the vibration damper and camshaft gear to the camshaft.
2. Remove the vibration damper from the camshaft gear.
3. Remove the gear from the camshaft.

Rocker Arm Shaft Removal

[213 LP]

⚠ CAUTION

On engines fitted with the engine brake, use rubber bands to contain the pistons within the rockers. The match between these pistons and their rockers must be maintained.

If the rocker shaft is to be disassembled, the order of rocker arm assembly must be maintained. Make certain the sets are kept together. Make certain the rocker arms are identified so they can be returned to their original positions on the shaft.

Failure to heed this caution may result in severe engine damage.

1. Remove the engine brake oil control valve or oil flow adapter (if so equipped) from the engine.

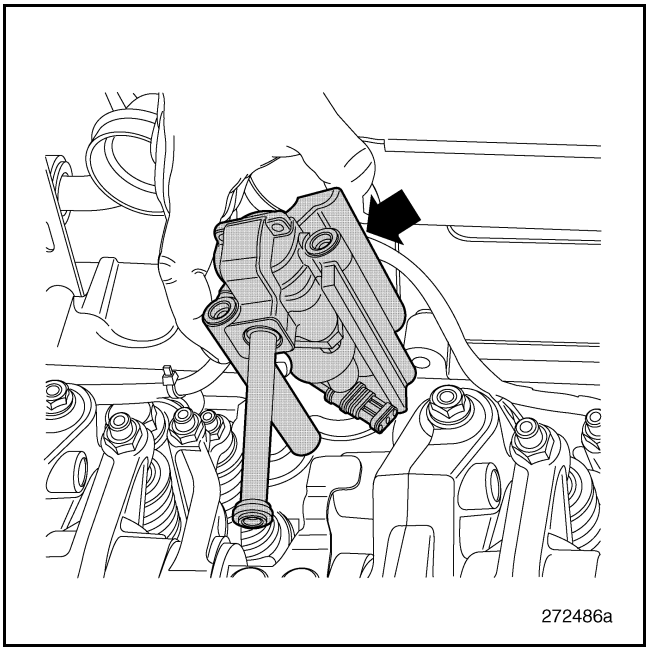


Figure 84 — Removing Engine Brake Oil Control Valve

NOTE

On engines without the engine brake, an oil flow adapter is used in place of the oil control valve. It is mounted in the same location on the cylinder head and provides oil to the rocker shaft.

2. Remove the screws and six engine brake plate springs (if so equipped) attached to the camshaft bearing caps.

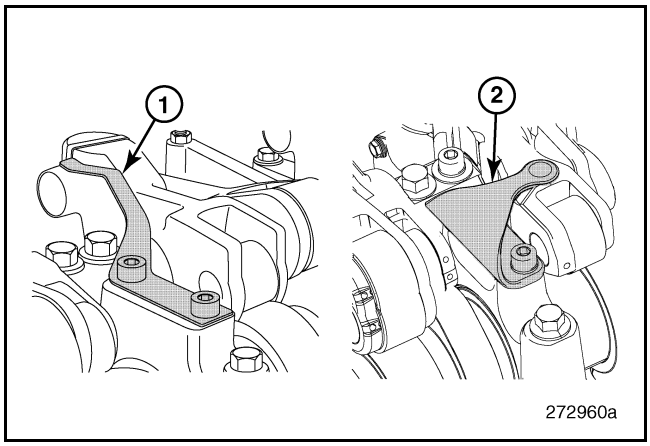


Figure 85 — Engine Brake Plate Springs

1. PowerLeash™ (3-Rocker)	2. PowerLeash™ (4-Rocker)

3. If equipped with an engine brake, secure the pistons in the exhaust rocker arms using rubber brands (or tie straps) to prevent piston damage.

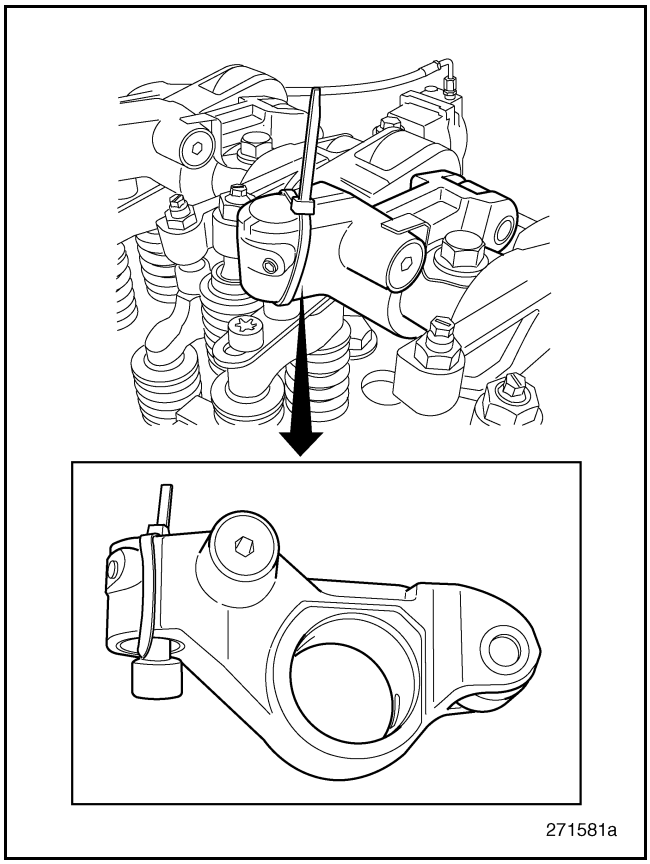


Figure 86 — Securing Pistons in Exhaust Rocker Arms

NOTE

Pistons and rocker arms are matched together and should not be mixed.

4. Beginning at the center camshaft bearing cap, begin loosening the fasteners at each cap evenly in stages, following the sequence shown in Figure 87 until all fasteners are completely loose. Once loosened, remove the fasteners.

⚠ CAUTION

The fasteners must be loosened evenly, in stages and in sequence to prevent bending or damaging the rocker arm shaft.

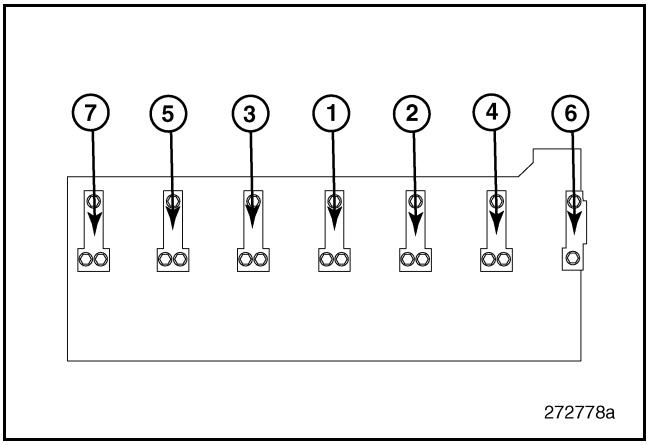


Figure 87 — Rocker Arm Shaft Fastener Loosening Sequence

5. Attach the lifting tool, 85109250, to the rocker arm shaft.
6. With the aid of an assistant, carefully remove the shaft assembly using the lifting tool. Place the shaft assembly in a secure location.

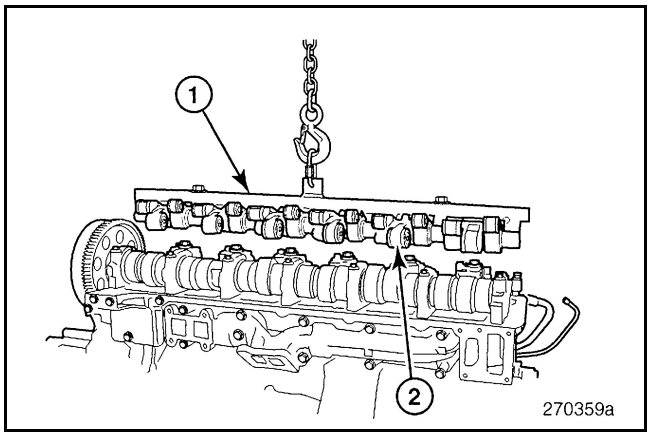


Figure 88 — Lifting Rocker Arm Shaft

1. Lifting Tool, 85109250	2. Rocker Arm Shaft Assembly

Valve Yoke (Bridge) Removal

[213 NV]

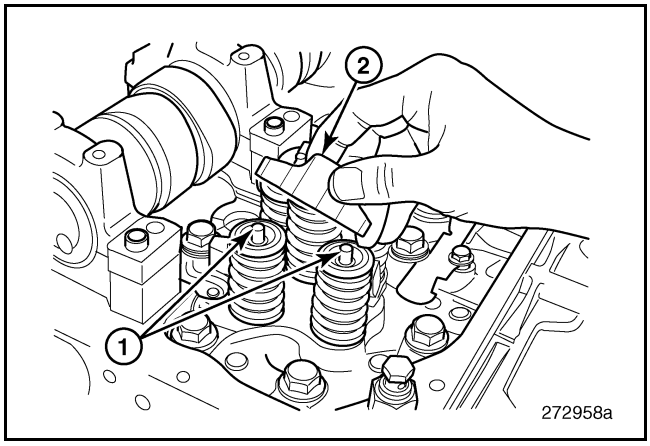


Figure 89 — Removing Valve Yoke (Bridge)

1. Inlet Valve Stems	2. Inlet Valve Yoke

1. Tag the yokes to facilitate reassembly in the locations from which they were removed.
2. Remove the yokes and set them aside.

Camshaft Removal

[213 CH]

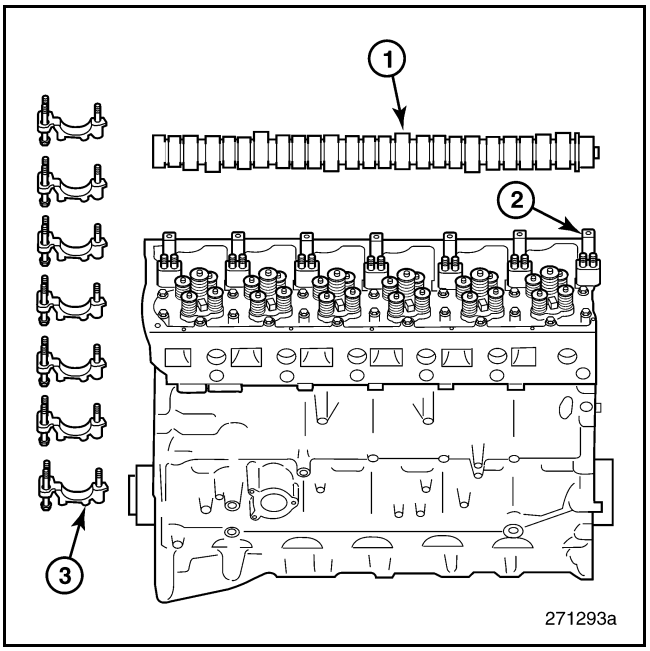


Figure 90 — Camshaft Installation

1. Camshaft 2. Camshaft Lower Bearing Supports (Saddles)	3. Camshaft Upper Bearing Caps

⚠ WARNING

The camshaft is heavy. Do NOT attempt to remove the camshaft without the help of an assistant or the use of a suitable lifting device. Failure to heed this warning may result in personal injury and component damage.

1. Mark the camshaft bearing caps (if not factory marked or identified), so that they can be reinstalled in the original bearing support locations.
2. Remove the remaining fasteners (outboard set) holding the upper bearing caps in place.

3. Use the cam cap removal tool, 85109980, in combination with slide hammer, 9990013, to remove the upper bearing caps. The upper bearing caps and lower supports (saddles) must be kept in sets and in their respective locations at reassembly.
4. Attach the lifting bar, 85109034, to the camshaft between the lobes and carefully remove the camshaft from the cylinder head.

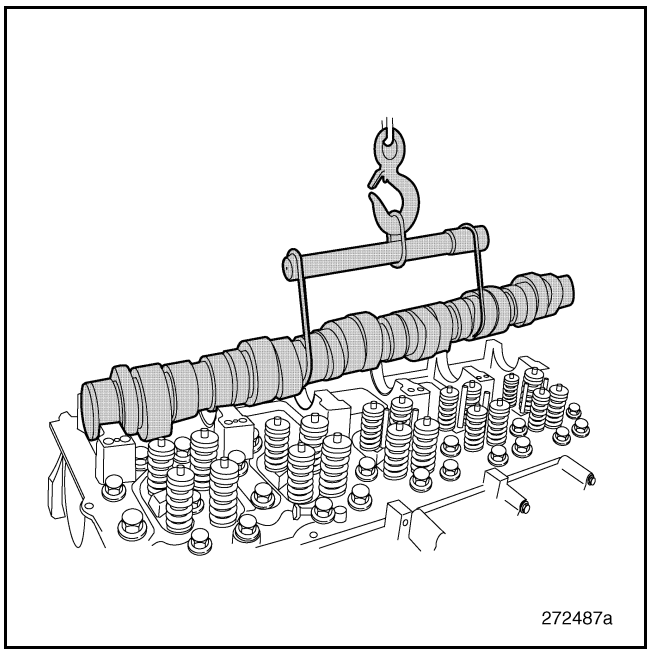


Figure 91 — Removing Camshaft

5. Carefully lift the camshaft and set it aside in a secure location for later inspection.

⚠ CAUTION

If the camshaft is not being replaced, stand the camshaft on end and secure it in place for storage. Use care to avoid damage to the guide pin.

6. Remove the bearing inserts (shells) from the camshaft lower bearing supports (saddles) and the upper bearing caps. Inspect the bearing inserts, bearing supports and caps for wear or damage. Replace the parts if excessive wear or damage exists.

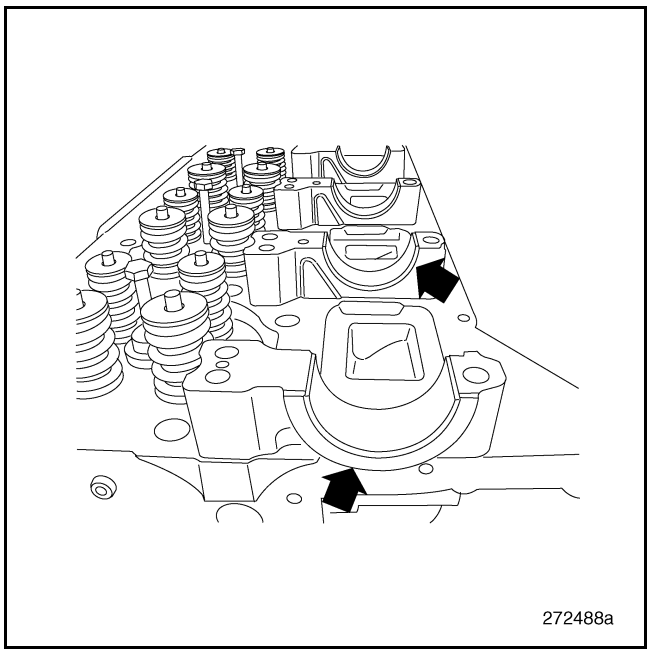


Figure 92 — Lower Bearing Inserts

NOTE

This procedure presumes that the camshaft lower bearing supports (saddles) are in place on the cylinder head, held in position by guide sleeves. If removed, the supports must be marked and returned to their original locations along with the respective bearing caps. If required, remove the bearing supports using a pry bar. Remove the No. 7 rearmost support using a soft-faced mallet by tapping side to side.

Unit Injector Removal

[221 GP]

⚠ CAUTION

Do NOT use a steel scraper or a steel wire brush to clean injector tips. Use cleaning kit J 42885.

Failure to heed this caution may result in severe component damage.

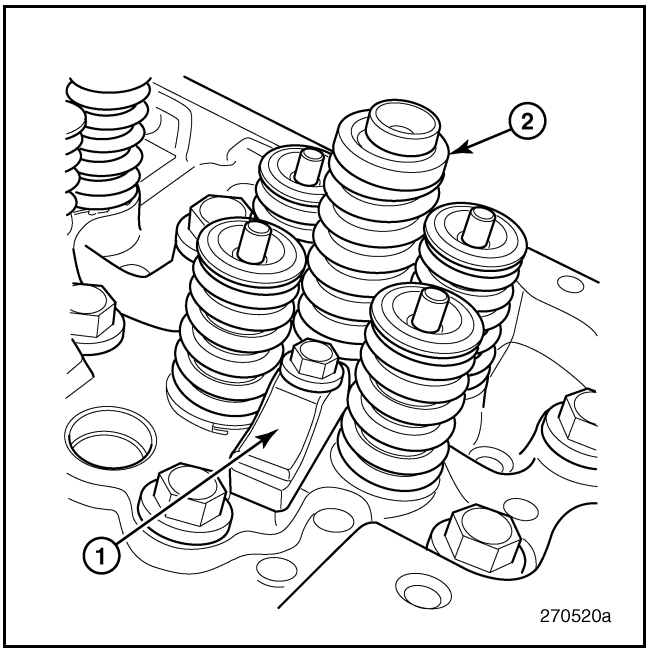


Figure 93 — Unit Injector

1. Injector Hold-Down Yoke and Screw	2. Unit Injector

1. Thoroughly clean around the unit injectors and check to ensure that the engine is completely drained of fuel.
2. Tag the injectors with the cylinder number before their removal from the cylinder head. If new injectors are not being installed, it is essential that the original injectors be reinstalled in the cylinders from which they were removed.
3. Remove the fasteners securing the injector hold-down yokes.

⚠ CAUTION

Use hand tools to remove the injectors. DO NOT use air tools on the injector puller shaft. Using air tools may result in damage to components.

4. Place a pry bar, tool 9998511 or equivalent, in position under the hold-down yoke or injector lip and pry up to remove the injector.

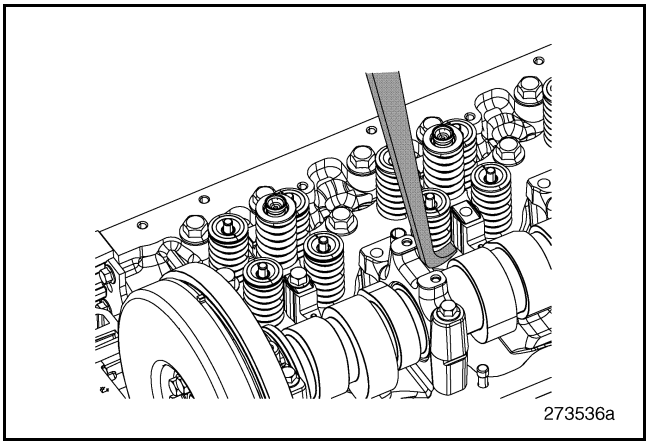


Figure 94 — Removing Injector with a Pry Bar

NOTE

Use care when removing the unit injector because the injector hold-down is not secured and could fall off if not held in place.

5. If the injector cannot be removed using the pry bar, install the heavy-duty unit injector puller, J 48922, onto a unit injector. Position the puller forks in the grooves on the unit injector. Secure the puller by sliding the lock collar down over the forks holding the unit injector. Remove the injector from the cylinder head bore using hand tools. **The injectors must be lifted out with their hold-down yokes.**

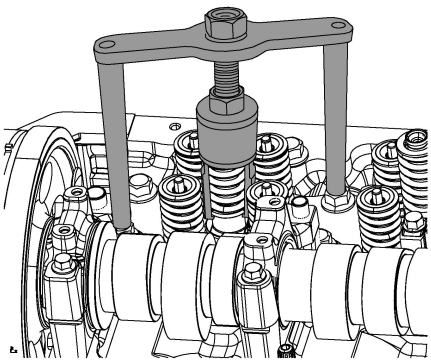


Figure 95 — Unit Injector Puller, J 48922

⚠ CAUTION

If excessive combustion leakage has resulted in the copper sleeve being stuck-fast to the unit injector by carbon, the unit injector must be replaced. The condition is found when the unit injector is removed and the copper sleeve comes out with the injector.

6. Remove and discard all injector nozzle gaskets (flat washers) from injector tips or bottoms of copper sleeves. Also, remove and discard all O-rings and yoke screws. **New** injector nozzle gaskets (flat washers), O-rings and yoke screws are required for installation.

NOTE

If an injector nozzle gasket (flat washer) had been used for the seal joint between the injector copper sleeve and the injector, discard the used gasket immediately after the injector is removed. A used gasket must not be reused. When the injector is removed, this gasket may come out attached to the injector or it may remain in the bottom of the injector sleeve.

NOTE

If the nozzle gasket (flat washer) is attached to the injector, loosen it with gentle prying from a thin flat gasket scrapper blade. If the gasket is in the bottom of the injector sleeve, initially attempt to remove it with a magnet. If this is unsuccessful, use a standard flat blade screwdriver with a long thin shank and narrow width blade to loosen the gasket. Locate the blade in the recess between the outside of the gasket and the injector sleeve. Use the blade to apply force on the outside of the gasket at different locations around the gasket. Continue this until the gasket separates from the sleeve.

7. Insert the injector into a protection sleeve, 9998249.

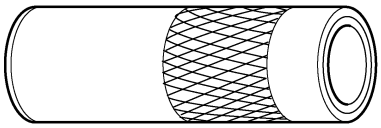


Figure 96 — Injector Protection Sleeve, 9998249

8. If the injector is not being installed immediately, install the protective plug into the unit injector bore of the cylinder head to protect it from debris.

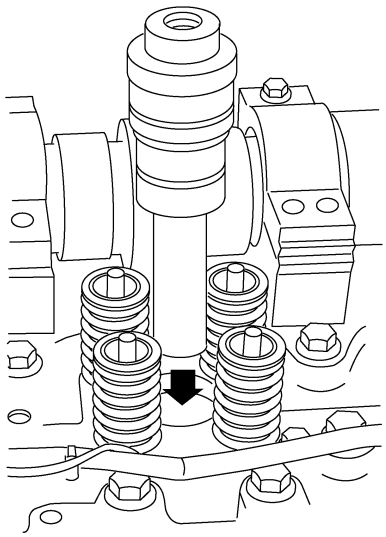


Figure 97 — Installing Injector Bore Protective Plug

9. Repeat the process to remove the remaining injectors, if required.

Starter Removal

[272 DH]

The starter is held in place by nuts assembled over studs installed at the front right side of the flywheel housing.

⚠ WARNING

The starter is heavy. Do NOT attempt to remove the starter without the help of an assistant or the use of a suitable lifting device. Failure to heed this warning may result in personal injury and component damage.

1. If not already done, disconnect the wiring harness from the starter motor.
2. Loosen the nuts fastening the starter to the flywheel housing.

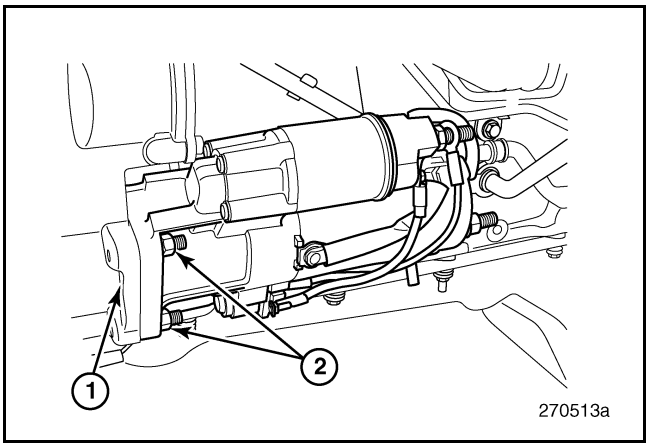


Figure 98 — Starter

1. Flywheel Housing	2. Attaching Nuts

3. With the help of an assistant or a lifting device, remove the starter from the engine.

Exhaust Pressure Governor (EPG) Removal

1. Disconnect the air supply line to the exhaust governor end cover fitting.

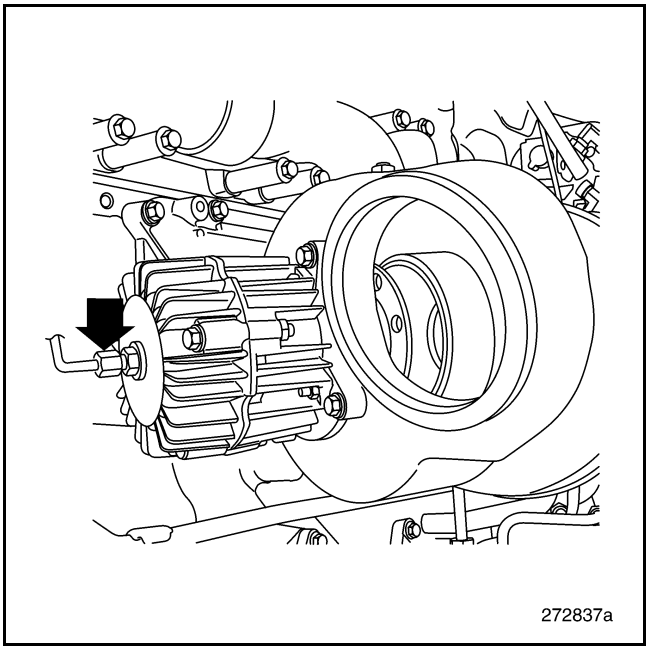


Figure 99 — EPG Air Line Attachment

2. Remove the exhaust clamp from the Exhaust Pressure Governor (EPG) housing to the turbocharger.

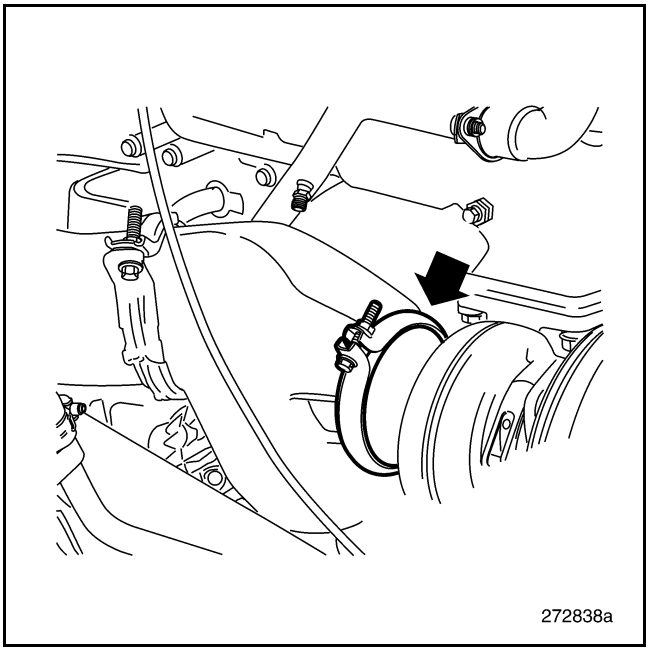


Figure 100 — EPG-to-Turbo Clamp

3. Loosen the clamp and remove the exhaust pipe from the EPG housing.

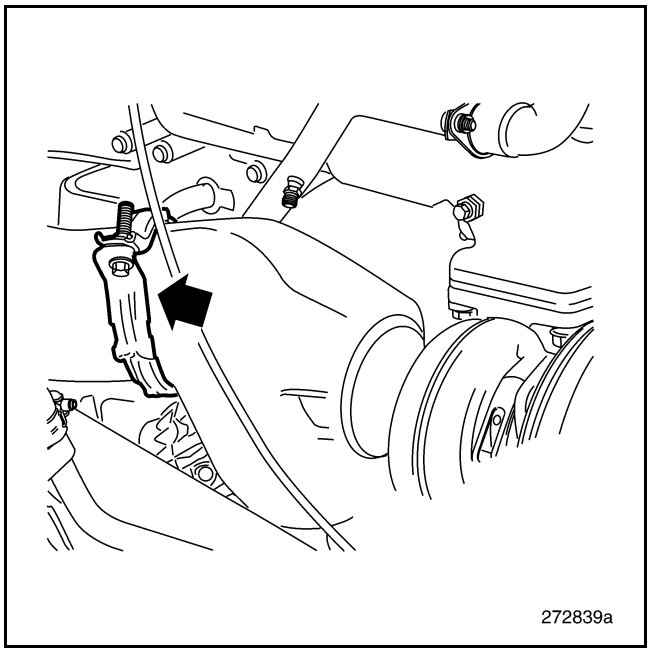


Figure 101 — Exhaust Pipe-to-EPG Housing

4. Remove the gasket between the EPG housing and exhaust pipe.

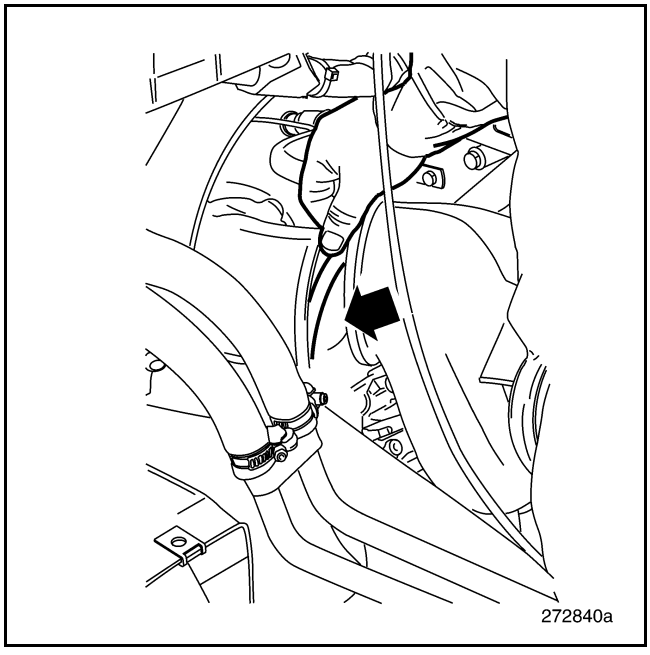


Figure 102 — EPG Housing Gasket

5. Separate the EPG housing from the exhaust pipe and turbocharger; lift and remove the EPG unit from the engine.

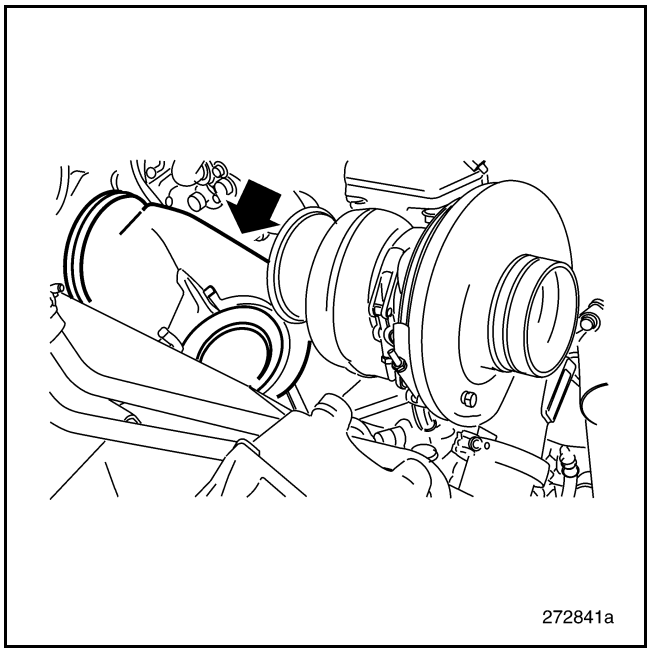


Figure 103 — EPG Housing Separated from Turbo

Turbocharger Removal

[214 SC]

⚠ WARNING

The turbocharger is heavy. Do NOT attempt to remove the turbocharger without the help of an assistant or the use of a suitable lifting device. Failure to heed this warning may result in personal injury and component damage.

⚠ CAUTION

Thorough cleanliness is required. Small particles can cause severe rotor damage and component damage if inducted during high-speed operation. Be sure to plug the inlet and outlet ports while handling the turbocharger. Also, cap the oil line openings to prevent contamination.

1. Remove the clamp from the EPG housing to the turbocharger, if not previously removed.

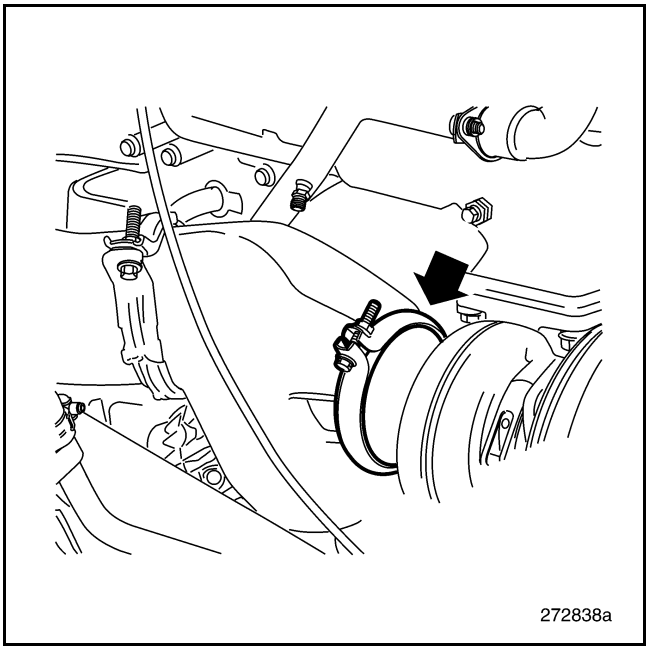


Figure 104 — EPG-to-Turbo Clamp

2. Remove the turbocharger oil supply line (upper).

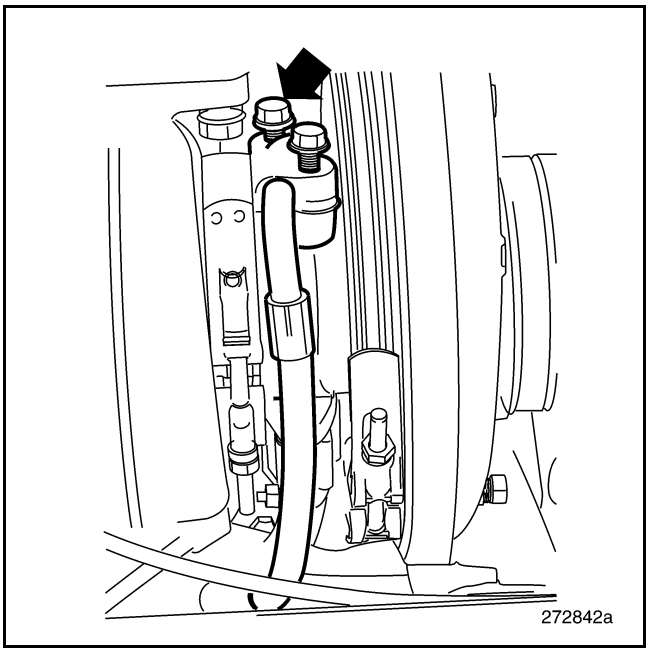


Figure 105 — Turbo Oil Supply Line

3. Remove the oil return line (lower).

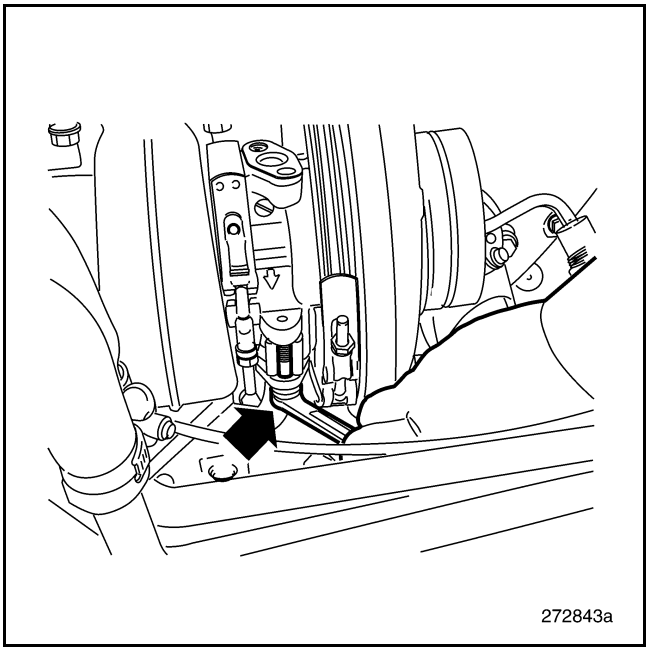


Figure 106 — Turbo Oil Return

4. Remove the lower charge air pipe from the turbocharger and midpipe support fastener.
5. Remove the turbocharger flange mounting nuts and spacers.

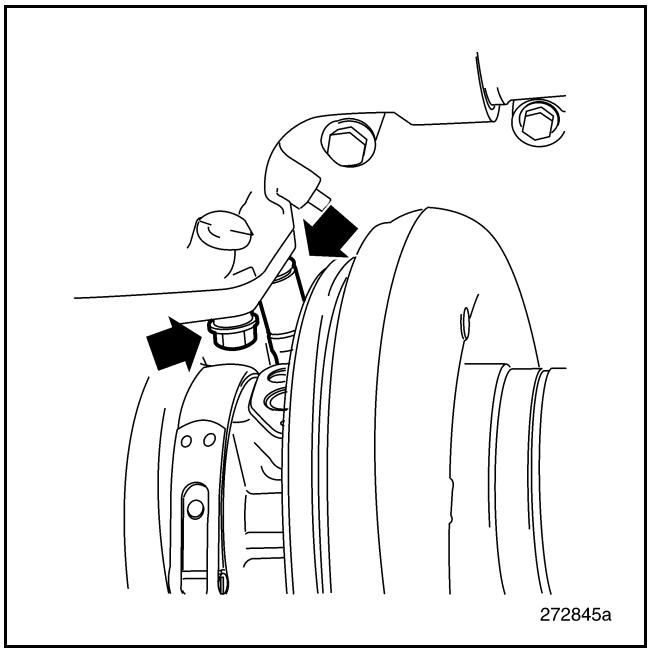


Figure 107 — Removing Turbocharger Fasteners

6. Lower the turbocharger away from the exhaust manifold and lift out.

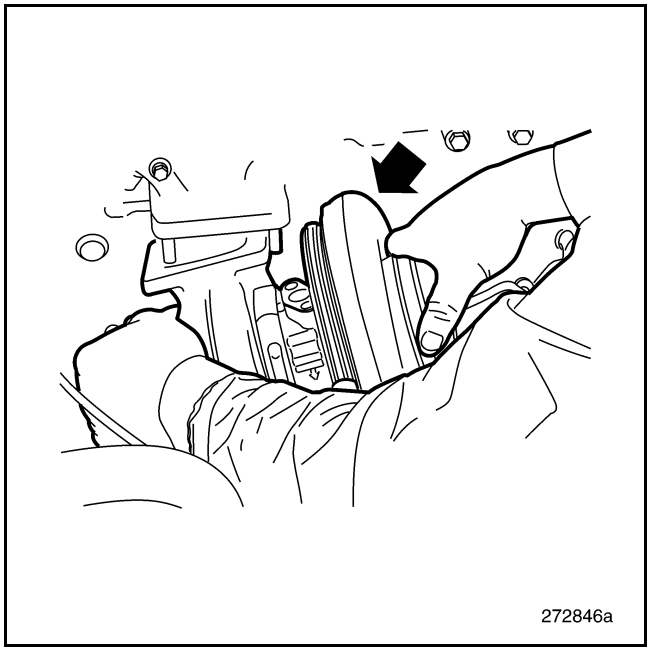


Figure 108 — Removing Turbocharger

Exhaust Manifold Removal

⚠ WARNING

The exhaust manifold consists of three castings that are not clamped together. These could separate unexpectedly when the attaching screws are removed from the cylinder head. To prevent personal injury and damage to the parts, take care to control all pieces until they can be separated safely.

1. While supporting the exhaust manifold, remove the attaching screws and spacers.

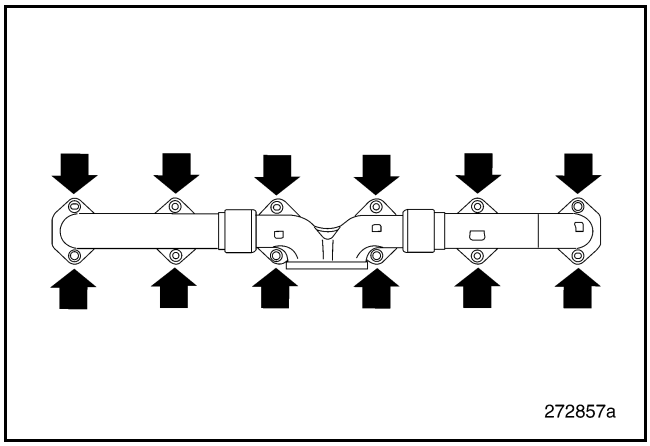


Figure 109 — Exhaust Manifold

2. Set the spacers and screws aside for reassembly.
3. Remove the exhaust manifold from the cylinder head.
4. Remove and discard the exhaust manifold gaskets.
5. Inspect the exhaust manifold. If there are signs of exhaust leakage between the cast segments of the manifold, replace the seals.

Oil Filter Valve Housing Removal

[219 EP]

N O T E

Provide suitable rags and containers for collecting oil drainage at each step.

1. Remove the screws and remove the oil tube from the front of the oil filter housing and the cooling duct cover. Discard the gaskets.

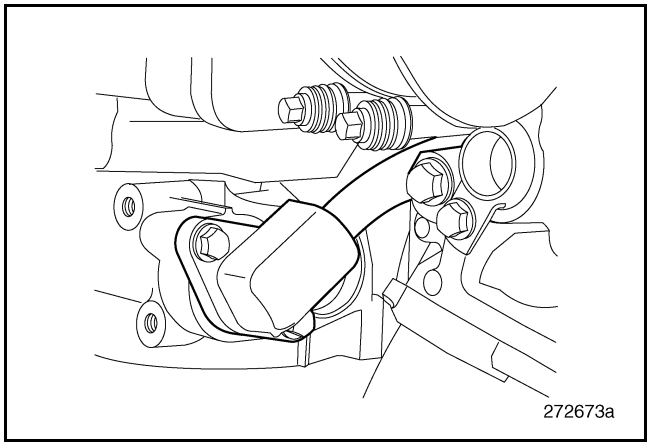


Figure 110 — Oil Tube (at Housing Front)

2. Remove the screws and remove the oil tube between the valve housing at the rear and the duct cover. Discard the gaskets.

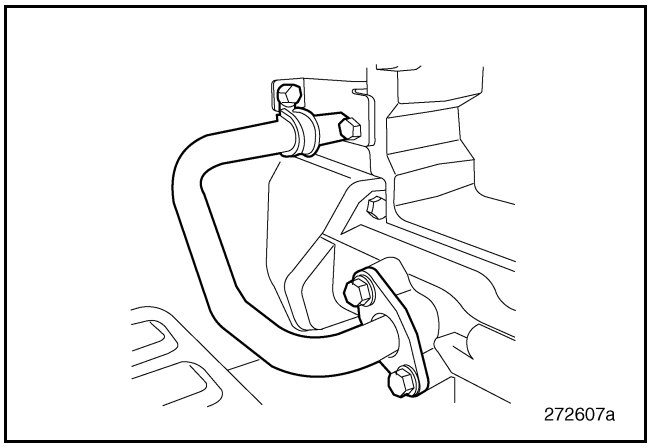


Figure 111 — Oil Tube (at Housing Rear)

3. Remove the fasteners and remove the oil filter valve housing from the cylinder block. Discard the gasket.

Coolant and Pump Inlet Housings Removal

[215 SW]

N O T E

Provide suitable containers to collect coolant that may escape during removal procedures.

1. Remove the fasteners and remove the coolant pipe (bypass) housing from the cylinder head. Discard the flange seal ring.

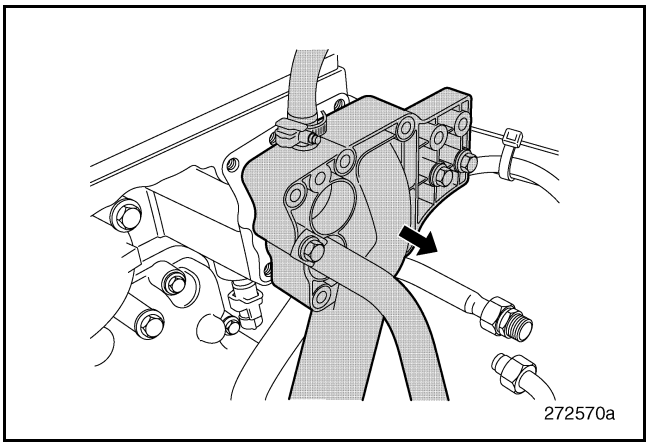


Figure 112 — Upper Coolant Pipe (Bypass) Housing

2. Remove the screws and remove the pump inlet housing at the rear of the coolant pump. Discard the flange seal ring.

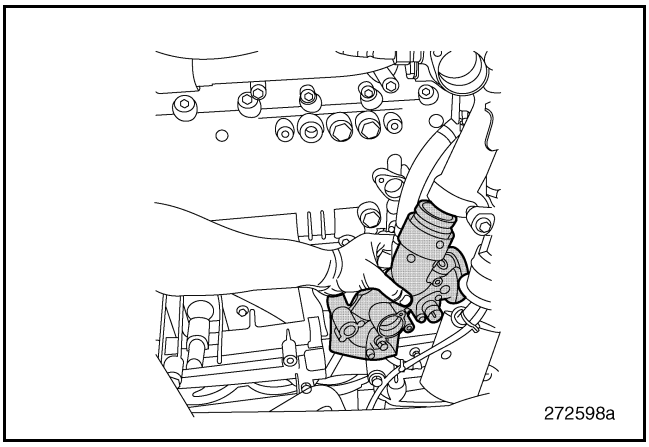


Figure 113 — Removing Pump Inlet Housing

Cooling Duct Cover and Oil Cooler Removal

[215 DW, 219 EP]

To remove the oil cooler, the cooling duct cover must be removed first. The oil cooler is attached to the inside of the cooling duct cover.

COOLING DUCT COVER REMOVAL

1. Remove the cooling duct cover fasteners and remove the duct cover and oil cooler assembly from the cylinder block.

N O T E

Note the location of all fasteners for reassembly; different lengths are used.

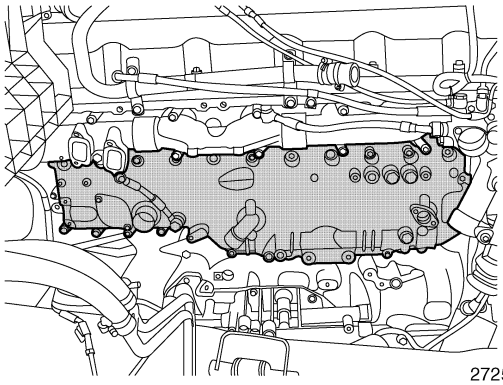


Figure 114 — Cooling Duct Cover

2. Carefully remove the seal from the perimeter groove in the cover. Discard the seal; it cannot be reused.

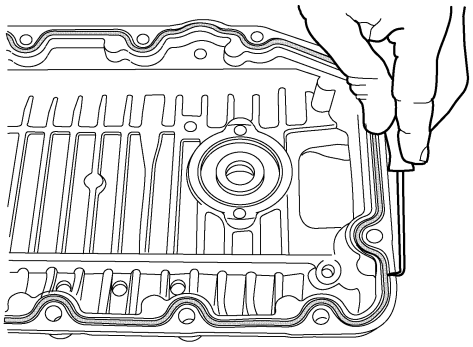


Figure 115 — Removing Duct Cover Seal

3. Remove and discard the cover-to-pump base plate seal.

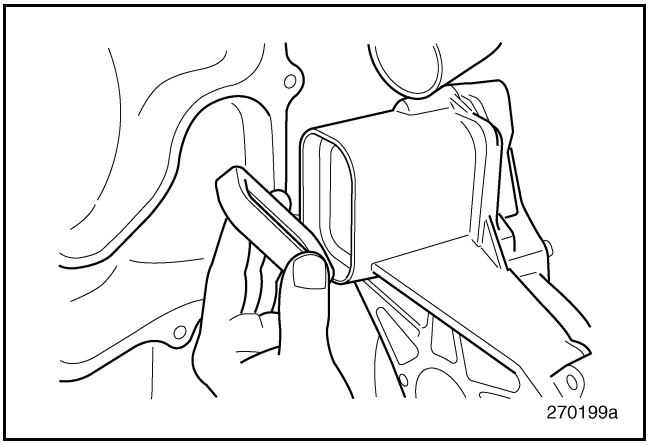


Figure 116 — Cooling Duct Cover-to-Pump Base Plate Seal

OIL COOLER REMOVAL

1. Place the cooling duct cover assembly on a clean work surface. Remove the fasteners and remove the flow plate covering the oil cooler.

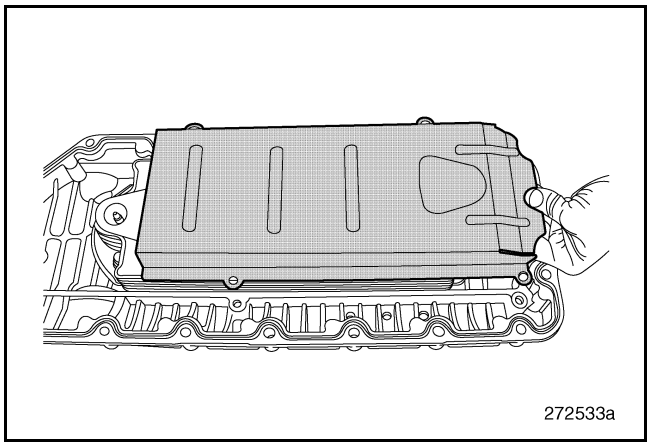


Figure 117 — Removing Flow Plate

2. Remove the oil cooler fasteners and remove the cooler from the cover.

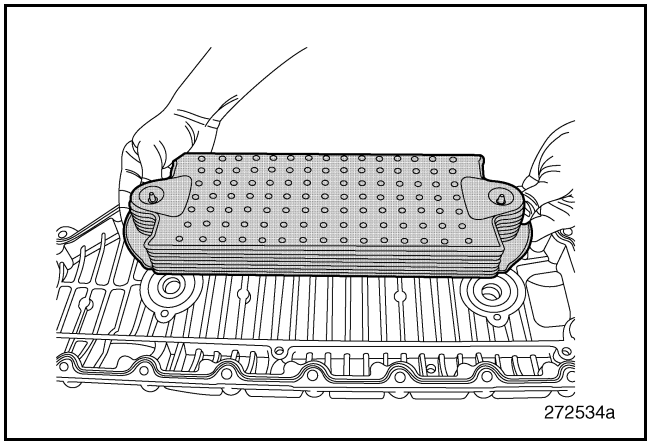


Figure 118 — Removing Oil Cooler

3. Remove the oil cooler sealing O-ring gaskets between the oil cooler and cover. Discard the O-rings.

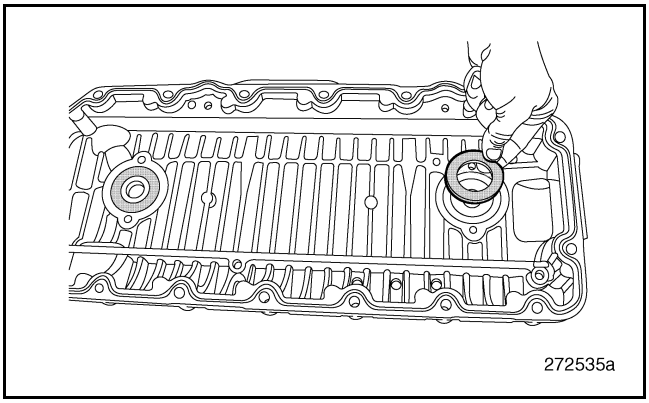


Figure 119 — Removing Cooler O-Rings

Drive Belts and Fan Hub Removal [232 HB]

Remove the drive belts, idlers and hub bracket from the front of the engine as follows:

1. Remove the fasteners and remove the fan drive and coolant pump belt tensioner from the coolant pump housing.
2. Remove the fasteners and remove the accessory drive belt tensioner from the cylinder block.
3. Remove and set aside the drive belts.

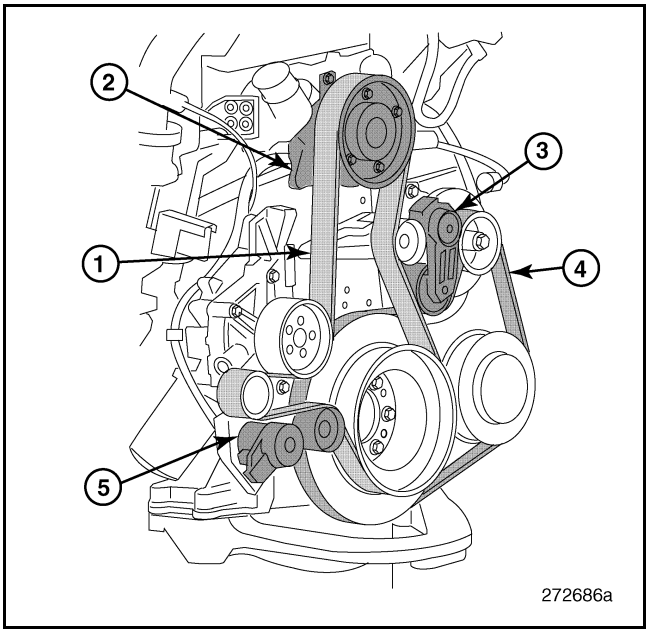


Figure 120 — Fan Hub and Accessory Drive System

1. Fan Drive Belt 2. Fan Hub Bracket 3. Accessory Drive Belt Tensioner	4. Accessory Drive Belt 5. Fan Drive and Coolant Pump Belt Tensioner

4. Remove the fasteners and fan hub bracket assembly.

Inlet Air Preheater/Spacer Removal [291 DR]

1. Remove the fasteners securing the inlet adapter, spacer or preheater, if so equipped, to the inlet manifold.

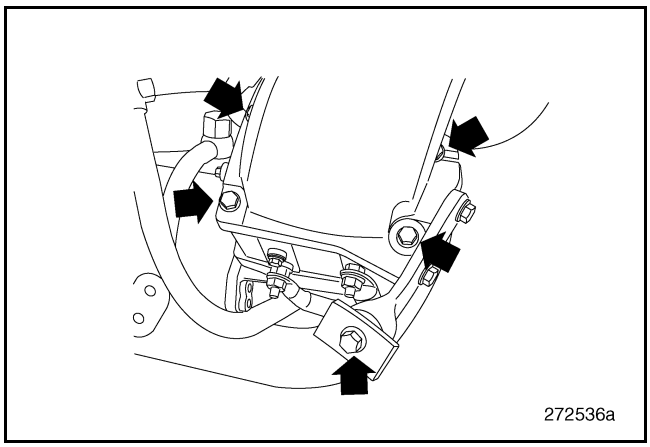


Figure 121 — Manifold Inlet Adapter

2. Remove the spacer block from the inlet air manifold. Or, if so equipped, remove all power and ground cables from the inlet air preheater and remove the preheater from the manifold.

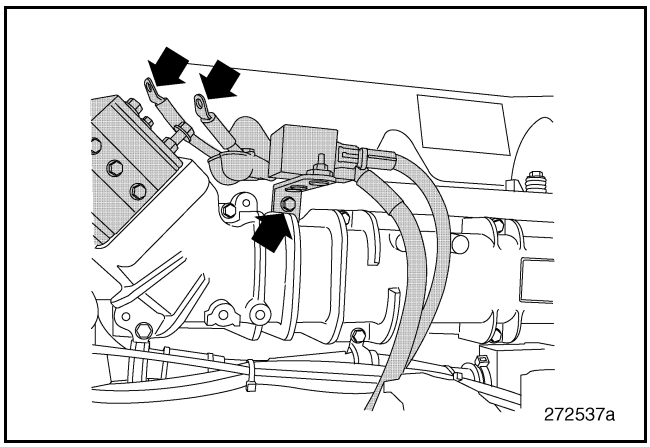


Figure 122 — Preheater Cable Connections

NOTE

Mark the cable locations before removal to ensure correct installation at reassembly.

3. Remove and discard the gasket between the spacer block or preheater base and the inlet manifold.

Crankcase Ventilation (CCV) Separator Removal

1. If not already done, loosen the clamps and disconnect the inlet and outlet hoses at the CCV separator. Remove the retainers and remove the hoses.

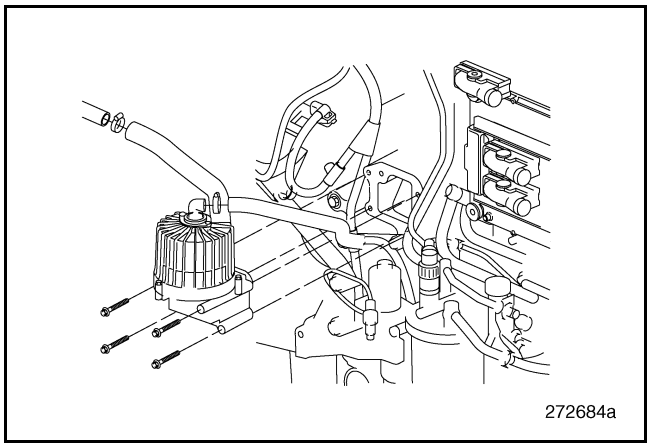


Figure 123 — Crankcase Ventilation Separator

2. Remove the fasteners and remove the separator assembly from the cylinder block.

Fuel Lines and Filter Valve Housing Removal

If not already removed, remove the fuel lines and filter valve housing using the following procedure.

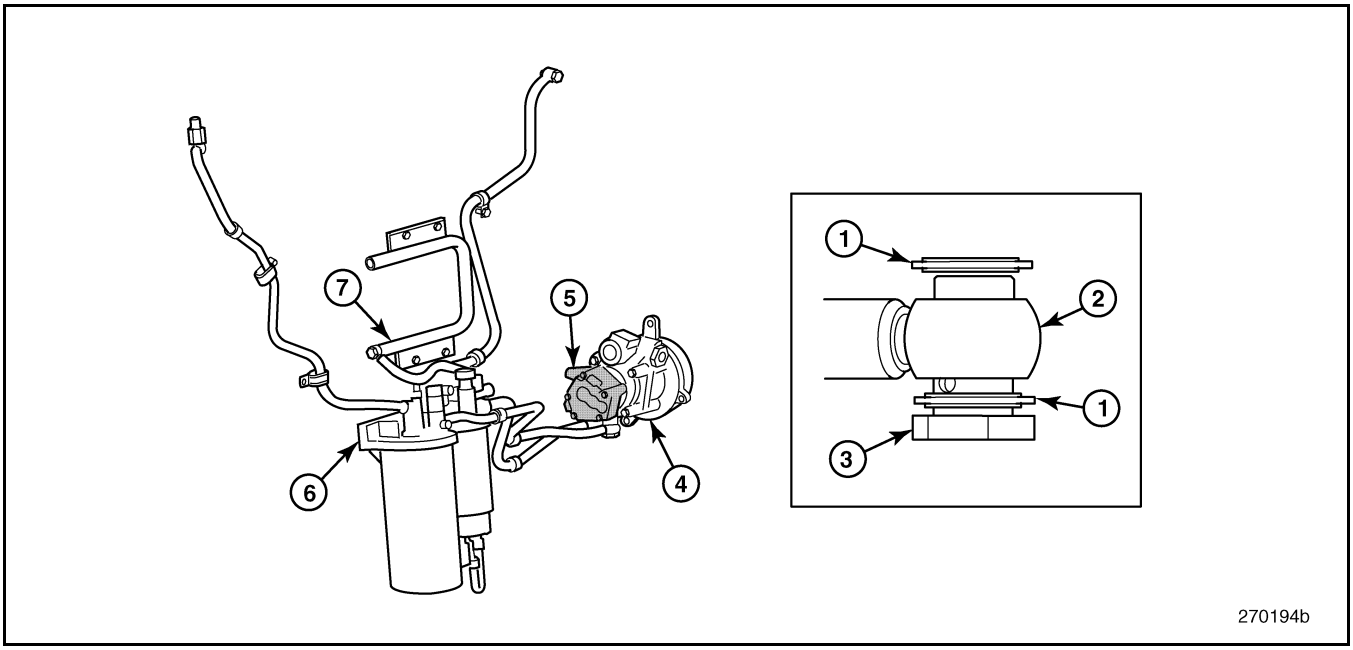


Figure 124 — Fuel Pump, Filter Assembly and Lines

1. Washers 2. Banjo Fitting 3. Banjo Screw 4. Power Steering Pump	5. Fuel Pump 6. Fuel Filter Bracket 7. EECU Cooler

1. Loosen the fuel line banjo fittings. Remove the banjo fittings, clamps and the following fuel lines from the left side of the engine.

NOTE

Be sure to capture the banjo sealing washers and hollow screws while removing them.

- Fuel return line — EECU cooling plate-to-filter valve housing
- Fuel return line — cylinder head (at front)-to-filter valve housing
- Fuel supply line — filter valve housing-to-cylinder head (at rear)
- Fuel supply and return lines — fuel pump-to-filter valve housing

2. Remove the filter valve housing.

Figure 125 — Fuel Filter Valve Housing

EECU and Cooling Plate Removal

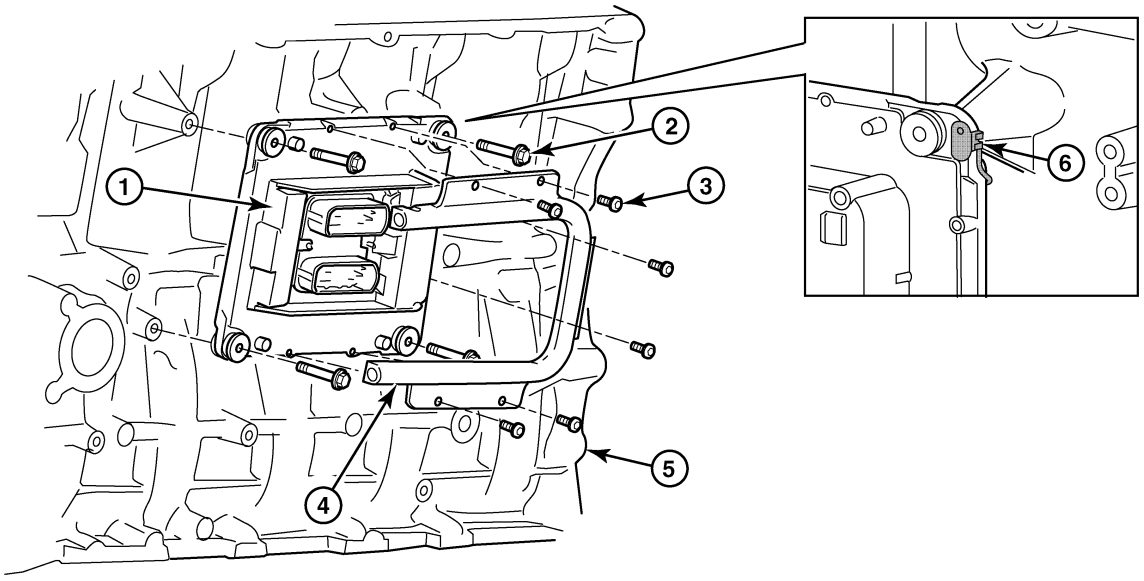


Figure 126 — EECU and Cooling Plate

1. EECU 2. Module Mounting Screws 3. Cooling Plate Mounting Screws	4. Cooling Plate 5. Cylinder Block 6. Ground Strap

If not already done for mounting the engine in the repair stand, or if the engine is not being completely disassembled for overhaul and only the EECU is to be removed, remove the EECU following the procedure below.

1. Unlock and remove the end connectors attached to the EECU. Remove the screws from the harness retainer clamps. Then, push the connector locks inward and rotate outward to disconnect both wiring harnesses from the EECU.

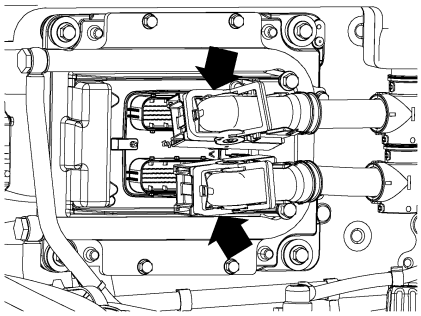


Figure 127 — EECU Harness Connectors

⚠ CAUTION

Use care to avoid damaging the terminal pins.

2. Position the harness connectors back out of the way.

NOTE

Provide suitable rags and containers for collecting fuel drainage.

3. Remove the fuel lines from the cooling plate and set aside.

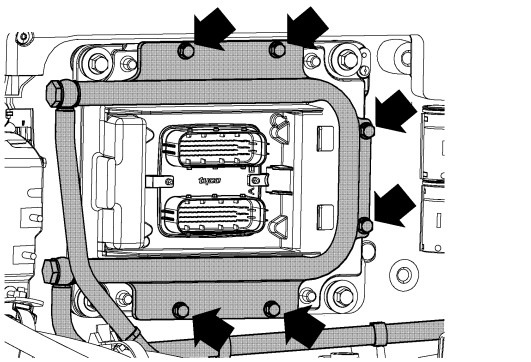


Figure 128 — EECU Mounting Screws

4. Remove the screws and the cooling plate from the EECU.
5. Remove the screws and the EECU from the engine.

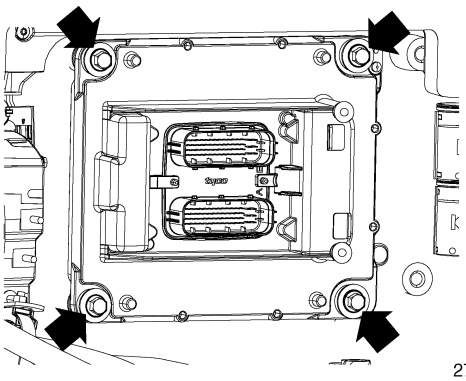


Figure 129 — EECU Mounting Screws

Inlet Manifold Removal

1. Remove the two top intake manifold mounting fasteners and install two alignment pins to support the manifold during removal.
2. Remove the remaining inlet manifold mounting fasteners. Using a plastic mallet, carefully tap the manifold loose and remove it from the cylinder head.

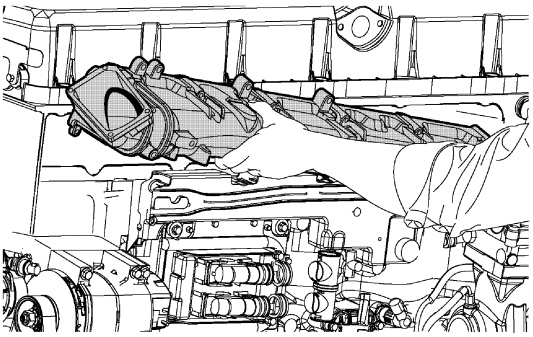


Figure 130 — Removing Inlet Manifold

3. Using a sharp pick, remove the rubber seal (molded gasket) from the groove in the inlet manifold. Discard the manifold seal.

Tandem Pump (Fuel and Power Steering) Removal

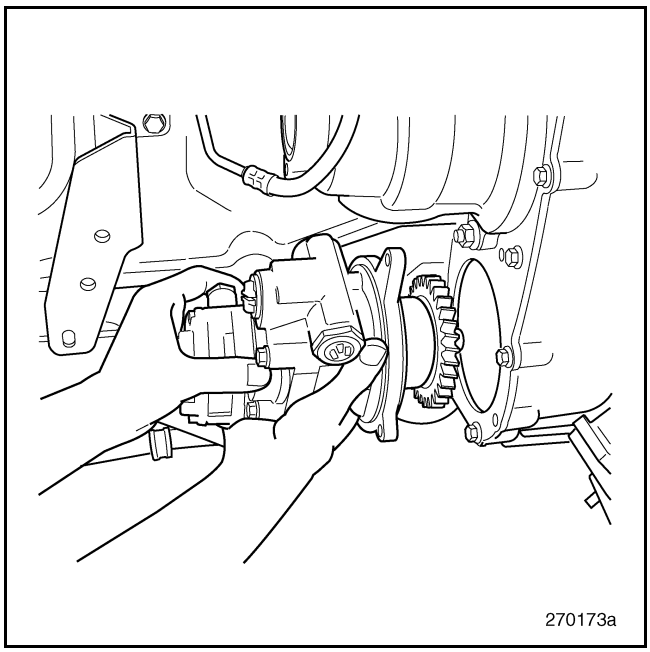


Figure 131 — Removing Tandem Pump

NOTE

Provide suitable rags and containers for collecting oil and fuel drainage at each step.

Be sure to capture the banjo sealing washers and hollow screws while removing them.

1. If not already done, remove the power steering oil supply and return lines from the tandem pump and set aside.
2. Remove the fuel supply and return lines from the fuel pump and set aside.
3. Remove the fasteners securing the pump to the flywheel housing and remove the tandem pump assembly from the engine.

Air Compressor Removal [261 CK]

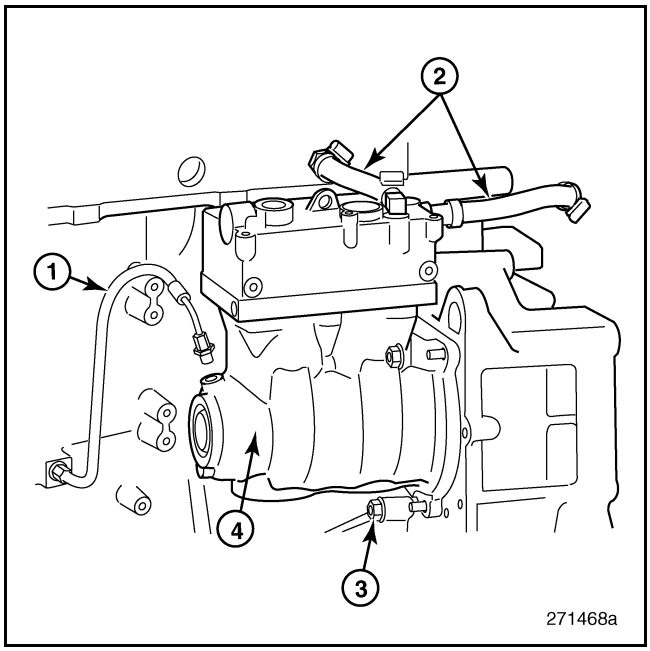


Figure 132 — Air Compressor and Fittings

1. Lubrication Line	3. Mounting Stud and Nut
2. Coolant Lines	4. Air Compressor

1. Disconnect and remove the compressor coolant lines from the engine.
2. Disconnect and remove the compressor oil supply line.
3. While supporting the air compressor, remove the flange nuts securing the compressor to the flywheel housing and remove the compressor from the engine.

Flywheel and Pilot Bearing Removal

TIMING GEAR ALIGNMENT

If the engine is not being completely disassembled for overhaul and only the timing gears are to be removed for replacement, make sure that the camshaft is set at Top Dead Center (TDC) for the No. 1 cylinder, before removing the flywheel. If not, proceed as follows:

1. Using the engine barring tool, 9996956, bar the engine over manually so that the camshaft TDC mark is between the two lines on the rear camshaft bearing cap. The flywheel will be at 0° with the camshaft at TDC.

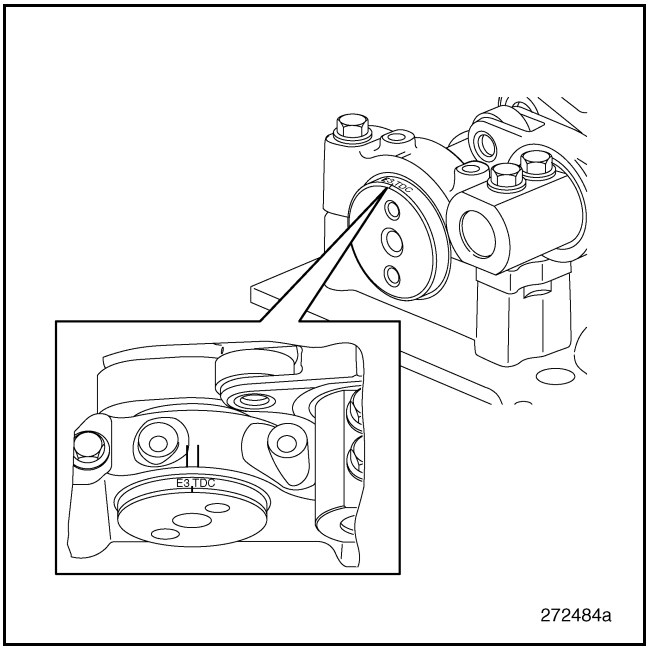


Figure 133 — Camshaft Timing Marks

2. The timing gears can now be removed. Use care to not rotate the gears as they are being removed so that the camshaft and crankshaft remain in the TDC position.

FLYWHEEL REMOVAL PROCEDURE

⚠ WARNING

The flywheel is heavy. Do NOT attempt to remove the flywheel without the help of an assistant or the use of a suitable lifting device. Failure to heed this warning may result in personal injury and component damage.

1. Remove the retainer screw and remove the engine speed sensor from the flywheel housing.

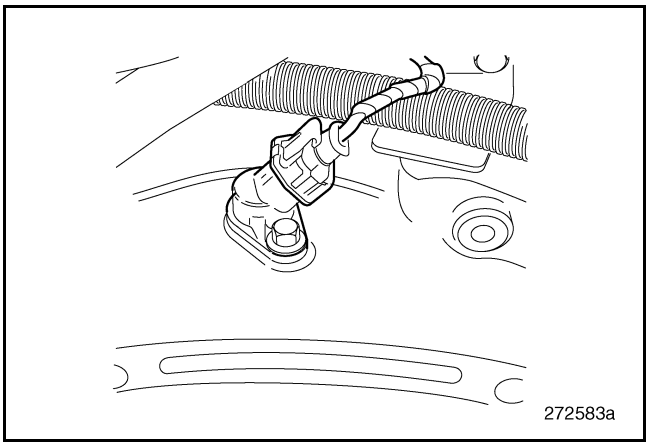


Figure 134 — Engine Speed Sensor

2. If present, remove the transmission pilot bearing using bearing extractor tool, 9991821.

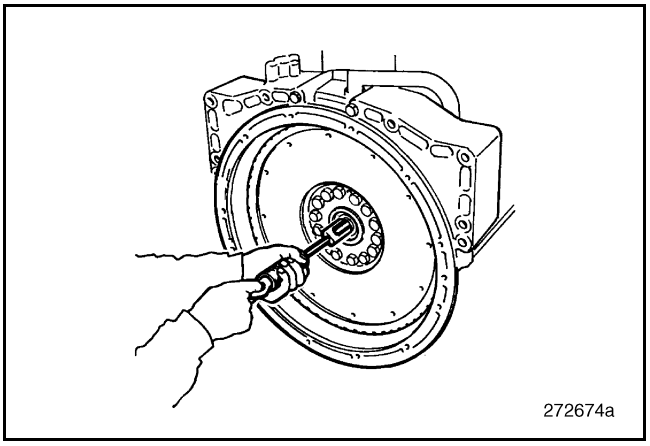


Figure 135 — Removing Pilot Bearing

3. Install two M10 x 100 screws in holes opposite each other at the outer perimeter of the flywheel. These screws will be used as handles to aid removal of the flywheel.

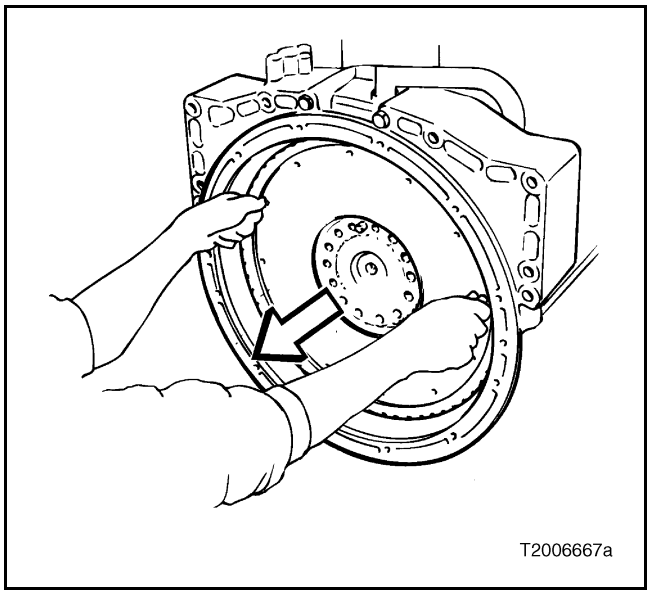


Figure 136 — Removing Flywheel

4. Remove the flywheel mounting fasteners.
5. While supporting the flywheel, carefully tap the flywheel, alternating from side to side, to work it off the aligning dowel pin and remove it from the crankshaft flange.

Power Take-Off (PTO) Assembly Removal

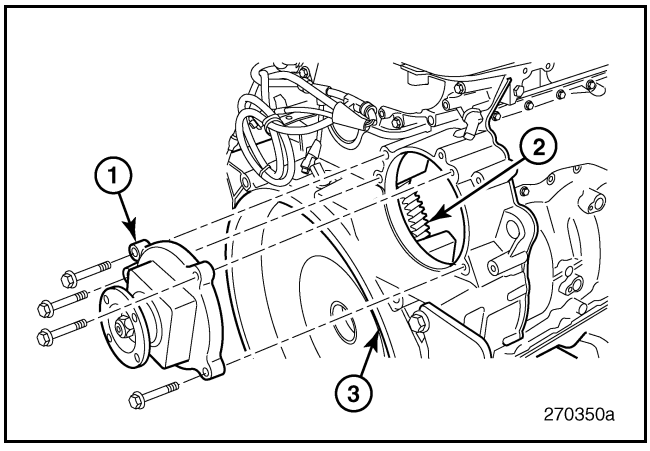


Figure 137 — Power Take-Off Assembly

1. PTO Assembly 2. Intermediate Idler Gearset	3. Flywheel Housing

1. If equipped with the optional PTO assembly, loosen and remove the fasteners securing the assembly to the flywheel housing.
2. Remove the PTO assembly from the flywheel housing and set aside.
3. Remove and discard the PTO housing seal.

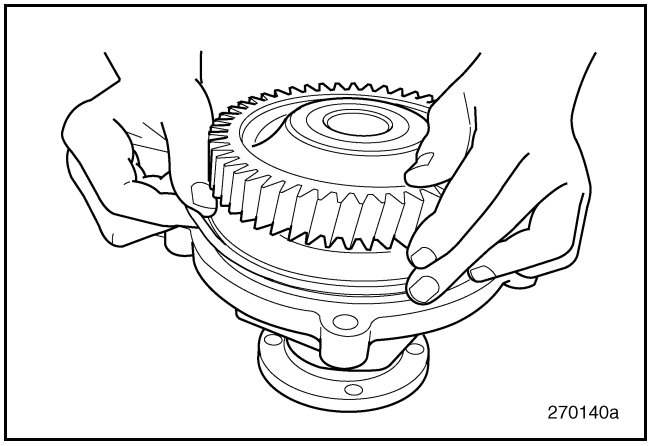


Figure 138 — Removing PTO Housing Seal

Flywheel Housing Removal

1. Remove the flywheel housing fasteners (item 2 in Figure 139) located at the front of the timing gear plate.

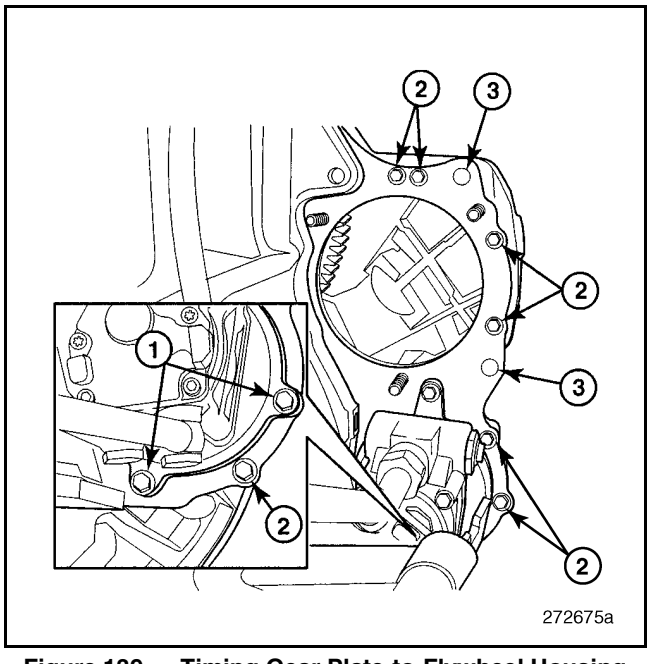


Figure 139 — Timing Gear Plate-to-Flywheel Housing Fasteners

1. Tandem Pump Fasteners 2. Flywheel Housing Fasteners	3. Engine Mounting Bolt Holes

2. Support the flywheel housing and remove the fasteners at the rear of the flywheel housing securing the housing to the cylinder block.

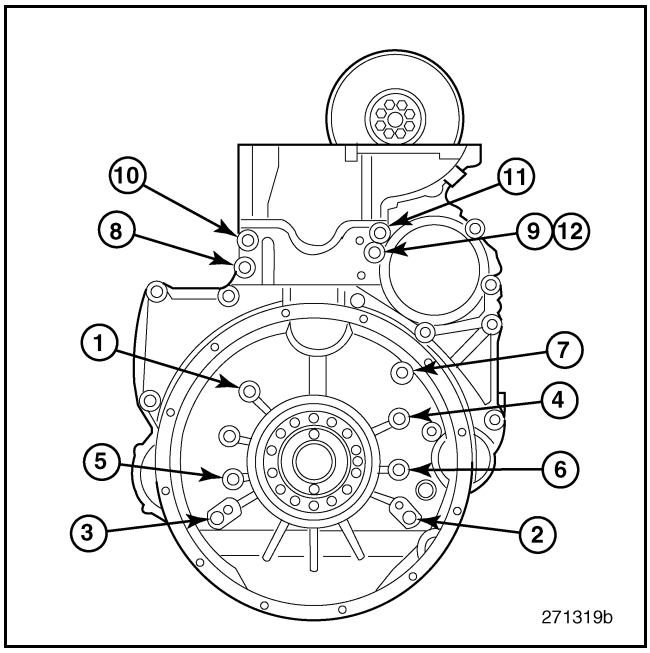


Figure 140 — Flywheel Housing Fasteners (Shown with Torque Sequence)

3. Remove the flywheel housing. It may be necessary to tap lightly on the housing with a soft mallet to separate the housing from the timing gear plate.

Crankshaft Rear Seal Removal

[212 JH]

With the flywheel housing removed, use a drift and hammer to remove the old seal from the crankshaft bore in the housing.

Timing Gear Train Removal

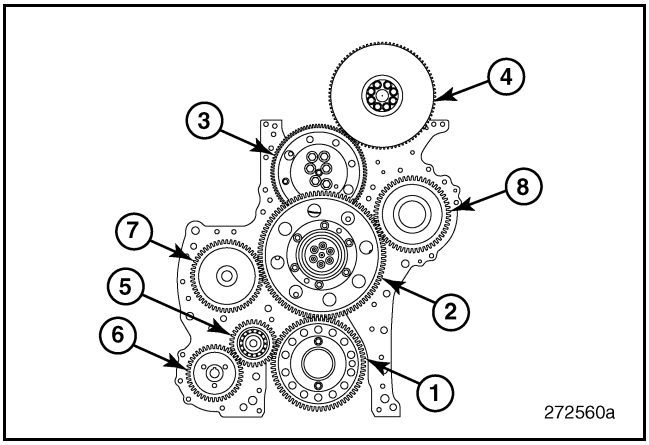


Figure 141 — Timing Gears

1. Crankshaft Gear 2. Intermediate Idler Gearset 3. Adjustable Idler Gear 4. Camshaft Gear	5. Lower Idler Gear 6. Tandem Pump Drive Gear 7. Air Compressor Drive Gear 8. PTO Drive Gear

N O T E

To simplify the reassembly process, avoid rotating the engine or timing gears while performing timing gear removal and reinstallation.

CRANKSHAFT GEAR AND IDLER GEARSET REMOVAL

1. Remove the two Allen-head screws that secure the gear to the crankshaft flange.
2. Using a suitable puller, remove the crankshaft gear.
3. Remove and set aside the lower (auxiliary) idler gear. Remove the seal ring from the bearing journal.
4. Remove the six Allen-head screws (inner circle) securing the intermediate idler gearset hub to the cylinder block and remove the gearset from the engine.

⚠ CAUTION

Do NOT disassemble the intermediate idler gearset. The intermediate idler gearset consists of two gears and back-to-back tapered roller bearings set to specified bearing preloads. The assembly is held together by a large spanner nut and six hex-head screws. Loosening and/or removing the fasteners in any way may change the bearing preload settings and result in bearing failure.

ADJUSTABLE IDLER GEAR REMOVAL

To remove the adjustable idler gear from the engine:

1. Remove and discard the six screws securing the adjustable idler gear hub to the cylinder head and engine block.

NOTE

The adjustable idler gear fasteners are one time use only.

2. Remove the adjustable idler gear, hub and thrust washers from the engine.

NOTE

If the engine is not being completely disassembled for overhaul and only the cylinder head is to be removed, it is not necessary to remove the adjustable idler gear. However, the six screws **A** and **B** which secure the timing gear mounting plate to the cylinder head and the four upper screws **C** securing the adjustable idler gear to the cylinder head MUST BE REMOVED (Figure 142). Refer to the “Cylinder Head Removal” procedure which follows later in this section.

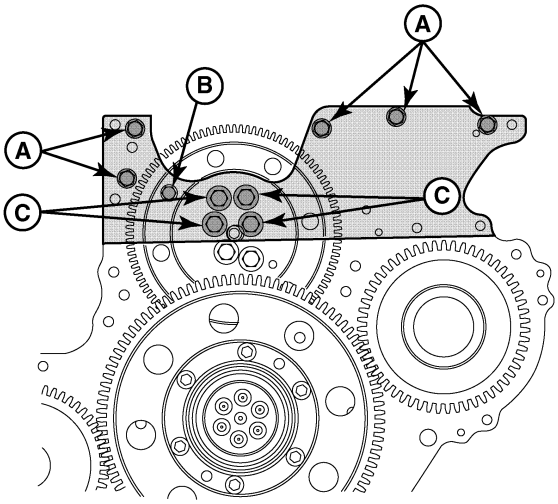


Figure 142 — Cylinder Head-to-Timing Gear Plate Screw Locations

Timing Gear Plate Removal

NOTE

If the engine is not being completely disassembled for overhaul and only the timing gears are being replaced, it is not necessary to remove the gear plate unless it is damaged and requires replacement.

⚠ WARNING

The timing gear plate is heavy. Do NOT attempt to remove the plate without the help of an assistant or the use of a suitable lifting device. Failure to heed this warning may result in personal injury and component damage.

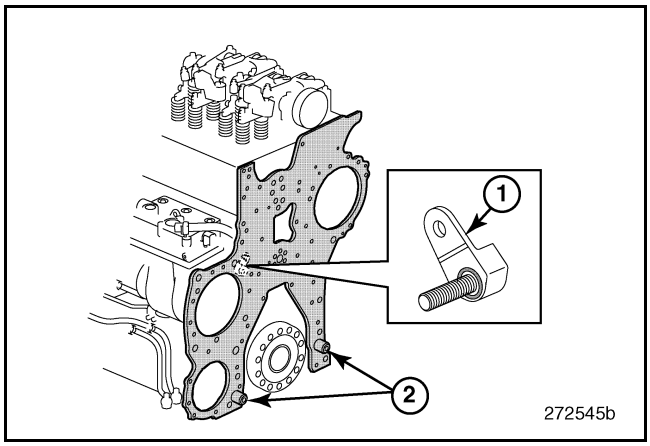


Figure 143 — Timing Gear Plate

1. Air Compressor Mounting Stud	2. Alignment Dowels, 9998267

1. Remove the compressor studs from the timing gear plate. Remove and discard the sealing ring from the studs.
2. Install the alignment dowels, 9998267, and tighten them to specification. This step is necessary to ensure proper alignment of the plate when reassembling the engine.
3. While supporting the plate to prevent it from falling, remove the fasteners.

NOTE

When the timing gear plate is being removed, it must be drawn straight out to avoid moving or damaging the alignment dowels.

4. Remove the plate from the engine.

Alternator and Refrigerant Compressor Removal

[271 CB, 264 DP]

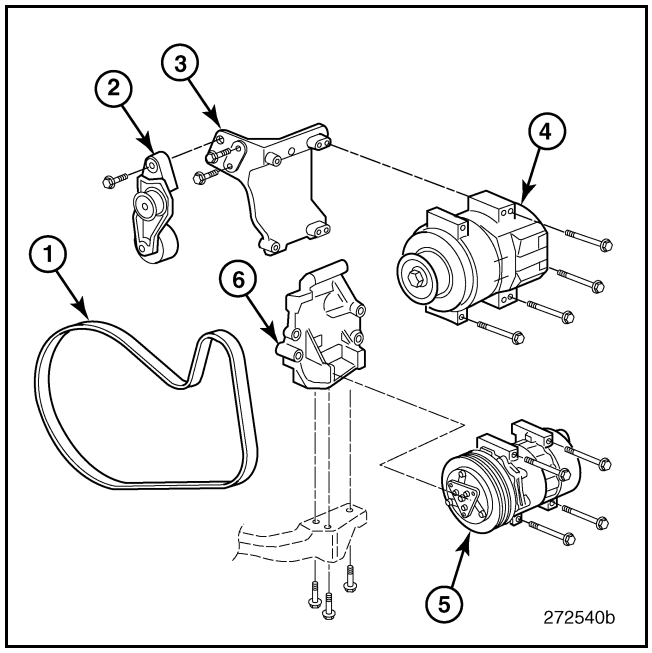


Figure 144 — Alternator and Refrigerant Compressor Mounting

1. Fan Belt	4. Alternator
2. Tensioner	5. Refrigerant Compressor
3. Alternator Mounting Bracket	6. Front Engine Support Mounting Bracket

NOTE

For this procedure, the engine is out-of-chassis, the fan drive and accessory drive belts are removed, the alternator harness wiring is disconnected, and the A/C compressor refrigerant lines are removed.

1. While supporting the alternator, remove the fasteners and remove the alternator from the upper mounting bracket.
2. While supporting the refrigerant compressor, remove the fasteners and remove the compressor from its mounting pads on the front engine support mounting bracket.

3. If necessary, remove the fasteners and remove the belt tensioner from the upper mounting bracket.
4. Remove the fasteners and remove the upper mounting bracket from the cylinder block.

NOTE

It is not necessary to remove the front engine support mounting bracket unless it is damaged and in need of replacement.

Thermostat and Cover Removal

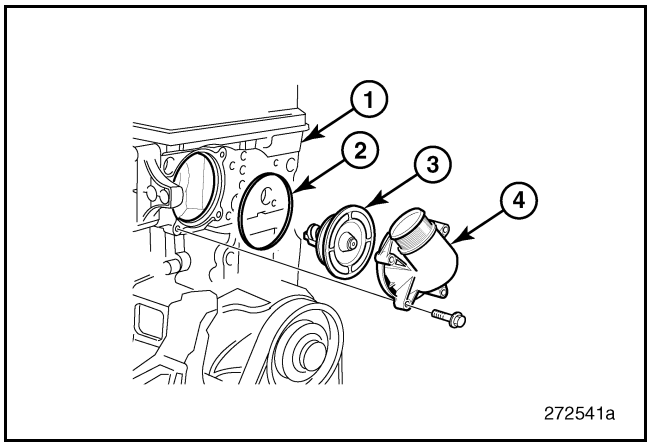


Figure 145 — Thermostat and Cover

1. Cylinder Head 2. Sealing Ring	3. Thermostat 4. Thermostat Cover

1. Remove the fasteners, thermostat cover, thermostat and sealing ring.
2. Carefully clean the thermostat seat and all cylinder head-to-thermostat cover mating surfaces.

Coolant Pump Removal [215 SW, SG, SR]

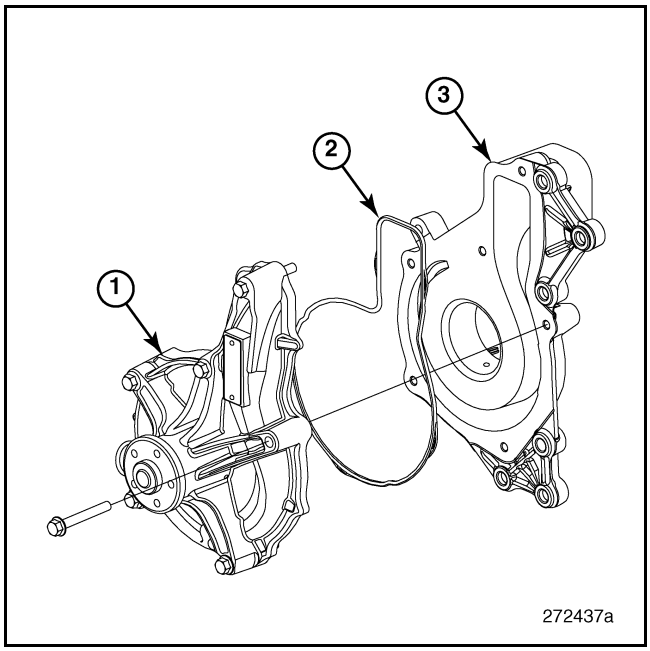


Figure 146 — Coolant Pump

1. Coolant Pump Impeller Assembly 2. Pump Seal	3. Coolant Pump Base Plate

1. Remove the fasteners and remove the belt tensioner and idler bracket from the front of the cylinder block if not already done.
2. Remove the pump impeller assembly fasteners and remove the impeller assembly from the base plate.
3. Remove and discard the pump seal.
4. Remove the fasteners and the coolant pump base plate from the cylinder block.

Cylinder Head Removal

[213 EV]

⚠ CAUTION

*If the engine is not being completely disassembled for overhaul and only the cylinder head is to be removed, the six screws **A** and **B** which secure the timing gear plate to the cylinder head and the four upper screws **C** securing the idler gear hub to the cylinder head MUST BE REMOVED (Figure 147). Failure to do so may result in severe damage to the cylinder head and other engine components as the cylinder head is removed. See "REMOVING THE TIMING GEAR PLATE-TO-CYLINDER HEAD SCREWS" on page 107.*

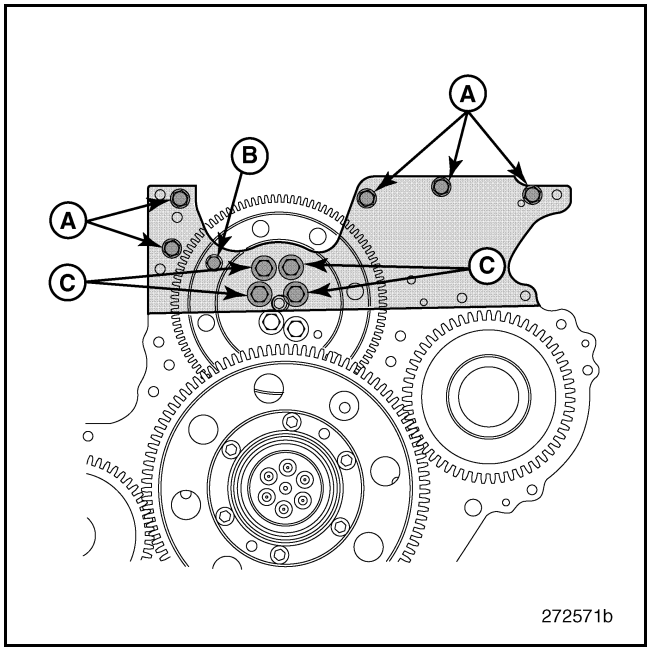


Figure 147 — Cylinder Head-to-Timing Gear Plate Screw Locations

REMOVING THE TIMING GEAR PLATE-TO-CYLINDER HEAD SCREWS

If not already done, remove the 10 screws (**A**, **B** and **C** in Figure 147) securing the cylinder head to the timing gear plate as follows:

1. Remove the five screws through the timing gear plate on either side of the adjustable idler gear.

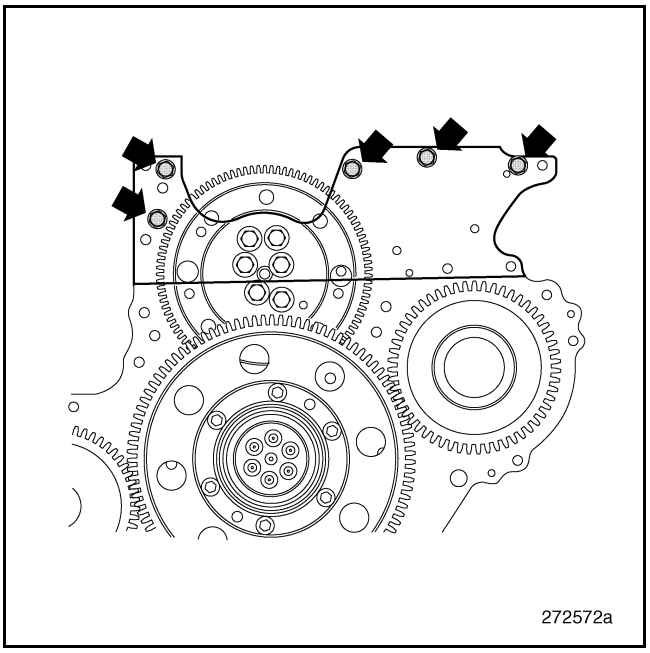


Figure 148 — Head-to-Plate Attaching Screws

2. Bar the engine over to align a hole in the adjustable idler gear with the hidden screw through the plate into the cylinder head. Remove the screw.

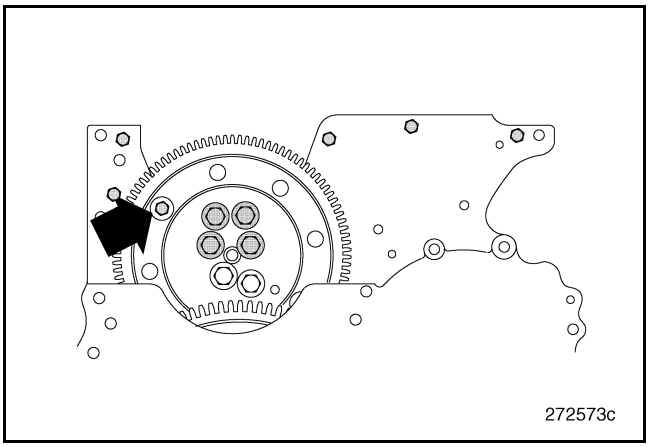


Figure 149 — Hidden Screw (Behind Gear)

3. Remove the four upper screws in the adjustable idler gear hub.

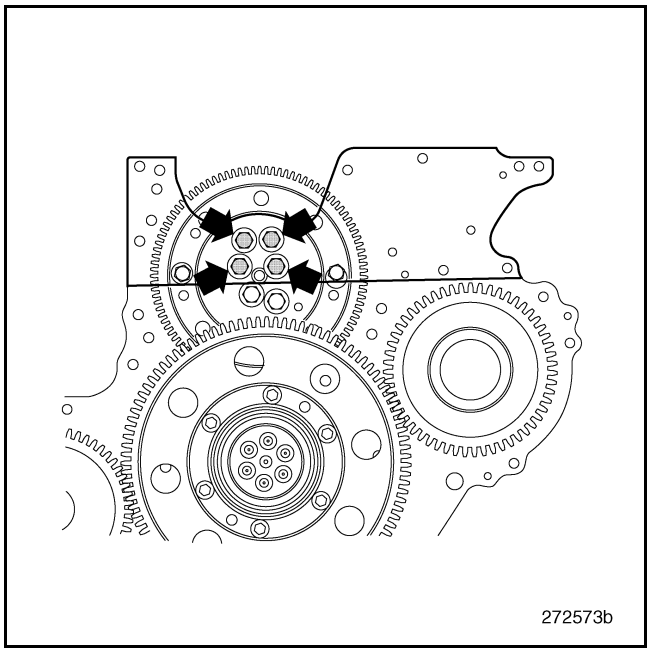


Figure 150 — Upper Four Adjustable Idler Gear Hub Screws

4. Remove any residual engine oil from the “hollows” beneath the camshaft to prevent oil from running into the coolant channels.

REMOVING THE CYLINDER HEAD

With the timing gear mounting plate-to-cylinder head screws removed (**A**, **B** and **C** in Figure 147), proceed as follows to remove the cylinder head.

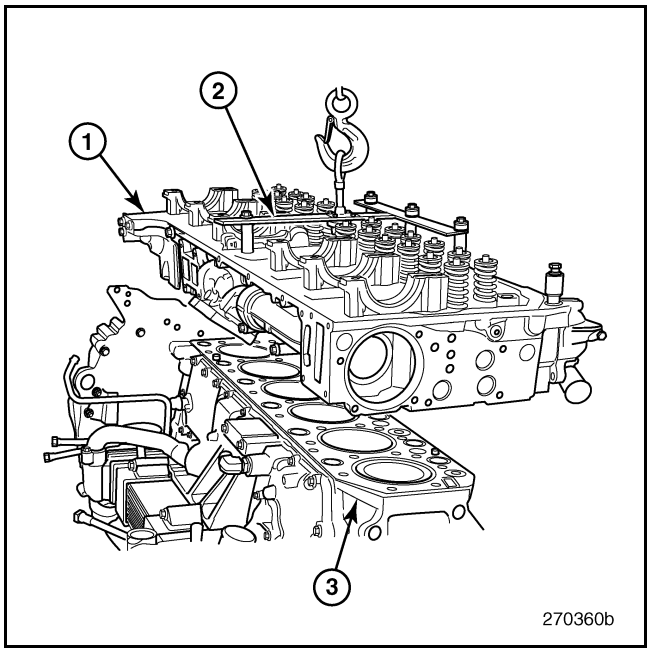


Figure 151 — Cylinder Head Removal

1. Cylinder Head 2. Lifting Tool, 88800188	3. Cylinder Block

1. Remove the cylinder head bolts.
2. Using the cylinder head lifting tool, 88800188, carefully remove and set aside the cylinder head.

3. Remove and discard the cylinder head gasket.
4. Attach cylinder liner hold-down tools, 9996966, to the cylinder block to keep the liners in place temporarily.

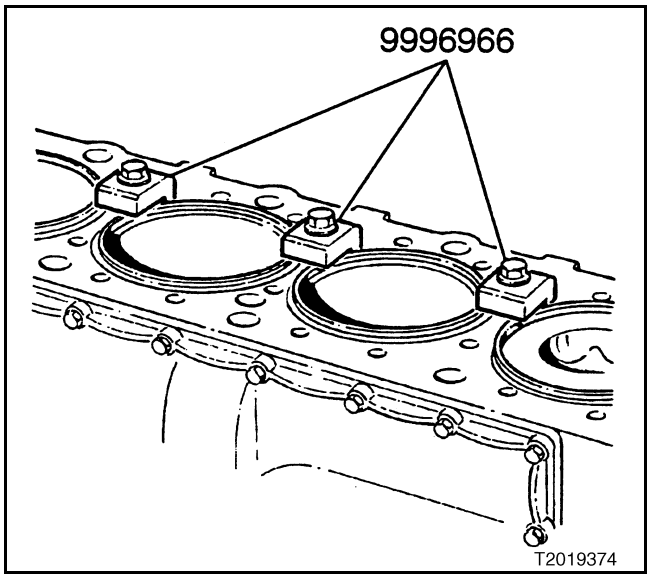


Figure 152 — Cylinder Liner Retainer

Crankshaft Vibration Damper and Fan Pulley Removal

[212 RB, RP]

⚠ CAUTION

When handling a vibration damper, be careful not to damage the housing. Dents in the outer housing may render the damper ineffective, causing an imbalance and vibration in the engine. The vibration damper cannot be repaired.

The fan pulley nests within the damper using the same attaching screws.

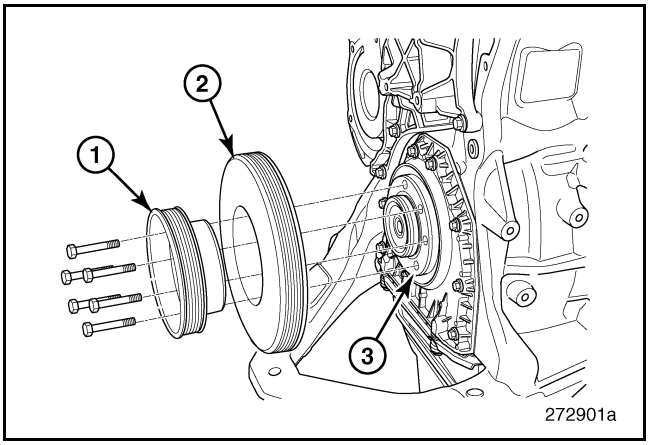


Figure 153 — Vibration Damper and Fan Pulley

1. Pulley, Fan Drive and Coolant Pump 2. Vibration Damper/Pulley	3. Crankshaft Hub

1. If not already done, release the tensioners and remove the drive belts.
2. Remove the front engine power take-off (FEPTO) unit, if so equipped.
3. Remove the fasteners and remove the crankshaft vibration damper and fan pulley.

Crankshaft Front Cover Removal [211 JB]

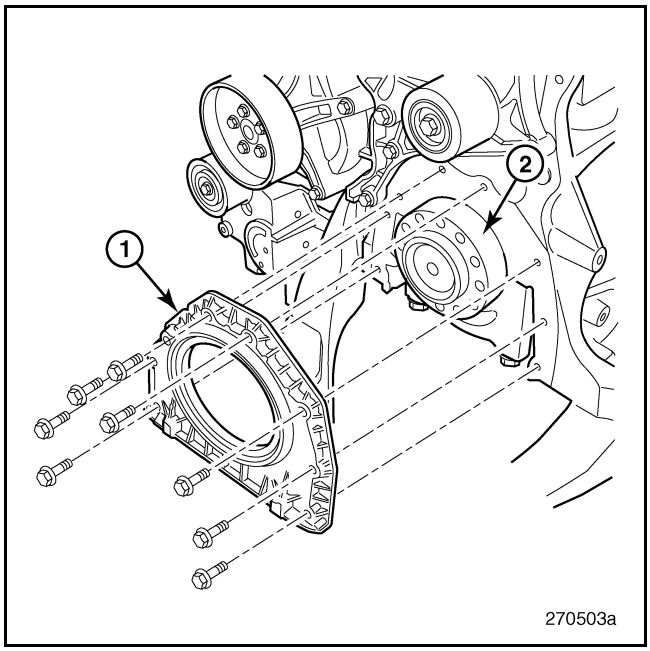


Figure 154 — Crankshaft Front Cover

1. Front Cover	2. Crankshaft Hub

1. While supporting the front cover, remove the eight fasteners attaching the cover to the cylinder block.
2. Remove the crankshaft front cover from the engine by sliding it off the crankshaft flange.

Crankshaft Front Seal Removal [211 JB]

With the crankshaft front cover removed, use a drift and hammer to remove the old seal from the cover bore.

If the engine is not being completely disassembled for overhaul and only the crankshaft front seal is to be replaced, remove the seal using the following procedure.

1. Drill two 3.5 mm (0.138 inch) holes in the metal rim of the front crankshaft seal using the holes in the rim of the seal remover/installer.

NOTE

Apply grease to the drill bit to collect metal chips when drilling holes in the seal.

2. Using two self-tapping M5 screws of suitable length, attach the front crankshaft seal remover/installer, 88800021, to the seal.
3. Using two M10 screws of suitable length threaded into the tapped holes in the crossmember of the remover/installer, remove the seal and discard it.
4. Clean the seal seating surface in the crankshaft front cover and the sealing surface on the crankshaft hub.

Oil Fill Pipe and Dipstick Retainer Removal

NOTE

Provide suitable rags and containers for collecting oil drainage at each step.

1. If not already done, remove and set aside the dipstick.

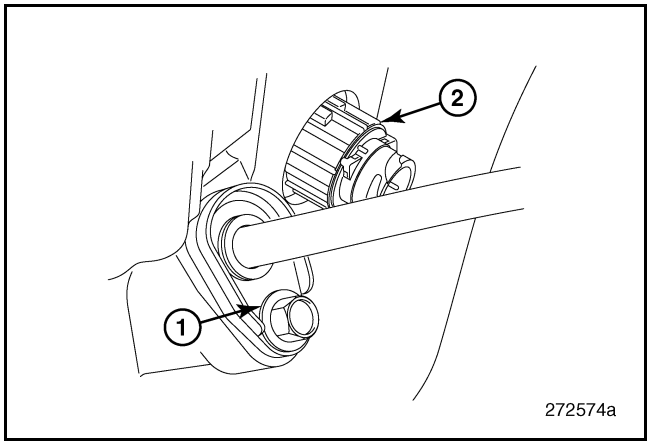


Figure 155 — Oil Dipstick Port

1. Retainer Screw	2. Oil Level Sensor Connector

2. Remove the retainer screw from the dipstick pipe flange and remove the pipe from the engine.
3. Remove the fasteners from the oil fill pipe mounting flange and remove the oil fill pipe.

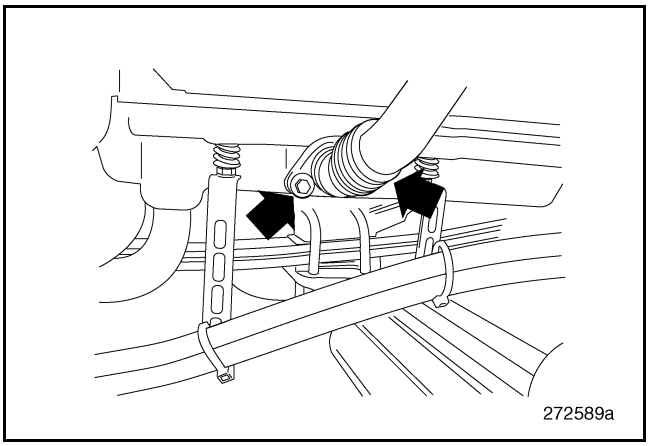


Figure 156 — Oil Fill Pipe Mounting Flange

Oil Pan Removal

[211 NB]

NOTE

If the engine is in the vehicle, provide a lifting device to assume the weight of the oil pan during removal.

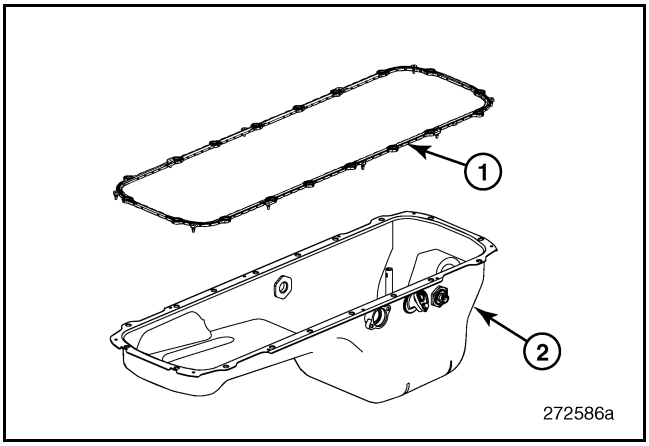


Figure 157 — Oil Pan

1. Elastomer Seal	2. Oil Pan

1. If the vehicle is equipped with an optional transmission oil cooler and not already done, remove the transmission cooler line bracket nuts and separate the brackets from the oil pan fasteners.
2. Remove the screws and springs securing the oil pan to the crankcase.

NOTE

The oil level sensor need not be removed unless it is to be replaced.

3. Remove and set aside the oil pan.
4. Remove and discard any O-rings found on the oil pan screws.
5. Remove the elastomer seal from the oil pan and inspect it. If the seal is damaged, it must be replaced.

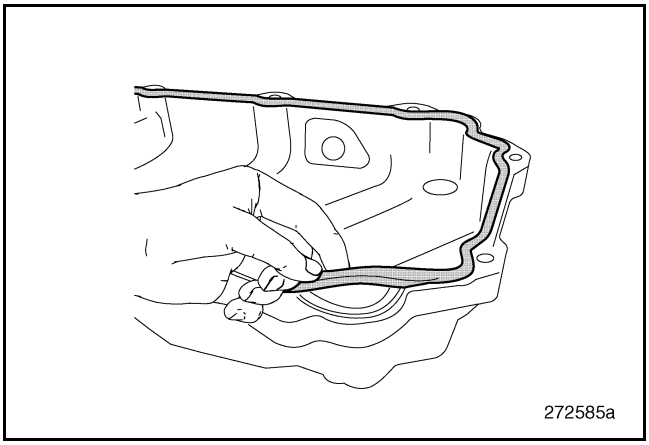


Figure 158 — Removing Oil Pan Gasket

Front Engine Support Removal [299 GV]

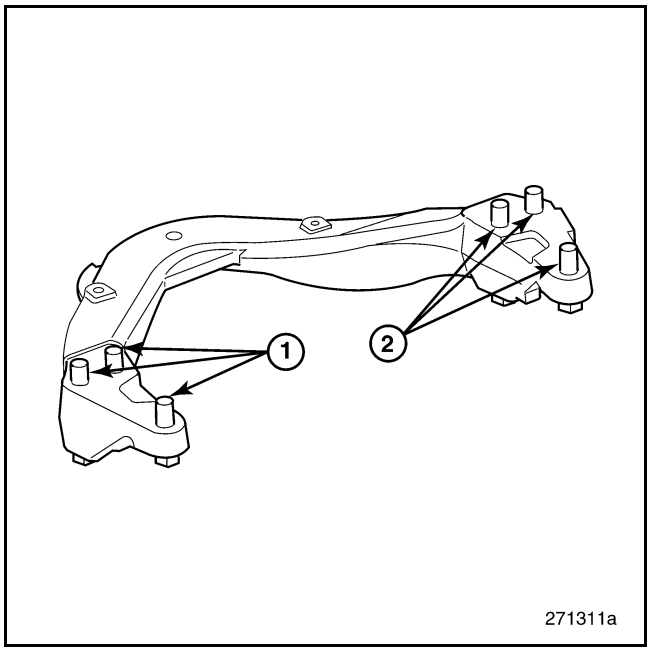


Figure 159 — Front Engine Support

1. Left-Side Attaching Screws	2. Right-Side Attaching Screws

Remove the fasteners at the left and right sides of the engine support and remove the support from the mounting brackets at each side of the cylinder block.

Block Stiffener Plate Removal

The inlet pipe with a front sump oil pan is longer than the one with a rear sump oil pan. Both the shorter and longer pipes attach to a bracket mounted on the stiffener frame and cylinder block.

1. Remove the support retaining fasteners and remove the pump inlet pipe. Remove and discard the seal ring.

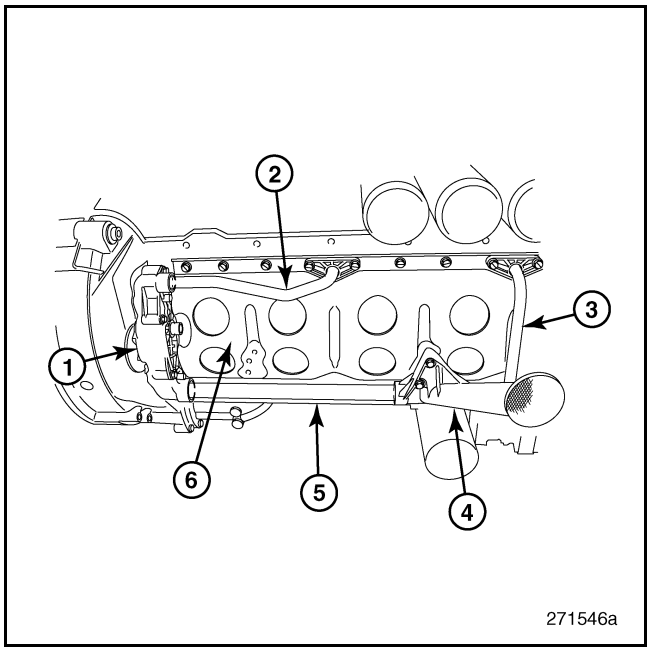


Figure 160 — Inlet, Outlet and Crossover Pipes (Front Sump Shown)

1. Oil Pump	4. Strainer
2. Pump Outlet Pipe	5. Pump Inlet Pipe
3. Crossover Pipe	6. Block Stiffener Plate

2. Remove the fasteners from the pump outlet (pressure side) pipe flange and remove the pipe from the engine. Remove and discard the seal rings.
3. Remove the fasteners from the crossover pipe flange and remove the pipe.
4. Remove the remaining fasteners securing the stiffener plate to the cylinder block.

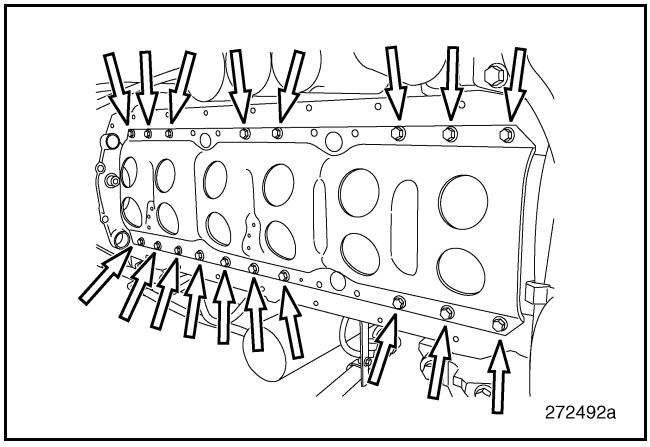


Figure 161 — Block Stiffener Plate

5. With the help of an assistant, remove the block stiffener plate.

Oil Pump Removal

[219 MU, 219 NT]

If the engine is not being completely disassembled for overhaul and only the oil pump is to be replaced, instructions are provided in a separate section entitled “OIL PUMP REPLACEMENT (IN CHASSIS)” for removing and reinstalling the oil pump with the engine in the chassis.

1. If necessary for access to the oil pump mounting fasteners, rotate the crankshaft using engine barring tool, 88800014.
2. Remove the fasteners securing the oil pump to the No. 7 main bearing cap.

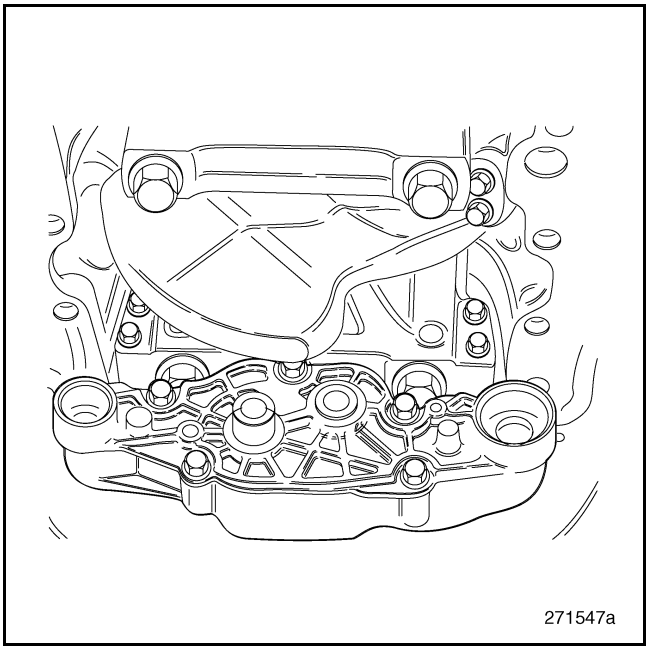


Figure 162 — Oil Pump (Installed on No. 7 Bearing Cap)

3. Carefully remove the oil pump from the bearing cap.

Piston and Connecting Rod Assembly Removal

[212 NP, 212 LP]

1. Rotate the crankshaft so that the connecting rod bearing cap for the desired cylinder is positioned for easy removal of the rod cap bolts.

N O T E

The rod bearing caps can be removed in the companion cylinder sets: Nos. 1 and 6, 2 and 5, and finally 3 and 4.

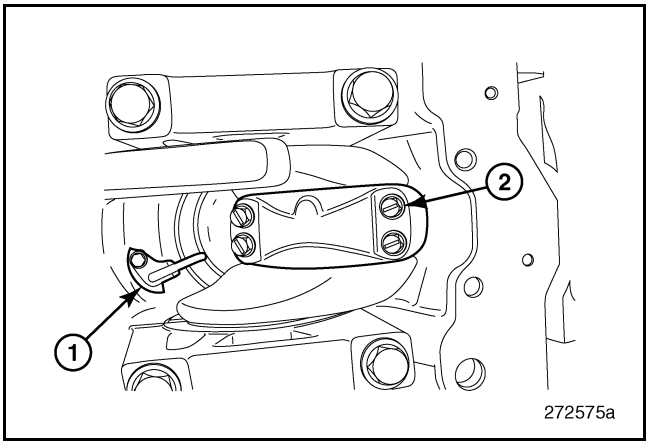


Figure 163 — Connecting Rod Bearing Cap

1. Piston Cooling Nozzle	2. Bearing Cap Bolts

2. Remove the piston cooling nozzle to prevent it from being damaged.
3. Remove the four bolts and remove the bearing cap.
4. Discard the lower bearing insert (shell) in the cap.
5. Using a suitable tool, push up on the bottom of the piston until the rings are free of the cylinder liner. The upper inner surface of the liner may have to be scraped and cleaned if there is excessive carbon build-up to make it easier to remove the piston.

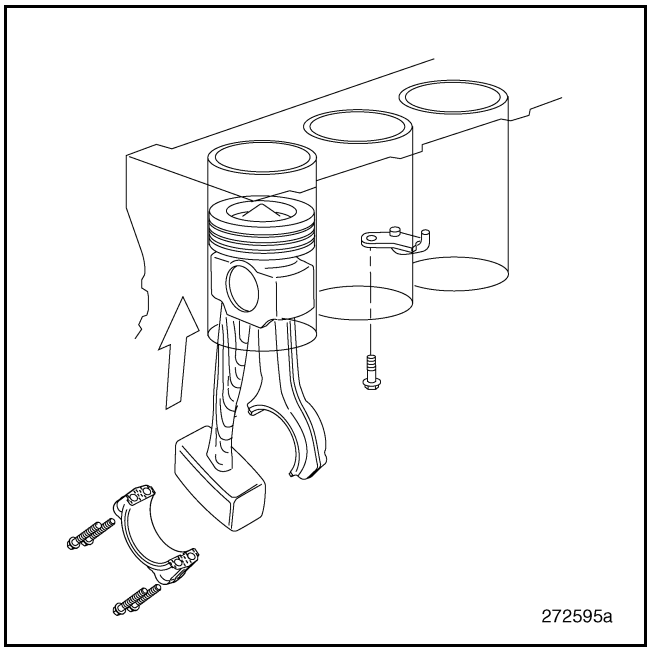


Figure 164 — Piston Removal

⚠ CAUTION

Use care to avoid contact between the connecting rod and liner during removal. Contact may cause damage to the liner.

6. From the cylinder deck, pull up to remove the piston and connecting rod from the engine. Mark the piston assembly to show its location in the engine and set it aside for disassembly and inspection (see the CONNECTING ROD AND PISTON BENCH PROCEDURES section).

NOTE

The connecting rod and bearing cap are a matched set. Use care to ensure that the respective bearing caps and rods are kept together.

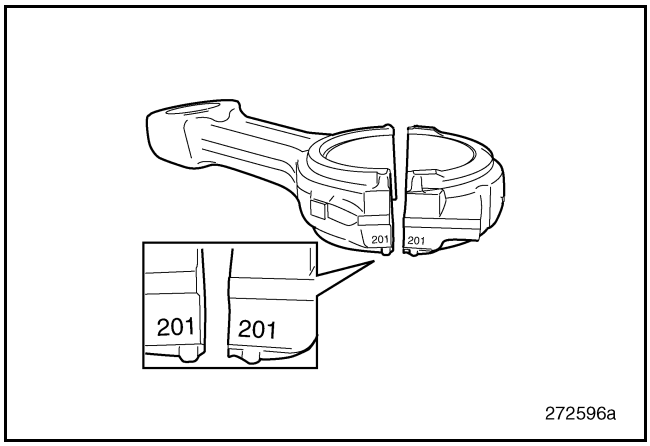


Figure 165 — Connecting Rod-Cap Markings

7. Remove and discard the upper bearing insert in the connecting rod.
8. Repeat steps 1 through 7 to remove the remaining pistons.

Main Bearing Cap Removal [212 HH]

NOTE

Bearing caps are marked. Be sure to return each bearing cap to its original location at assembly.

1. With the engine inverted (crankcase side up) on the repair stand, loosen and remove the bolts securing the main bearing caps.

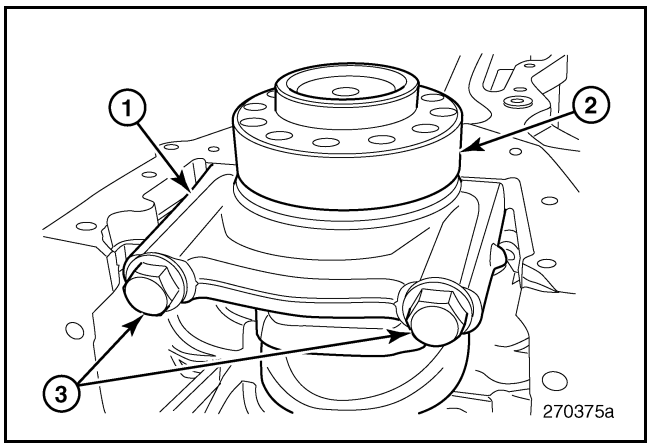


Figure 166 — Crankshaft No. 1 Main Bearing Cap

1. No. 1 Main Bearing Cap 2. Crankshaft Hub	3. Attaching Screws

2. Using puller 9990114, adapter 9990262 and slide hammer 9996400, remove and set aside the bearing caps.

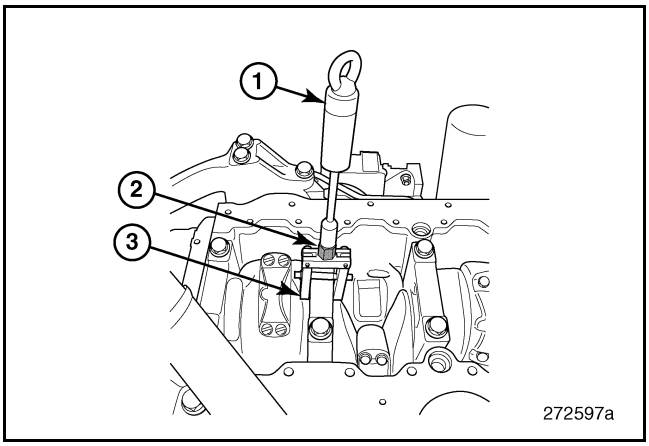


Figure 167 — Removing Main Bearing Caps

1. Tool No. 9996400 2. Tool No. 9990262	3. Tool No. 9990114

3. Remove and make note of the part number on the inserts (shells). Discard the inserts.

NOTE

In addition to the main bearing inserts, the No. 4 crankshaft journal includes four thrust washer inserts, an upper and lower at each side of the crankshaft journal.

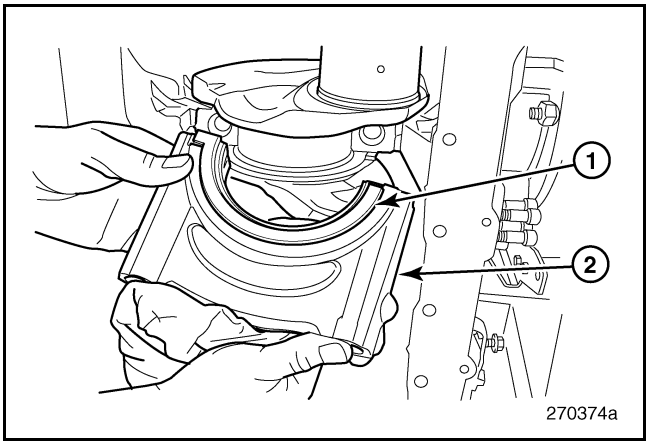


Figure 168 — Crankshaft No. 4 Main Bearing Cap with Thrust Washers

1. Thrust Washer Insert, Lower	2. No. 4 Main Bearing Cap

4. Remove and discard the thrust washer inserts.

Crankshaft Removal

[212 HP]

⚠ WARNING

The crankshaft is extremely heavy. Do NOT attempt to remove the crankshaft without the help of an assistant or the use of a suitable lifting device. Failure to heed this warning may result in severe personal injury and component damage.

⚠ CAUTION

Exercise extreme care when lifting and moving the crankshaft to avoid striking other objects. No nicks, scratches, burrs or other signs of distress on the journals or fillets are acceptable.

1. With an assistant and using the crankshaft lifting tool, J 49002, lift the crankshaft to remove it from the cylinder block.

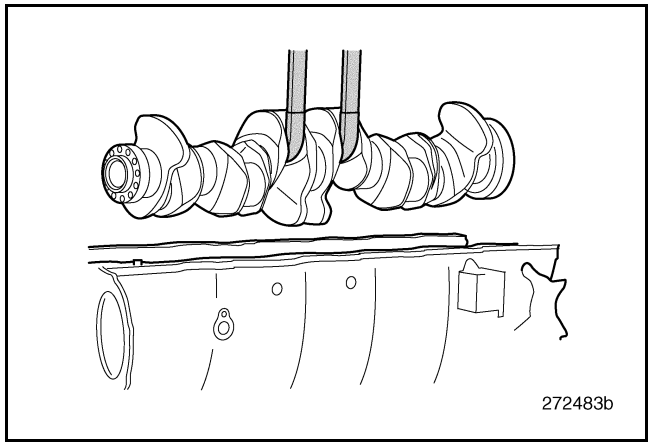


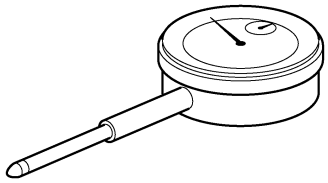
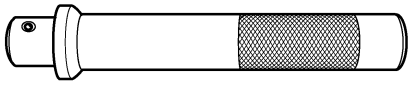
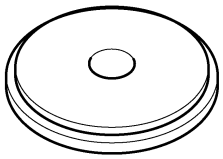
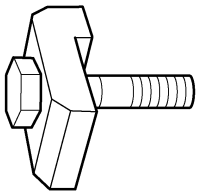
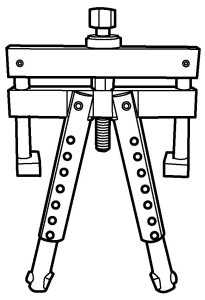
Figure 169 — Removing the Crankshaft

2. Remove and discard the upper main bearing inserts from the cylinder block.

CYLINDER BLOCK RECONDITIONING [211 DB]

Tools and Equipment

SPECIAL TOOLS

Tool No.	Description	Images
9989876	Dial Indicator (Available)	 006899a
9992000	Handle with various uses (fits 25 mm hole) (Essential)	 006785a
9996599	Liner Installation Plate (Available)	 006792a
9996966	Liner Hold-Down Tool (Essential)	 006796a
PT-6435 or PT-6400-C	Cylinder Liner Puller (Available) **Note:** Alternate tools for liner removal — 9992955, 9996394, 9996395 and 9996645 in combination.	 006808a

Piston Cooling Spray Nozzle Removal

[219 RV]

⚠ CAUTION

To avoid damaging the spray nozzles, remove them before removing the liners.

SERVICE HINT

It is best to use a 12 mm, 6-point socket on a 300 mm (12 inch) extension to remove the nozzle retaining capscrews.

1. Remove the piston cooling spray nozzle by removing the retaining capscrew.
2. Carefully pull outward on the spray nozzle to remove it from the cylinder block.
3. Repeat steps 1 and 2 to remove the remaining spray nozzles.

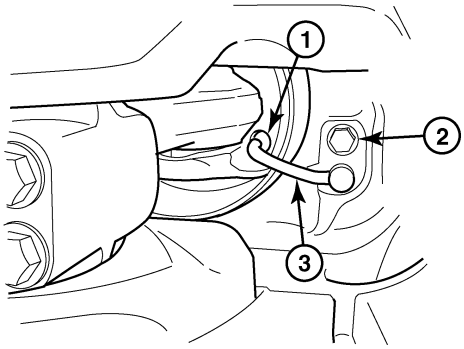


Figure 170 — Spray Nozzle Removal

1. Piston Cooling Duct 2. Attaching Screw	3. Spray Nozzle

Cylinder Liner Removal

[212 NC]

1. Install the cylinder liner puller, tool PT-6435 or equivalent, in position over the cylinder liner to be removed.

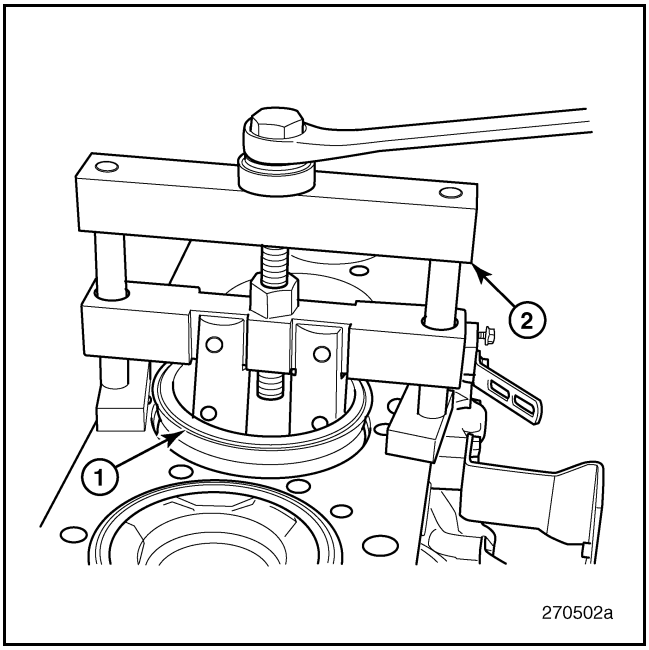


Figure 171 — Cylinder Liner Removal

1. Cylinder Liner	2. Liner Puller Assembly

⚠ CAUTION

Be sure the cogs on the puller legs do not extend beyond the outside diameter of the liner. Failure to heed this caution may result in severe component damage.

2. Hooking puller legs on the bottom of the cylinder liner, tighten the center screw on the puller until the liner comes free of the cylinder block bore.
3. Remove the liner and puller assembly from the cylinder block. Then, remove the puller from the liner.
4. Repeat the procedure to remove the remaining cylinder liners.

NOTE

As an alternative, tool Nos. 9992955, 9996394, 9996395 and 9996645 in combination, can be used for cylinder liner removal.

Block Cleaning and Inspection

The engine should have been thoroughly steam cleaned prior to component removal. If heavy accumulations of dirt and grease are still present, steam clean the block as thoroughly as possible before attempting to clean with solvents.

⚠ WARNING

Cleaning solvent is flammable and toxic to the eyes, skin and respiratory tract. Skin and eye protection is required. Avoid repeated or prolonged contact. Use only in a well-ventilated area. Failure to heed this warning may result in severe personal injury.

⚠ WARNING

Compressed air used for cleaning can create airborne particles that may enter the eyes or irritate the skin. Pressure must not exceed 207 kPa (30 psi). Eye protection is required. Use only with effective chip guarding and personal protective equipment (goggles/shield, gloves, etc.). Failure to heed this warning may result in severe personal injury.

NOTE

Cleaning the cylinder block is important. While cleaning the cylinder block, carefully inspect the areas around the cup plugs and the coolant duct cover. If cup plugs or pipe plugs show signs of leaking, they should be replaced.

Cleaning the cylinder block is a good time to inspect it for cracks or other possible defects that may be reason for rejection. Refer to the TROUBLESHOOTING section for information on testing for leaks in the cylinder head and cylinder block. If damage is not found until after the engine is assembled, the engine must be disassembled and rebuilt again.

SOLVENT TANK CLEANING

NOTE

Use a cleaning tank large enough to accommodate the largest component to be cleaned. Fill the tank with a suitable solvent. Parts may be dried with compressed air.

⚠ WARNING

Always use caution while cleaning parts with solvents. Failure to heed this warning may result in personal injury.

1. Scrape any remaining gasket material from the cylinder block.
2. Using a wire brush or rotary wheel, remove any rust, corrosion or other debris from the cylinder block.
3. Clean all other cylinder block surfaces with mineral spirits or other suitable solvent.
4. Using due care and caution, clean and dry the cylinder block with compressed air.

INSPECTION

NOTE

A complete discussion of the proper methods for precision measuring and inspection is outside the scope of this procedure. However, every shop should be equipped with standard gauges, such as bore gauges, dial indicators, outside and inside micrometers, thickness gauges and straightedges.

Check the cylinder block for indications of cracking or coolant leakage. If any damage is suspected, use a standard dye penetrant to determine if cracks exist. A cracked cylinder block must be replaced and never reused.

Counterbore Inspection and Cleaning

[211]

If the cylinder liner counterbore surface shows excessive pitting or erosion, recut the counterbore as required. Shims are available if the counterbore depth must be changed. Do not resurface the block deck.

NOTE

This procedure can be performed either in or out of the chassis. If performing the procedure in the chassis, be sure to cover the crankshaft and any holes in the cylinder block to prevent contamination from machining chips.

Liner Height Measurement

[212 NC]

To determine liner height above the cylinder block deck, proceed as follows:

1. Insert a replacement liner (**without** sealing rings) into the cylinder block bore. Secure the liner in place, using two hold-down tools, 9996966.
2. Mount the dial indicator, tool 9989876, in the holder, tool 9992479. Place the holder and dial indicator in position across the top of the cylinder liner. Set the tip of the dial indicator against the cylinder block deck and zero the dial indicator gauge.

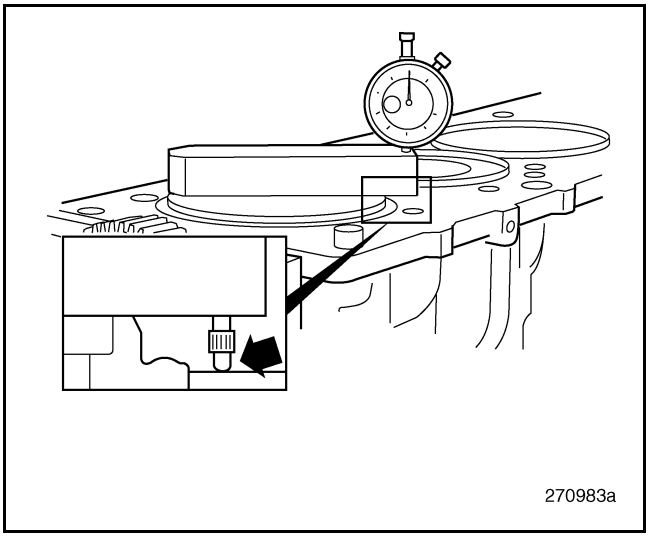


Figure 172 — Zeroing the Dial Indicator to the Block Deck

3. Reset the tip of the dial indicator against the high point on the convex surface of the cylinder liner. Measure and record the height of the liner ledge above the cylinder block deck.

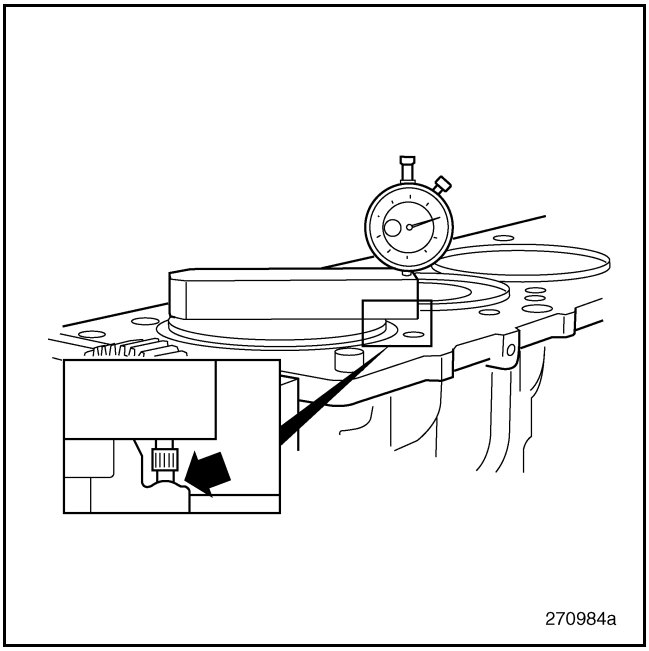


Figure 173 — Measuring the Cylinder Liner Height

4. Measure and record the height of the liner ledge above the cylinder block deck at four points, 90 degrees apart.
5. Calculate an average height, using the **highest** recorded measurement and the measurement taken diagonally across the cylinder bore. Check the calculated height against specifications. Then, calculate the thickness of the shim(s) required, if any. Use the fewest possible number of shims.
6. Using a marking pen, mark the position of the liner in the cylinder bore for final installation. Then, remove the liner and adjustment spacer (if required) from the cylinder block and place on a clean work surface.
7. Repeat the procedure for the remaining cylinders.

Cylinder Liner Installation

[212 NC]

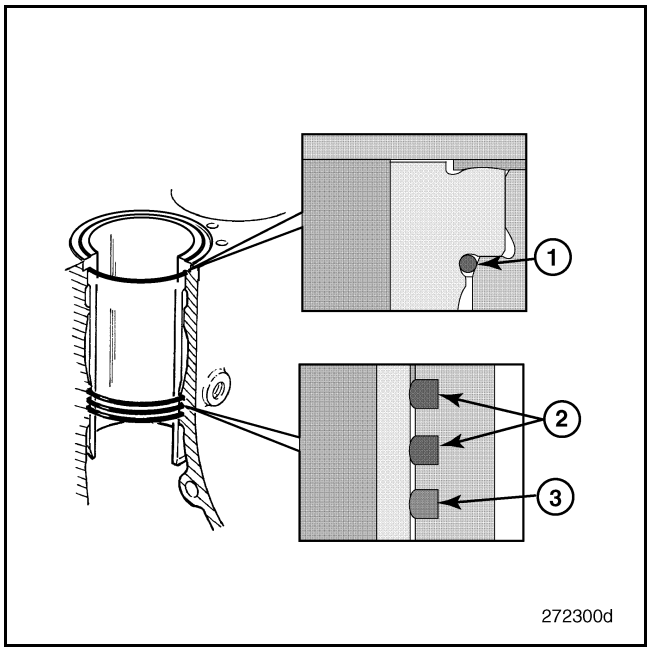


Figure 174 — Seal Ring Installation

1. EPDM (Black) 2. EPDM (Black)	3. Viton (Purple)

1. Apply lubricant (included in liner kit) to **new** seals and install them in the four annular grooves, one under the flange of the cylinder liner and three near the bottom. The purple gasket is installed in the lowest groove.
2. If the cylinder liner is being installed with a spacer (shim), apply a 0.8 mm (0.03 inch) bead of 342SX33 MACK-approved sealant to the counterbore ledge in the cylinder block. Do NOT apply the sealant between the spacer and the cylinder liner flange.

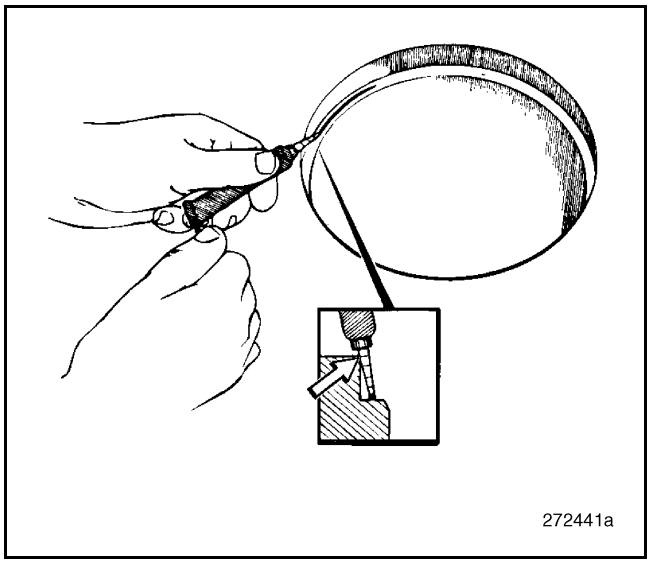


Figure 175 — Applying Sealant to Counterbore

3. Using liner installation plate, 9996599, and handle, 9992000, press the liner (with spacer if appropriate) into the bore until seated.

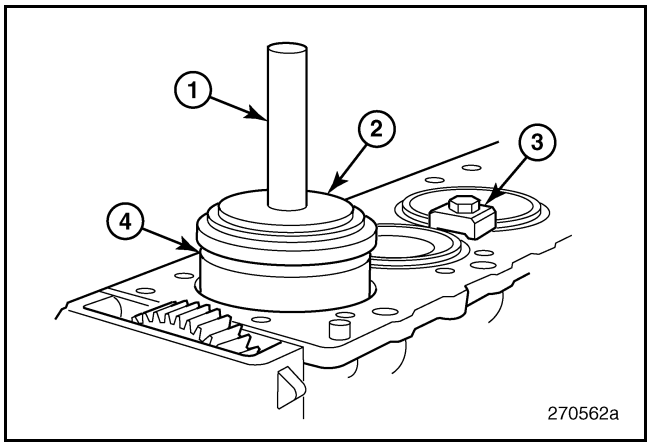


Figure 176 — Cylinder Liner Installation

1. Handle 9992000 2. Liner Installation Plate 9996599	3. Liner Hold-Down Tool 9996966 4. Cylinder Liner

4. Secure the liner in place using two liner hold-down tools, 9996966.

⚠ CAUTION

The liners must be installed and secured in place within 20 minutes after application of the sealant to the liners.

FLYWHEEL BENCH PROCEDURES

Flywheel Ring Gear Replacement [21687-5]

1. Heat the ring gear around the outer edge with a torch.

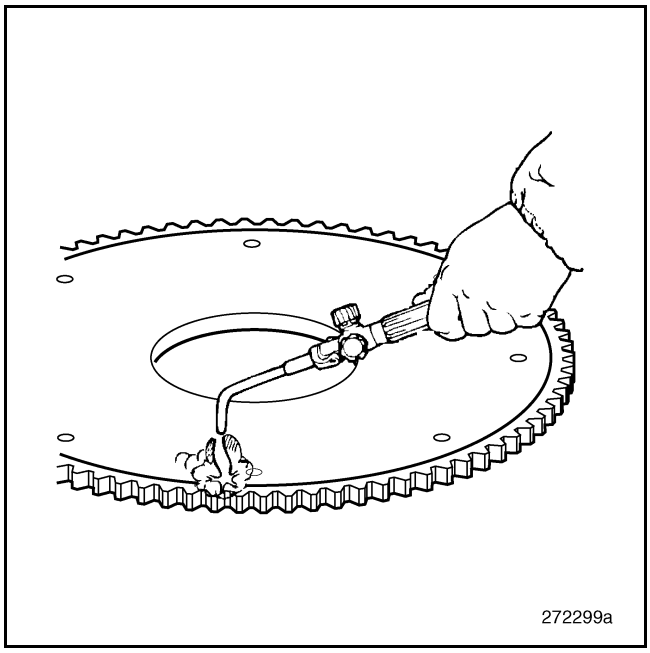


Figure 177 — Ring Gear Removal

2. Use a punch to remove the ring gear from the engine flywheel.
3. Use a steel brush to clean the engine flywheel.

⚠ CAUTION

Use caution not to heat the ring gear excessively or damage will occur to the new ring gear.

4. Heat the new ring gear with a torch or in a furnace to 180–200°C (356–392°F). Heat the gear evenly around the entire surface. A good indication that the correct temperature has been reached is when bright metal turns a bluish color.

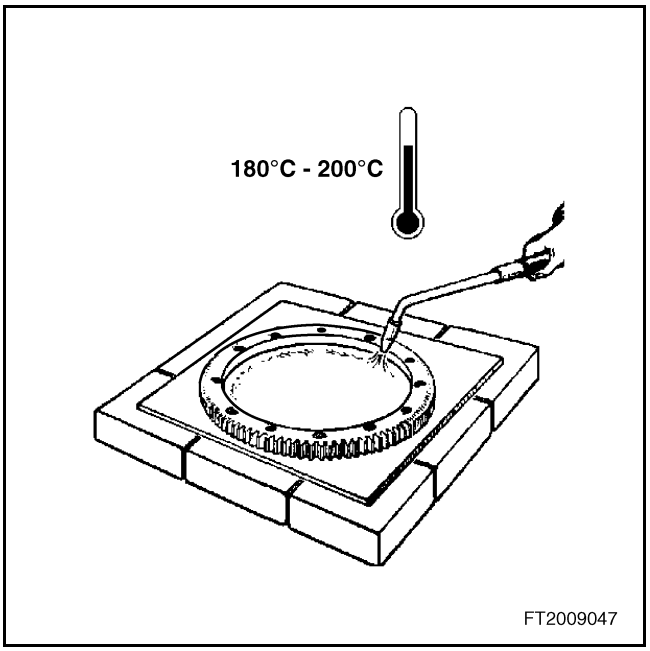


Figure 178 — Ring Gear Heating

5. Install the heated ring gear on the engine flywheel. Let the ring gear air cool naturally.

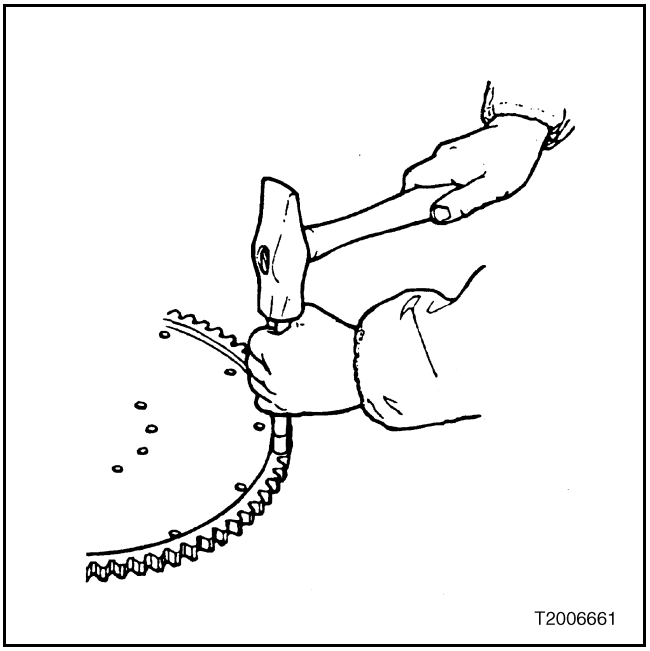


Figure 179 — Ring Gear Installation

CONNECTING ROD AND PISTON BENCH PROCEDURES

Connecting Rod — Piston Disassembly

[212 LP]

New rods for service arrive with caps attached. The cap must be separated by holding the rod in a soft-jawed vise and striking the cap with a rubber-faced hammer. Care must be taken to prevent damage to the rod, cap and bearing surfaces.

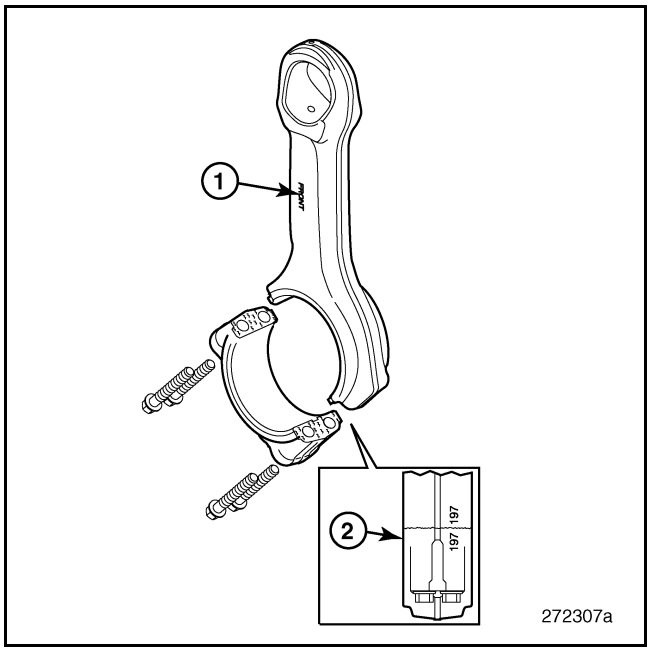


Figure 180 — Connecting Rod

1. The word, **Front**, faces the front of the engine.	2. The numbers must agree and be aligned on the same side.

It is essential that a cap and rod be kept together when removed from the engine and when installed. Each rod and cap is marked with matching numbers to identify them as a set. At assembly, the numbers must appear side by side and the notches must be aligned. Refer to Figure 180. Tag the sets on removal so each set can be returned to the cylinder from which it was removed.

⚠ CAUTION

Do not install a damaged connecting rod assembly. Failure to heed this caution may result in severe component damage.

⚠ CAUTION

*Do **NOT** use a pneumatic impact wrench to tighten connecting rod screws. It will damage the mating surfaces. Failure to heed this caution may result in severe component damage.*

WRIST PIN REMOVAL

1. Using snap ring pliers, remove the snap ring at each end of the wrist pin.
2. Remove the wrist pin from the piston and connecting rod.

INSPECTION

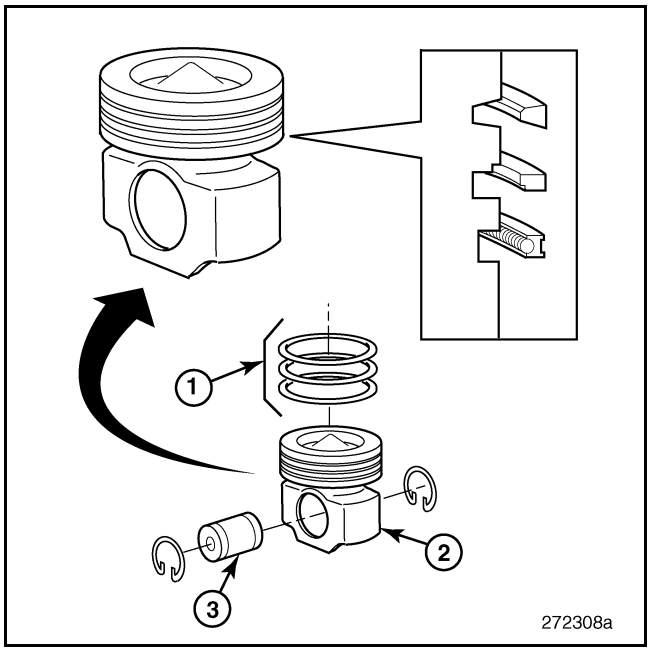


Figure 181 — Piston Assembly — Exploded View

1. Piston Rings 2. Piston	3. Wrist Pin

Inspect each connecting rod and cap for the following conditions. If any fault appears, replace both rod and cap.

1. Inspect the connecting rods for nicks, cracks, signs of overheating and unacceptable bending and twisting.
2. Inspect the bolt holes for elongation and damaged threads.
3. Inspect the mating surfaces between the connecting rod and cap for correct fit.
4. Inspect the bolt holes for elongation or stripped threads.
5. Inspect the wrist pin.
6. Inspect the wrist pin bearing surface in the connecting rod.
7. Inspect the crankshaft journal bearing surfaces of the connecting rod and cap.

SERVICE HINT

If it is determined that any component is in questionable condition, replace it.

CONNECTING ROD ALIGNMENT

Visually inspect the connecting rod for twist and bend. Replace the connecting rod if necessary.

Piston Inspection and Cleaning [212 NP]

DISASSEMBLY

1. Using a suitable piston ring expander, remove the piston rings.
2. Clean the piston ring grooves, combustion bowl area and the snap ring grooves thoroughly.

⚠ CAUTION

Remove all carbon. Carbon left in the grooves reduces ring clearance and prevents proper seating.

Be sure that the cleaning solvent is approved for steel and aluminum. Incompatible solvents may damage the pistons.

Failure to heed this caution may result in severe engine damage.

3. Using a brass brush and an approved cleaning solution, clean the pistons.

NOTE

Avoid damaging the pistons while cleaning.

INSPECTION

Inspect the piston ring grooves, lands, skirt and combustion bowl for wear, scuff marks, cracks and blow-by. Pistons are NOT repairable. Discard worn or damaged pistons.

⚠ CAUTION

Do not stamp or engrave on the TOP of the piston. Failure to heed this caution may result in severe engine damage.

Piston Ring Inspection and Replacement

[212 NV]

OIL RING GROOVE SIDE CLEARANCE INSPECTION

1. Using a thickness gauge, measure oil ring groove side clearance.

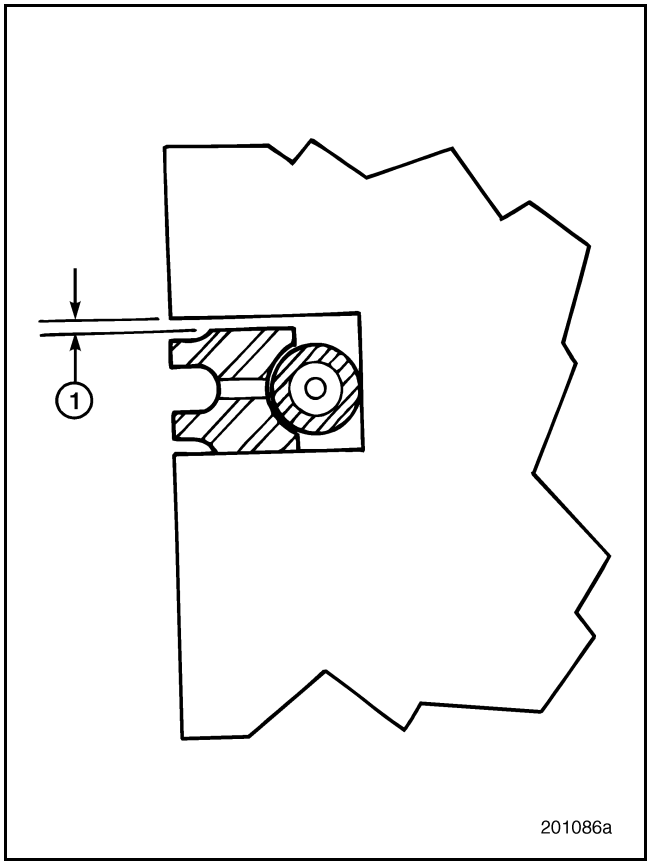


Figure 182 — Side Clearance Measurement

1. Ring Groove Side Clearance

   a. Insert a **new** oil control ring in the groove.
   b. Insert a thickness gauge between the ring and upper land of the groove.
   c. Record the measurement and compare the reading with the information in *Fits and Limits* in the **SPECIFICATIONS** section.

RING END GAP INSPECTION

1. Using an inverted piston, push a piston ring into a cylinder liner making sure it is squarely aligned.
2. Using thickness gauges, measure the gap between the ring ends. Refer to *Fits and Limits* in the **SPECIFICATIONS** section for gap information.
3. Repeat steps 1 and 2 for each ring.

⚠ CAUTION

Do not file or grind chrome-plated piston rings. This may cause the chrome to flake resulting in ring failure. Failure to heed this caution may result in severe engine damage.

RING INSTALLATION

NOTE

Identification markings on the rings should face the piston top. The keystone ring goes in the top ring groove.

Follow the directions on each piston ring packet.

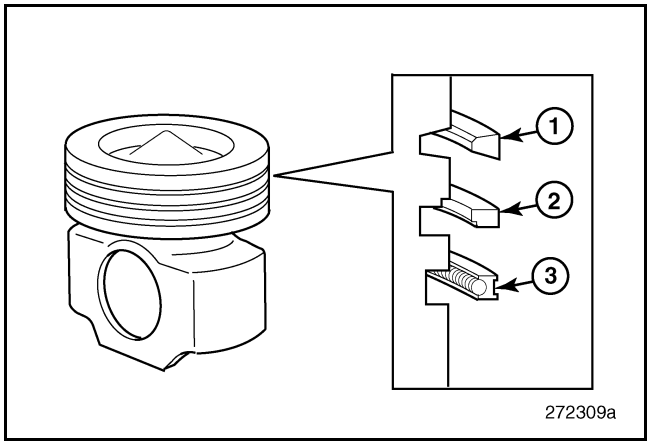


Figure 183 — Piston Rings

1. Upper Compression Ring (Keystone-Shaped)	2. Lower Compression Ring 3. Oil Control Ring

1. To prevent distortion, use the proper size piston ring expander, to insert the rings in the grooves.
2. Stagger the ring gaps so that they are not aligned and none is directly over the wrist-pin bore.

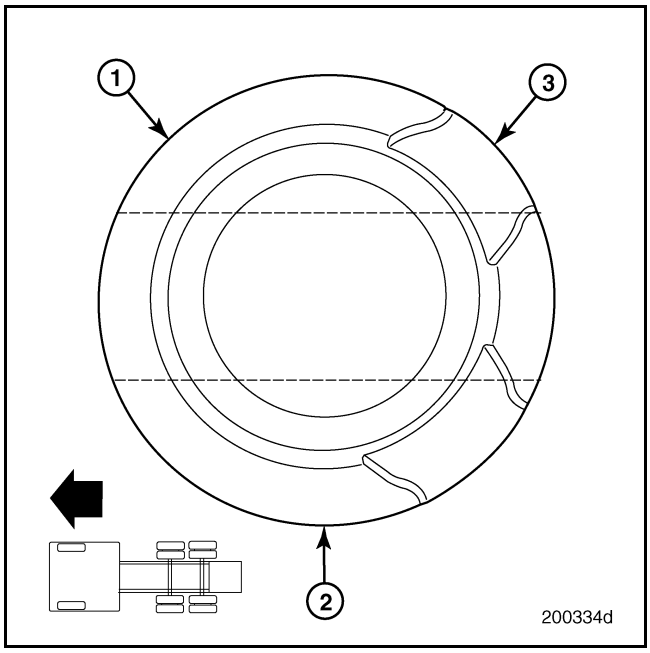


Figure 184 — Ring Gap Locations

Connecting Rod — Piston Assembly

[212 LP & NP]

⚠ CAUTION

Be sure that the piston and rod assemblies are clearly marked with their cylinder location. They must be returned to the same cylinder from which they were removed. Failure to heed this caution may result in severe engine damage.

1. Insert a snap ring in one of the wrist pin retaining grooves.
2. Insert the connecting rod in the piston assembly.

NOTE

Align the FRONT mark on the connecting rod with the arrow on the piston. Refer to Figure 180.

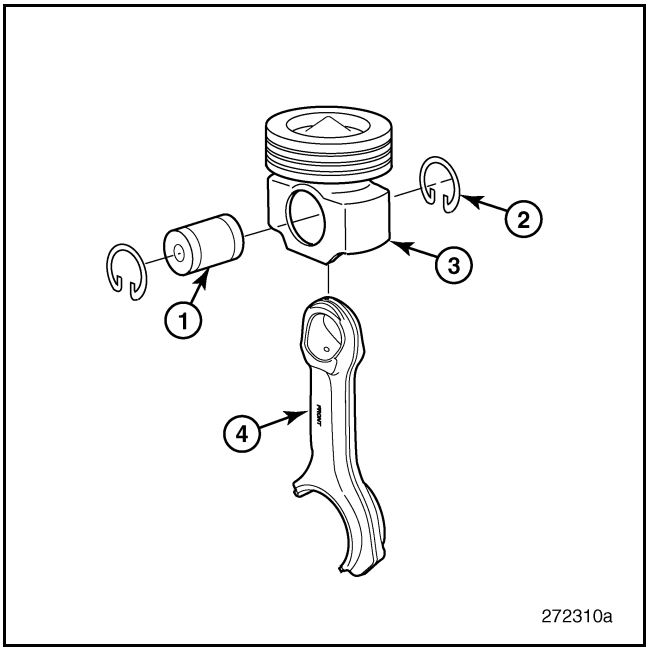


Figure 185 — Connecting Rod Piston Assembly

1. Wrist Pin 2. Snap Ring	3. Piston 4. Connecting Rod

3. Using a generous amount of clean engine oil on the wrist pin and rod bearing, press the wrist pin into the bore.
4. Insert a snap ring in the other wrist pin retaining groove.
5. Set the assembled piston aside in a clean location until it is needed.
6. Repeat steps 1 through 5 for each piston.

⚠ CAUTION

Connecting rod capscrews can only be re-used four times. Screw heads must be punched at each overhaul to indicate the number of times used. Failure to heed this caution may result in severe component damage.

A screw with four punch marks (A) must be replaced with a **new** screw.

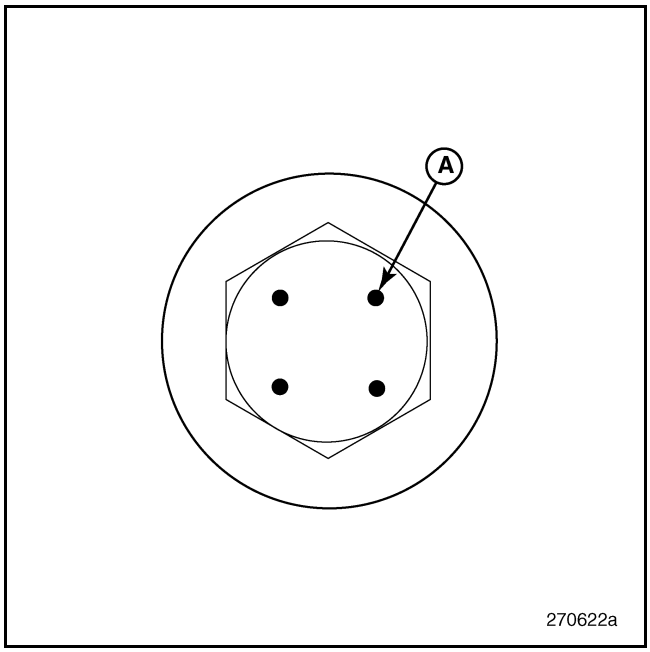


Figure 186 — Connecting Rod Screw with Maximum Punch Marks (Replace)

Used connecting rod screws must be lightly oiled on the threads and under the head. New screws are coated with phosphate and oil and must be assembled dry.

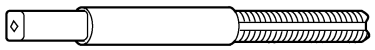
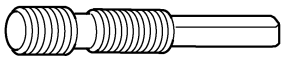
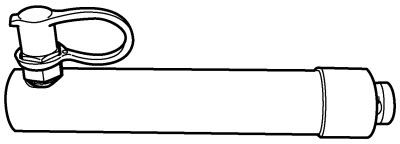
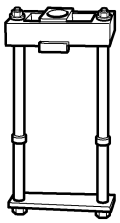
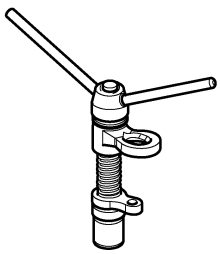
⚠ CAUTION

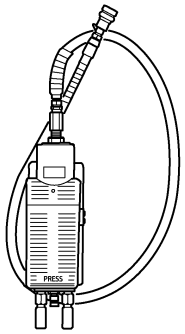
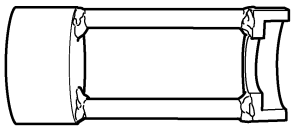
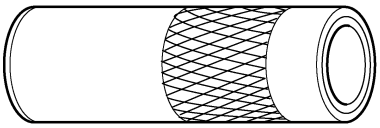
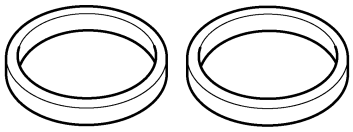
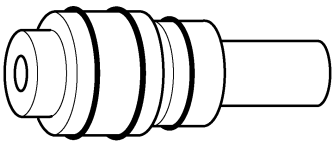
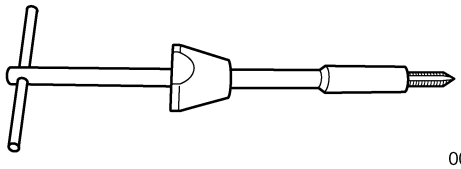
If the capscrews are incorrectly assembled or tightened to an incorrect torque, the assembly must be discarded. Failure to heed this caution may result in severe component damage.

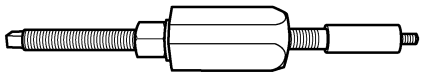
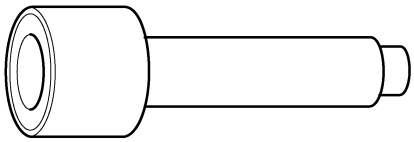
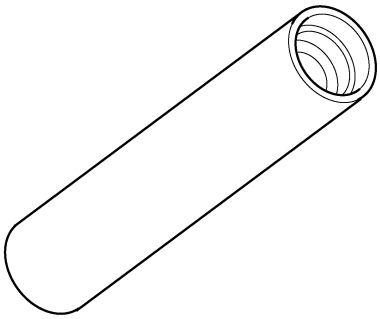
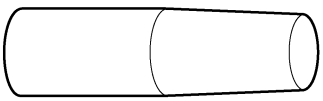
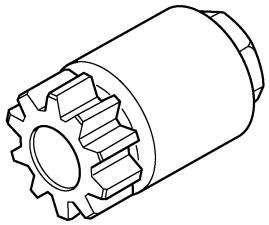
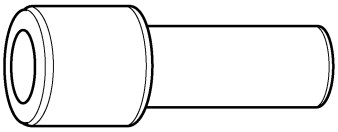
CYLINDER HEAD OVERHAUL [213 EV]

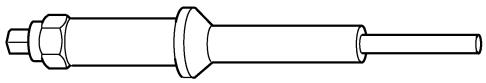
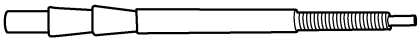
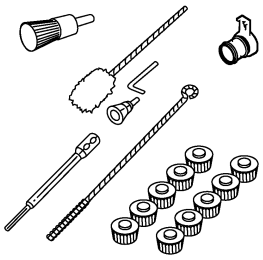
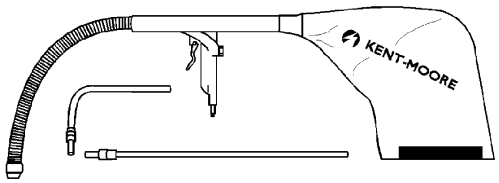
Tools and Equipment

SPECIAL TOOLS

Tool No.	Description	Image
9809667	9 mm Tap, use with 9998252 (Available)	 006840a
9809668	9 mm Bit, use with 9998253 (Available)	 006841a
9809729	Hydraulic Ram (Available)	 006777a
9990176	Tool Press for Valve/Valve Guide Replacement (Available)	 006781a
9990210	Valve Spring Compressor (Essential)	 006782a

Tool No.	Description	Image
9996222	Hydraulic Pump (Available)	 006790a
9998246	Valve Spring Compressor Adapter (Available)	 006797a
9998249	Unit Injector Protection Sleeve (Essential)	 006798a
9998250	Unit Injector Bore Gallery Sealing Rings (Available)	 006799a
9998251	Unit Injector Bore Sealing Plug (Essential)	 006800b
9998252	Unit Injector Sleeve Tap (Essential)	 006801a

Tool No.	Description	Image
9998253	Unit Injector Sleeve Remover (Essential)	 006802a
9998263	Valve Guide Removal Tool (Available)	 006803a
85112460	Valve Stem Seal Installation Tool	 006966a
88800011	Valve Stem Seal Protection Tool	 006773a
88800014	Flywheel Turning Tool (Essential)	 271485a
88800062	Inlet and Exhaust Valve Guide Installation Tool (Available)	 006776a

Tool No.	Description	Image
88800196	Swaging Tool for Installing Unit Injector Copper Sleeve (Essential)	 006805a
88880010	Swaging Bit for Copper Sleeve (Available Separately)	 006842a
J 42885	Unit Injector Bore Cleaning Kit (Essential)	 006926a
PT-2900	Chip Vacuum	 006962a

Inlet and Exhaust Valve Removal [213 NB]

GENERAL INFORMATION

The MP8 has a single cylinder head, valves in the head and a single overhead camshaft. The single rocker arm shaft rests on the inboard end of seven camshaft bearing caps. The seventh bearing cap also provides a connection for lubricant. The optional engine brake electronic oil control valve connects the oil passages in the head and rocker arm shaft.

A copper sleeve and washer lines the bottom of each injector port. An O-ring seals each sleeve. An opening in the right front corner receives the thermostat. There are three special screws and washers used to align the cylinder head, two in the block and one in the cylinder head. Valve seat counterbores are cut in the block side. Valve guides pressed into place project from the upper side.

A gallery delivers fuel to the injectors and fuel pressure regulator. The inlet manifold attaches to the left (driver's) side of the head: the exhaust manifold to the right side.

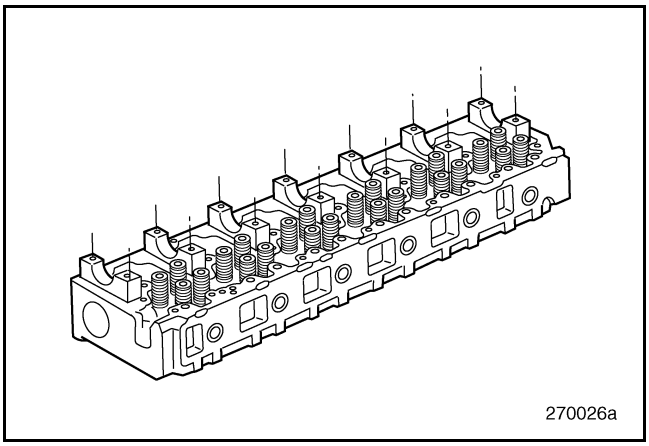


Figure 187 — Cylinder Head

REMOVAL PROCEDURE

1. Using the spring compressor, 9990210, compress a valve spring set to access the keepers.
2. Using a magnet, remove the keepers from the valve stem.
3. Remove the valve spring set.
4. Using a suitable tool, remove the valve stem seals.
5. Remove the valves.

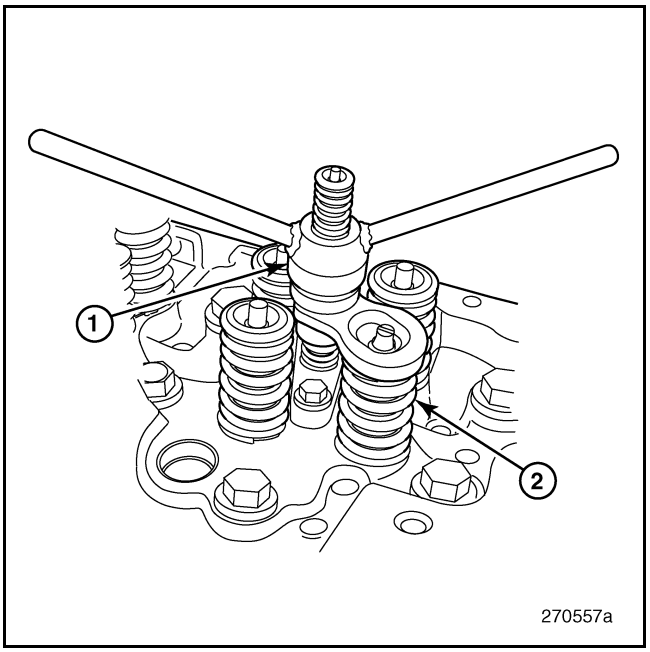


Figure 188 — Valve Spring Keeper Removal

1. Valve Spring Compressor 9990210	2. Valve Spring

Valve Stem Seals

For standardization, the valve guide and seal are used at the inlet locations as well as the exhaust locations.

Cylinder Head Cleaning and Inspection

Cleaning the cylinder head is important. While cleaning the cylinder head, carefully inspect the areas around the expansion plugs and the cooling duct cover. If the cup or pipe plugs show signs of leaking, they should be replaced. The cylinder head should also be inspected for cracks or other possible defects that may be reason for replacement. If damage is not found until after the engine is assembled, the cylinder head must be removed, disassembled and rebuilt again.

SOLVENT TANK CLEANING

⚠ WARNING

Cleaning solvent is flammable and toxic to the eyes, skin and respiratory tract. Skin and eye protection are required. Avoid repeated or prolonged contact. Use only in a well ventilated area.

Compressed air used for cleaning can create airborne particles that may enter the eyes or irritate the skin. Pressure must not exceed 207 kPa (30 psi). Eye protection is required. Use only with effective chip guarding and personal protective equipment (goggles/shield, gloves, etc.).

Using care and caution at all times:

1. Fill a tank with a suitable solvent.
2. Immerse the parts in the solvent to loosen dirt and debris.
3. Scrape remaining gasket material from the cylinder head.
4. Using a wire brush or rotary wheel, remove rust and other debris from the cylinder head.
5. Rinse the cylinder head making sure that all surfaces are clean and free of debris.
6. Using compressed air, blow dry the cylinder head.

INSPECTION

Check the cylinder head deck surface for warping, pitting and other imperfections.

⚠ CAUTION

Do NOT machine the cylinder head. This will change the extension of the injector and upset injector timing.

Valve Guide Replacement

[213 EP]

Refer to the “ENGINE MECHANICAL SPECIFICATIONS” section for dimensions applicable to the valve guides.

INSPECTION

NOTE

Worn valve guides may result in poor valve-to-seat contact, valve damage or excessive oil consumption.

1. Inspect the valve guides for wear, damage, cracks and looseness.
2. Using a suitable gauge, measure the inside diameter of each guide.
3. Using a suitable gauge, measure the valve guide extension.

NOTE

When reconditioning the cylinder head, it is recommended that all valve guides be replaced.

VALVE GUIDE REMOVAL

SERVICE HINT

Clean the exhaust valve guide OD (shoulder) before removal. With the guide removed, use a rotary brush to prevent scoring while cleaning the exhaust valve guide bore.

1. Assemble the hydraulic ram, 9809729, press tool, 9990176, pump, 9996222, and valve guide remover, 9998263, on top of the cylinder head.

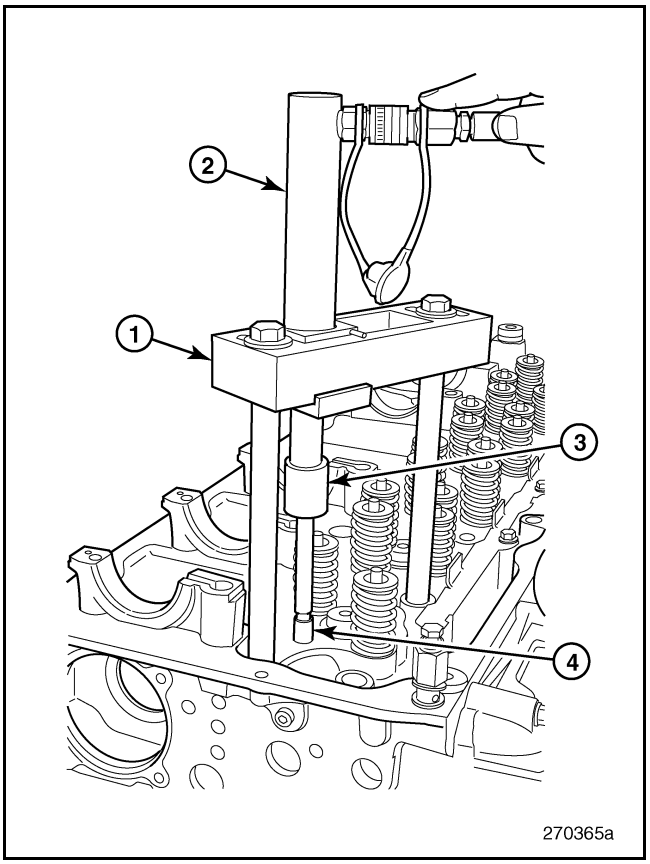


Figure 189 — Valve Guide Removal

1. Press Tool 9990176 2. Hydraulic Ram 9809729	3. Valve Guide Remover 9998263 4. Valve Guide

2. Press out the old valve guides from the top of the cylinder head using the press.
3. Clean all surfaces thoroughly.

VALVE GUIDE INSTALLATION

1. Heat the cylinder head with hot water and at the same time cool valve guide to minus 60–200°C (76–328°F) using dry ice or equivalent. Lubricate cylinder head valve guide bore before installation.
2. Using protective gloves, place a **new** valve guide in position on the cylinder head.
3. Assemble the hydraulic ram, 9809729, press tool, 9990176, pump 99996222, and the appropriate valve guide installer (88800062 for inlet and exhaust) on top of the cylinder head.
4. Oil the outside of the guide before installation.
5. Using the press tool setup, press the valve guide into its bore from the top of the cylinder head.

⚠ CAUTION

It is essential that the correct valve guide installation tool (88800062 for inlet and exhaust) be used to install the current valve guide. If the incorrect tool is used, the valve guide and seal installed height will be incorrect and may result in premature failure of the components.

6. Thoroughly clean all debris from the valve guides and surrounding area.
7. Install the valves in the cylinder head and check for binding, looseness and other conditions that may result in premature valve or valve guide failure.

Valve Spring Inspection

[213 MB]

NOTE

If the inside surface of a spring coil is rough or grooved, it **must** be replaced.

If spring strength is not within specifications, it **must** be replaced.

For indications of grooving or roughness:

1. Inspect the inside surfaces of each spring coil visually.
2. Feel the inside surfaces of each spring coil with a finger.
3. Replace faulty springs with new ones.
4. Using a spring tester as shown in Figure 190, measure the effort required to compress a spring.

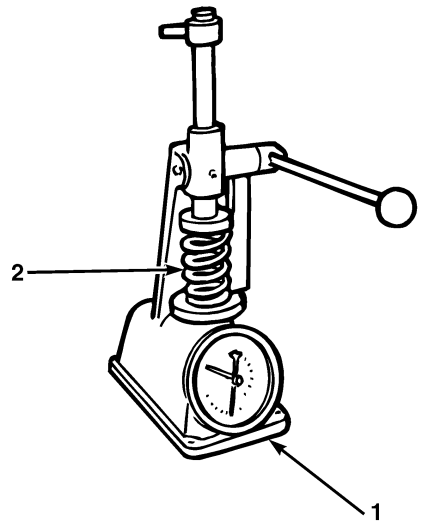


Figure 190 — Checking Valve Spring Pressure

1. Spring Tester	2. Valve Spring

Injector Sleeve Replacement

[213 GB]

CYLINDER HEAD REMOVED

The injector sleeve is swaged in place in its bore.

REMOVAL PROCEDURE

1. Remove the injector or the plug, 9998251, to access the injector sleeve bottom.
2. Remove and discard the sealing washer in the bottom of the copper sleeve.
3. Install two sealing rings to prevent dirt from entering the fuel gallery when the copper sleeve is removed.

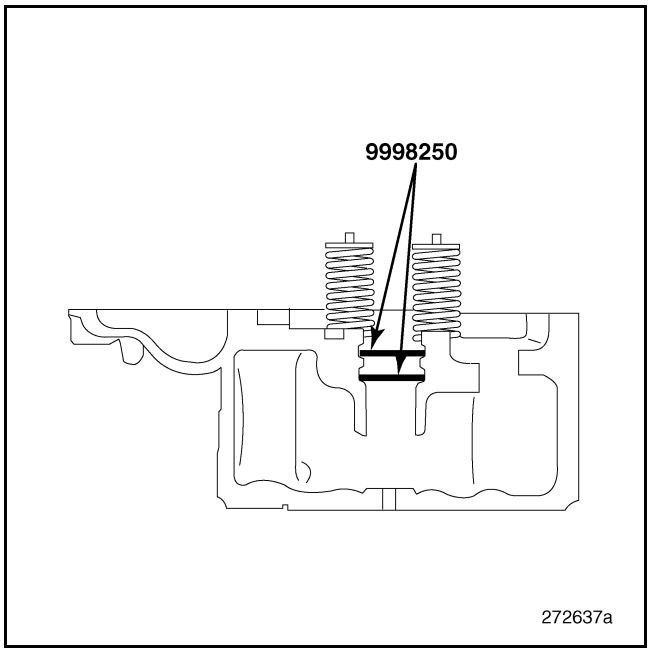


Figure 191 — Fuel Gallery Sealing Rings

NOTE

Two sealing rings are required to cover the fuel gallery.

4. Adjust the 9 mm tap so that it extends a minimum of 25 mm or 1 inch (dimension A) from the end of the tapping tool.

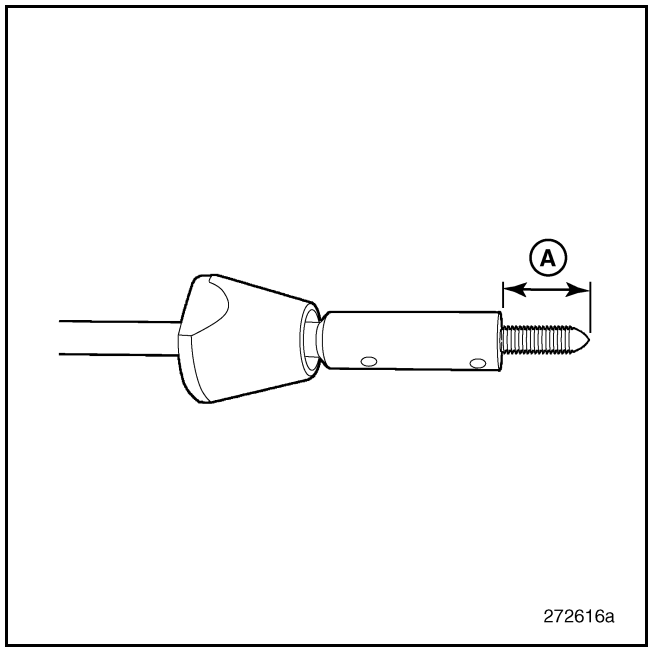


Figure 192 — Copper Sleeve Tapping Tool

NOTE

This ensures that the tip of the copper sleeve is tapped all the way through.

5. Lubricate the tip of the 9 mm tap with grease.
6. Thread the tap in small increments. Remove the tap and wipe off the grease and copper sleeve shavings. Apply fresh grease, reinstall the tapping tool and thread more of the copper sleeve. Continue this process to thread the tap all the way through the copper sleeve until no resistance is felt and the tap turns freely. Tapping in small increments and removing the shavings minimizes the chance of the sleeve turning in the cylinder head. Ensure that the tap is completely through the copper sleeve.

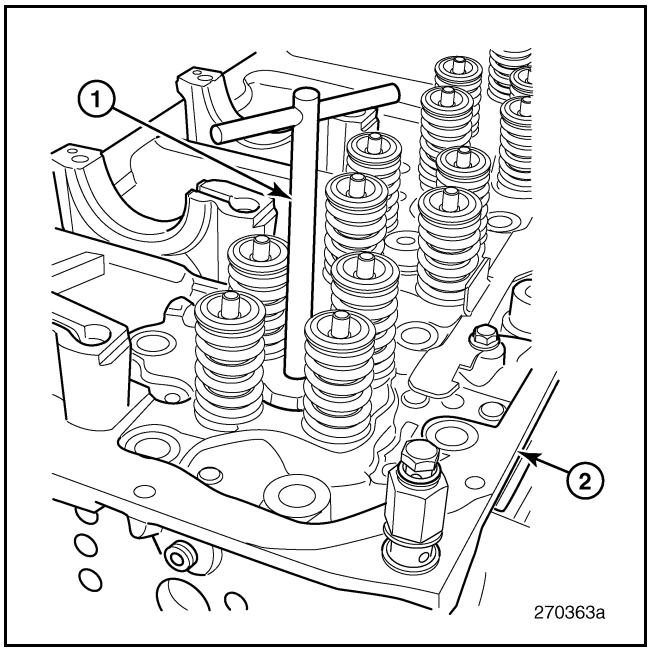


Figure 193 — Tapping Injector Sleeve

1. Tap 9998252	2. Cylinder Head

7. Remove the tap and tapping tool.
8. Using the chip vacuum, remove any remaining shavings from the copper sleeve.
9. Install the extractor bolt into the end of the extractor tool. Adjust the bolt until it extends approximately 22 mm (0.9 inch) beyond the end of the tool (dimension A).

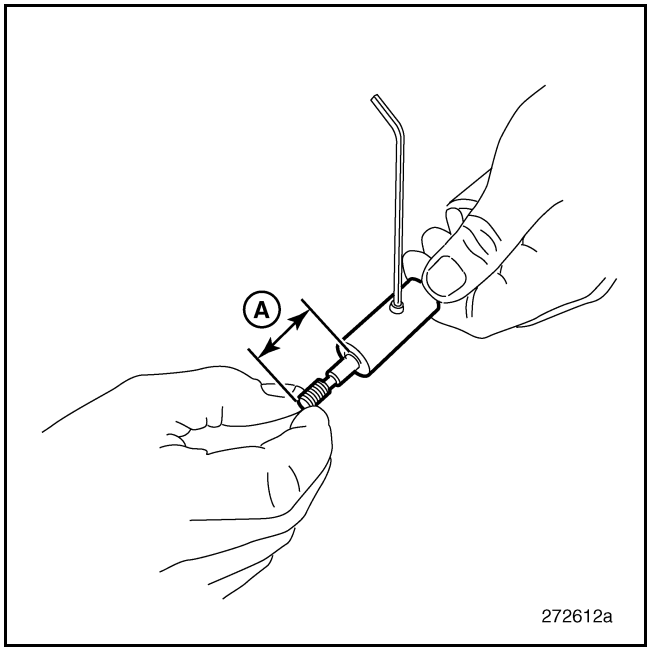


Figure 194 — Adjusting Copper Sleeve Extractor Bolt

10. Tighten the set screw of the extractor tool to secure the bolt. Make sure that the set screw is seated against the flat part of the extractor bolt.
11. Place the extractor tool with the bolt into the injector bore. Make sure the nut on the spindle is backed off so that the threaded end can be completely installed through the copper sleeve tip. Hand tighten until the bolt bottoms out in the sleeve.

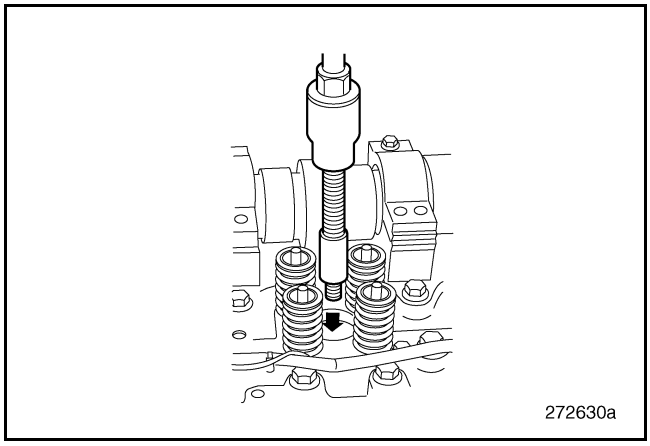


Figure 195 — Extractor Tool Installation

⚠ CAUTION

Make sure the extractor bolt is threaded completely into the copper sleeve before attempting to remove it or the tip of the sleeve may break off as it is removed.

12. Screw the injector sleeve removal tool, 9998253, completely into the injector sleeve and then back it out 1/2 turn. Remove the sleeve by turning the nut while holding the threaded shaft of the removal tool.

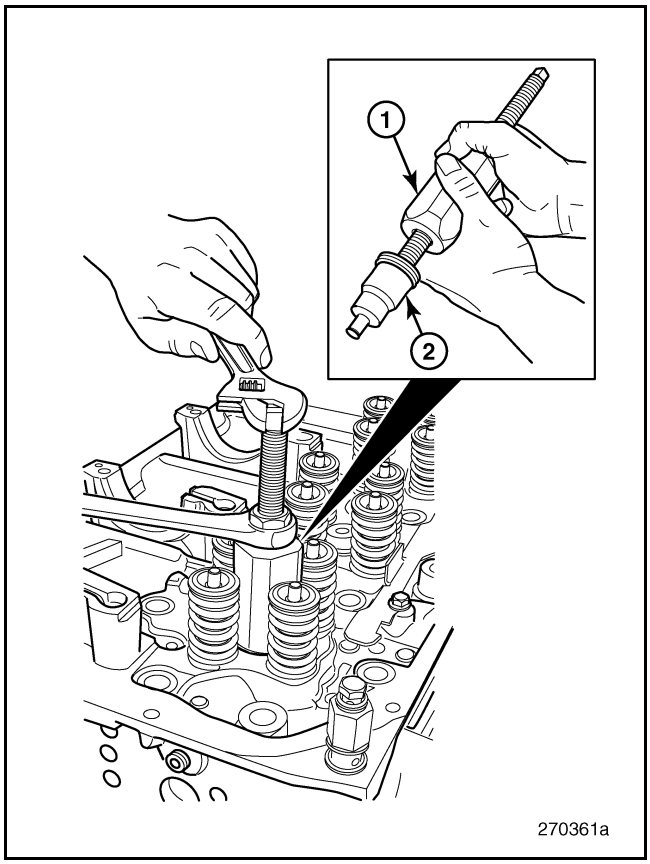


Figure 196 — Removing Injector Sleeve

1. Injector Sleeve Remover 9998253	2. Injector Sleeve

NOTE

When the copper sleeve is removed, make sure that the extractor bolt is extended at least one thread beyond the copper sleeve. If not, make sure that no part of the copper sleeve has broken off.

⚠ CAUTION

Do not use air tools to remove copper sleeves, or damage to the injector bore can result.

13. Remove the two sealing rings from the fuel passage. Using the chip vacuum, remove any remaining debris from the injector bore.

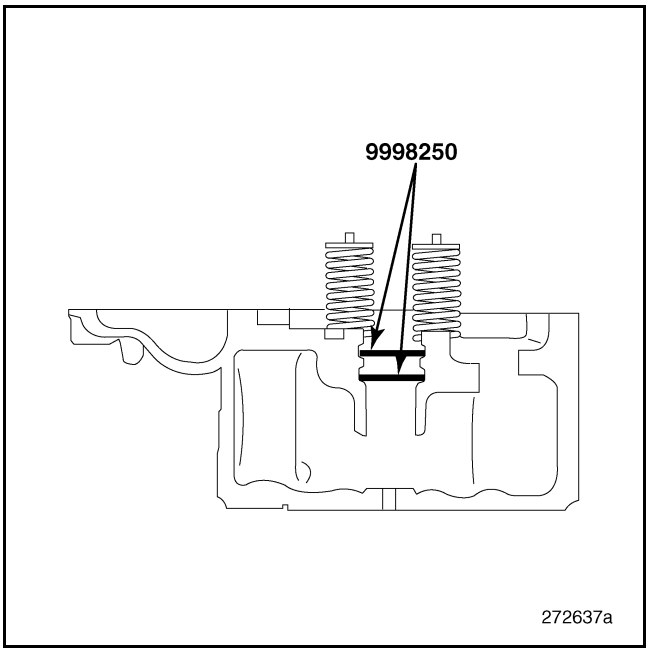


Figure 197 — Fuel Gallery Sealing Rings

14. Install the injector bore sealing tool (J 42885-25) to protect the fuel passage area and prevent debris from entering. Use the unit injector hold down bolt to secure the tool in the cylinder head.
15. Using the injector bore cleaning kit, clean the copper sleeve seat of the cylinder head.

NOTE

The injector bore sealing tool must be used to prevent dirt from entering the fuel passage.

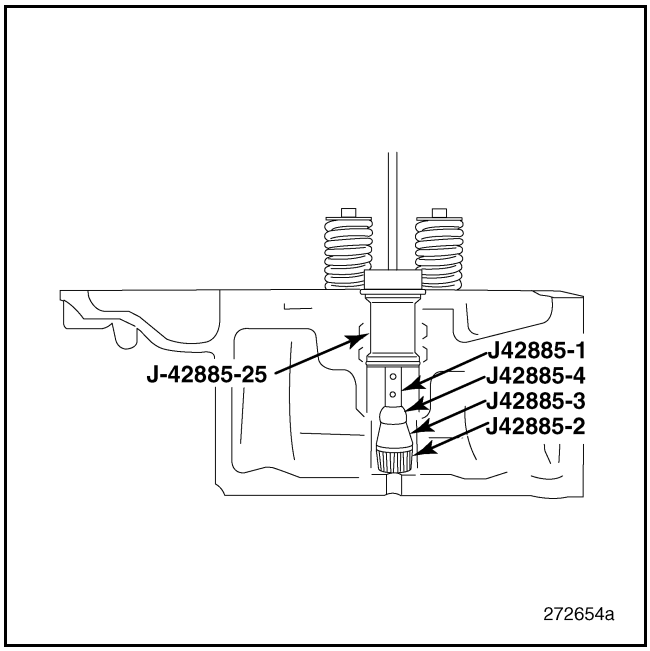


Figure 198 — Cleaning Copper Sleeve Seat

16. Using the brush, clean the cylinder head injector bore walls for the copper sleeve.

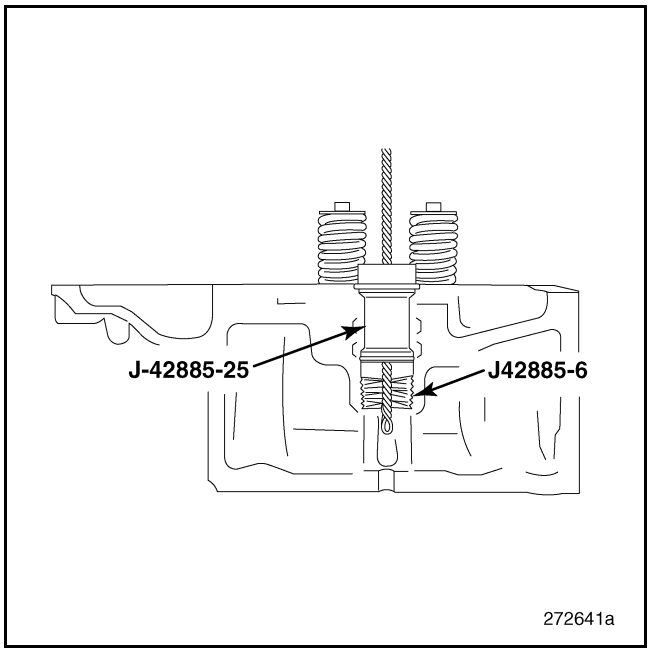


Figure 199 — Cleaning Copper Sleeve Bore Walls

NOTE

The injector bore sealing tool must be used to prevent debris from entering the fuel passage.

17. Using the brush, clean the copper sleeve opening in the cylinder head.

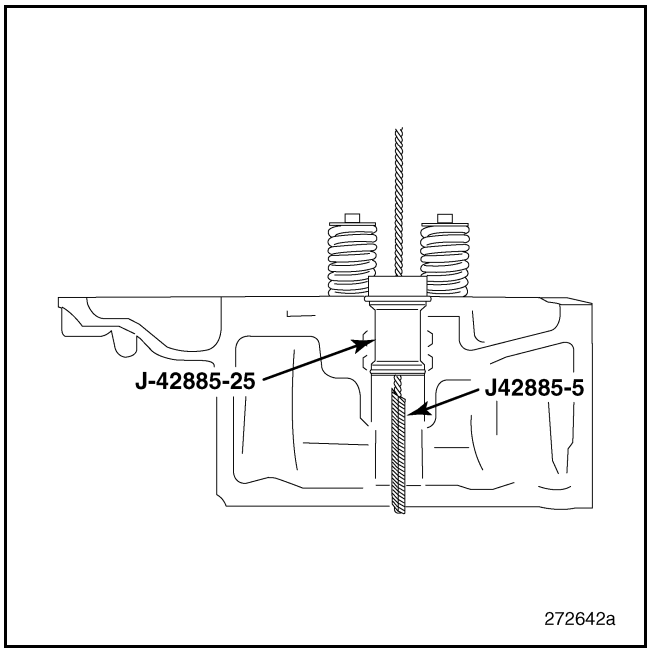


Figure 200 — Cleaning Injector Tip Bore

NOTE

The injector bore sealing tool must be used to prevent debris from entering the fuel passage.

When replacing the copper sleeves, it is important to check that the sleeve bore in the cylinder head is free from any carbon deposits or other residue (i.e., pieces of O-ring, etc.) before installing a new copper sleeve. Reclean if necessary.

18. Using the chip vacuum, remove all debris from the copper sleeve bore.

SERVICE HINT

Do not attempt to blow away debris using compressed air. Doing so can result in eye injury.

19. Remove the injector bore sealing tool from the cylinder head. Using the chip vacuum, remove any remaining debris.

INSTALLATION PROCEDURE

1. Before installing the copper sleeve, inspect it to ensure that it is the correct part. The correct sleeve is identified by two concentric circular grooves machined into the top surface.

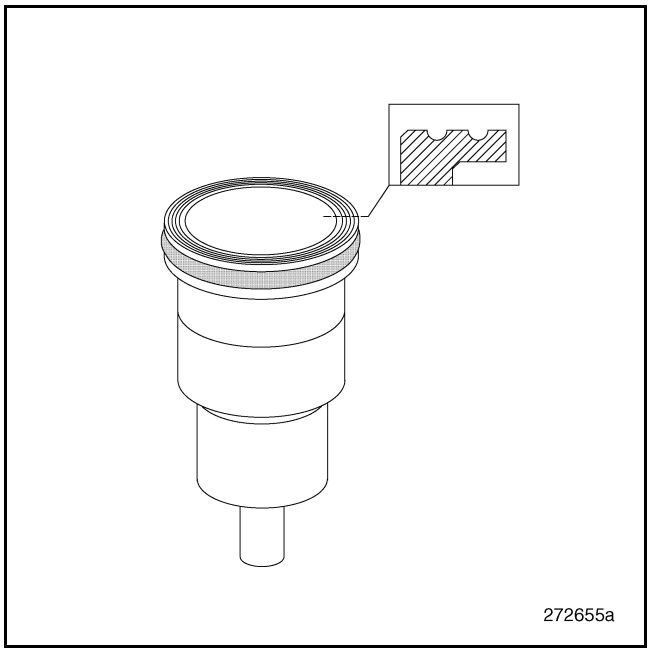


Figure 201 — Copper Sleeve Identification

2. Lubricate a **new** copper sleeve O-ring with coolant. Install the O-ring on the copper sleeve and lubricate again with coolant. Always use a **new** O-ring.
3. Place the **new** copper sleeve on the installation tool.

NOTE

Do not place the injector nozzle gasket (flat washer) in the copper sleeve, as this will damage the swaging bit.

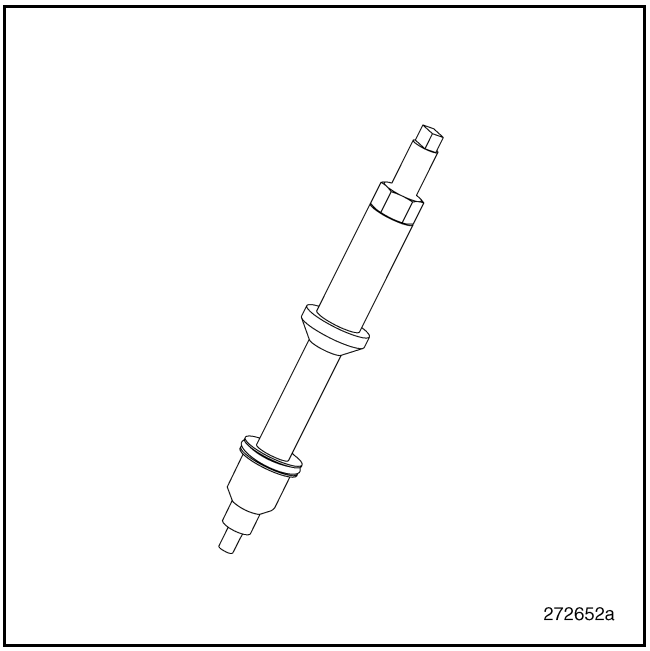


Figure 202 — Installation Tool Identification

NOTE

Before installing the sleeve on the installation tool, inspect the tool to ensure that it is the correct tool. The correct tool is identified by a bottom surface that is perfectly flat with no machined circular recess. Use of a tool with a machined circular recess on the bottom may result in damage to the copper sleeve.

4. Using calipers, measure the swaging bit to make sure that the proper swaging tool is used. Measurement should read approximately 7.8 mm. Also, verify that the length of the swaging bit is 108 mm.

⚠ CAUTION

Failure to use the proper bit can result in the bit breaking off into the cylinder head.

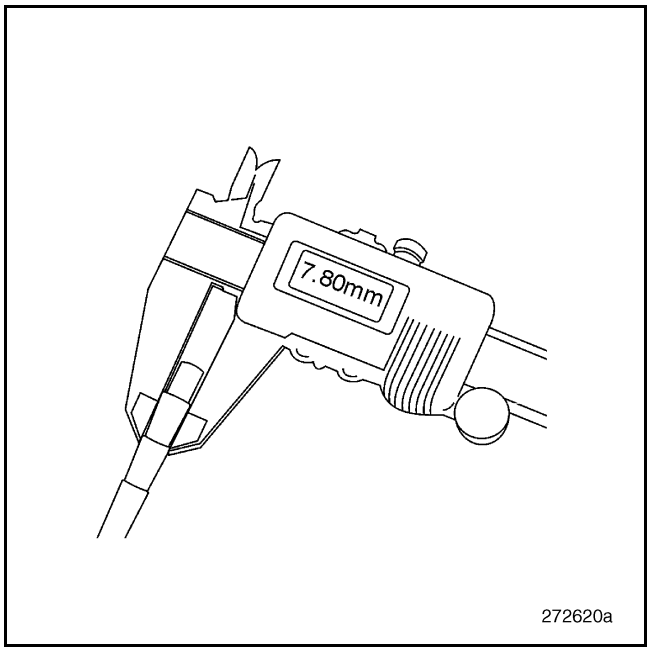


Figure 203 — Swaging Bit Verification

NOTE

Swaging bit can be ordered as a spare part if the bit is worn or broken.

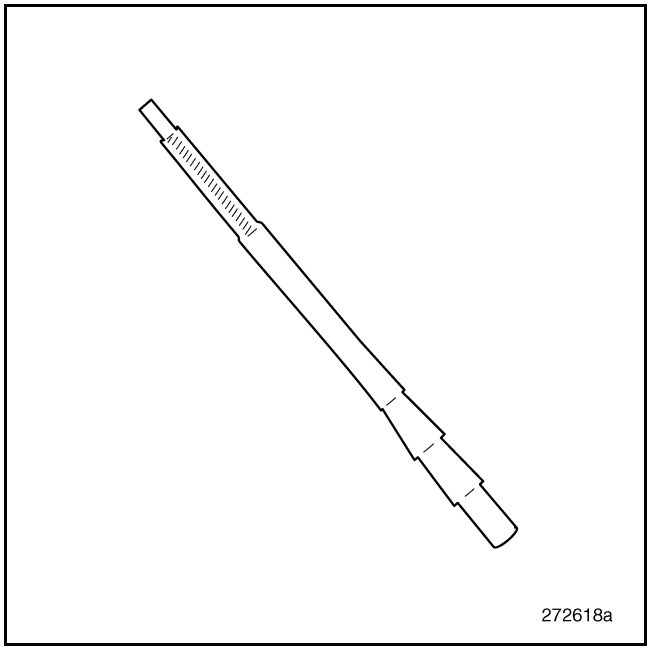


Figure 204 — Swaging Bit

5. Thread the swaging bit completely into the flaring tool until it stops (finger tight).
6. Screw the swaging tip through the copper sleeve and completely into the swaging tool holder, 88800196, until it stops (finger tight). Ensure that the tool is fully seated in the copper sleeve.

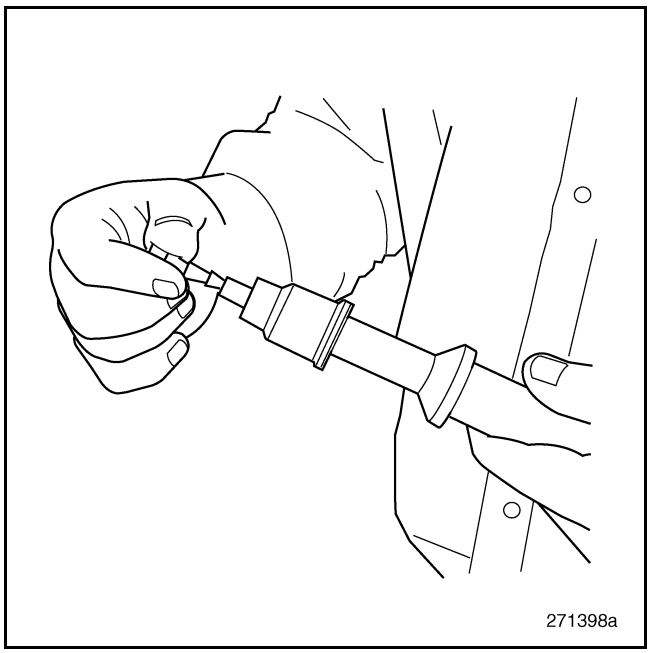


Figure 205 — Swaging Tool

7. Loosen the swaging bit 180 degrees before installing the tool in the cylinder head.

⚠ CAUTION

Failure to loosen the swaging bit can result in the bit being twisted or broken.

8. Lubricate the swaging bit and the threads on the tool with oil.
9. Carefully place the sleeve installation tool (with new copper sleeve attached) into the unit injector bore of the cylinder head. Carefully move the copper sleeve downward into the injector bore so that the swaging bit is guided into the injector tip bore in the cylinder head. Push downward on the installation tool using hand force to move the copper sleeve downward until it bottoms out on the injector sleeve seat in the bottom of the injector bore. Use the unit injector hold down and bolt to hold the tool in position. To ensure that the copper sleeve is bottomed in the cylinder head, tighten the unit injector hold down bolt to specification.

NOTE

Remove any oil from the injector hold down bolt holes to avoid hydraulic lock for this step and when the injector is installed.

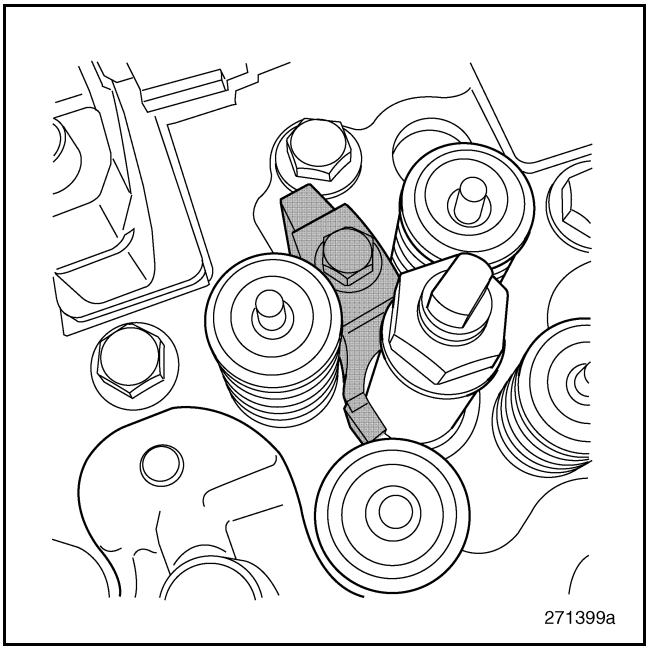


Figure 206 — Injector Yoke and Sleeve Installation Tool

10. Flare the copper sleeve by turning the nut (1) clockwise while holding the spindle until the swaging bit has been pulled completely through the copper sleeve.

⚠ CAUTION

Failure to hold the spindle can result in a twisted or broken swaging bit.

NOTE

The swaging tip has three sections of increasing diameter. Resistance increases as the swaging tip advances through the hole. Continue to pull the tip until it is free of the hole.

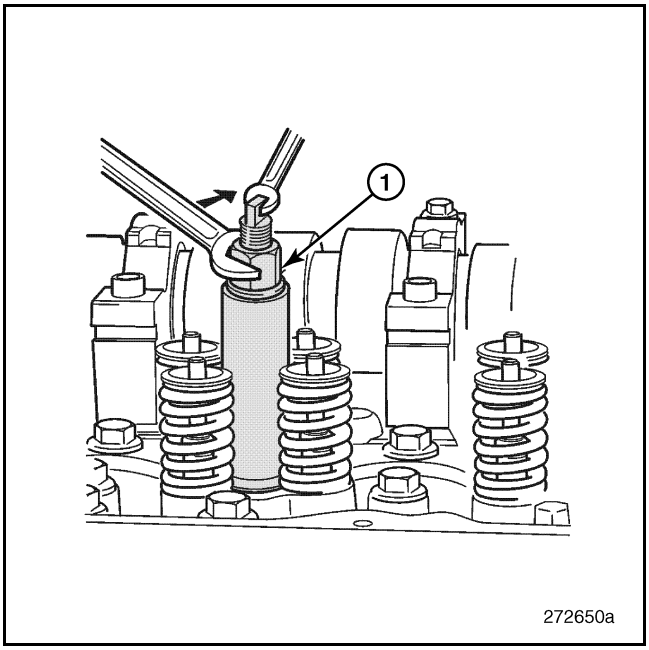


Figure 207 — Flaring Copper Sleeve Using Installation Tool

1. Flaring Tool 88800196

11. Remove the sleeve installation tool from the injector bore.
12. Using brush, J 42885-9, and extension, J 42885-1, ensure that the copper sleeve bore is clean. Insert a **new** washer and the injector or a sealing plug, 9998251.

NOTE

If the injector is not being installed immediately, install the sealing plug into the injector bore to protect it from debris.

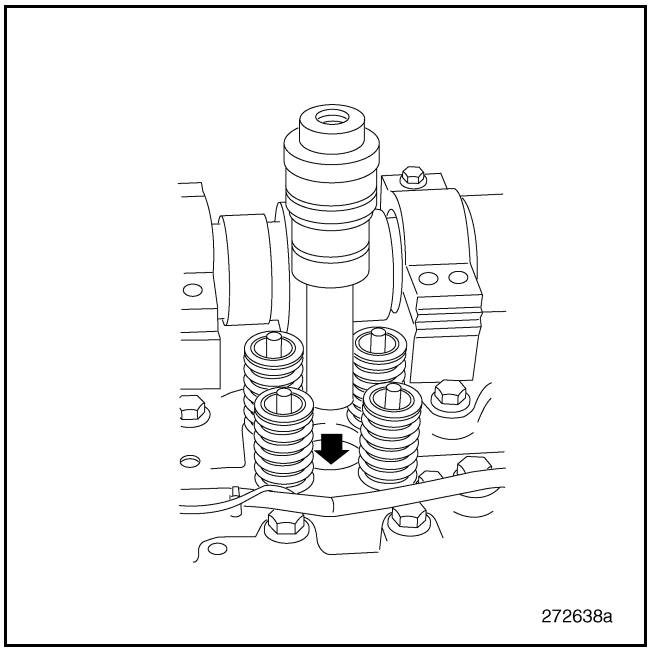


Figure 208 — Unit Injector Bore Sealing Plug

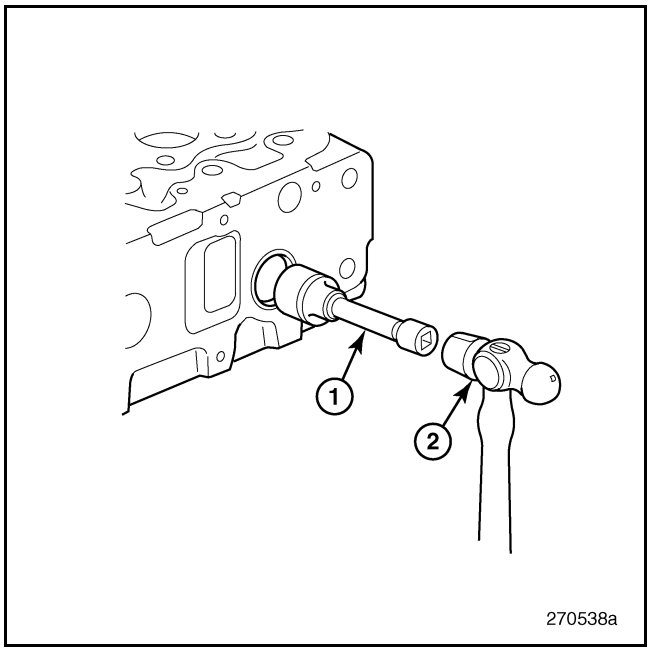


Figure 209 — Expansion Plug Installation

1. Socket and Extension	2. Hammer

Expansion Plug Replacement

[213 FP]

The cylinder head has three expansion plugs of different sizes.

— 29 mm (1-9/64 or 1.142 inch)

— 40 mm (1-37/64 or 1.575 inch)

— 50 mm (1-31/32 or 1.968 inch)

All are installed using the following procedure:

1. Clean the plug bore thoroughly.
2. Apply Loctite® 277 sealer, or equivalent, to the expansion plug and plug bore.
3. Using a socket, extension and a hammer, press the expansion plug into the plug bore.
4. Repeat steps 1–3 for each new plug.

NOTE

The plug should be installed flush to 0.508 mm (0.020 inch) below the surface.

Valve Inspection

1. Inspect the valves for cracks, pits and other conditions that may cause improper operation.
2. Inspect the stem ends of the valves for nicks and burrs that may damage the seals at assembly.
3. Measure the valve seat angle.
4. Measure valve stem length and diameter.
5. Discard and replace damaged or worn valves.

Valve Installation

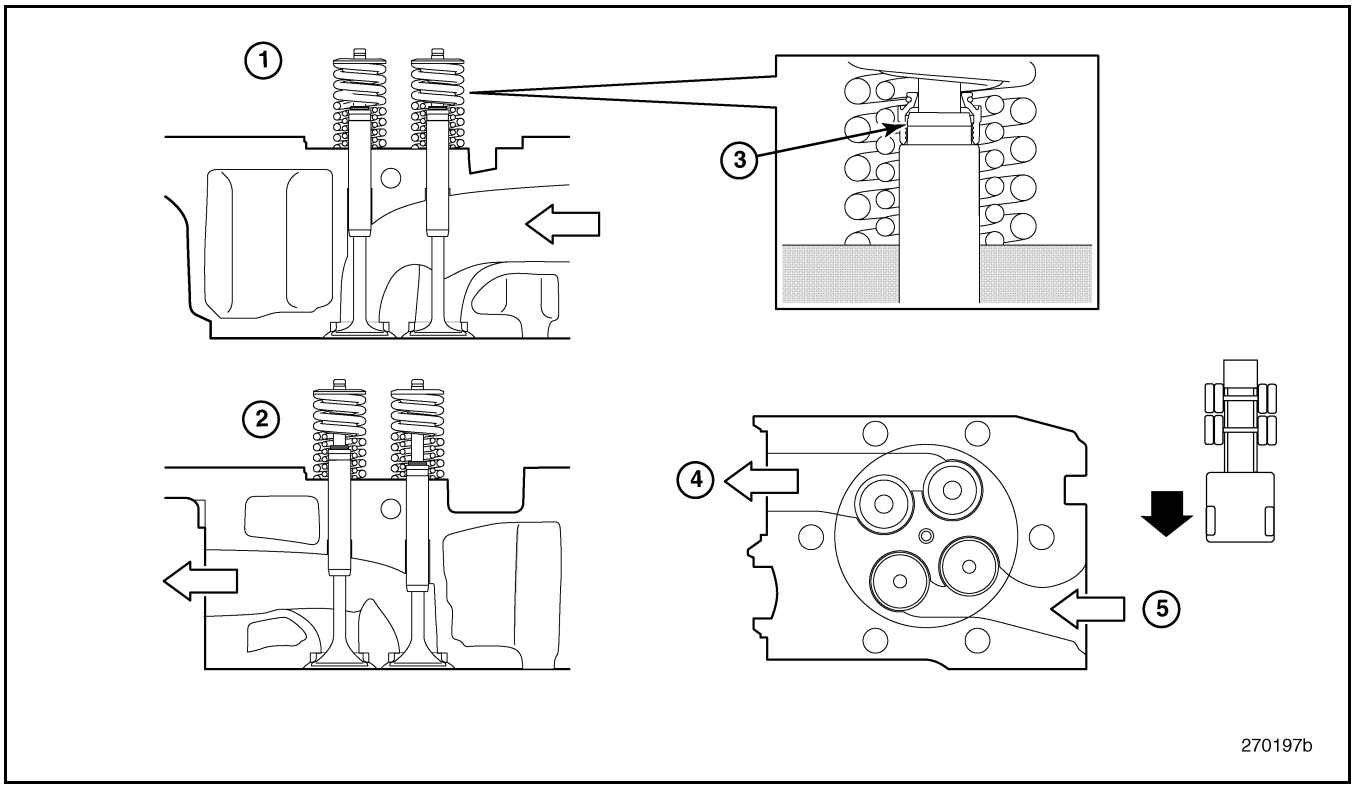


Figure 210 — Valve, Springs and Stem Seals

1. Inlet Valves and Springs 2. Exhaust Valves and Springs 3. Valve Stem Seal	4. Exhaust Port 5. Inlet Port

⚠ CAUTION

The inlet and exhaust valve head diameters are different. Take care when installing the valves. Incorrect installation may result in engine failure with extensive damage.

1. Using engine oil, lubricate the valve stems.
2. Slide the stem back and forth in its guide to spread the lubricant.
3. Using the appropriate valve seal installer, 85112460, assemble the seals on the valve guides.
4. Drop a bottom washer, a spring set and a top washer over each stem.
5. Using the spring compressor, 9990210, to compress the springs, assemble the keepers on the stems.

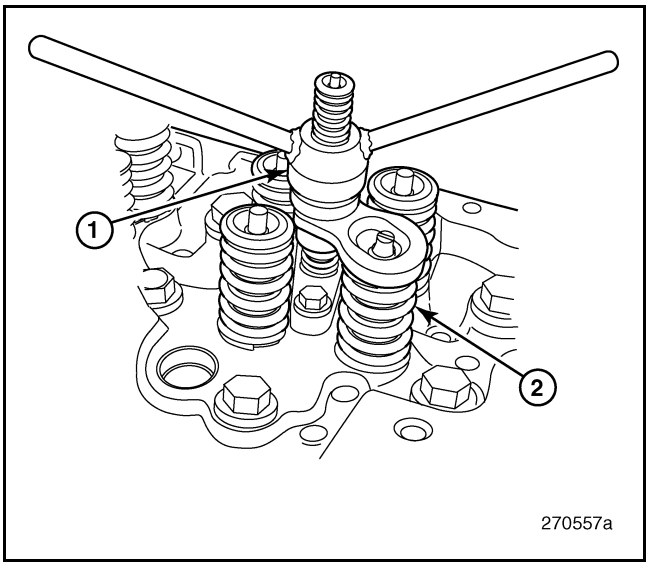


Figure 211 — Valve Spring Keeper Installation

1. Valve Spring Compressor 9990210	2. Valve Spring

ROCKER ARM SHAFT BENCH PROCEDURES (MACK MP8 EURO 3 ENGINE) [213 LP]

Description

The MP8 rocker arm shaft assembly is held in place by the same screws that hold the inboard ends of the camshaft bearing caps. A specific sequence for tightening these screws is described in the **ENGINE TORQUE SPECIFICATIONS** section.

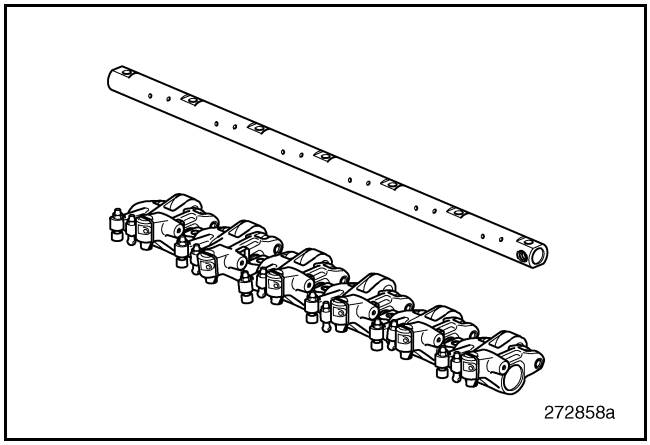


Figure 212 — Rocker Arm Shaft Assembly

Rocker Arm Shaft Disassembly

WITH OR WITHOUT ENGINE BRAKE

Disassemble the shaft and components as follows.

1. Mark the rocker arms and bridges so they can be put back in their original locations.
2. Slide the rocker arms off the shaft.

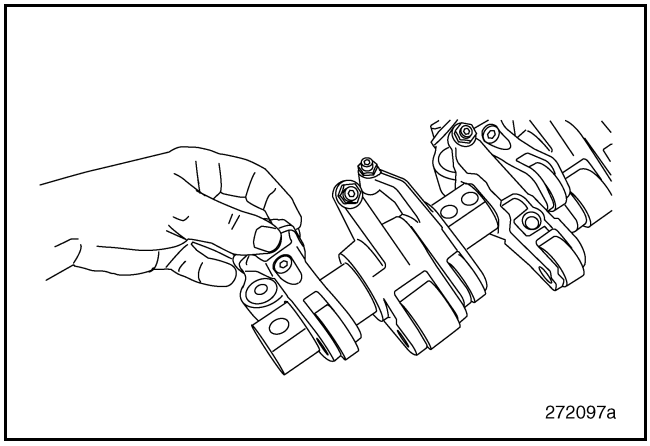


Figure 213 — Rocker Arm Removal

Inspection

ALL COMPONENTS

1. Inspect all components of the rocker arm assembly for damage and excessive wear. If the roller does not move or binds, replace the rocker arm.
2. Check the valve and piston action on the exhaust rocker arms for any signs of binding. Replace as necessary.
3. Inspect the rocker shaft for galling, scoring or excessive wear. Replace as necessary.

Rocker Arm Shaft Assembly

WITH OR WITHOUT ENGINE BRAKE

The assembly procedure for the rocker arm shaft is described below.

1. Arrange the rocker arms in sets according to the markings made at disassembly.
2. Lubricate the shaft and the rocker arm bores. Then, slide the rocker arm sets onto the shaft according to the markings made at disassembly.

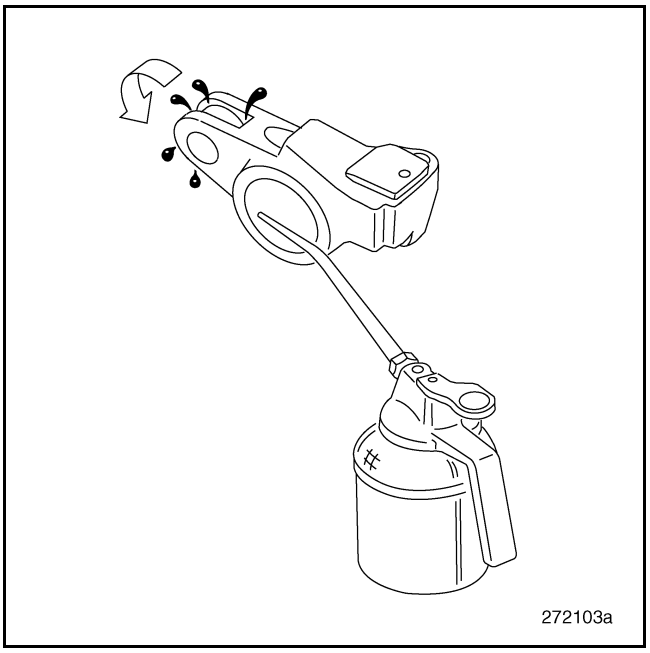


Figure 214 — Rocker Arm Lubrication

CAMSHAFT BENCH PROCEDURES

Camshaft Inspection

[213 CH]

CAMSHAFT GEAR REMOVAL

⚠ CAUTION

Handle the camshaft carefully to avoid bending it. Slight but harmful bends can go unnoticed. Failure to heed this caution could result in premature engine failure.

NOTE

The vibration damper and camshaft timing gear are separate components attached to the shaft by the same screws.

The timing gear and vibration damper can be removed while the camshaft remains on the cylinder head.

1. Provide means of controlling the damper and gear when the attaching screws are removed.
2. Remove the attaching screws.
3. Set aside the damper and gear in a safe place.

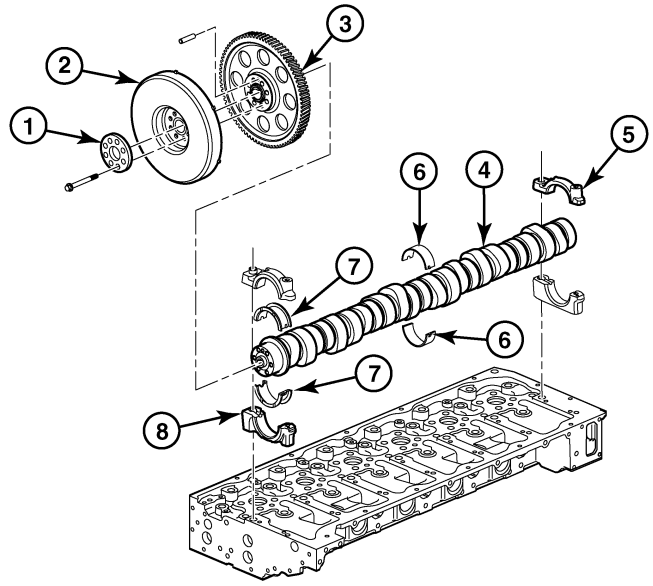


Figure 215 — Camshaft Assembly Components

1. Spacer	5. Upper Bearing Cap
2. Vibration Damper	6. Bearing Inserts
3. Camshaft Gear	7. Thrust Bearing Inserts
4. Camshaft	8. Lower Bearing Cap (Support)

INSPECTION

1. Clean the camshaft thoroughly.

NOTE

If any component displays cracking, pitting, scoring or excessive wear, replace it.

2. Inspect the camshaft, lobes and journals.
3. Inspect the camshaft gear.
4. Inspect the vibration damper.

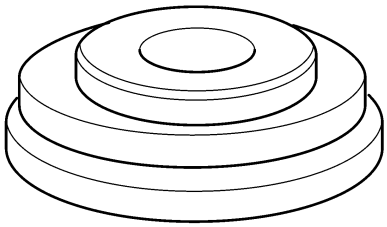
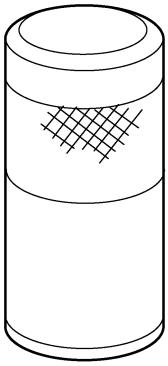
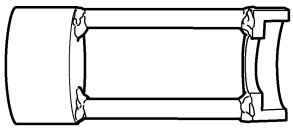
CAMSHAFT GEAR INSTALLATION

The camshaft can be installed on a properly installed cylinder head before attaching the timing gear and vibration damper.

1. Using two or three attaching screws, loosely assemble the damper, gear and shaft.
2. Install the remainder of the screws loosely.
3. Tighten the screws according to the sequence specified in the ENGINE TORQUE SPECIFICATIONS section.

EXHAUST PRESSURE GOVERNOR, OVERHAUL

Special Tools

Tool No.	Description	Image
9992610	Drift (Available)	 006975a
9998225	Drift (Available)	 006974a
9998246	Valve Spring Installer (Available)	 006797a

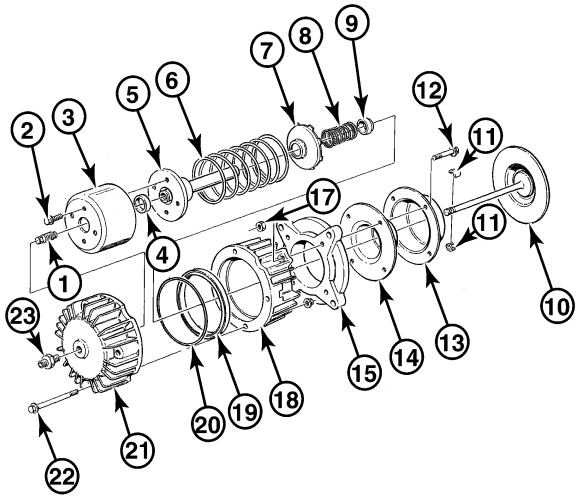


Figure 216 — Exhaust Pressure Governor

1. Set Screw	13. Cover
2. Bolts	14. Heat Shield
3. Plunger	15. Securing Flange
4. Seals	16. Nut
5. Plunger Rod	17. Nut
6. Spring	18. Housing
7. Spring Holder	19. Seals
8. Spring	20. Seals
9. Seal	21. End Cover
10. Shutter	22. End Cover Bolts
11. Valve Keepers	23. End Cover Fitting
12. Bolts	

Disassembly

1. Remove the end cover from above the plunger.
2. Remove the bolts and take out the plunger.
3. Remove the seals (4, 20 and 19). Refer to Figure 216.
4. Remove the set screw on the plunger rod.
5. Place the exhaust pressure governor into a press. Compress the spring enough to remove the valve keepers.

NOTE

Do not press more than necessary to remove the keepers. Compressing the spring fully can damage the cover.

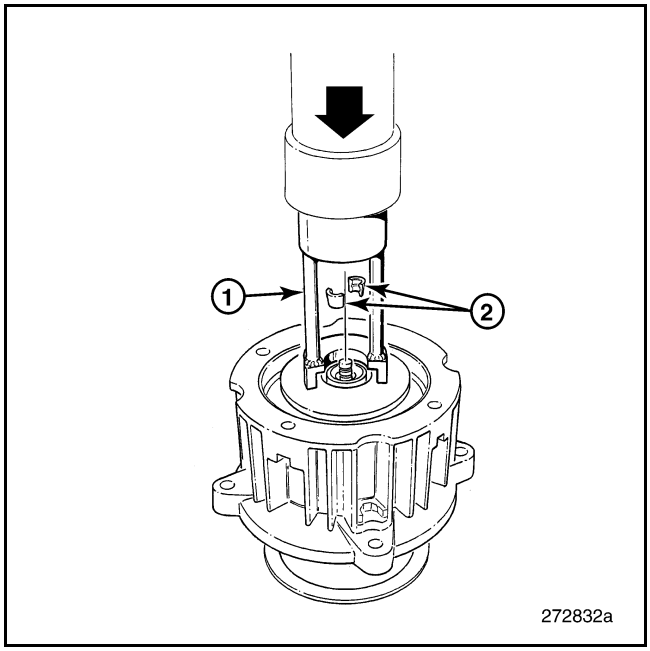


Figure 217 — Removing Valve Keepers

1. Tool 9998246	2. Valve Keepers

6. Remove the plunger rod, spring and shutter.
7. Remove the bolts holding the cover, heat shield and securing flange.
8. Carefully tap out the spring holder that secures the spring and seal (9) (Figure 216).

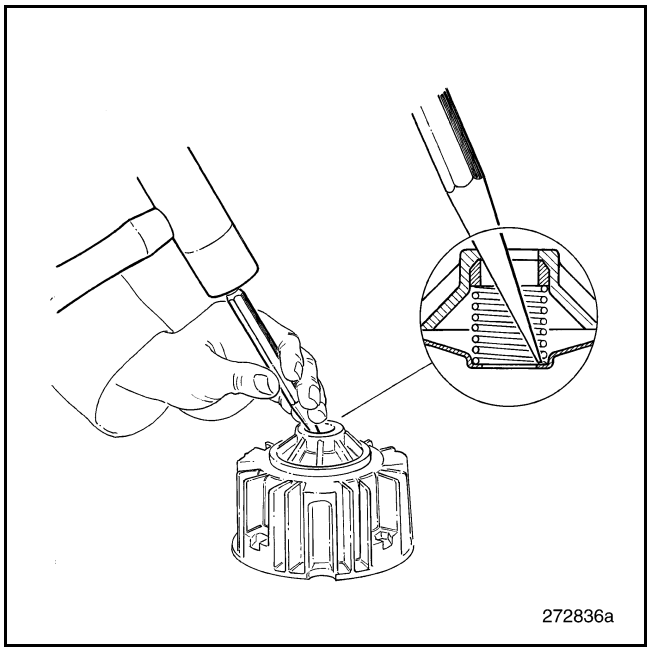


Figure 218 — Removing Spring Holder

9. Clean all parts and replace any that are damaged or worn.

Assembly

1. Install the plunger rod into the housing from behind so as to center the spring holder. Install a **new** seal with the beveled edge facing inside the housing. Install the spring and a **new** spring holder.

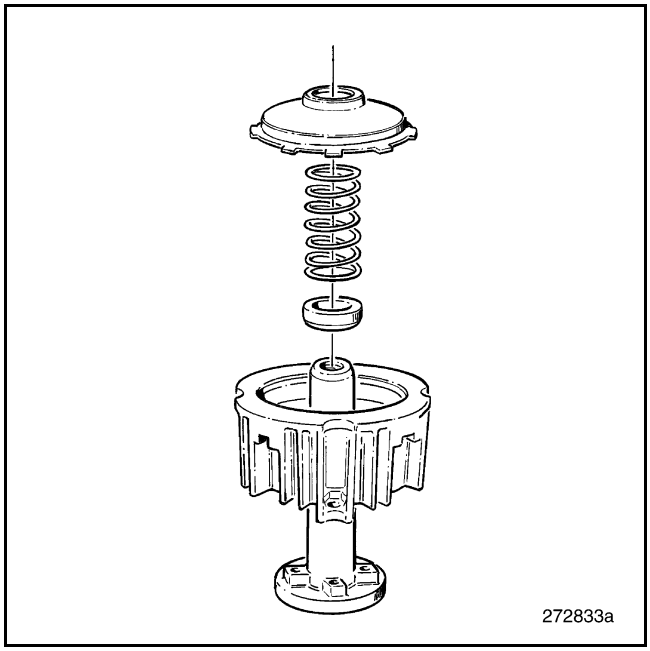


Figure 219 — Housing Assembly

2. Put the plunger rod onto drift 9992610 in a press. Using drift 9998225, press on the spring holder until it bottoms in the housing. Remove the plunger rod. Check to make sure that the spring holder is correctly centered.

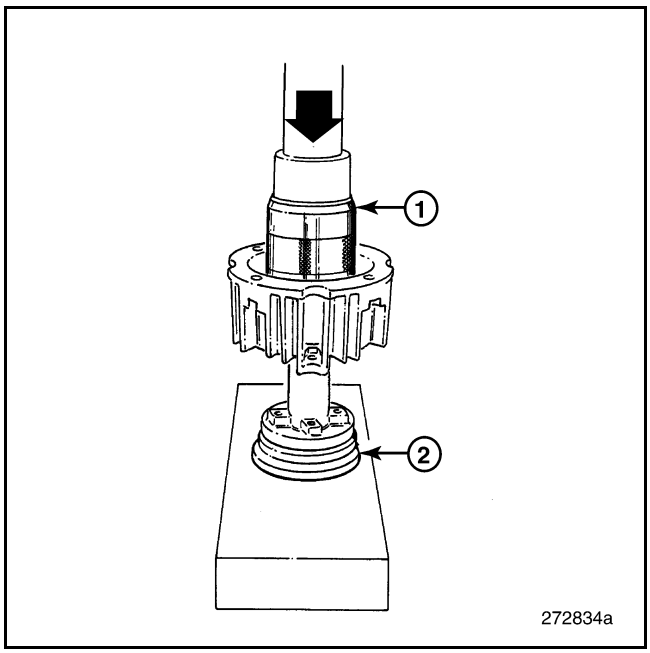


Figure 220 — Plunger Rod Installation

1. Tool 9998225	2. Tool 9992610

3. Install the securing flange, heat shield and cover. Tighten the bolts to specification.
4. Install the shutter, spring and plunger rod into the housing.
5. Compress the spring by hand, making sure that the shutter shaft and plunger rod fit together and that the plunger rod fits correctly into the seal. Stop applying pressure if undue resistance is felt. Install the valve keepers.

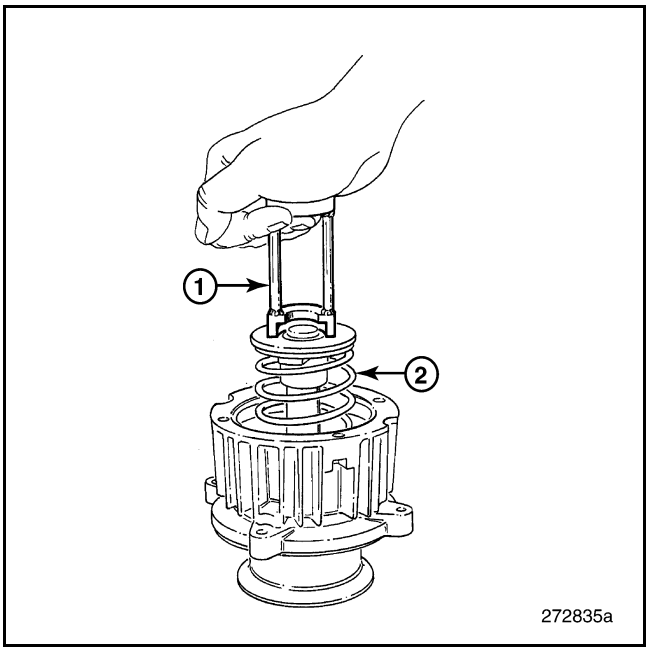


Figure 221 — Depressing Spring

1. Tool 9998246	2. Spring

6. Install the set screw into the plunger rod. Apply sealant to the set screw before installing. Tighten the set screw to specification.
7. Install a **new** seal into the plunger rod and install the plunger. Apply sealant to the bolts and tighten them to specification.
8. Install the end cover using **new** seals. Make sure that the seal bottoms in the housing. Install the seal with the flat side facing the housing. Tighten the end cover bolts to specification.

COOLING SYSTEM COMPONENTS BENCH PROCEDURES

Oil Cooler Reconditioning

[215 DW]

The oil cooler cannot be disassembled. Should it fail, replace it.

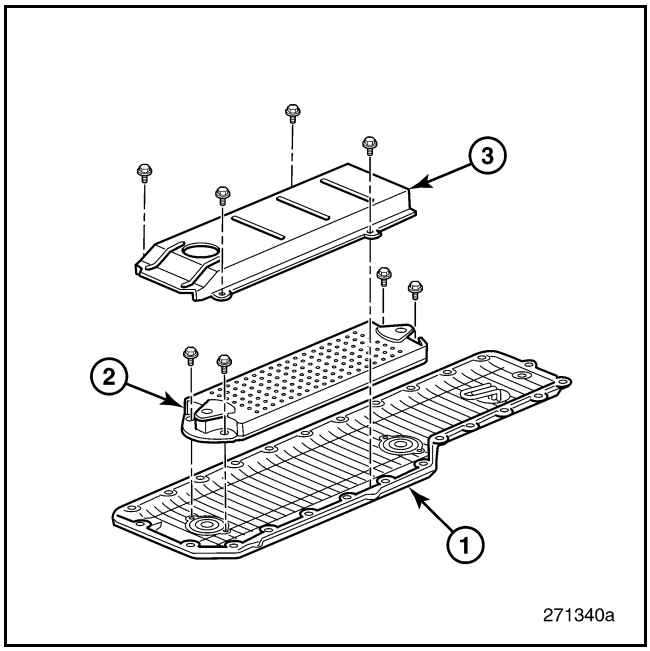
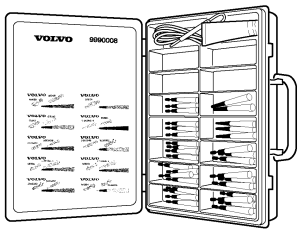
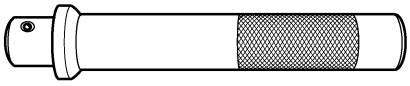
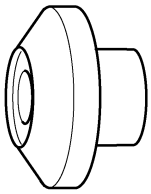
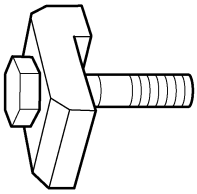
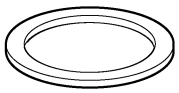


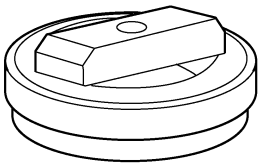
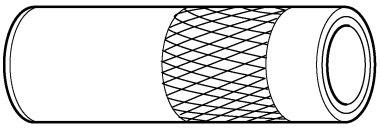
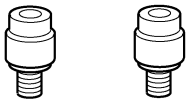
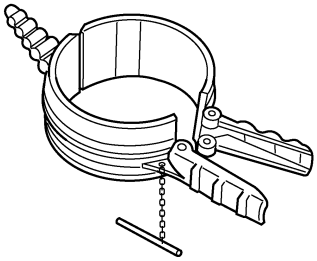
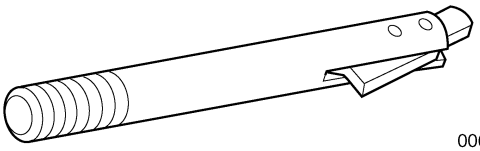
Figure 222 — Oil Cooler Assembly

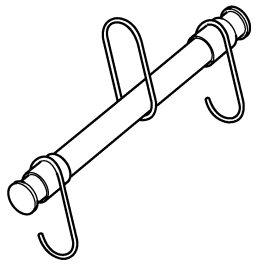
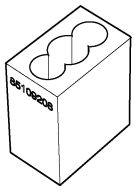
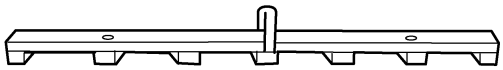
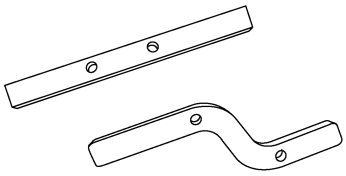
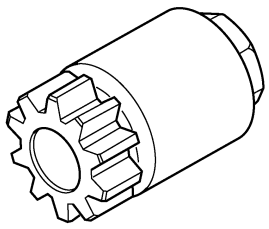
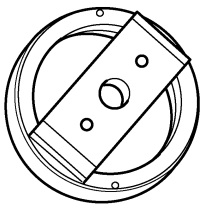
1. Cooling Duct Cover 2. Oil Cooler	3. Flow Plate

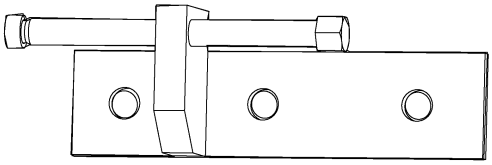
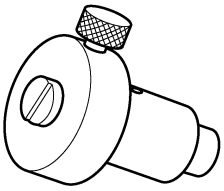
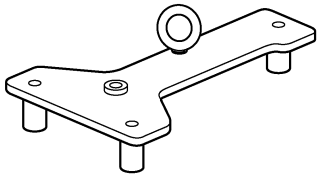
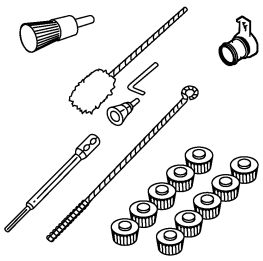
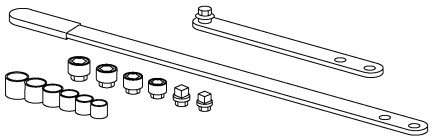
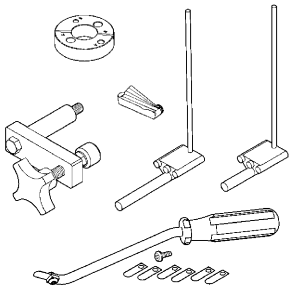
ENGINE REASSEMBLY
MACK MP8 Euro 3 Engine
[200 EA]

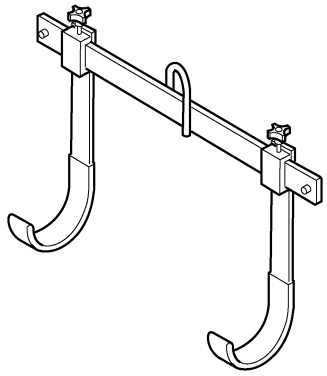
Special Tools

Tool No.	Description	Image
9990008	Set of Test Pins	 006951a
9992000	Handle with various uses (fits 25 mm hole), use with 9990113 (Essential)	 006785a
9992564	Driver for Installation of Pilot Bearing, use with 9991801 (Essential)	 006786a
9998043	Liner Hold-Down Tools (Essential)	 006796a
9998170	Front Cover Spacer Ring (Essential)	 006947a

Tool No.	Description	Image
9998238	Rear Main Seal Remover/Installer, use with 9992000 (Essential)	 006780a
9998249	Unit Injector Protection Sleeves (Essential)	 006798a
9998267	Guide Tool (Essential)	 006952a
9998531	Piston Ring Compressor (Essential)	 006834a
9998649	Stiffening Frame Tool	 006894a
9999683	Sweep Dial Indicator (Essential)	006948a

Tool No.	Description	Image
85109034	Camshaft Lifting Bar (Essential)	 006835a
85109208	Bearing Cap Press Tool (Essential)	 006949a
85109250	Rocker Shaft Assembly Lifting Tool (Essential)	 006770a
85111422 (A, B)	Upper Rear Cover Alignment Tool (Essential)	 006924a
88800014	Flywheel Turning Tool (Essential)	 271485a
88800021	Front Main Seal Remover/Installer (Essential)	 006774a

Tool No.	Description	Image
88800022	Cooling Duct Cover Installation Tool	 006893a
88800031	Camshaft Sensor Depth Gauge (Essential)	 006804a
88800188	Cylinder Head Lifting Tool (Essential)	 006923a
J 42885	Injection Bore Cleaning Kit (Essential)	 006926a
J 44392	Belt Tensioner Release Tool (Essential)	 272697a
J 44514-B	Engine Timing Kit (Essential)	 006889a

Tool No.	Description	Image
J 49002	Crankshaft Lifting Tool (Essential)	 007089a

General Instructions

[210 EN]

This section includes step-by-step procedures for complete reassembly of the engine. Major components that were inspected and overhauled or replaced under the respective bench procedure sections of this manual are reinstalled here as assemblies. Screw tightening sequences, torque specifications and sealant application patterns for major component parts appear in this section and also in the **ENGINE TORQUE SPECIFICATIONS** section.

⚠ WARNING

Failure to follow the sequence of operations may result in damage to components or personal injury.

NOTE

- After cleaning the components, store them where they will remain clean until needed for reassembly.
- When required for installing components, be sure to use clean engine oil of the approved type.
- Do not reuse M8 bolts. Lubricate threads, washers and under screw heads with clean engine oil except as noted.
- Do not lubricate coated bolts.

SERVICE HINT

Room temperature vulcanizing (RTV) sealant cures in 20 minutes of exposure to the atmosphere. If it should cure before assembly of mating components, remove it and apply fresh.

Crankshaft Installation

[212 HP]

⚠ WARNING

The crankshaft is heavy. Do NOT attempt to install the crankshaft without the help of an assistant or the use of a suitable lifting device. Failure to heed this warning may result in severe personal injury and component damage.

1. Perform a visual inspection of the crankshaft journals, block and bearing caps for signs of wear and/or damage. Check the back of the bearing for bearing size. Bearings can be stamped as “STD” for standard, or with a number indicating the oversize of the bearing insert (shell).
2. Clean the main bearing seats in the cylinder block and install **new** bearing inserts (shells). Lubricate the bearing insert surfaces with engine oil.

NOTE

The bearing shells should not be lubricated on the outside.

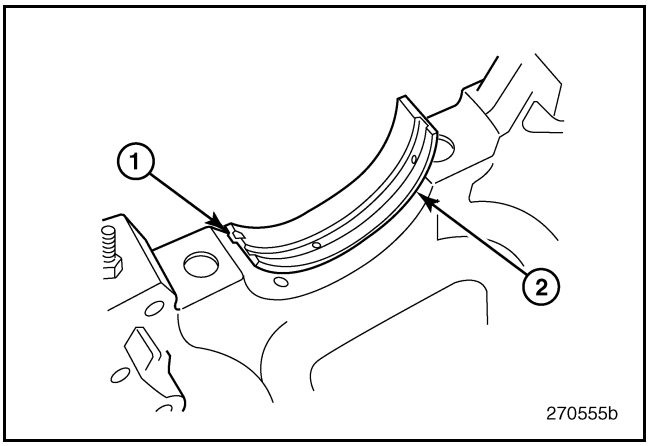


Figure 223 — Main Bearing (Upper)

1. Locating Tab	2. Bearing

3. Using the crankshaft lifting tool, J 49002, carefully position the crankshaft in the cylinder block.

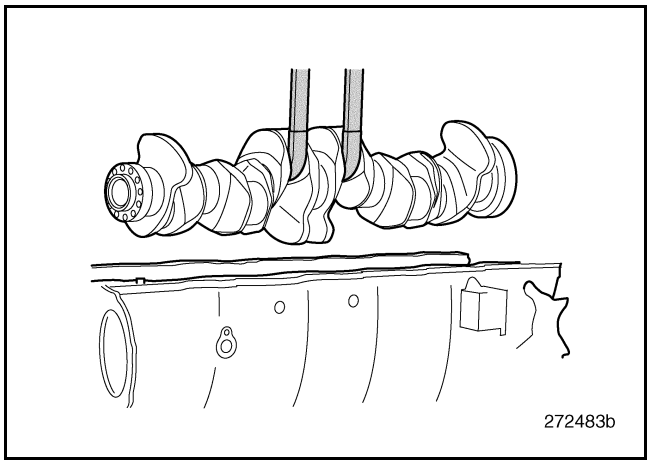


Figure 224 — Crankshaft Installation

Main Bearing Cap Installation

[212 HH]

1. Clean the bore in the bearing cap and back of the lower bearing.
2. Install the bearing in the bearing cap. The bearing must be installed dry.

NOTE

Lubricate the bearing insert surfaces with clean engine oil.

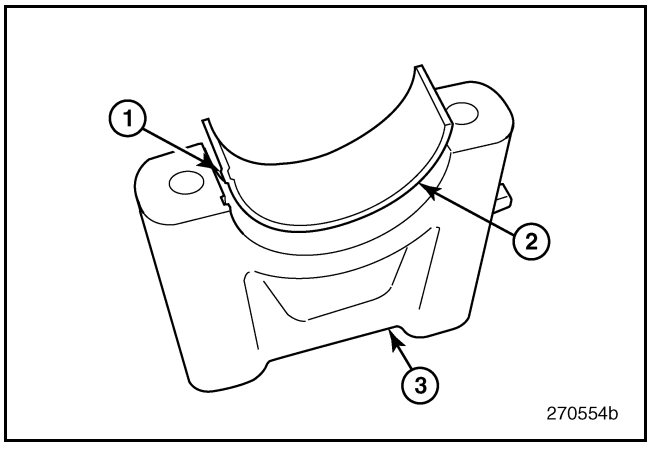


Figure 225 — Main Bearing Cap Installation (Lower)

1. Locating Tab 2. Bearing Insert	3. Bearing Cap

3. Lubricate the threads of the fasteners with clean engine oil and insert in the caps.
4. Position the No. 1 bearing cap over the No. 1 crankshaft journal and start the capscrews in the threaded holes in the cylinder block.

NOTE

Make sure the bearing caps are correctly fitted (see markings on the cap).

5. Using a plastic mallet, tap the bearing cap down until it contacts the machined mounting surface.
6. Tighten the capscrews finger-tight.

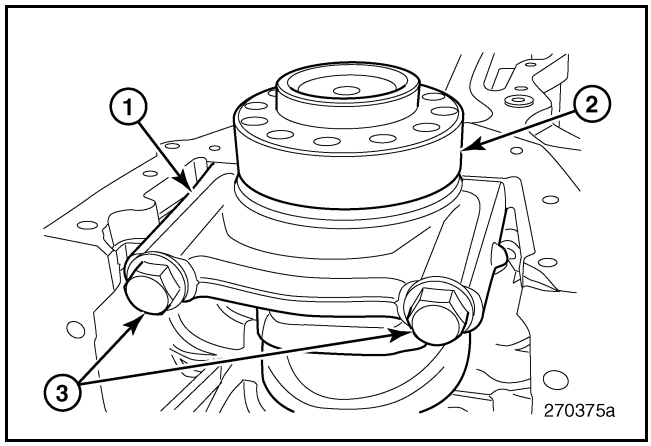


Figure 226 — No. 1 Main Bearing Cap — Assembled

1. No. 1 Main Bearing Cap 2. Crankshaft Hub	3. Cap Attaching Capscrews

7. Repeat the above steps for the bearing cap Nos. 2, 3, 5, 6 and 7. The center bearing cap, No. 4, is installed later.
8. Using a torque wrench, tighten the bearing capscrews according to specification.

NOTE

- Thrust washers are steel with a bronze facing. The facing has oil grooves cut into the material.
- Use standard thickness thrust washers initially.

9. Place the upper thrust washer sections in position in the cylinder block at the center bearing location. The steel side of the thrust washer faces the block. The bronze side faces the crankshaft. This applies to both upper and lower thrust washer sections.

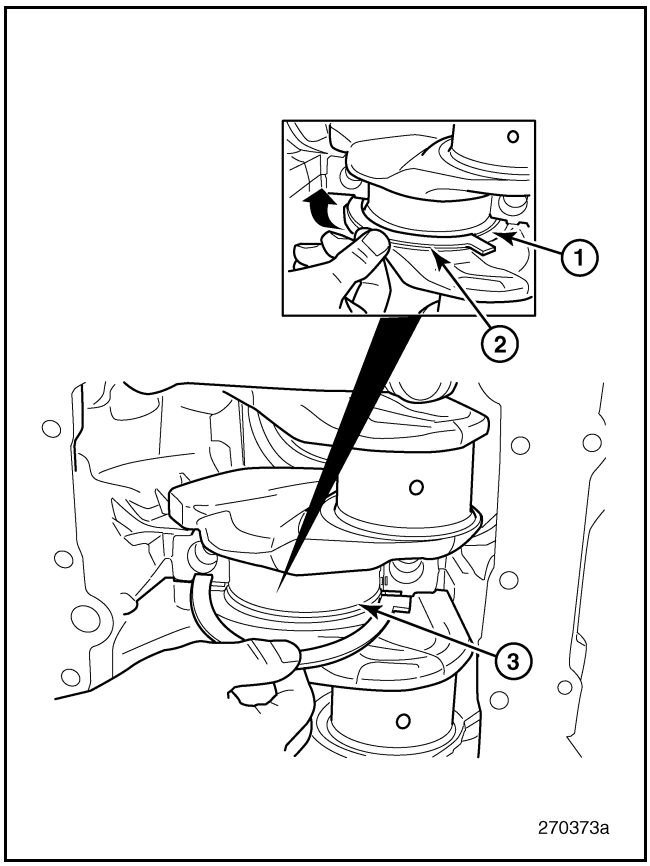


Figure 227 — Crankshaft Thrust Washer Installation

1. Thrust Washer Groove 2. Thrust Washer, Upper Insert	3. No. 4 Crankshaft Journal

10. Position the lower thrust washer sections on the center bearing cap with the bronze side facing the crankshaft and assemble the cap and capscrews in the engine block.

NOTE

Lubricate thrust washer sections with engine oil upon installation.

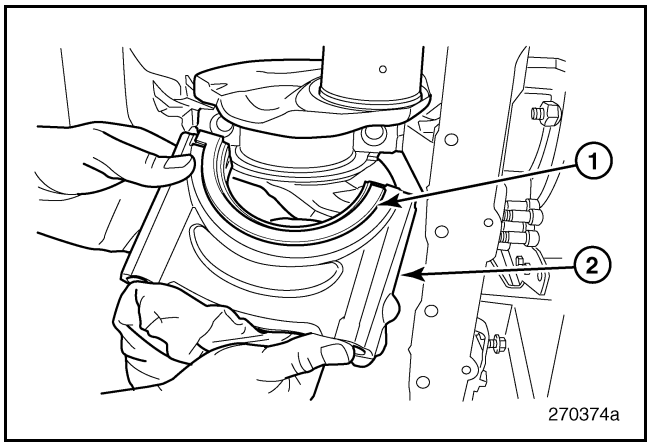


Figure 228 — Main Bearing Cap/Thrust Washer Installation

1. Thrust Washer, Lower Insert	2. No. 4 Main Bearing Cap

11. Using a torque wrench, tighten the capscrews according to specification.
12. Using a suitable pry bar, move the crankshaft toward the front or rear of the engine until it stops.
13. Using the pry bar, move the crankshaft in the opposite direction.

NOTE

Refer to allowable crankshaft end play tolerances under *Fits and Limits* in the **SPECIFICATIONS** section.

14. Using a magnetic base indicator tool with its tip against a crankshaft counterweight, check crankshaft end play as follows.
    a. Set the dial indicator to zero.
    b. Using the pry bar, move the crankshaft endwise and read the indicator.
    c. If end play is out of specification, remove the thrust washers and install washers of suitable thickness to meet specification.

⚠ CAUTION

The thickness of the thrust washers in the bearing cap must match the thickness of the thrust washers in the block. Be sure to put the bronze bearing surface against the crankshaft. Failure to heed this caution may result in severe component damage.

15. Using a torque wrench with the correct thrust washer sections in place, tighten all bearing cap capscrews according to specification.
16. Recheck the end play to be sure that the thrust washers have been installed correctly and that end play is within specification.
17. Rotate the crankshaft by hand several rotations to verify that the bearings have been properly installed and that the crankshaft turns freely.

Piston and Connecting Rod Assembly Installation

[212 NP, 212 LP]

PISTON AND ROD ASSEMBLY

1. Rotate the crankshaft so that the journals for the No. 1 and No. 6 cylinders are at Bottom Dead Center (BDC).

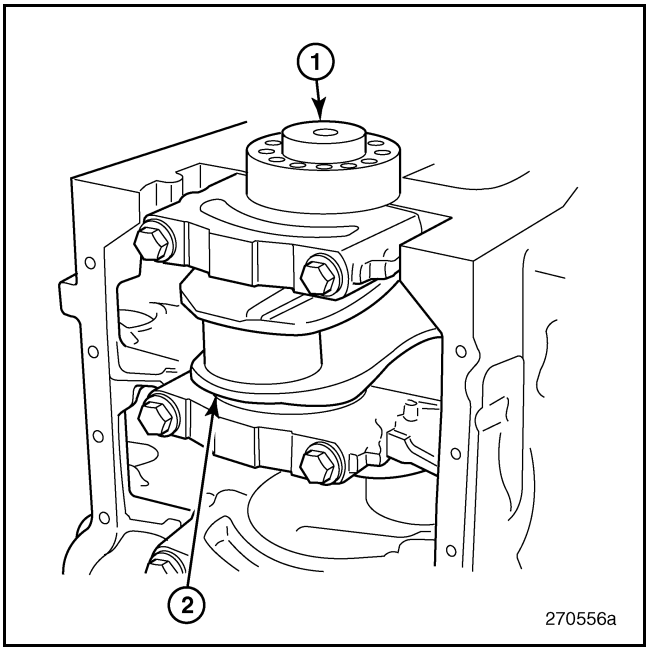


Figure 229 — No. 1 Cylinder (Crankshaft at BDC)

1. Crankshaft	2. No. 1 Journal

2. Apply a light coat of clean engine oil to the piston and rings. Check that the piston ring gaps are equally displaced around the circumference of the piston at a 120-degree relationship to one another.
3. Apply a light coat of clean engine oil to the inside surface of the piston ring compressor tool.
4. Carefully clean the bearing contact on the connecting rods and bearing caps. Also, clean the bearing seats.
5. Position a **new** upper bearing insert into the connecting rod. Align the tab in the bearing with the notch in the rod.

NOTE

The bearing size is found on the back of the bearing shell.

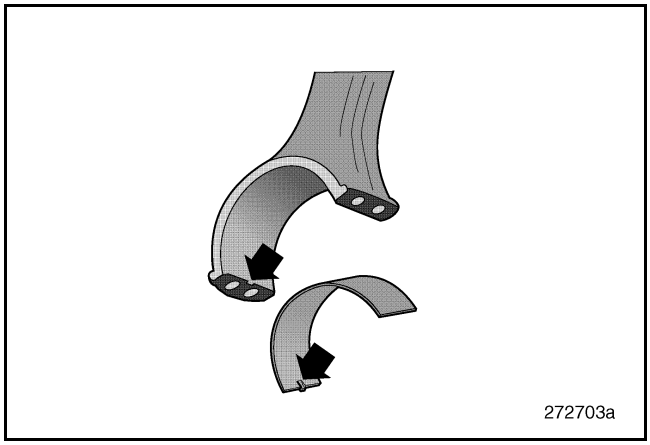


Figure 230 — Connecting Rod Bearing Shell

6. Apply a light coat of clean engine oil to the bearing surface.
7. Apply a light coat of clean engine oil to the inside surface of the cylinder liner.
8. Temporarily remove the press tool, 9996966, when the piston is to be installed. Reinstall the press tools when the piston is in position.

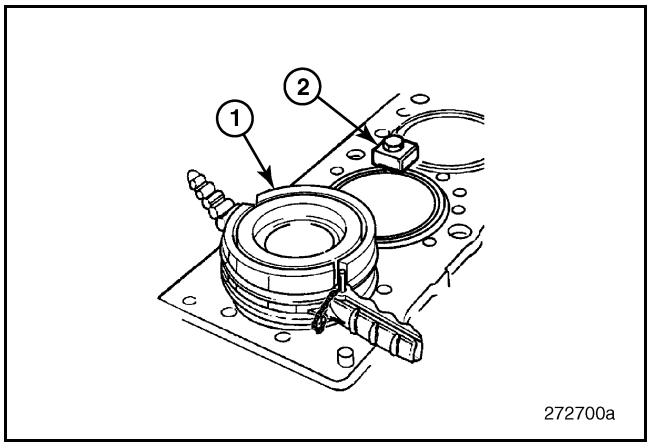


Figure 231 — Piston Installation

1. Piston Ring Compressor, 9998531	2. Press Tool, 9996966

9. Using the ring compressor, slide the piston and rod assembly into the cylinder until the compressor contacts the top of the liner.

⚠ CAUTION

*The arrow on top of the piston and the word **FRONT** on the connecting rod must be facing the front of the engine. This ensures that the notch in the lower rim of the skirt clears the piston cooling nozzle.*

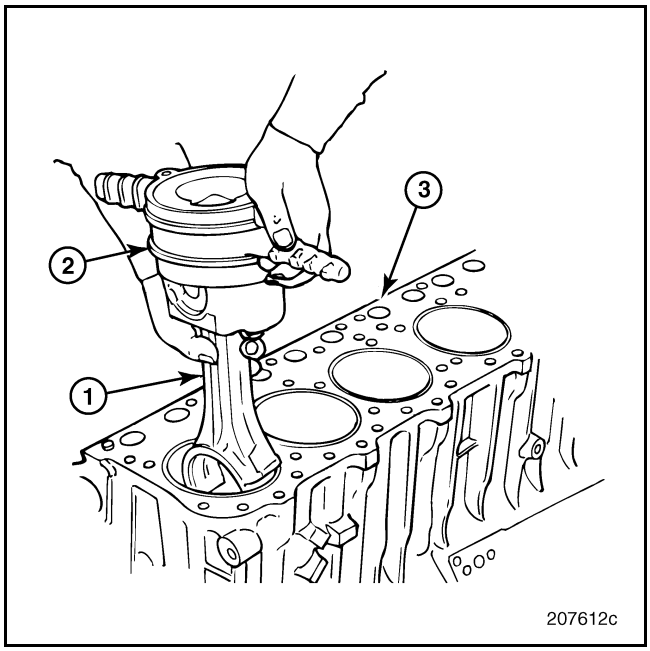


Figure 232 — Piston and Connecting Rod Installation

1. Connecting Rod Assembly	2. Piston Ring Compressor Tool 3. Cylinder Block

10. Make sure the connecting rod is aligned with the crankshaft journal.

11. While using a hammer handle to push the piston through the tool, apply pressure to the ring compressor tool to maintain contact with the cylinder liner. Continue pushing the piston until the top ring has passed into the cylinder liner.

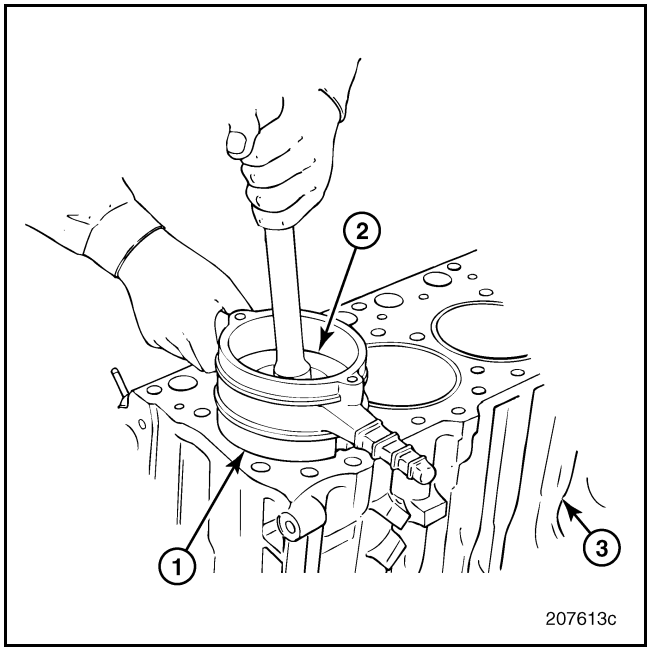


Figure 233 — Pushing Piston into Cylinder Sleeve

1. Piston Ring Compressor Tool	2. Piston 3. Cylinder Block

⚠ CAUTION

Do not use excessive force on the piston. High resistance indicates an incorrectly aligned ring. Remove the piston assembly, correct the problem, and then reinsert it. Make sure the compressor tool remains in contact with the cylinder sleeve until the piston clears the tool. Failure to heed this caution may result in severe engine damage.

12. Lubricate the crankshaft bearing inserts and crankshaft journals with engine oil.

13. Ensure that the correct cap is fitted to the correct connecting rod (refer to the marks).

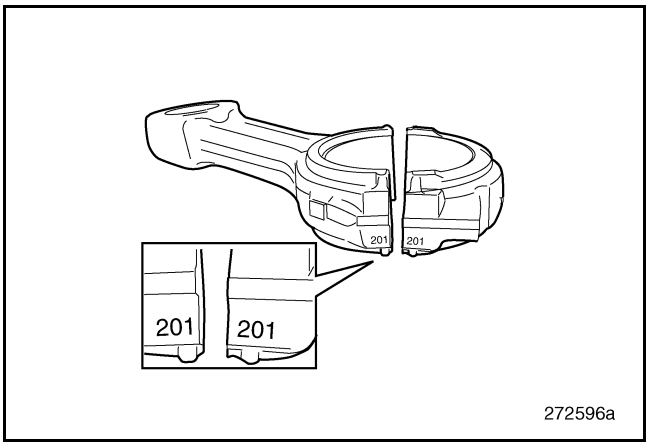


Figure 234 — Connecting Rod Bearing Shell

14. Install the fasteners and tighten to specification.

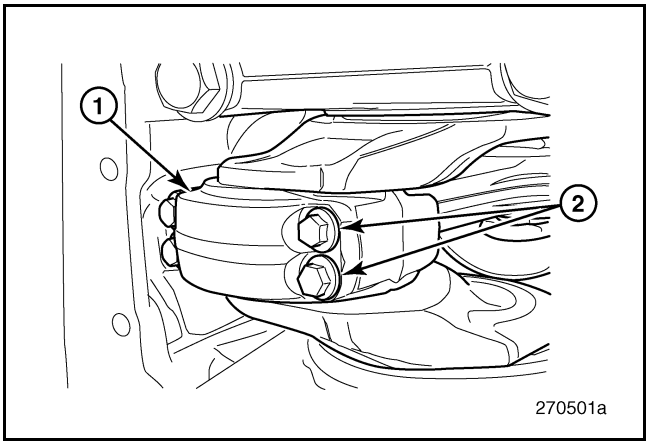


Figure 235 — Connecting Rod Cap Installed

1. Connecting Rod Cap	2. Attaching Capscrews

15. Repeat the above steps to install the No. 6 piston.

16. Rotate the crankshaft so that the journals for the No. 2 and No. 5 cylinders are at bottom dead center and install the No. 2 and No. 5 pistons following the above steps.

17. Rotate the crankshaft so that the journals for the No. 3 and No. 4 cylinders are at bottom dead center and install the No. 3 and No. 4 pistons, again following the above steps.
18. Install all piston cooling nozzles using **new** fasteners. Tighten the fasteners to specification.

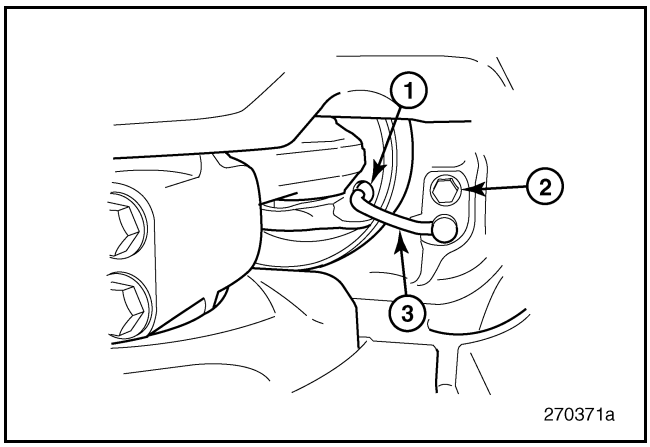


Figure 236 — Piston Cooling Nozzle Installation

1. Piston Duct 2. Attaching Screw	3. Piston Cooling Nozzle

Oil Pump and Block Stiffener Plate Installation

[211 DD]

OIL PUMP

NOTE

Clean the oil pump mounting surface of the rear main bearing cap before installing the **new** oil pump.

1. Position the oil pump to the rear main bearing cap and install the pump fasteners.

NOTE

The crankshaft may need to be rotated to allow access for the oil pump fasteners.

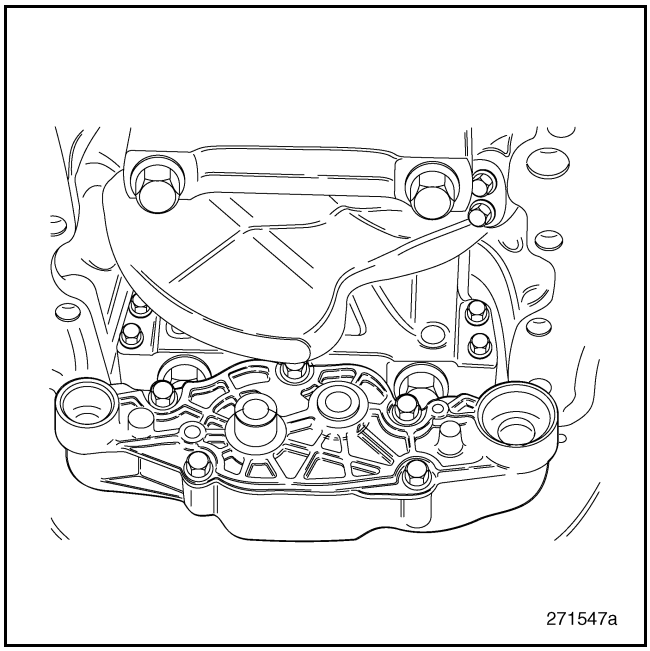


Figure 237 — Oil Pump Fastener Access

2. Torque-tighten pump fasteners to specification.

BLOCK STIFFENER FRAME

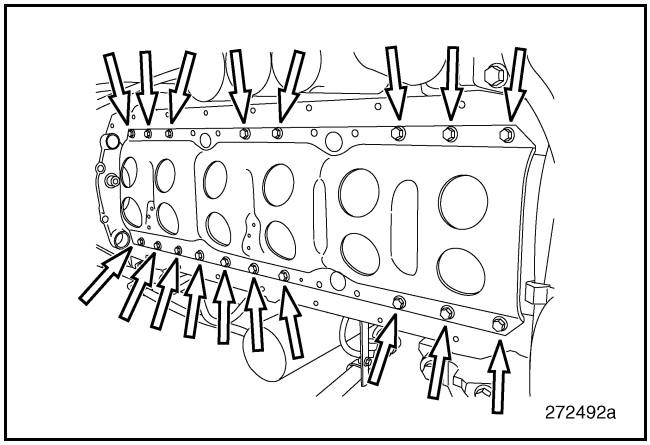


Figure 238 — Block Stiffener Plate

⚠ WARNING

The engine stiffening frame has sharp edges that can cause injury. To prevent injury, wear protective gloves when handling.

1. Assemble the stiffener plate on the block with **new** fasteners. Do NOT tighten the fasteners at this time.

NOTE

- The engine stiffening frame attaching fasteners are ONE TIME USE ONLY. New fasteners must be installed.
- The available tool, 9998649, can be used to hold stiffening frame in position while fasteners are started.

2. Install the oil pressure pipe and the crossover pipe before torque-tightening the stiffening frame.
3. Using a torque wrench, tighten the attaching fasteners in sequence according to specification.

Oil Pump Pipes and Strainer Installation

[219 MU, 219 NT]

1. Replace the O-rings on the oil pressure pipe, oil suction pipe and oil crossover pipe. Lubricate the O-rings with engine oil before installation.

NOTE

Separate the oil suction pipe from the oil strainer as needed to replace the O-ring. Clean and inspect the oil strainer, suction pipe, crossover pipe and pressure pipe for cracks. Replace if necessary.

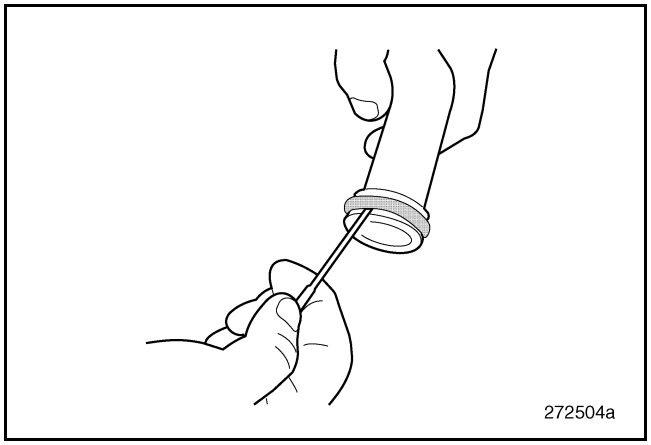


Figure 239 — Oil Pump Pipe O-Ring Replacement

2. Assemble the oil strainer, suction, pressure and crossover pipes into the pump as follows:
   - Slide the oil pressure pipe into the oil pump, position the pipe flange to the cylinder block, install the fasteners and torque-tighten to specification.
   - Position the oil crossover pipe to the skirts of the cylinder block, install the fasteners and torque-tighten to specification.
   - Assemble the oil strainer and oil pickup pipe. Slide the oil pickup pipe into the oil pump, position the oil strainer to the engine stiffening frame, install the fasteners and torque-tighten to specification.

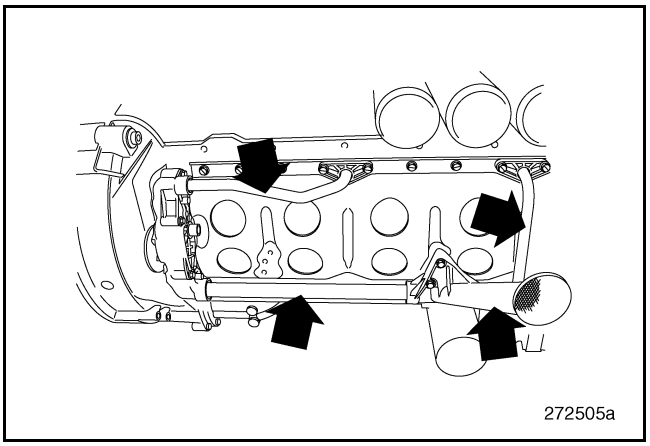


Figure 240 — Oil Pump Pipe Installation

Front Engine Support Installation

[299 GV]

1. If removed, assemble the front engine support mounting bracket to the cylinder block and tighten fasteners to specification.

NOTE

The bracket also serves as the A/C compressor mount.

2. Assemble the front engine support onto the block mounted brackets and install the six fasteners.
3. Using a torque wrench, tighten all fasteners in sequence to specification.

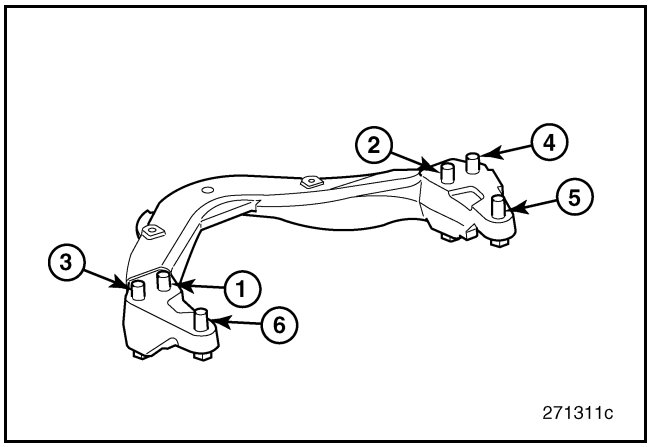


Figure 241 — Front Engine Support

Crankshaft Front Cover and Seal Installation

[211 JB]

1. Place the crankshaft front cover with spacer, 9998170, in the center on a flat surface. Install a **new** crankshaft seal with plastic ring in the crankshaft front cover. The spacer ring prevents the plastic ring from sliding off. Carefully tap the crankshaft seal into the front cover with drift, 88800021, and handle, 9992000, until the crankshaft seal is level with the front cover.

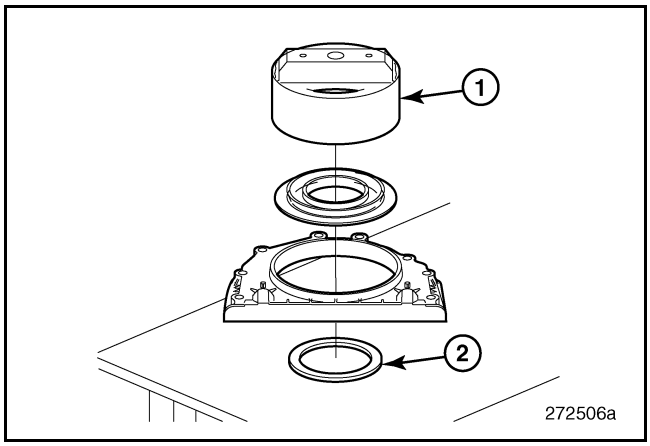


Figure 242 — Crankshaft Front Cover Seal Installation

1. Front Main Seal Remover/installer, 88800021	2. Plastic Spacer, 9998170

2. Apply a 2 mm (5/64 inch) bead of MACK-approved silicone sealant to the rear face of the cover according to the pattern shown.

NOTE

Make sure that the crankshaft front cover and block flanges are cleaned thoroughly before applying sealant.

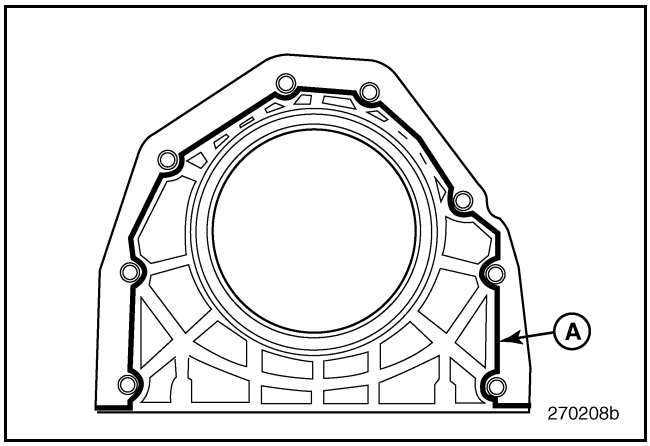


Figure 243 — Sealant Application Pattern — Crankshaft Front Seal Cover to Block

A. 2 mm (5/64 inch) bead of MACK-approved silicone sealant

3. Within 20 minutes of sealant application, install the front cover to the engine block. Center the crankshaft front cover against the crankshaft using the plastic ring.
4. Install the front cover. Note that there are two different types:

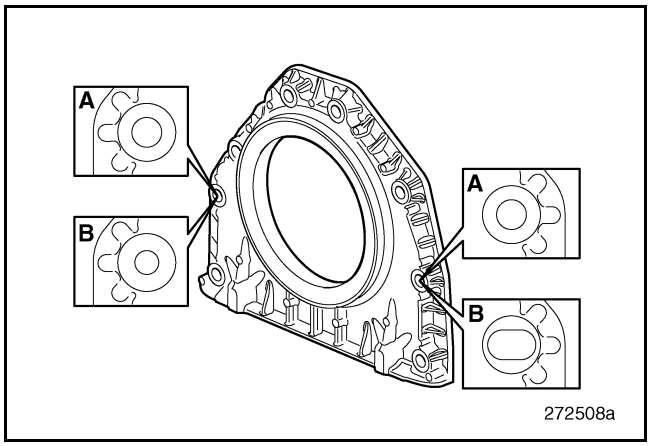


Figure 244 — Crankshaft Front Cover

- **For earlier type (A), the following installation instructions apply:**

  Install the bolts without tightening them. Using a straightedge rule, make sure the cover is flush with the lower edge of the engine block.

- **For later type (B), the following installation instructions apply:**

  Install the bolts in both bolt holes that align the cover to the correct position. Tighten by hand so that the cover is fixed. Install the remaining bolts.

NOTE

For the later type cover, the left-hand hole is smaller and the right-hand hole is oval. This change allows the later cover to be correctly aligned.

5. Using a torque wrench, tighten the capscrews in sequence according to specification.

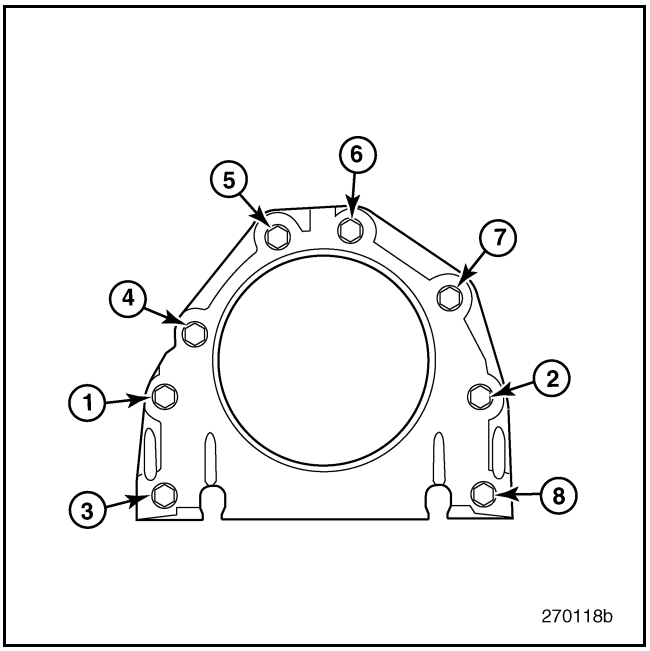


Figure 245 — Front Cover Torque Sequence

6. Remove the plastic ring from the crankshaft hub. Drive in the crankshaft seal with drift, 88800021, and handle, 9992000, until the drift bottoms against the crankshaft.

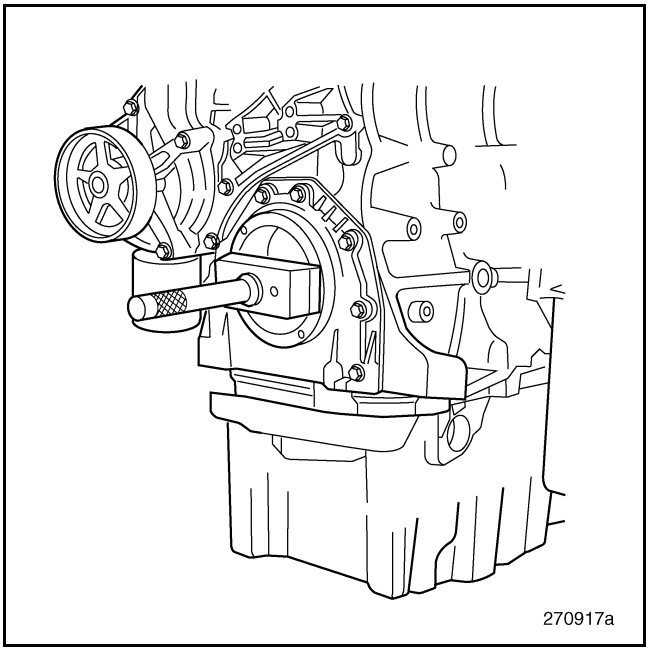


Figure 246 — Crankshaft Front Seal Installation

7. Remove the tool and check the seal to be sure it has been evenly installed.

Timing Gear Plate Installation

[211 AA]

NOTE

Rotate the engine block so the rear surface is at the top.

NOTE

If the cylinder head is installed after the timing gear plate is in place, do not apply sealant in the cylinder head area until ready to assemble the head on the block.

1. Clean the timing gear plate on both sides.
2. Clean the contact surfaces on the engine block and cylinder head. Remove sealing compound from the groove on the engine block side.
3. Apply a 2 mm (5/64 inch) bead of 342SX33 MACK approved silicone sealant (A) to the front face of the plate according to the pattern shown.

NOTE

Sealing compound must be applied **outside** the groove in the timing gear plate. This causes the excess compound to be forced down into the groove, which allows for better sealing.

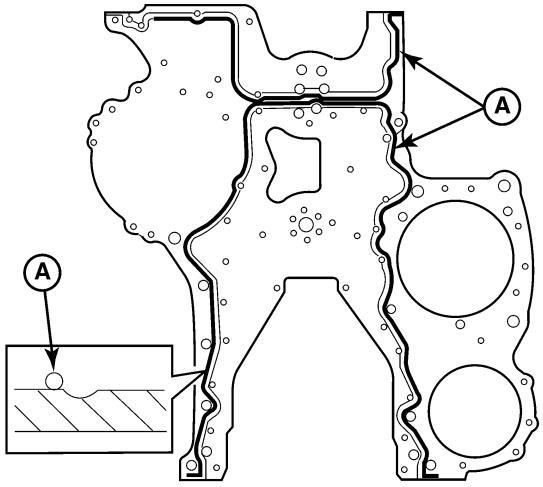


Figure 247 — Sealant Application Patterns — Head and Block to Plate

4. Within 20 minutes of the application of the sealant, assemble the timing gear plate over alignment guides, 9998267, that were installed into the block at disassembly.

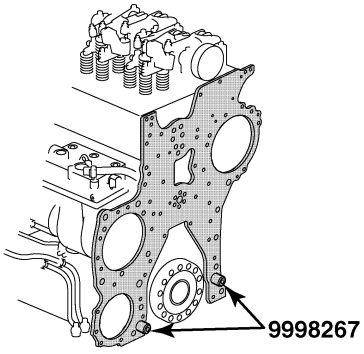


Figure 248 — Gear Plate Installation

5. With timing gear plate in position over guide pins, install **new** timing gear mounting attaching fasteners.

6. Using a torque wrench, tighten the attaching fasteners in sequence according to specification.

NOTE

Clean away excessive sealing compound before it dries.

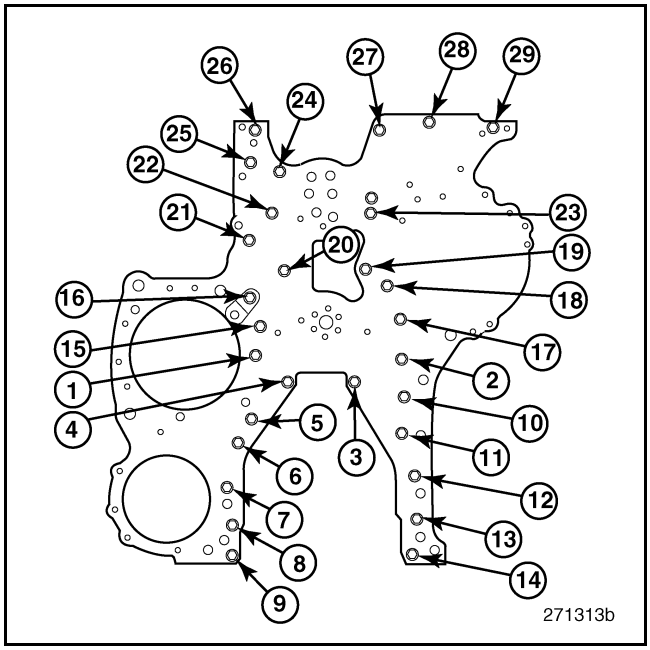


Figure 249 — Timing Gear Plate Torque Sequence

7. Install the compressor stud with a **new** sealing ring and **new** fastener.

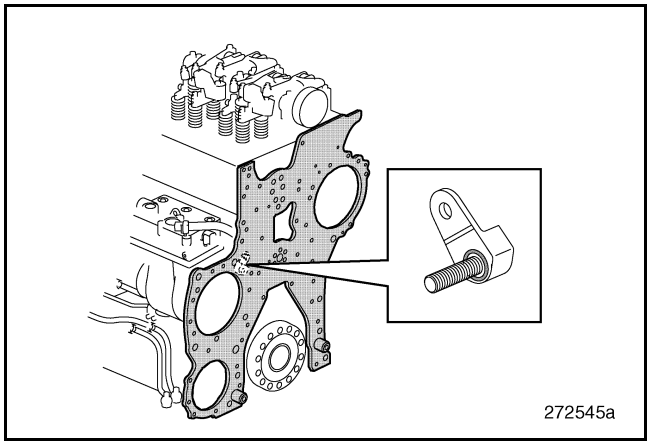


Figure 250 — Compressor Stud

8. Remove alignment guides, 9998267, from the timing gear plate.

Cylinder Head Installation

[213 EV]

⚠ WARNING

The cylinder head is heavy. Do NOT attempt to install the cylinder head without the help of an assistant and the use of a suitable lifting device. Failure to heed this warning may result in severe personal injury and component damage.

NOTE

All MACK head gaskets are precoated and do not require any type of additional sealing compound.

1. If necessary, clean the unit injector copper sleeves with brush J 42885-9 and extension J 42885-1 with J 42885-25 installed to protect the fuel passages. These tools are available in kit J 42885.

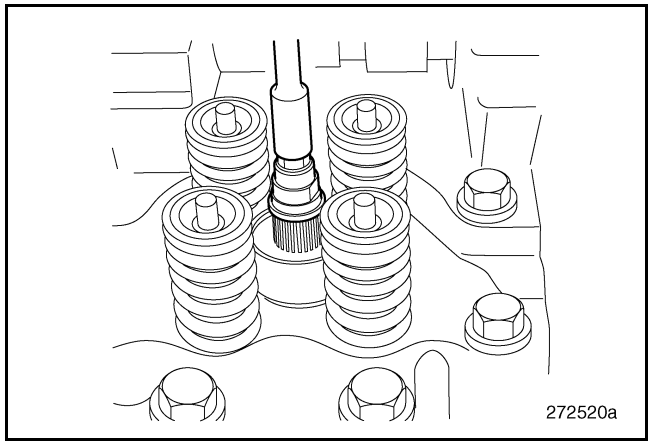


Figure 251 — Injector Copper Sleeve Cleaning

NOTE

With any cleaning of the unit injectors, **under no circumstances** may rotary wire brushes, hand wire brushes or similar tools be used on the injector nozzle. Use of such tools poses a risk that the injector holes could be damaged and blocked, causing power delivery problems. Instead, use a rag soaked in paraffin or equivalent.

2. Install fuel injector bore plugs, 9998251.
3. Ensure that the engine block and deck are clean and free from any dirt, grease or oil.
4. Carefully clean the cylinder head and install the head lifting tool, 88800188. Check that the guide washers on the engine block and cylinder head are clean and free of rust.

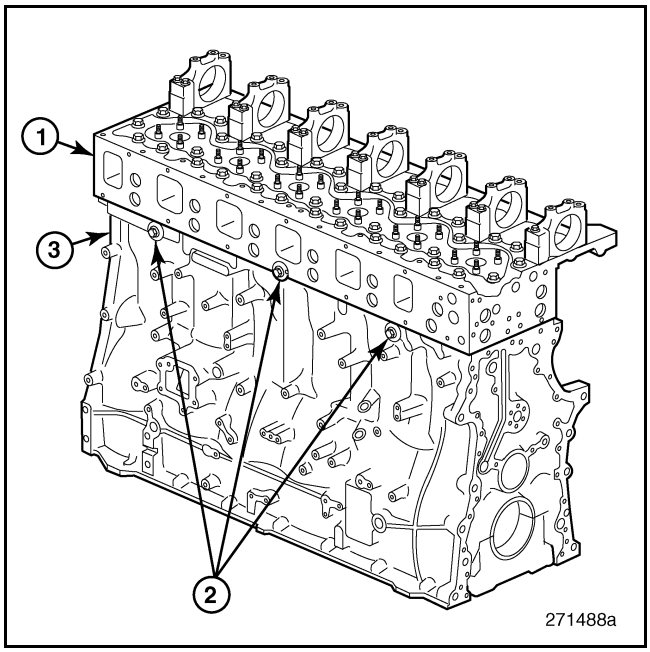


Figure 252 — Guide Washer Locations

1. Cylinder Head 2. Guide Washers	3. Cylinder Block

5. If in place, remove the cylinder liner clamping tools, 9996966, from the block.

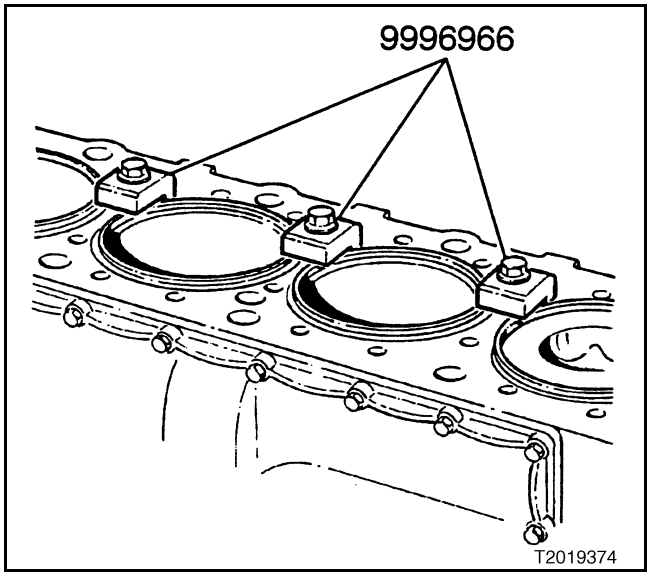


Figure 253 — Cylinder Liner Clamping Tools

6. Apply a 2 mm (5/64 inch) thick bead of silicone sealant to the surface at the side of the “track” on the timing gear plate (as shown in the illustration).

NOTE

The cylinder head must be installed and torque-tightened within 20 minutes after the sealant has been applied.

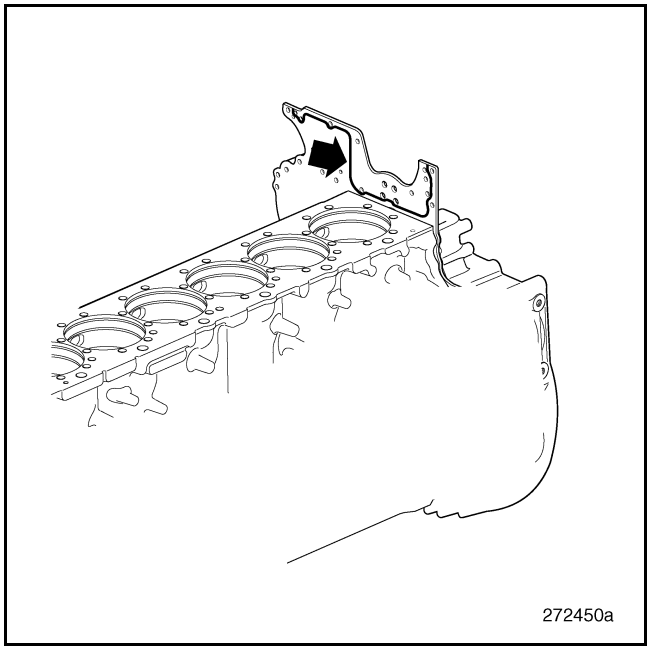


Figure 254 — Sealant Application Pattern — Head to Plate

7. Place a **new** head gasket on the engine block deck.

NOTE

- Check that the seals are correctly positioned with their holes all centered.
- There are points embossed in the gasket that will temporarily protect the seals from the head. These will be compressed when the head bolts are tightened.
- The head gasket should be discarded if the head is removed. A **new** gasket should be used when the head is installed.

8. Carefully lower the cylinder head about 9 mm (3/8 inch) forward of the gear mounting plate until it makes contact with the cylinder head gasket. Press the cylinder head against the timing gear cover and the guide washers at the left side. (There are two guide washers on the cylinder block and one on the cylinder head.)

NOTE

A three-step process is used for installation of the cylinder head.

a. It is first lowered onto the block deck and gasket, about 9 mm (3/8 inch) forward of the gear plate. As it is lowered, the guide washers ensure proper alignment of the cylinder head with the left side of the cylinder block.

b. Once lowered, screws inserted through the adjustable idler gear hub and plate are used to draw the cylinder rearward against the plate.

c. In the final step, the head bolts are inserted and tightened to specification, securing the cylinder head to the block.

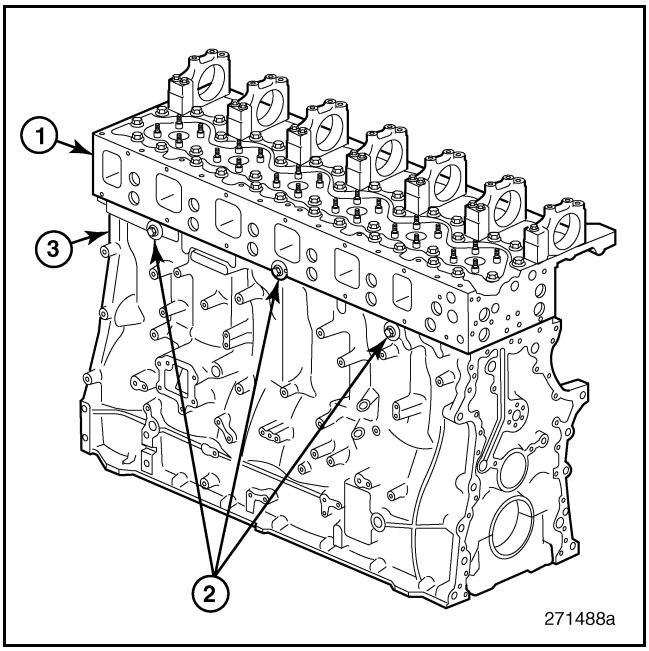


Figure 255 — Guide Washer Locations

1. Cylinder Head	2. Guide Washers 3. Cylinder Block

9. Temporarily install the adjustable idler gear hub and insert bolts through the timing gear plate and the adjustable idler gear hub. Tighten the bolts to 85 ±15 N•m (63 ±11 lb-ft) to draw the cylinder head toward the plate.

NOTE

If not loosened, there is a risk that the bolts will break when the cylinder head bolts are tightened.

10. Check the condition of the cylinder head attaching capscrews and lubricate the heads (underside) and threads with clean engine oil.

NOTE

Do NOT oil the threads in the block.

11. The cylinder head capscrews must **not** be used more than five times. Mark the cylinder head capscrews by punching them.

12. Insert four cylinder head capscrews into locations 24, 26, 28 and 30. Tighten the capscrews to specification.

13. Remove the cylinder head lifting bracket.

14. Torque-tighten and angle-tighten all cylinder head capscrews in sequence to specification.

15. Install the fasteners securing the timing gear plate to the rear of the cylinder head. Tighten the fasteners to specification.

16. Ensure that the crankshaft is at the top dead center (TDC) position and assemble the camshaft, camshaft gear and damper according to the instructions under *Timing Gear Train Installation*.

Camshaft Installation

[213 CH]

⚠ WARNING

The camshaft is heavy. Do NOT attempt to install the camshaft without the help of an assistant or the use of a suitable lifting device. Failure to heed this warning may result in severe personal injury and component damage.

1. If removed, install the camshaft bearing saddles to the original positions. Carefully tap the bearing saddles onto the guide pins using a soft-faced hammer until fully seated.
2. Insert the camshaft lower bearings and apply a generous coating of clean engine oil to the camshaft bearings.
3. Make sure there is a bearing insert on each lower bearing saddle. The bearing inserts at the No. 7 camshaft journal have integral thrust washers.

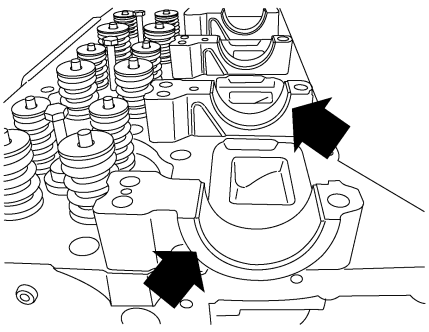


Figure 256 — No. 7 Camshaft Lower Bearing Insert

4. Clean and inspect the camshaft using solvent and compressed air.
5. Lower the camshaft carefully into place on the lower bearing saddles and remove the lifting tool, 85109034. Rotate the camshaft by hand to ensure the camshaft is not binding on the lower bearing saddles.

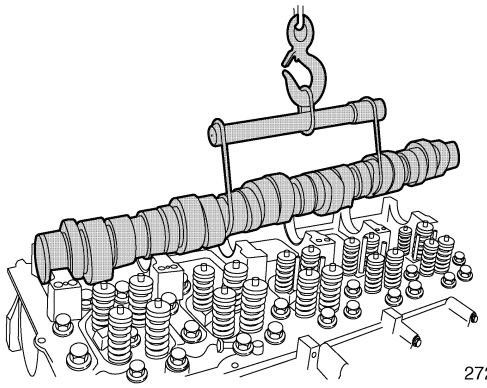


Figure 257 — Camshaft Installation

6. Install the camshaft upper bearing inserts into the camshaft bearing caps, lubricate the bearings and install the bearing caps to the respective bearing saddles. Use a soft-faced mallet to seat the bearing caps over the dowel pins.
7. Insert and hand-tighten the exhaust side bearing cap bolts and tighten to specification. Final tightening to the specified torque value will be done later when the rocker arm shaft is installed.
8. Install the bearing cap press tool (two required) at the number 7 and the number 1 bearing caps as shown in the illustration.

NOTE

The tool is used when adjusting the timing gear backlash when the rocker shaft assembly is not installed.

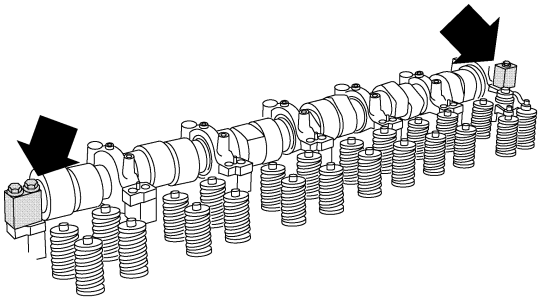


Figure 258 — Bearing Cap Press Tool

Timing Gear Train Installation

NOTE

Apply a light coat of clean engine oil to all parts before assembly.

⚠ CAUTION

DO NOT overtighten the mounting flange fasteners when installing any of the gears in the timing gear train. Overtightening the fasteners can cause stripped threads in the cylinder block.

1. Assemble a **new** O-ring on the crankshaft rear hub.
2. Apply a film of oil to the O-ring and assemble the crankshaft gear on the crankshaft hub.

NOTE

Leave two fasteners loose enough to aid in turning the crankshaft with a lever for gear alignment purposes.

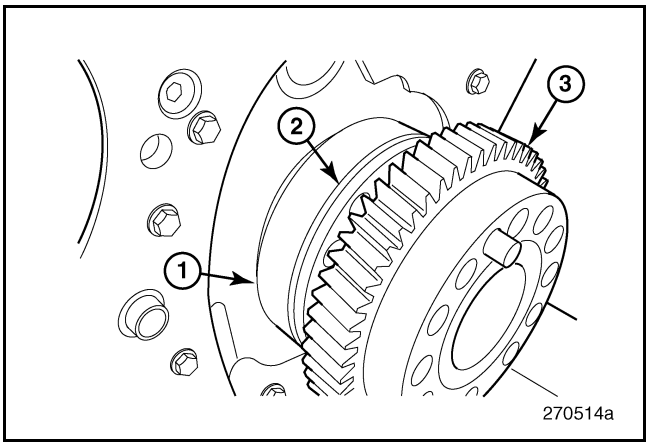


Figure 259 — Crankshaft Gear-to-Hub Assembly

1. Crankshaft Rear Hub 2. O-Ring	3. Crankshaft Gear

3. Assemble the adjustable idler gear (item 3 in Figure 260), hub, bushing, thrust washer and fasteners on the plate. Hand tighten the fasteners.

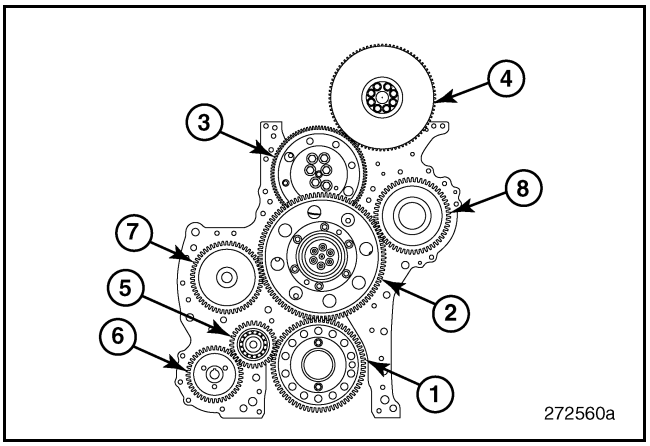


Figure 260 — Adjustable Idler Gear

1. Crankshaft Gear 2. Intermediate Idler Gearset 3. Adjustable Idler Gear 4. Camshaft Gear	5. Lower Idler Gear 6. Tandem Pump Drive Gear 7. Air Compressor Drive Gear 8. PTO Drive Gear

4. Check that the camshaft is positioned at TDC.

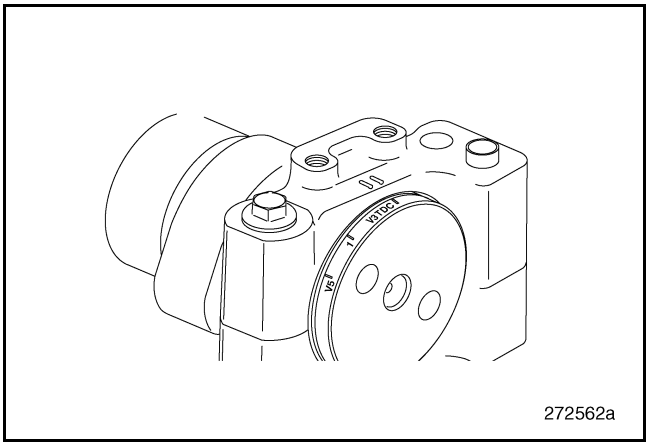


Figure 261 — Camshaft Positioning

5. Align the punch marks on the camshaft gear teeth to straddle the alignment hole in the timing gear plate and install the camshaft gear without the damper as shown in Figure 262. Install the clamp plate tool, J 44514-1A, using **Position B** of the gauge plate tool to secure the camshaft gear to the camshaft and loosely install the two retaining bolts.

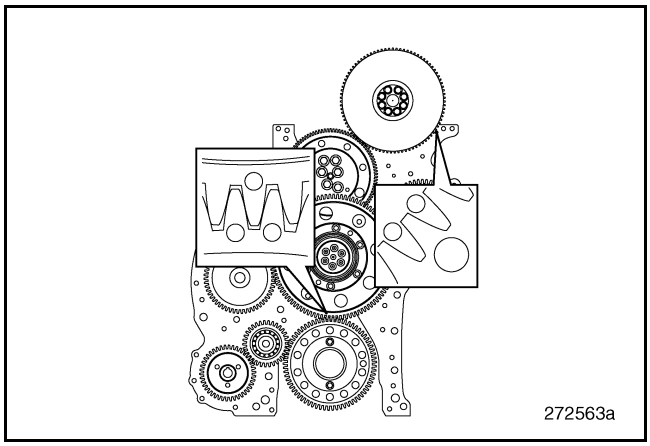


Figure 262 — Camshaft Gear Check

6. Insert the alignment tool J 47450-1, into the hole in the cylinder head to engage the camshaft gear teeth with the rod of the tool in the slot of the clamp tool. It may be necessary to rotate the camshaft until this occurs. With the alignment pin properly positioned in the clamp plate slot, check that the camshaft TDC mark is still positioned between the two timing marks on the bearing cap.

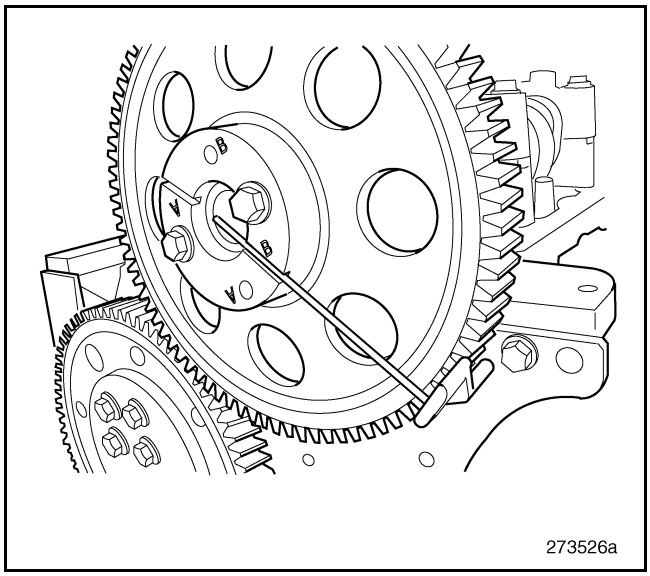


Figure 263 — Camshaft Gear Timing Marks Alignment

7. Remove the alignment pin and clamp plate tool from the camshaft gear and install the vibration damper and clamp plate using **new** fasteners. Tighten the fasteners to specification.

NOTE

Mark the bolts to aid in tightening the bolts to the degree rotation specification.

8. Insert a 0.1 mm (0.004 inch) thickness gauge. Adjust the idler gear so that there is slight pressure on the thickness gauge. Tighten the bolts by hand only.

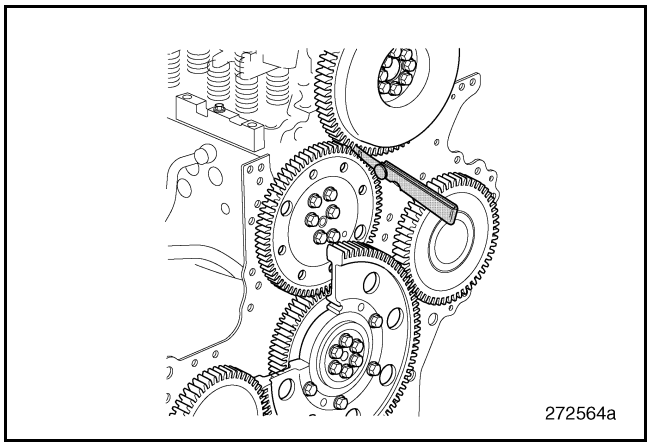


Figure 264 — Camshaft Thickness Gauge Check

9. Remove the thickness gauge.

NOTE

There should be a slight resistance on the thickness gauge when removed.

10. Install the J 44514-5 clamp assembly tool to the timing gear plate. Screw the hold-down against the adjustable idler gear so the adjustable idler gear does not rotate.

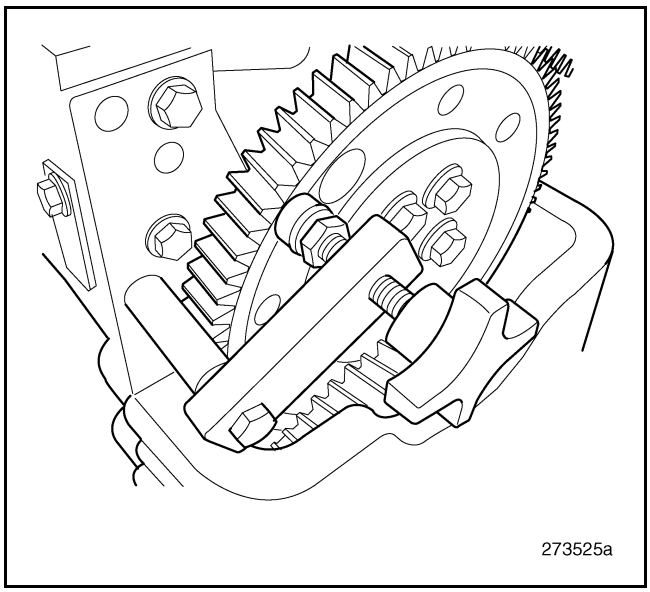


Figure 265 — Clamp Assembly Tool

11. Install the magnetic stand, 9999696, and dial indicator, 9999683, so that the tip of the dial indicator rests on a tooth of the camshaft gear.

    Check the gear backlash by rotating the camshaft gear back and forth slightly to measure the backlash. For backlash specification, refer to the SPECIFICATIONS section.

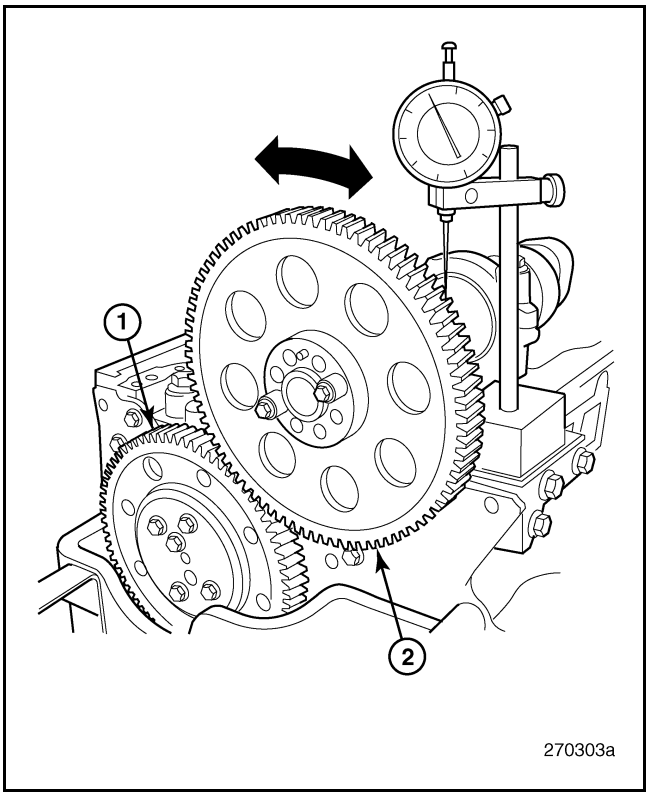


Figure 266 — Camshaft Backlash Check

1. Idler Gear	2. Camshaft Gear

12. If the backlash measurement is out of specification, adjust the gear flank clearance as follows:

    a. Loosen the J 44514-5 clamp assembly tool from the adjustable idler gear hub.

    b. Loosen the adjustable idler gear hub screws slightly. Loosening the hub screws will allow the idler gear to be moved slightly in/out from the camshaft gear.

    c. Insert a 0.1 mm (0.004 inch) thickness gauge on the pressure side of the adjustable idler gear tooth and camshaft gear tooth by using feeler gauge holder J 44935 and J 44514-6 feeler gauge.

    d. While holding the adjustable idler gear in against the thickness gauge and camshaft gear, tighten, but DO NOT torque the adjustable idler gear hub fasteners.

    e. Reinstall and tighten the J 44514-5 clamp assembly tool against the adjustable idler gear.

f. Remove the feeler gauge from the adjustable idler gear and camshaft gear.

g. Recheck the backlash. With the specified backlash attained, replace each adjustable idler gear hub screw with **new** and tighten the screws to specification one at a time so the attained backlash is not disturbed.

13. Install the intermediate idler (double idler) gearset (2) to the timing gear plate, using **new** fasteners.

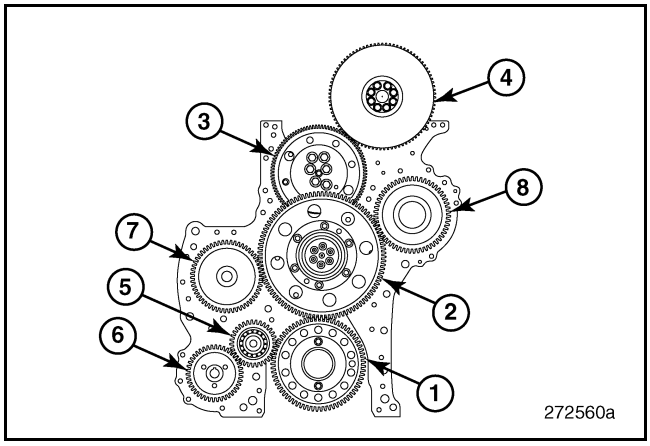


Figure 267 — Intermediate Idler (Double Idler) Gearset

1. Crankshaft Gear	5. Lower Idler Gear
2. Intermediate Idler Gearset	6. Tandem Pump Drive Gear
3. Adjustable Idler Gear	7. Air Compressor Drive Gear
4. Camshaft Gear	8. PTO Drive Gear

14. Check that the idler gear marking aligns with the markings on the crankshaft gear teeth.

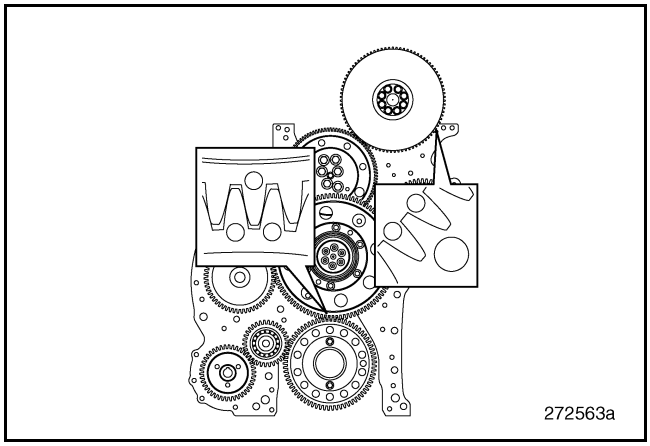


Figure 268 — Camshaft and Double Idler Gear Check

15. Tighten the intermediate gearset (double idler) mounting bolts in sequence to specification.

16. Install the auxiliary idler gear onto the timing gear plate.

17. Remove the bearing cap press tools, 85109208.

Unit Injector Installation [221 GP]

NOTE

If a unit injector is reused, it must be fitted to the bore from which it was removed.

1. If not previously performed, install protective sleeve, J 42885-25, and clean the unit injector copper sleeve with the appropriate brush and extension.

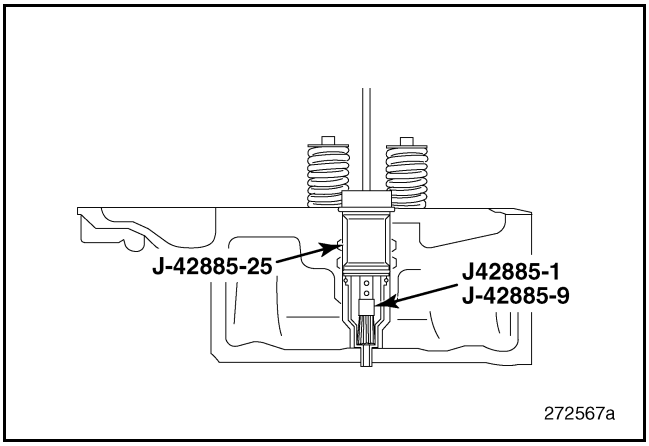


Figure 269 — Unit Injector Copper Sleeve Cleaning

NOTE

After cleaning the copper sleeve, carefully inspect the inside surface of the sleeve, especially the bottom surface where the injector seal is located. Any remaining contamination is unacceptable and must be removed. Also, if there is any indication of a discrepancy that raises concern about suitability of the sleeve for reuse, replace it with a **new** sleeve.

2. Before reusing an injector, cleaning is required to ensure suitability for reuse. Before doing any cleaning, the injector fuel inlet and outlet ports and the electrical connector opening must be covered to prevent contamination from the cleaning process. Also, there must be no lower O-ring installed in the injector. Refer to “UNIT INJECTOR CLEANING” on page 244 for further information.
3. Remove the bore protection sleeve, 9998251.

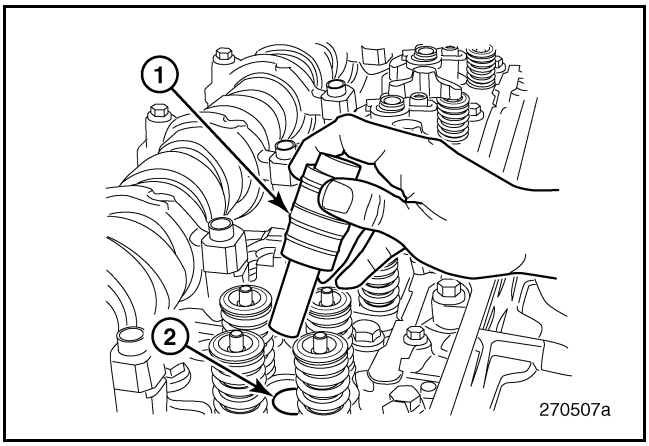


Figure 270 — Unit Injector Bore Protection Sleeve

1. Unit Injector Protection Sleeve, 9998251	2. Unit Injector Bore

4. Install **new** O-rings on the unit injector as follows:
   - Upper ring — large diameter, violet
   - Lower ring — small diameter, violet
5. Lubricate both O-rings and the cylinder head injector bore with clean engine oil.
6. Install a **new** injection nozzle gasket (flat washer) on the injector, using hand force to push it over the tip and down until it is fully seated against the bottom of the injector. DO NOT use grease or any other material to secure the gasket to the injector; the gasket must be installed dry. Three small projections (grippers) on the inside diameter of this gasket retain it to the injector during installation.

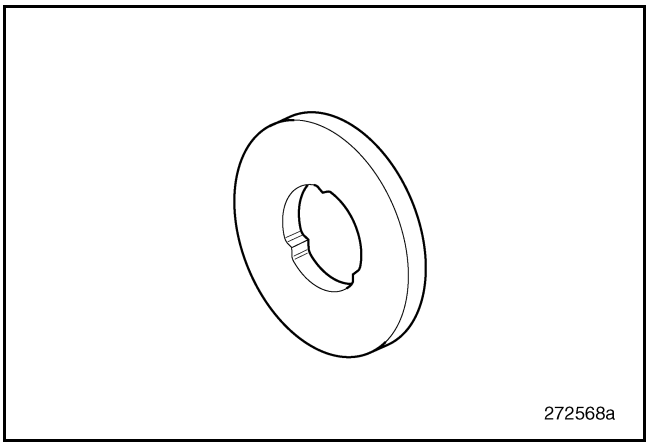


Figure 271 — Injector Nozzle Gasket

N O T E

Some early production MP8 engines used the original design copper sleeves with integral “raised bead” at the bottom of the copper sleeve. This design does NOT use a gasket (flat washer) between the injector tip and the copper sleeve. These original raised-bead design copper sleeves can be identified by a single groove, or no groove at all around the upper circumference.

The current production “flat-bottom” design copper sleeves, which require the gasket (flat washer) at the injector tip, can be identified by two grooves around the upper circumference of the sleeve.

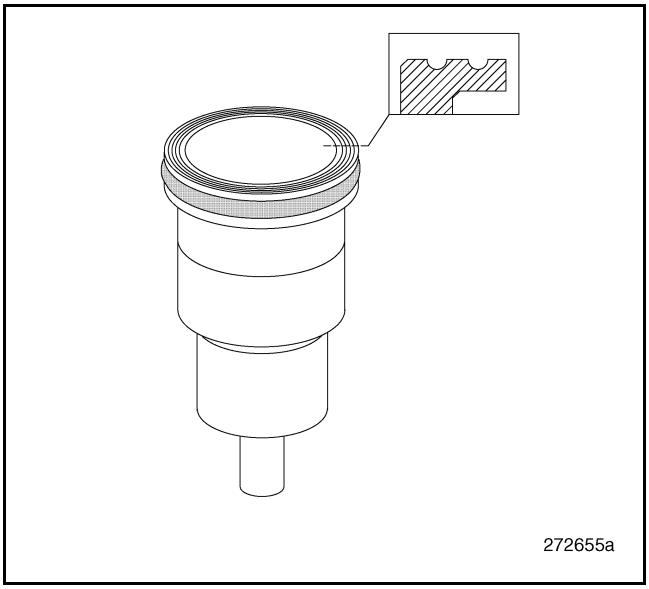


Figure 272 — Copper Sleeve (Shown Removed for Clarity)

NOTE

A revised gasket (flat washer) having a thin black rubber coating for improved sealing was implemented in production beginning mid-August 2008. Service replacement gaskets now have the rubber coating. DO NOT remove the rubber coating.

The gasket (flat washer) is preassembled on new injectors.

7. Slip the injector hold down and a **new** screw of correct length onto the unit injector.

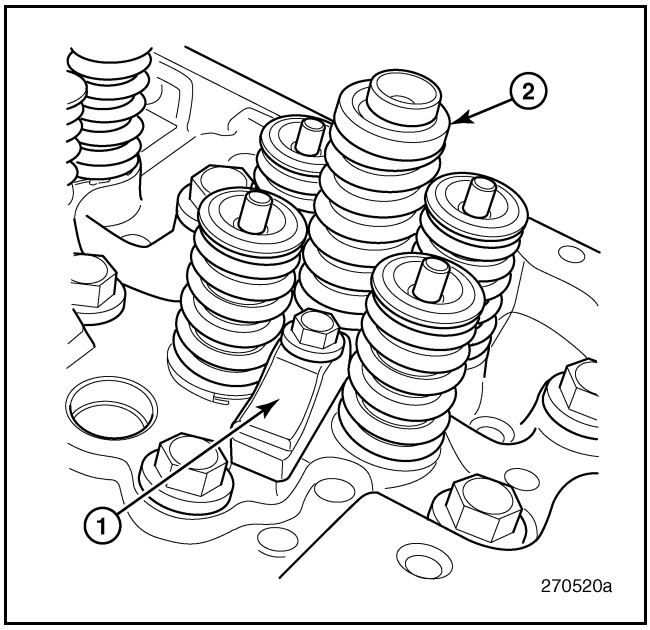


Figure 273 — Unit Injector Retainer

1. Injector Hold-Down Yoke	2. Unit Injector

8. Make sure that the injector is reinstalled to the same cylinder from which it was removed (or injector trim codes will need to be reprogrammed in the EECU).
9. Center the unit injector between the valve springs and then push down on the unit injector using hand pressure to seat the O-rings. Hand tighten the **new** hold-down screw.

NOTE

The unit injector hold-down screw must be replaced whenever it is removed from the hold-down and cylinder head

10. Ensure that the injector electrical connector is central between the valve springs with equal space on both sides. If the harness is installed, plug in the injector electrical connector until fully engaged. Push in the connector until you hear a distinct “click”.

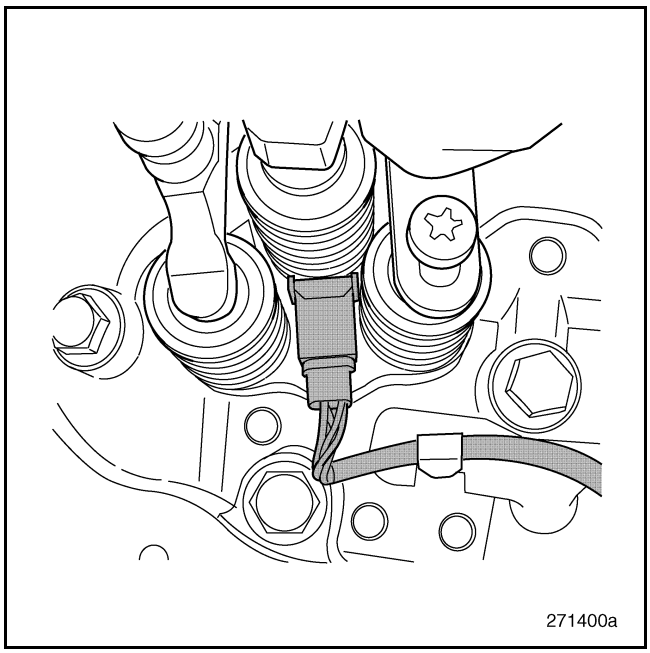


Figure 274 — Electrical Connector for Unit Injector

11. Using a torque wrench, tighten the hold-down screw in stages to specification.
12. When replacing unit injectors, the control unit must be programmed with the new injector's trim codes. The code is printed on top of the unit injector electrical connector. The programming is performed using VCADS/TT and is necessary to ensure that engine timing and emission levels are correct.

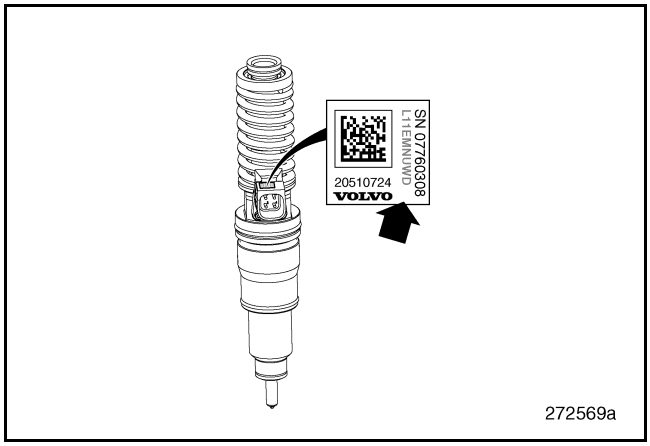


Figure 275 — Injector Trim Codes

NOTE

- Due to the Engine Electronic Control Unit (EECU) self learning capability, it is necessary to reset learned EECU parameters after servicing some engine-related components. This allows the EECU to learn the new component's behavior. After servicing is complete, perform the “Learned Data Reset” located in VCADS/TT.
- If reinstalling an injector into the same location, reprogramming is not required.

13. Repeat the installation steps for the remaining injectors.

Valve Yoke (Bridge) Installation

[213 NV]

NOTE

Used yokes have established wear patterns. Yokes being returned to service must be installed in the same cylinder location from which they were removed.

1. Lubricate the tip of a valve stem with a small drop of clean engine oil.
2. Lubricate the yoke sockets with a small drop of clean engine oil in each one.

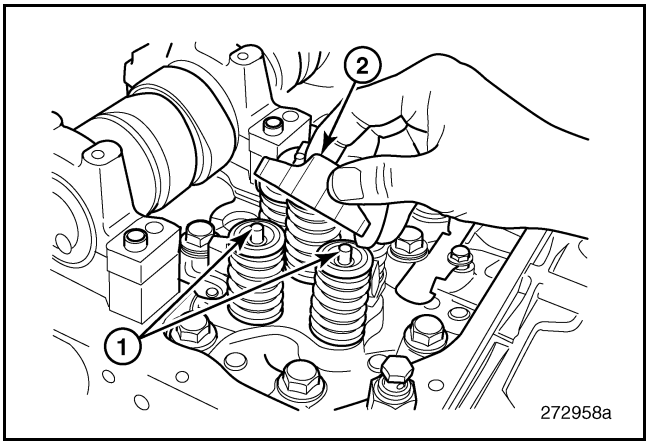


Figure 276 — Installing the Inlet Valve Yoke

1. Valves	2. Valve Yoke

3. Set the yokes on their respective valve stems. Make sure that they are properly seated.

Rocker Arm Shaft and Engine Brake Installation

[213 LP]

1. Oil the valve yokes and the camshaft lobes with engine oil.
2. Using the lifting tool, 85109250, and an assistant, place the shaft with rocker arms in position on the inboard side of the camshaft bearing caps.

NOTE

On engines with an engine brake, the exhaust rocker arm includes an integral valve and piston.

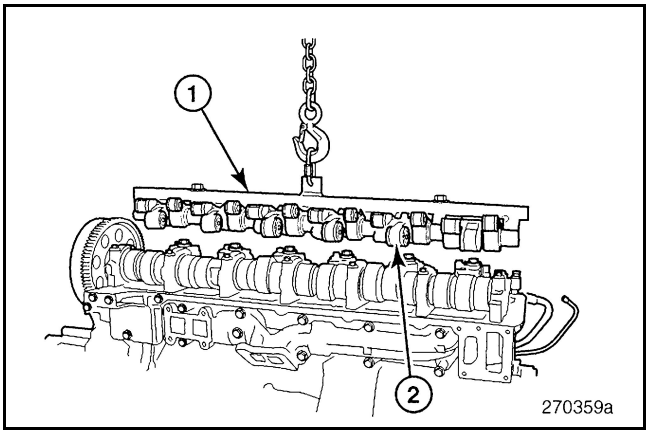


Figure 277 — Rocker Shaft Assembly Installation

1. Lifting Tool, 85109250	2. Rocker Shaft Assembly

3. Remove the lifting tool. Then, install and tighten the rocker arm shaft bolts a little at a time, evenly across the entire shaft so that the shaft does not become distorted, bent or fractured.

NOTE

Make sure that the rocker arm shaft is seated properly in the guide dowels of the camshaft bearing caps. On engines equipped with an engine brake, remove the restraints (rubber bands or tie straps) securing the exhaust rocker arm pistons.

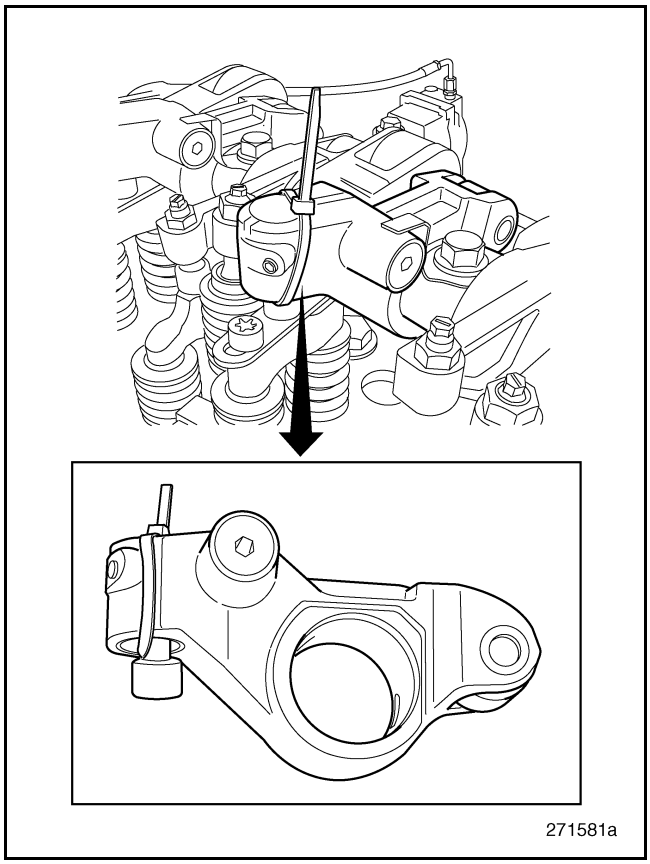


Figure 278 — Engine Brake Restraint

4. Lubricate the rocker arm rollers.
5. Insert the long fasteners (Nos. 8–20 in Figure 279) through the shaft, camshaft bearing caps and into the cylinder head.

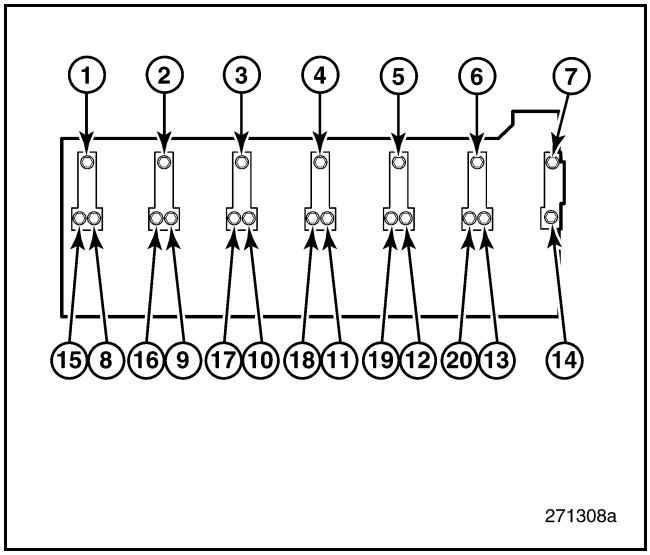


Figure 279 — Rocker Arm Shaft Screw Installation Sequence

6. Insert all remaining fasteners into the rocker arm shaft.
7. Torque-tighten and angle-tighten all camshaft bearing cap and rocker arm shaft bolts in sequence according to specification.

NOTE

The bolts have limited reusability and must be marked (A) with a punch each time they are installed in service. Bolts with four punch marks when removed have been tightened five times and must be discarded.

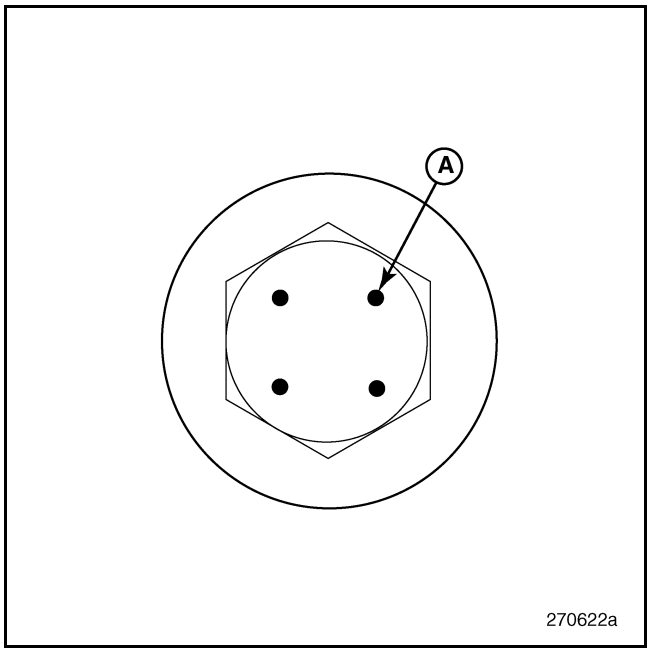


Figure 280 — Usage Marks on Rocker Fasteners

8. Replace the O-ring at the bottom of the engine brake control valve (if equipped with engine brake) or oil flow adapter.

NOTE

On engines without the engine brake, an oil flow adapter is used in place of the oil control valve. It is mounted in the same location on the cylinder head and is installed in the same manner as the engine brake control valve in steps 8 through 13. The adapter provides oil to the rocker shaft.

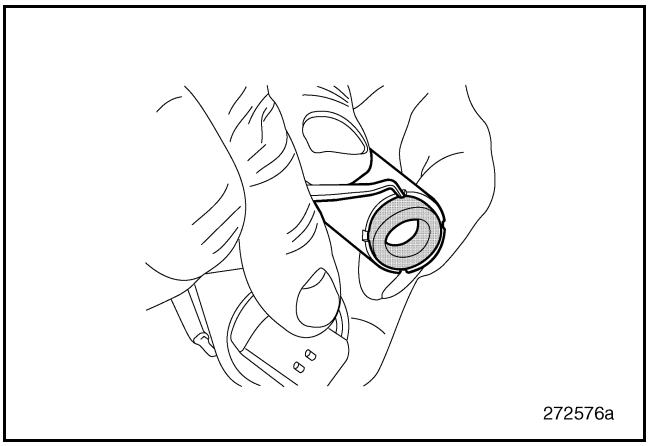


Figure 281 — Engine Brake Control Valve O-Ring

9. Clean the engine brake control valve oil pipe and replace the O-rings. Lubricate the pipe hole in the rocker arm shaft and the O-rings on the pipe.

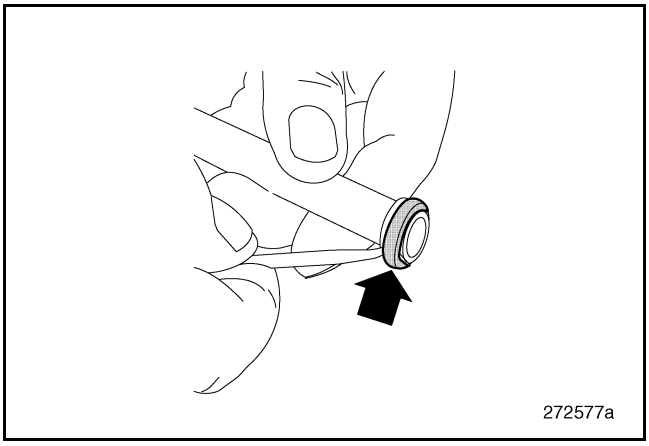


Figure 282 — Control Valve Pipe O-Ring

10. Insert the oil pipe into the oil hole of the engine brake control valve.

NOTE

Make sure that the O-ring is seated fully in the valve.

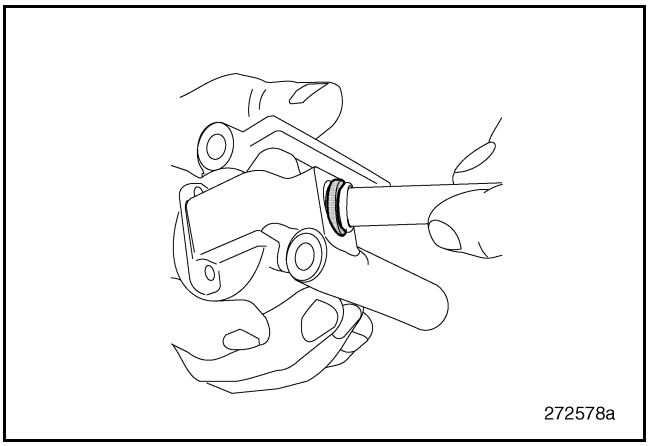


Figure 283 — Engine Brake Control Valve Pipe Installation

11. Position the control valve on the cylinder head.

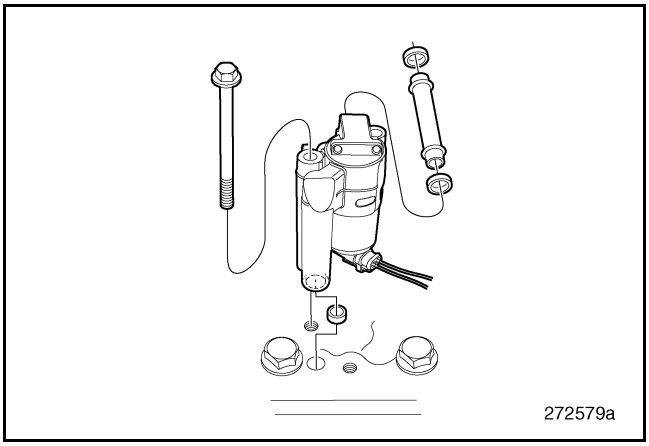


Figure 284 — Control Valve Position

12. Align the engine brake oil pipe and O-ring with the hole in the rocker shaft.

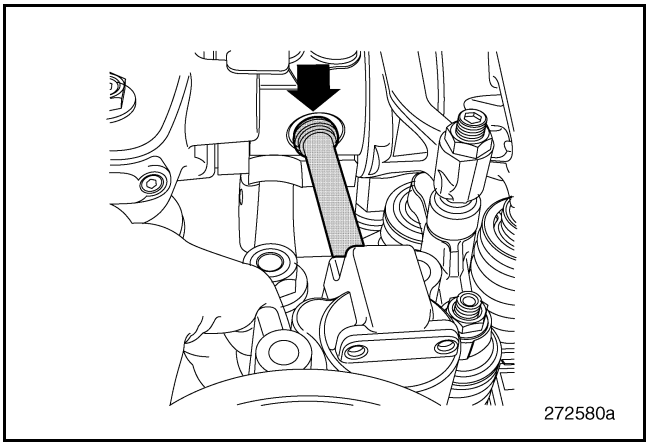


Figure 285 — Engine Brake Control Valve Pipe Installation

NOTE

Make sure the engine brake oil pipe O-ring is fully seated.

13. Install the control valve bolts and tighten to specification.

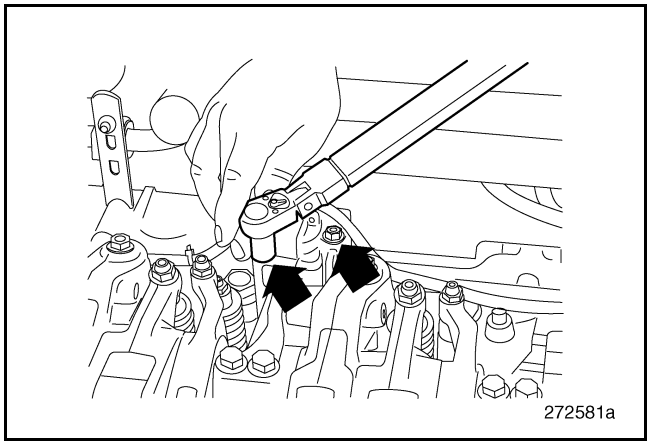


Figure 286 — Engine Brake Control Valve Installation

14. If harness is installed on engine, plug in the control valve harness connector.

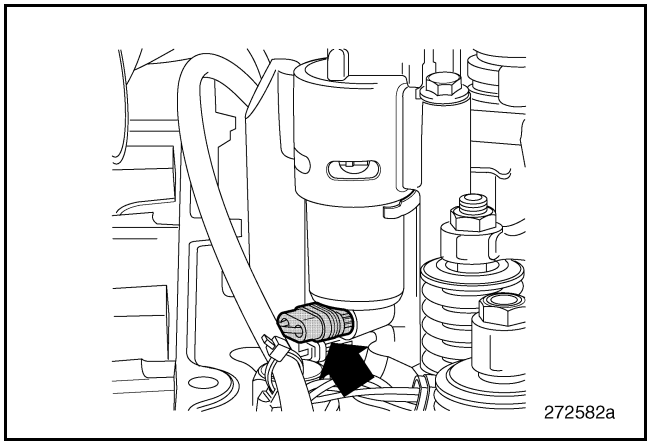


Figure 287 — Engine Brake Control Valve Connector

15. If installed, reposition the fuel injector harness over the control valve and secure with high temperature tie straps (983472).

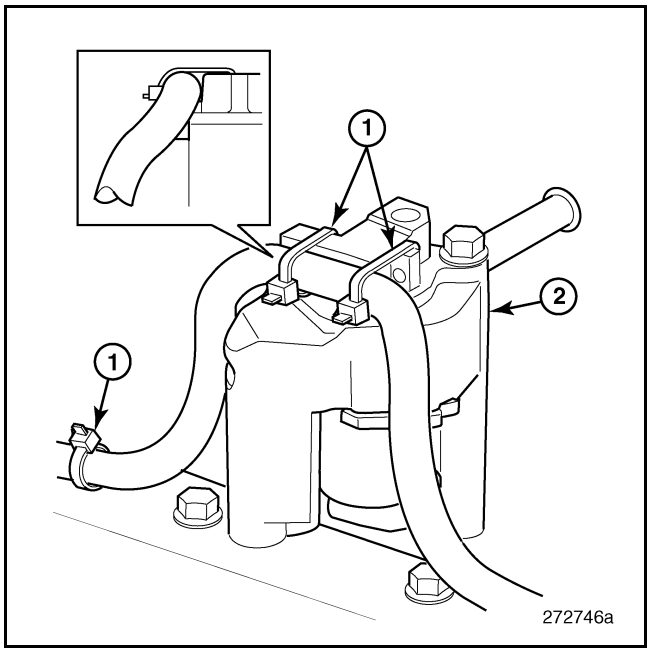


Figure 288 — Harness Routing Over Engine Brake Control Valve

1. Tie Straps	2. Control Valve

Flywheel Housing Installation

[211 HD]

Inspect the flywheel housing machined surfaces, bolt holes and pilot locations for cracks or wear. Replace the housing if cracks are evident.

1. Thoroughly clean the sealing area in the flywheel casing and the sealing surface against the crankshaft.
2. Apply an even 2 mm (5/64 inch) thick bead of MACK-approved sealant to the timing gear plate side of the flywheel housing according to the pattern shown.

NOTE

The flywheel housing must be installed within 20 minutes of the sealant being applied.

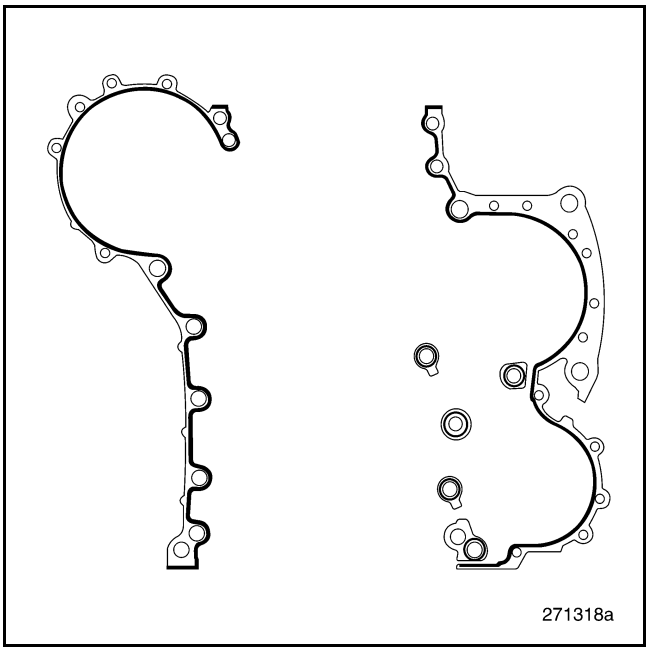


Figure 289 — Flywheel Housing Sealant Application Pattern

NOTE

Be sure to apply beads of sealant around the holes in the bosses as shown in the graphic.

Temporarily install guide pins in the two lower flywheel housing mounting holes in the timing gear plate/engine block.

3. Within 20 minutes of the application of the sealant, assemble the flywheel housing over the guide pins in the timing gear plate.
4. Insert and hand-tighten the attaching bolts. Remove the two guide pins and install the remaining bolts.

NOTE

If the engine was originally built with the longer idler gear bolts, the flywheel housing may need to be updated to block the idler gear bolt hole with a plug and washer from plug kit 21090322. Use the following procedure to thread the hole and install the plug:

a. Using a 3/4-16 UNF x 11.5 tap, thread the hole indicated in Figure 290.

b. Apply thread locking compound (Loctite® 277 or equivalent) to the threads of the plug.

c. Insert the plug with washer and tighten to specification.

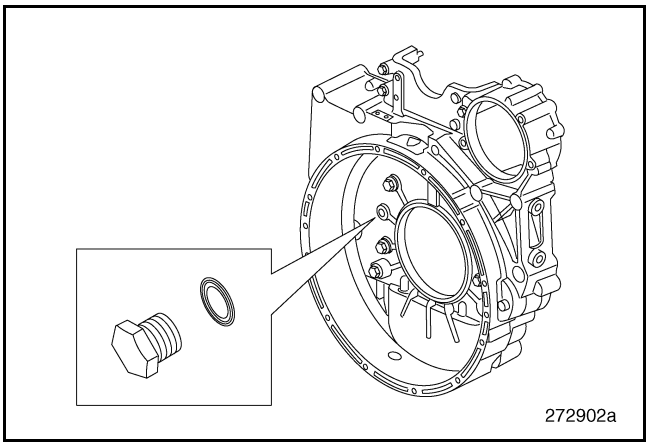


Figure 290 — Flywheel Housing Plug

5. Using a torque wrench, tighten the attaching bolts in sequence according to specification.
6. Remove any excess sealant.
7. Install the timing gear plate to the flywheel housing bolts (item 2 in Figure 291).

NOTE

- Item 1 secures the power steering and fuel pump mounting and is not installed at this time.
- Item 3 secures the rear engine mount to the flywheel housing and will be install upon installation into the chassis.

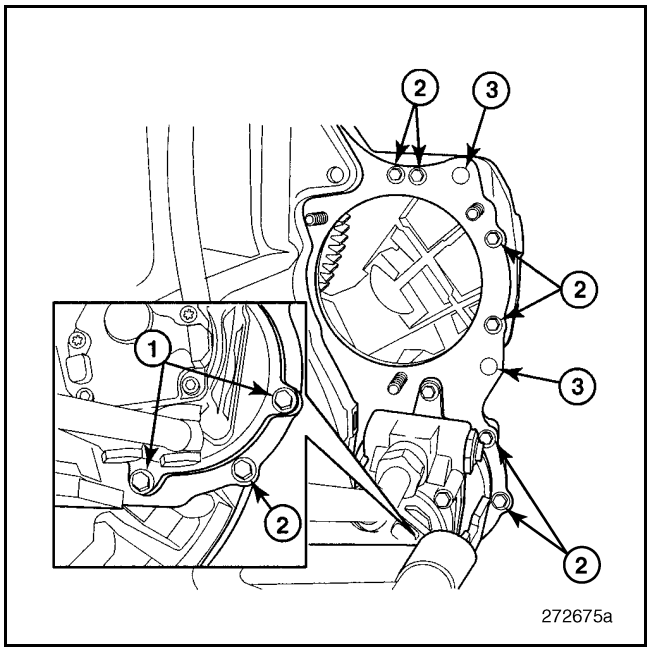


Figure 291 — Timing Gear Plate Attachment

1. Power Steering Attaching Bolts 2. Timing Gear Plate-to-Flywheel Attaching Bolts	3. Rear Engine Mount-to-Flywheel Housing Attaching Bolt and Nut

Crankshaft Rear Seal Installation

[212 JH]

1. If not previously done, thoroughly clean the sealing surfaces of the flywheel housing and the crankshaft gear wheel.

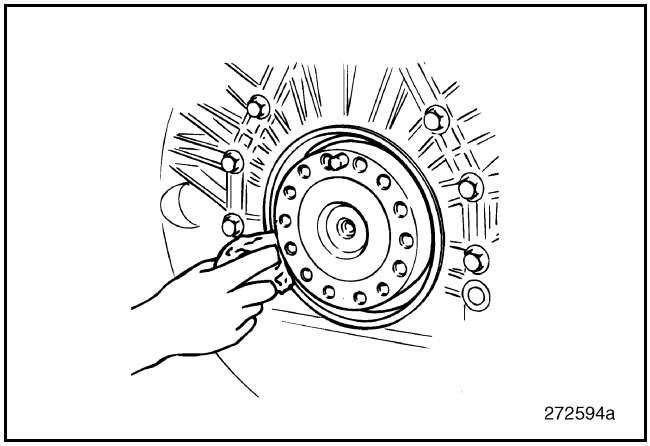


Figure 292 — Cleaning Sealing Surfaces

2. Lubricate the seal lips with clean engine oil.
3. Insert the handle, 9992000, in the remover/installer, 9998238.

⚠ CAUTION

Inspect the remover/installer carefully. Any damage on the tool will destroy the seal.

4. Position the **new** seal on the drift, making sure that the seal is turned in the proper direction. Carefully tap the seal into the flywheel housing using the handle and drift until the drift evenly contacts the crankshaft gear.

NOTE

Position the drift so that it does not interfere with the alignment dowel during installation. The rear crankshaft seal depth is set by the drift tool when fully seated.

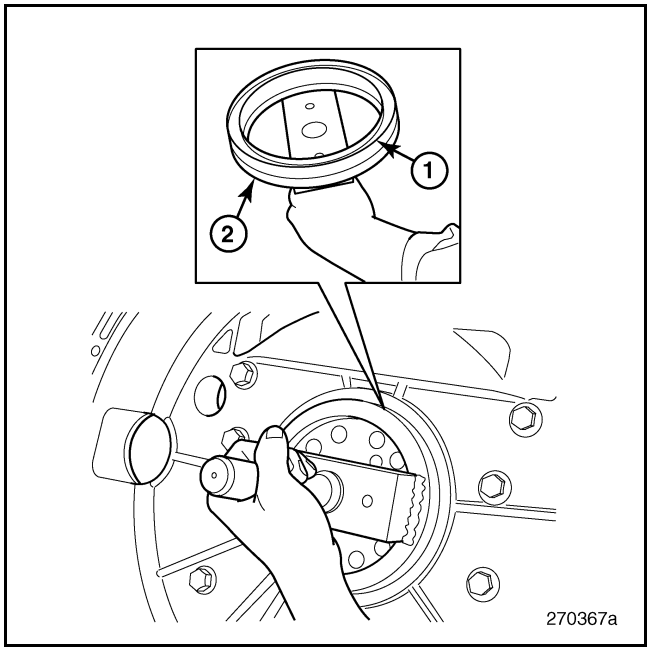


Figure 293 — Crankshaft Rear Seal Installation

1. Rear Main Seal	2. Rear Main Seal Installer, 9998238

5. Remove the tools.
6. Inspect the seal ring for proper seating.

Flywheel and Pilot Bearing Installation

[212 VC]

⚠ CAUTION

After resurfacing, any flywheel with drilled balance holes on the clutch side requires rebalancing by a machine shop.

NOTE

On vehicles equipped with an automatic transmission, it may be necessary to install different components to the flywheel retaining fasteners. Refer to the Automatic Transmission Drive Arrangement Assembly Instructions, 5-902, for installation instructions.

1. Clean the surface in the places where the flywheel lies flush against the crankshaft gear wheel.

   Clean the flywheel. Check that the grooved surfaces for the flywheel sensor are clean.

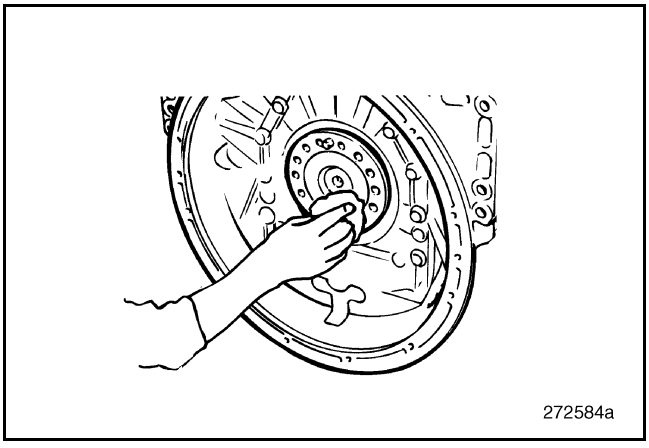


Figure 294 — Cleaning Sealing Surfaces

2. Make sure that the flywheel guide pin is correctly inserted in the crankshaft gear wheel. Ensure that there is no damage or leakage at the rear crankshaft seal.
3. Insert two alignment studs in the crankshaft flange to aid in installation.
4. With the aid of the two lifting bolts (M10 x 100), position the flywheel over the dowel pin and alignment studs on the flywheel mounting surface at the rear of the crankshaft.

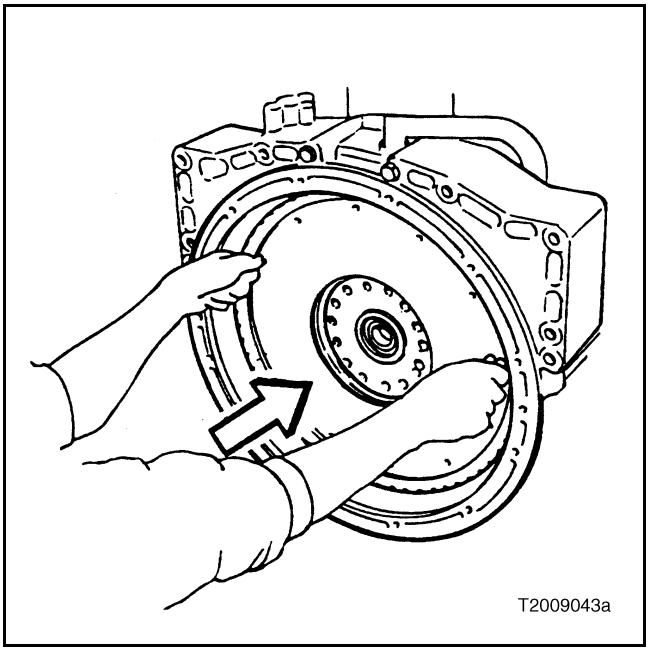


Figure 295 — Flywheel Installation

5. Install the flywheel mounting bolts in the exposed mounting holes. At this time, tighten the bolts finger-tight only.
6. Remove the two alignment studs and insert the remaining mounting bolts.
7. Remove the plug from the flywheel housing and install cranking tool, 88800014, and a handle as a counterhold.

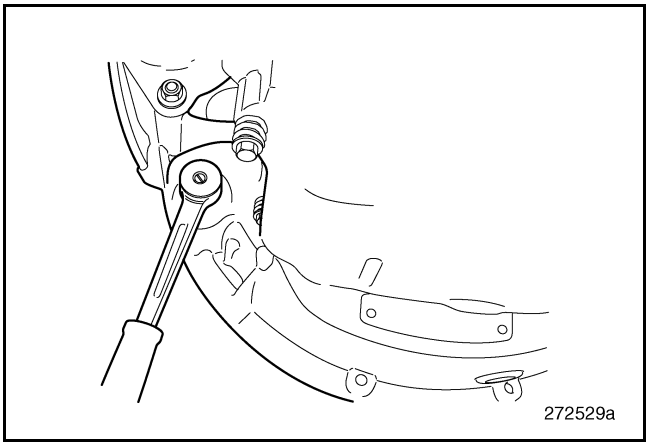


Figure 296 — Flywheel Turning Tool

8. Using a torque wrench, tighten the fasteners in sequence according to specification.

⚠ CAUTION

Do not tighten adjacent screws sequentially. Doing so can result in uneven flywheel alignment. Failure to heed this caution can result in severe engine damage.

9. Remove the cranking tool. Insert the plug.
10. Using tool assembly, 9991801 and 9992564, install a **new** pilot bearing in the flywheel bore.

⚠ CAUTION

*For this engine, **NO** snap ring is required on the pilot bearing. Do **NOT** substitute pilot bearings that do not bear the correct part number for this application. Failure to heed this caution may result in severe engine damage.*

11. Check for proper flywheel-to-position sensor clearance using the sensor depth gauge to determine if shims are required for sensor depth. The flywheel position sensor clearance specification is 0.3–1.0 mm (0.0118–0.0393 in.).
    a. Rotate the engine using the flywheel turning tool until a tooth of the flywheel toothed wheel is aligned with the sensor bore.
    b. Insert the tool into the sensor bore until the outer part of the tool is fully seated against the flywheel housing.
    c. Loosen the thumb screw of the tool and push the inner part of the tool until it contacts a tooth of the toothed wheel.
    d. Tighten the thumb screw to secure the inner part of the tool.
    e. Carefully remove the tool from the flywheel sensor bore and observe the location of the steps between the inner and outer portions of the tool:
        - Both steps below the surface of the tool = no shims required.
        - One step below the surface of the tool = one shim required.
        - Both steps above the surface of the tool = two shims required.

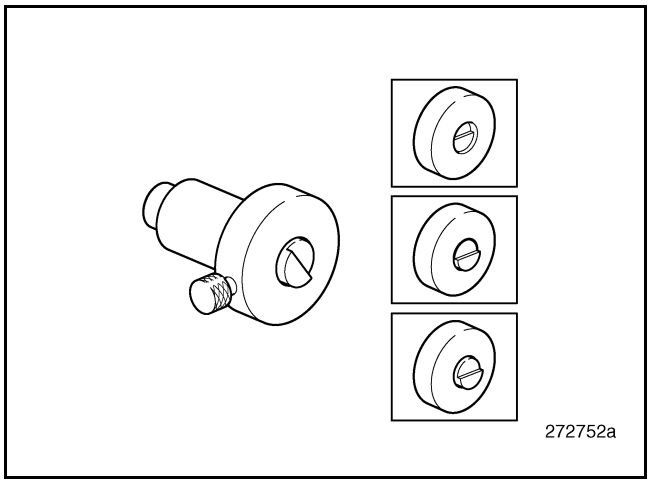


Figure 297 — Depth Sensor Gauge

12. Carefully install the flywheel position sensor with the appropriate shim(s) and **new** O-ring. Secure the sensor with a bolt tightened to specification and plug in the harness connection.

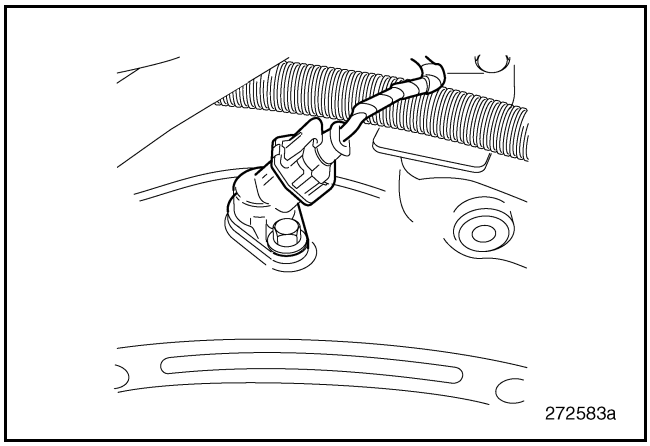


Figure 298 — Flywheel Position Sensor

Oil Pan Installation

[211 NB]

1. Apply a 2 mm (0.079 inch) wide bead of MACK-approved sealant at the seams between the flywheel housing and the timing gear mounting plate. Also, apply a 2 mm (0.079 inch) wide bead of sealant at the seams between the timing gear mounting plate and the engine block.

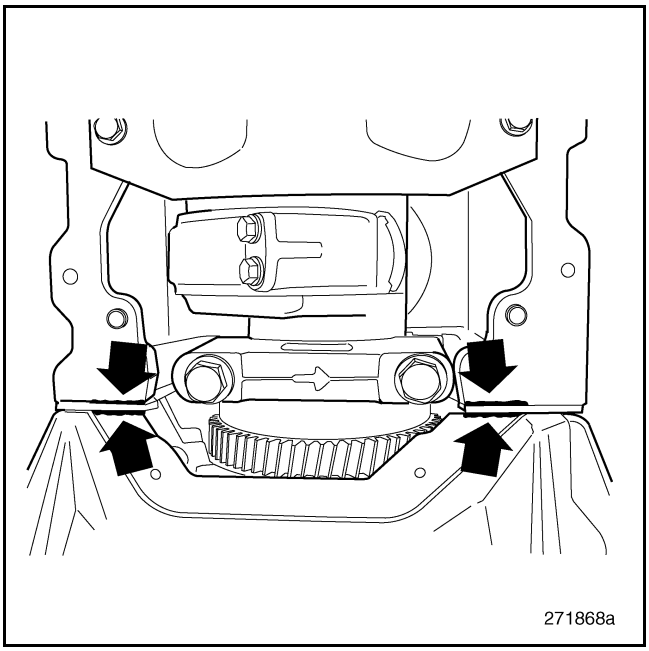


Figure 299 — Sealant Application for Oil Pan — Rear

2. Apply a 2 mm (0.079 inch) bead of MACK-approved sealant to the seam between the front seal cover and the block.

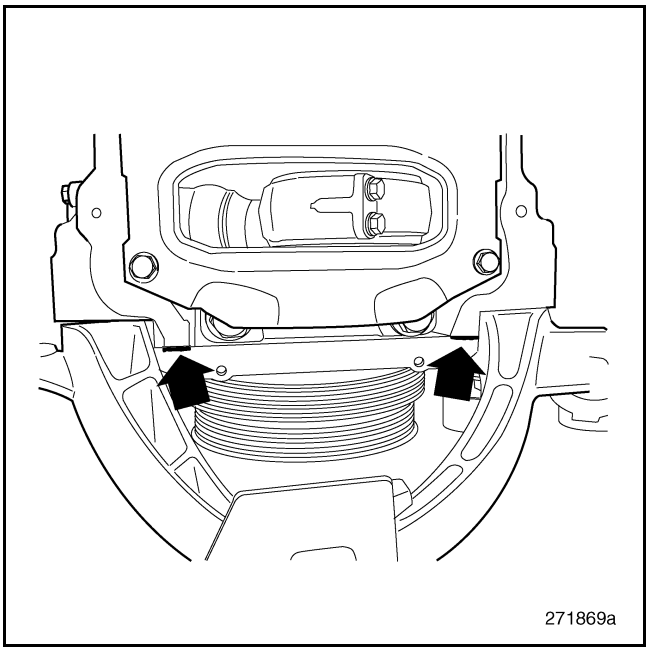


Figure 300 — Sealant Application for Oil Pan — Front

3. For plastic pan applications, install the oil pan seal into the groove of the oil pan. Check that the seal locating tabs are properly aligned and seated in the locating holes on the mounting flange.

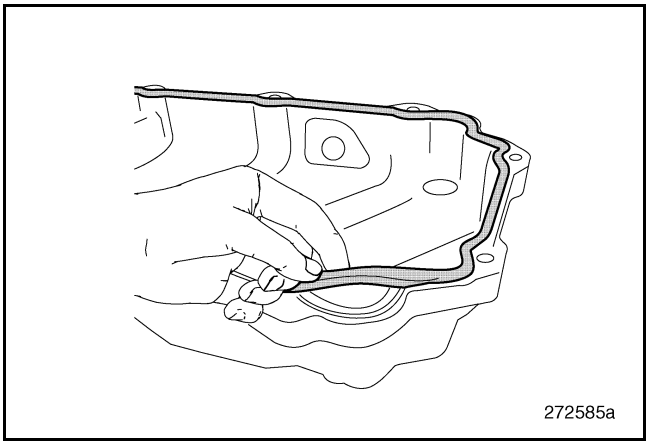


Figure 301 — Plastic Oil Pan

4. For steel pan applications, install the oil pan gasket on the oil pan flange. Check that the gasket locating tabs are properly aligned and inserted in the correct holes on the mounting flange.

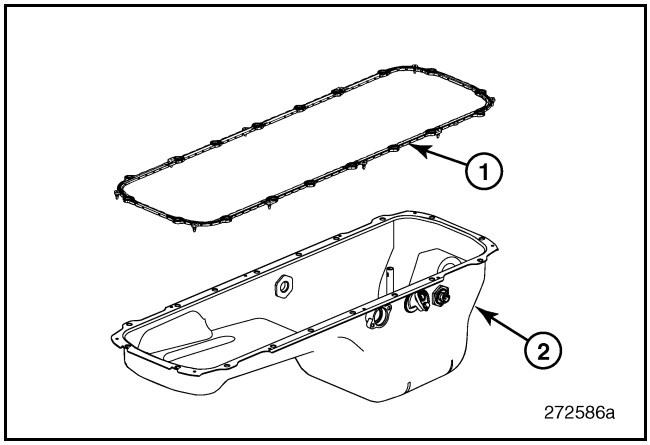


Figure 302 — Steel Oil Pan

1. Gasket	2. Oil Pan

5. With assistance, position the oil pan to the engine block and install the bolts marked A and B. Torque-tighten the bolts to specification.

NOTE

- Use care to prevent damage to the oil pickup.
- The oil pan must be installed within 20 minutes of the sealant being applied.

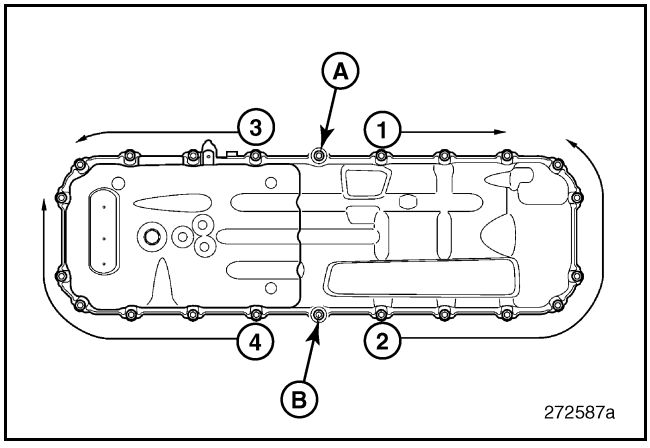


Figure 303 — Oil Pan Installation

6. Tighten the bolts from the middle and outwards in order 1–4 as shown. Torque-tighten the bolts to specification. Finish by checking the torque for bolts A and B.

NOTE

Install the transmission oil cooler bracket studs in locations marked previously.

7. Install the oil drain plug and torque-tighten to specification.

⚠ CAUTION

Do not use a copper washer with the hex-head oil drain plug. Always use the steel washer with the rubber gasket.

NOTE

Do not use air tools when installing the oil drain plug.

8. Ensure that the 12 locating pins on the seal are properly seated in the locating holes in the mounting flange.

NOTE

Be sure the oil pan seal is properly placed before tightening the fasteners.

9. If harness is installed, reconnect the oil level/temperature sensor connector to the side of the oil pan.

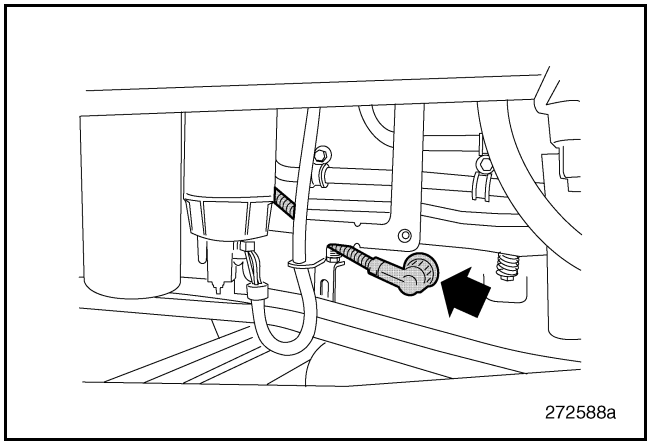


Figure 304 — Oil Level/Temperature Sensor

Oil Filler Pipe and Dipstick Pipe Installation

1. Install a **new** O-ring on the oil fill tube and install the tube to the side of the oil pan. Install the oil fill tube fasteners and tighten to secure.

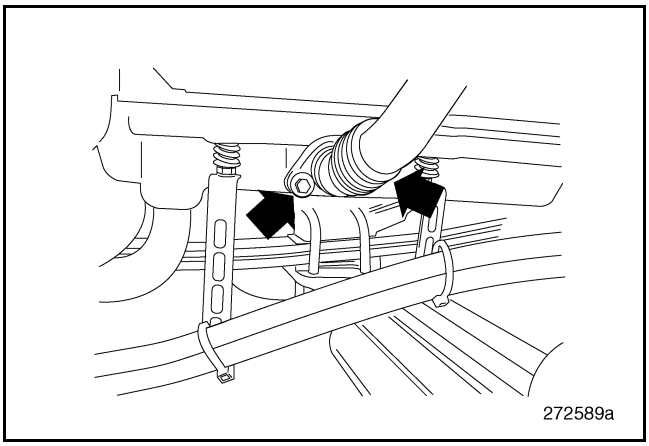


Figure 305 — Oil Fill Tube

2. Install a **new** O-ring on the dipstick tube, then install the tube and secure with the fastener. Install the dipstick.

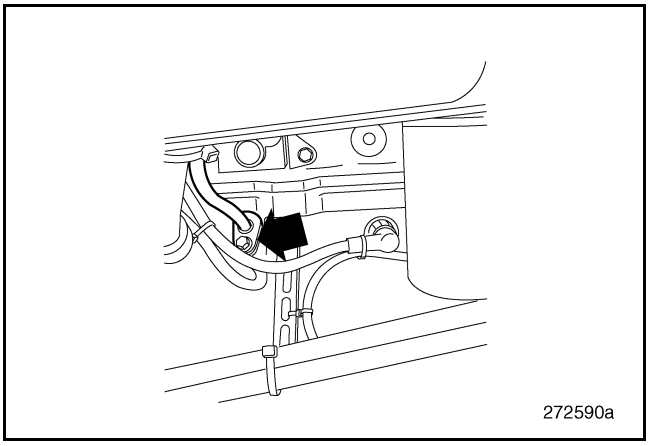


Figure 306 — Oil Dipstick

Power Take-Off Installation

If equipped with a power take-off (PTO), install the assembly using this procedure.

1. Lubricate and assemble a seal in the groove in the PTO assembly housing.

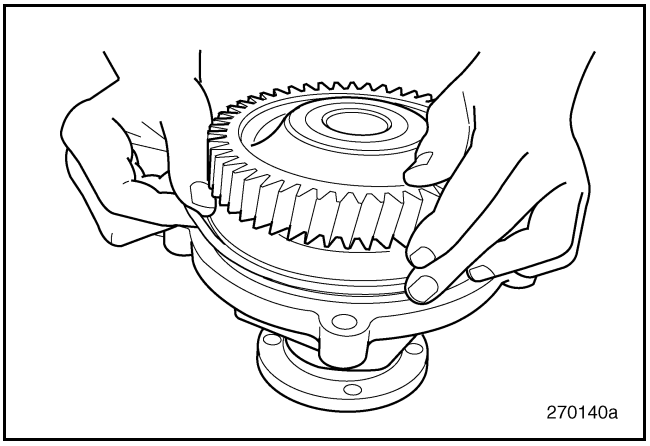


Figure 307 — PTO Housing Seal Installation

2. Assemble the PTO assembly on the flywheel housing.

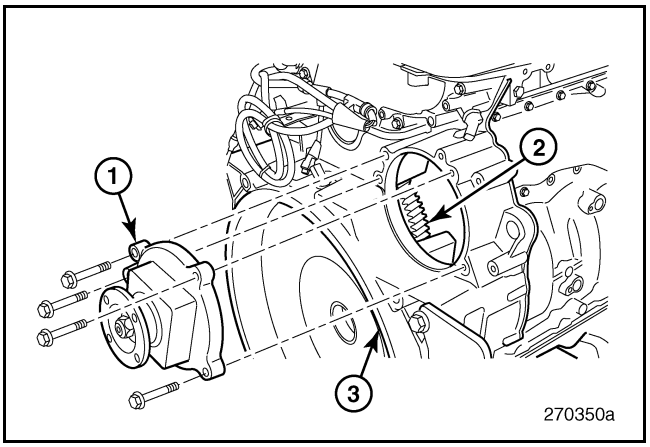


Figure 308 — Power Take-Off Installation

1. PTO Housing 2. Intermediate Idler Gearset	3. Flywheel Housing

3. Using a torque wrench, tighten the fasteners according to specification.

Timing Gear Cover Installation [211 AA]

1. Apply sealant in the bottom corners where the timing gear plate and the flywheel housing meet. Also apply sealant to the top of the timing gear plate (in the corner) next to the cylinder head.

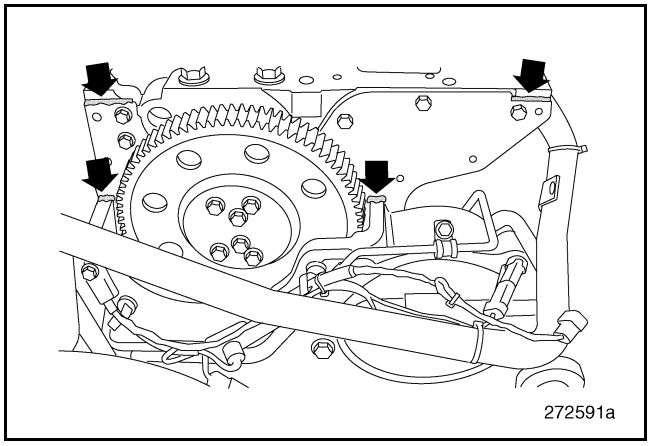


Figure 309 — Sealant Application — Engine

2. Install the timing gear cover seals and gaskets.

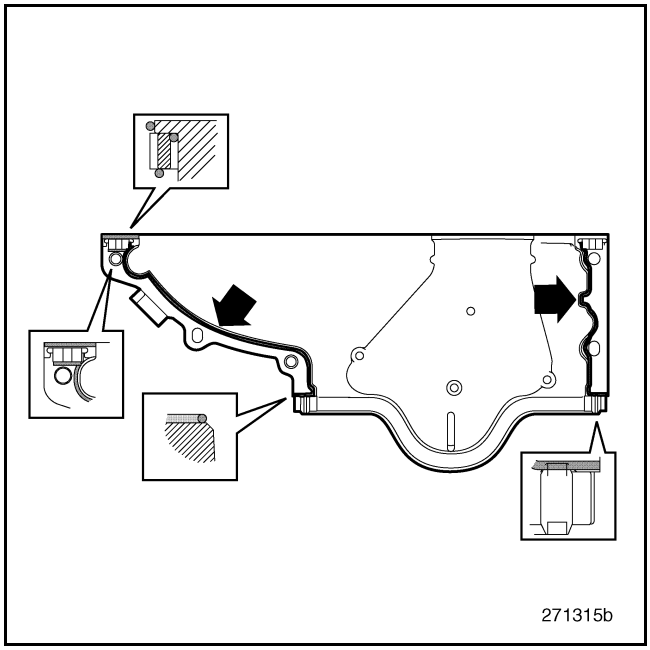


Figure 310 — Timing Gear Cover Seals

3. Apply sealant to the mating surfaces of the timing gear cover.

4. Position the timing gear cover on the flywheel housing at the rear of the cylinder head. Install the fasteners marked 1 and 2.

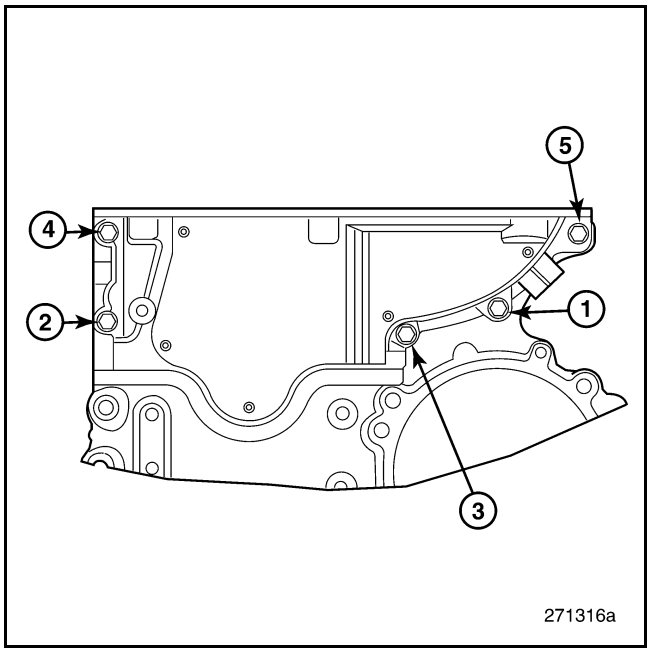


Figure 311 — Timing Gear Cover Installation Sequence

5. Install the timing gear cover alignment tools, 85111422-A and 85111422-B, to the cylinder head and timing gear cover as illustrated. Cover surface must be flush with the seal surface of the cylinder head.

NOTE

The timing gear cover must be installed within 20 minutes of the sealant being applied.

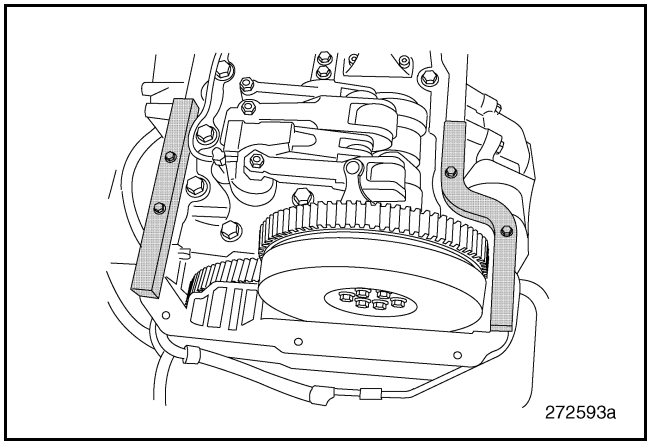


Figure 312 — Timing Gear Cover Alignment Tools

6. Install the remaining fasteners, 3, 4 and 5. Torque all of the timing gear cover fasteners to specification.
7. Remove the timing cover clamp tools.
8. Position the rear support bracket onto the rear of the engine and install the support bracket fasteners to secure.
9. Install all tie straps, P-clamps and other retainers used to restrain the engine harnesses, oil lines and coolant tubes to the rear of the engine.

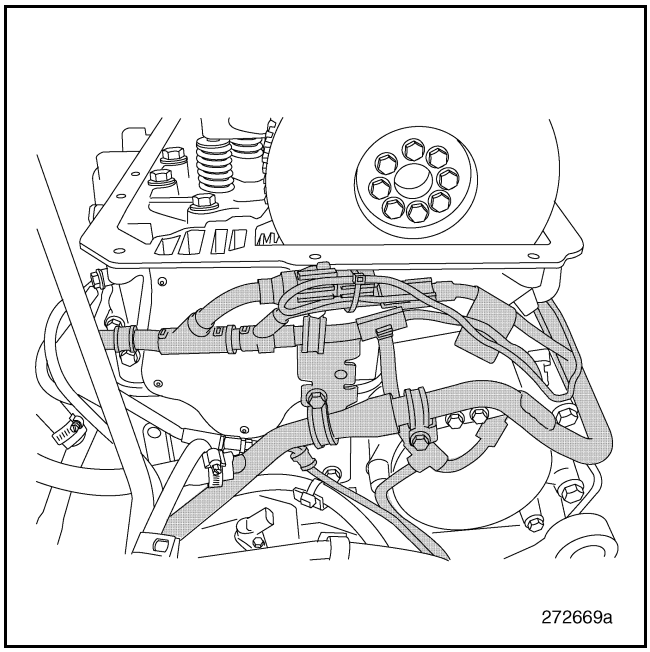


Figure 313 — Rear of Engine

CAMSHAFT SENSOR DEPTH, CHECK

1. Remove the plug from the flywheel housing and install the flywheel turning tool.

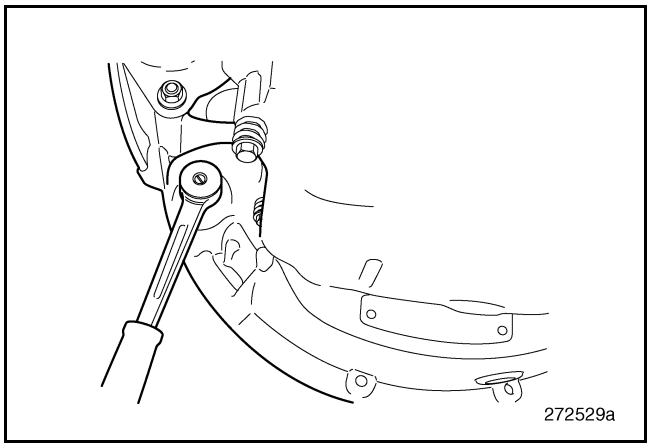


Figure 314 — Flywheel Turning Tool

2. Check for proper camshaft position sensor clearance using the sensor depth gauge, 88800031, to determine if shims are required for sensor depth.

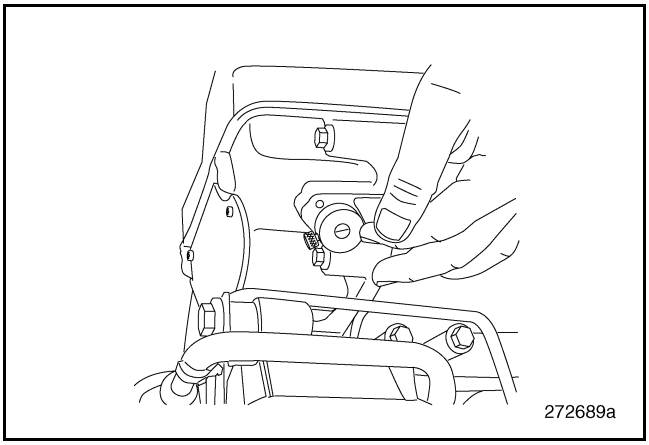


Figure 315 — Camshaft Position Sensor

a. Rotate the engine until a tooth of the camshaft toothed wheel is aligned with the sensor bore.

b. Insert the depth gauge into the sensor bore until the outer part of the gauge is fully seated against the timing gear cover.

c. Loosen the thumb screw of the gauge and push the inner part of the gauge in until it contacts a tooth of the toothed wheel.

d. Tighten the thumb screw to secure the inner part of the gauge.

e. Carefully remove the gauge from the camshaft sensor bore and observe the location of steps between the inner and outer portions of the gauge:

- Both steps below the surface of the gauge = no shims required.
- One step below the surface of the gauge = one shim required.
- Both steps above the surface of the gauge = two shims required.

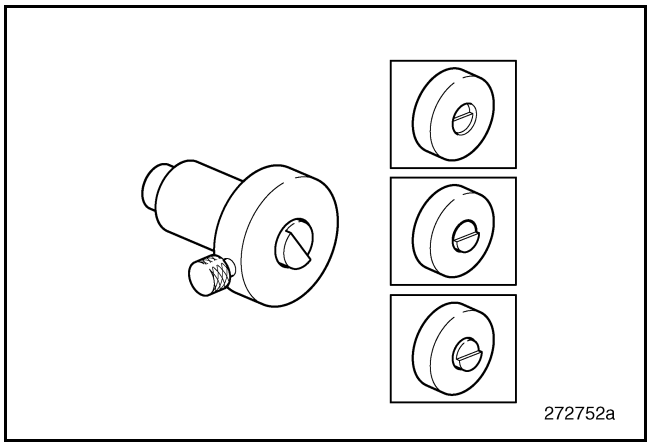


Figure 316 — Depth Sensor Gauge

3. Install the camshaft position sensor with the appropriate shim(s) and **new** O-ring. Secure the sensor with a bolt and plug in the harness connector.

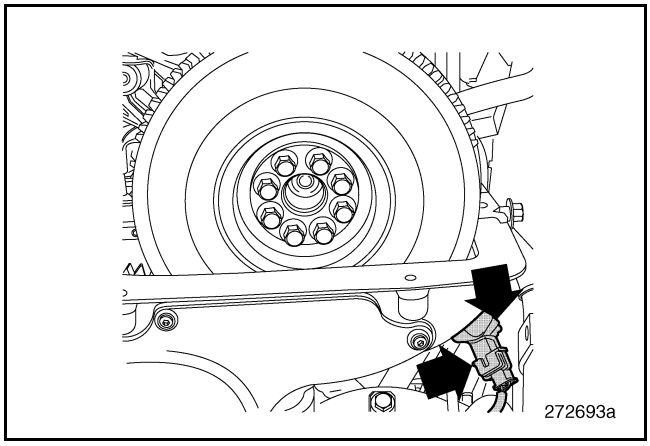


Figure 317 — Camshaft Position Sensor

Coolant Pump Installation

[215 SW, SG, SR]

1. If removed, place the coolant pump base plate in position at the front of the cylinder block and install the mounting bolts. Tighten the bolts to specification.
2. Press a **new** sealing ring into the groove of the replacement coolant pump.

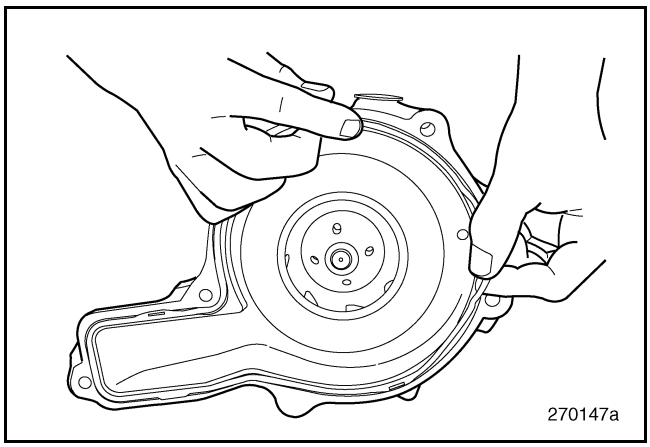


Figure 318 — Inserting Coolant Impeller Housing Seal

3. Position the replacement coolant pump impeller housing on the base plate and align the bolt holes.

NOTE

Make sure the sealing ring remains seated in the groove of the pump impeller housing.

4. Use care to ensure that the sealing ring remains properly seated and install the coolant pump bolts and tighten to specification.
5. Position the tensioner pulley on the front of the engine and install the tensioner bolts. Tighten the bolts to specification.

Thermostat and Cover Installation [215 NU, NG & LD]

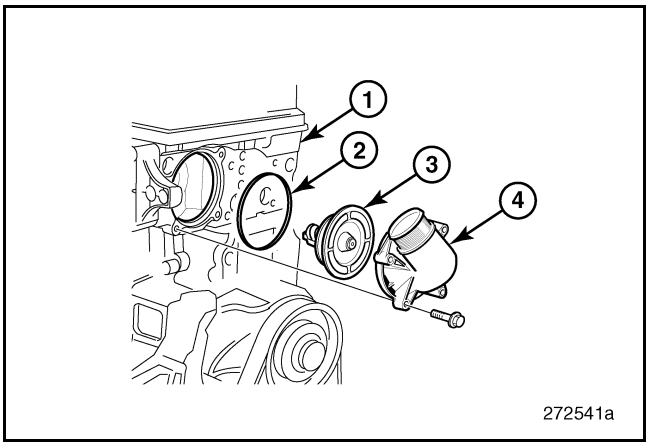


Figure 319 — Thermostat and Cover Installation

1. Cylinder Head 2. Thermostat Seal	3. Thermostat 4. Thermostat Cover

1. Use crocus cloth to remove any surface nicks, burrs, sharp edges and tool marks from the thermostat cover and cylinder head.
2. Lubricate the inner surface of the cover.
3. Install the **new** thermostat.

NOTE

Make sure that the rubber seal remains properly seated.

4. Position the thermostat cover to the cylinder head and install the bolts. Using a torque wrench, tighten the fasteners in a cross pattern according to specification.

Coolant Pipe Installation [215 SW]

UPPER COOLANT PIPE (BYPASS) HOUSING

1. Lubricate and assemble a **new** seal in the upper coolant pipe housing flange.

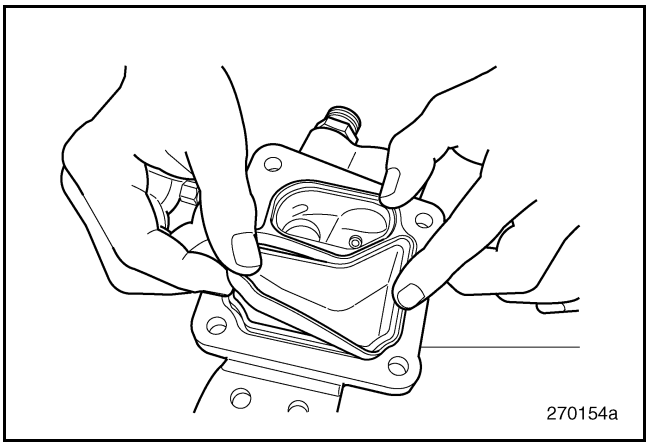


Figure 320 — Seal Installation — Upper Coolant Pipe Housing

2. Assemble the upper coolant pipe housing flange on the head.

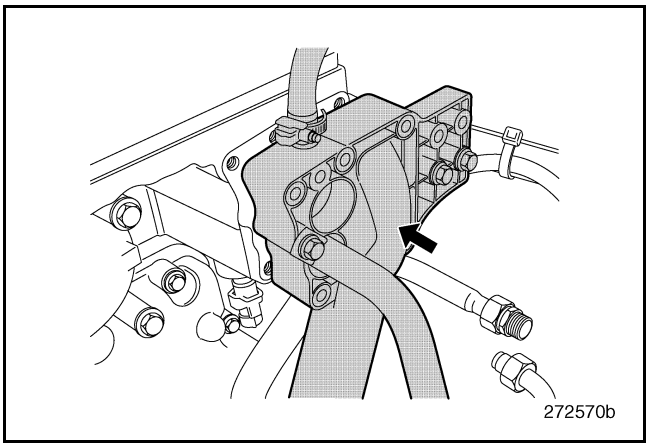


Figure 321 — Upper Coolant Pipe Installation

3. Using a torque wrench, tighten the upper coolant pipe fasteners in sequence according to specification.
4. Assemble the fan ring bracket to the upper coolant pipe housing.
5. Using a torque wrench, tighten the fasteners according to specification.

PUMP INLET HOUSING

1. Lubricate and assemble **new** sealing rings on the pump inlet pipe at the joint with the bypass connector.
2. Place the inlet housing in position between the upper coolant pipe and the pump inlet. Replace and lubricate all sealing O-rings.

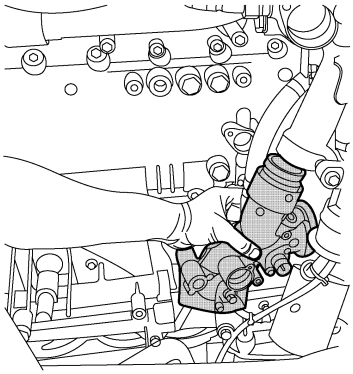


Figure 322 — Installing Pump Inlet Housing

3. Install the M8 fasteners and tighten to specification. Then, install the M10 fastener and tighten to specification.

NOTE

Secure the inlet housing flange to the pump first and then to the cylinder block.

Oil Cooler and Cooling Duct Cover Installation

[215 DW, 219 EP]

The oil cooler must be attached to the cooling duct cover before attaching the cover to the cylinder block.

OIL COOLER INSTALLATION

1. Using a sharp pick, carefully remove the rubber seal (molded gasket) from the groove in the oil cooler cover, if not already done. Clean the cover of any dirt, adhesives and inspect for damage to the sealing surface. Also, inspect the cylinder block and ensure the sealing surface is clean and undamaged.
2. Install a **new** formed gasket in the groove of the cover.

NOTE

Apply a minimal amount of silicone sealant in the seal groove to hold the seal in place during assembly. Install the cover within 20 minutes of applying the sealant.

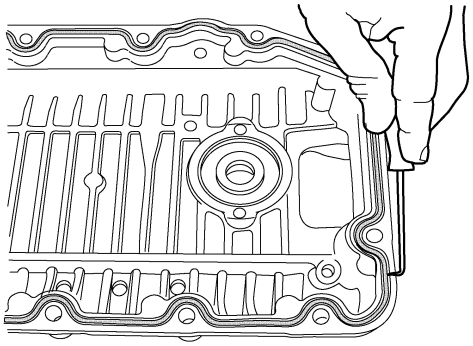


Figure 323 — Oil Cooler Cover Gasket

3. Install **new** oil cooler sealing O-rings between the oil cooler and cover. Install the sealing O-rings into the grooves in the cover.

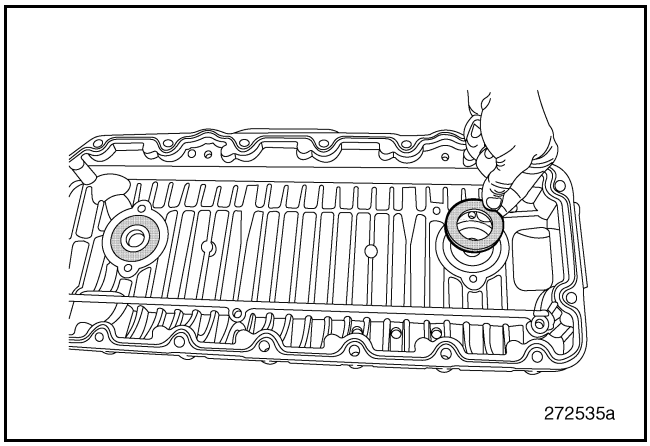


Figure 324 — Installing Cooler Seals

4. Install the oil cooler in the oil cooler cover.

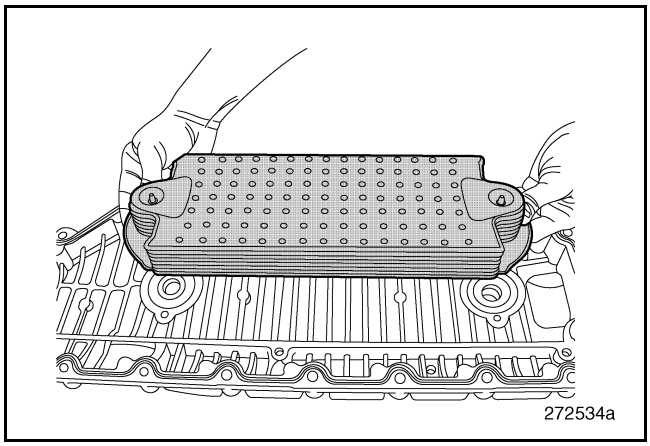


Figure 325 — Installing the Oil Cooler

5. Using a torque wrench, tighten the fasteners in sequence according to specification.
6. Install the oil cooler flow plate over the oil cooler. Tighten fasteners to specification.

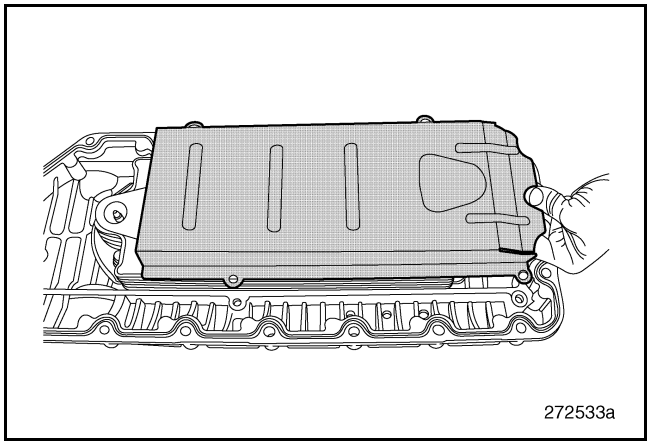


Figure 326 — Oil Cooler Flow Plate

COOLING DUCT COVER INSTALLATION

1. Replace the water pump inlet housing formed rubber gasket with a **new** gasket. Lubricate new gasket upon installation.

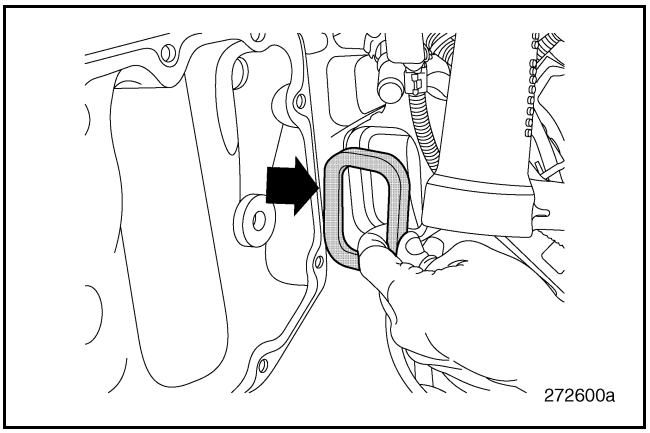


Figure 327 — Water Pump Inlet Housing Formed Gasket

2. With assistance, set the cooling duct cover assembly in place. Install the upper left corner fastener.

NOTE

This mounting location is slotted for adjustment.

3. Using the assembly tool, 88800022, push the cover forward to compress the formed rubber gasket at the water pump inlet. Install the upper right corner fastener.

NOTE

A small piece of metal stock should be used to keep from deforming the stamped cover that the tool foot is pressing against.

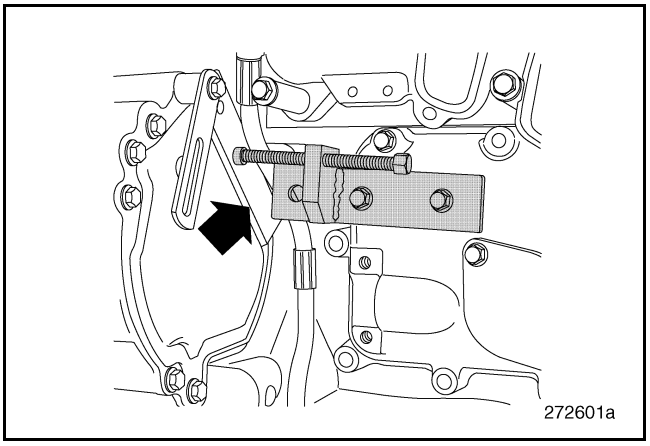


Figure 328 — Cooling Duct Cover Adjustment Tool

4. Adjust cover as required to allow upper and lower center fasteners to be installed.

NOTE

The upper center mounting location has a tighter tolerance than other mounting locations.

5. Start all remaining cover fasteners and torque-tighten fasteners to specification.

Oil Filter Housing Installation

[219 EP]

1. Install the rear pipe to the oil cooler cover with a **new** gasket. Place the retaining clamps in position on the oil cooler duct cover, install the fasteners and tighten to specification.

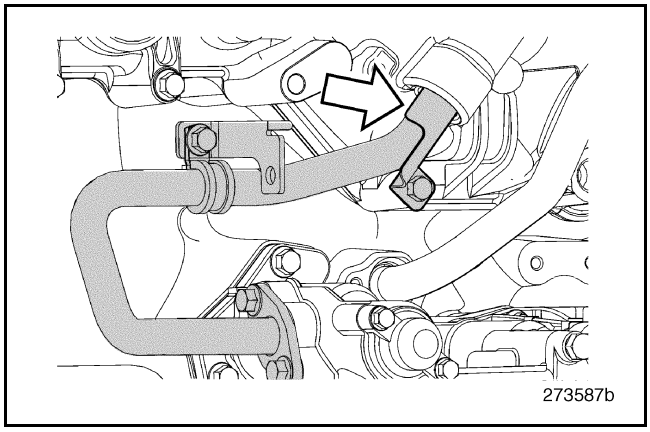


Figure 329 — Rear Pipe to Oil Cooler

2. Install two alignment pins — to hold the gasket in place and to aid in the alignment of the housing.

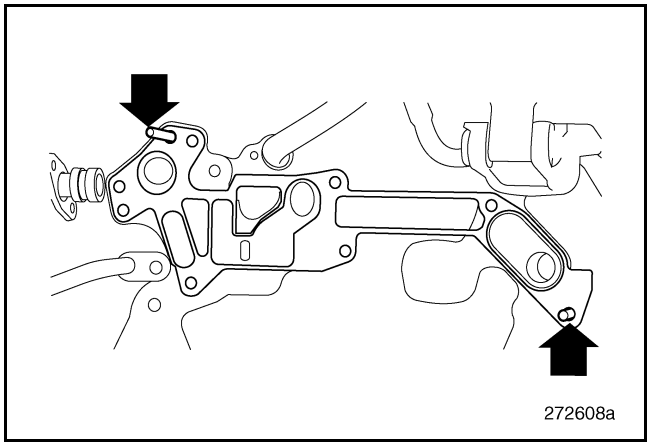


Figure 330 — Alignment Pins and Gaskets

3. Install the gasket to the engine block.
4. Install the oil filter housing onto the engine block and position the rear pipe. Torque the bolts to specification.
5. Install the fasteners to the rear pipe in the oil filter housing. Torque the bolts to specification.
6. Install the front pipe with **new** seals between the oil filter housing and the oil cooler cover.

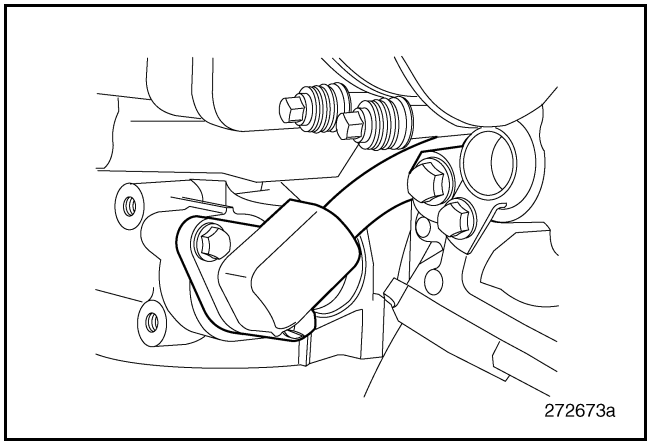


Figure 331 — Front Pipe Installation

7. Install all hard pipes (coolant and oil) to the oil cooler cover. Replace and lubricate all sealing O-rings. Also, replace sealing washers for the banjo fitting on the oil cooler cover. Tighten banjo fittings to specifications.

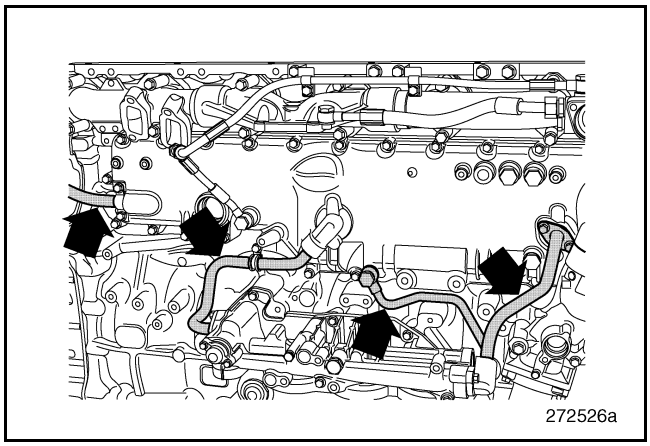


Figure 332 — Oil Cooler Hard Pipes

Exhaust Manifold Installation

[214 EG]

NOTE

The exhaust manifold mounting fasteners can be used five times unless the manifold is being replaced. If the manifold is being replaced, use **new** fasteners.

1. Clean the manifold mounting surface on the cylinder head.
2. Temporarily install an alignment stud at each exhaust manifold flange location on the cylinder head.

NOTE

This is done to hold the manifold while positioning the manifold gaskets for installation of the bolts and spacers.

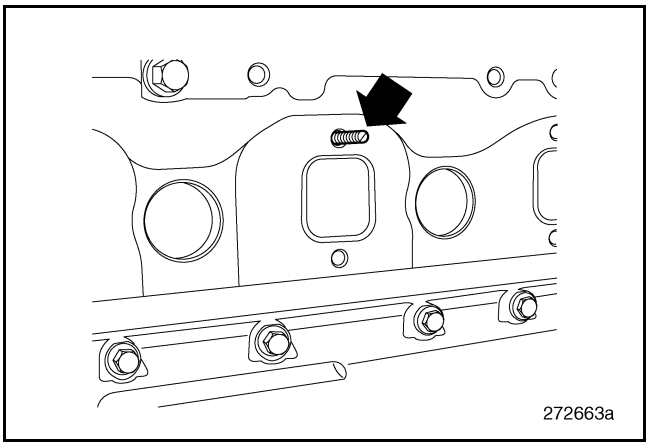


Figure 333 — Alignment Pin Installation

3. Install **new** gaskets onto the alignment pins with the seal side facing the cylinder head.

NOTE

The gaskets are marked “MANIFOLD SIDE” to aid in installation. Make sure to place this side of the gasket toward the exhaust manifold. The graphite fiber side of the gasket faces the cylinder head.

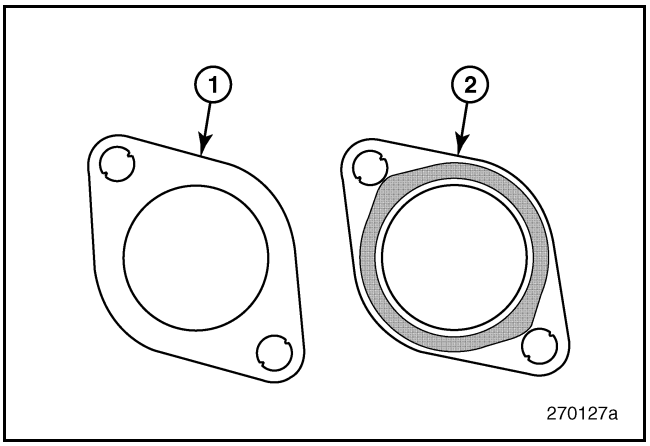


Figure 334 — Manifold Gasket

1. Manifold Side (Metal)	2. Cylinder Head Side (with Seal)

4. Apply anti-seize compound to the threads and under the heads or contact surfaces of all the manifold fasteners.

NOTE

Anti-seize helps prevent fastener oxidation corrosion and reduces friction to help achieve the intended clamp load on the component when tightening the fasteners to specification.

5. Install the exhaust manifold over the alignment pins. Install fasteners with spacers in the lower holes. Now the upper alignment pins can be removed one at a time and replaced with mounting fasteners and the original spacers.

NOTE

- Make sure the spacers are seated properly in the manifold step bore hole location.
- Exhaust manifold fasteners can be used up to five times.

6. Tighten the fasteners to specification.

Turbocharger Installation

[214 SC]

⚠ CAUTION

- *Use only **new** and approved gaskets at the various air, oil and exhaust connections to the turbocharger. Avoid the use of sealing or joint compounds at all flanged connections.*
- *Thorough cleanliness is required. Small particles can cause severe rotor damage if inducted during high-speed operation. Be sure to plug the inlet and outlet ports while handling the turbocharger.*
- *After completing engine reassembly, fill the turbocharger oil passage with clean engine oil before starting the engine. Refer to the procedure under Turbocharger in the **ENGINE PREPARATION AND OPERATIONAL CHECK** section.*

1. Inspect the intake and exhaust systems leading to and from the turbocharger to make sure there is no foreign material including burrs and loose lining fragments.
2. Clean the contact surface on the exhaust manifold, oil return/drain back pipe and adapter block.
3. Retain the protective caps over the turbocharger ports to keep debris and dirt out of the turbocharger as engine reassembly progresses.
4. Apply anti-seize compound to the threads and under the heads or contact surfaces of the fasteners. Anti-seize helps prevent fastener oxidation corrosion and reduces friction to help achieve the intended clamp load on the component when tightening the fasteners to specification.
5. Install **new** high-temperature gaskets between the turbo flange and exhaust manifold.
6. Position the turbocharger and gaskets against the exhaust manifold.

Figure 335 — Turbocharger Installation

7. Install the turbocharger flange nuts and spacers to the exhaust manifold and torque-tighten to specifications.

NOTE

Apply anti-seize compound to the threads and under the contact surfaces of the fasteners.

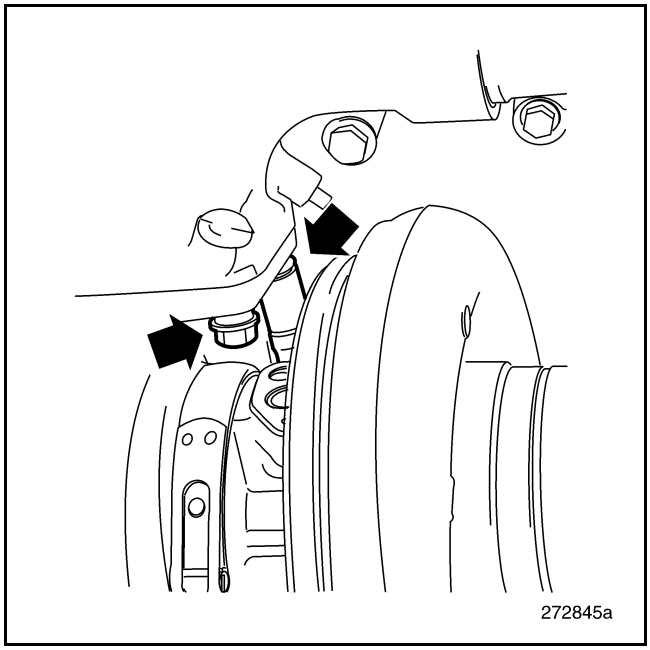


Figure 336 — Turbo Attachment

8. Install the turbocharger oil return pipe (lower) with a **new** gasket.

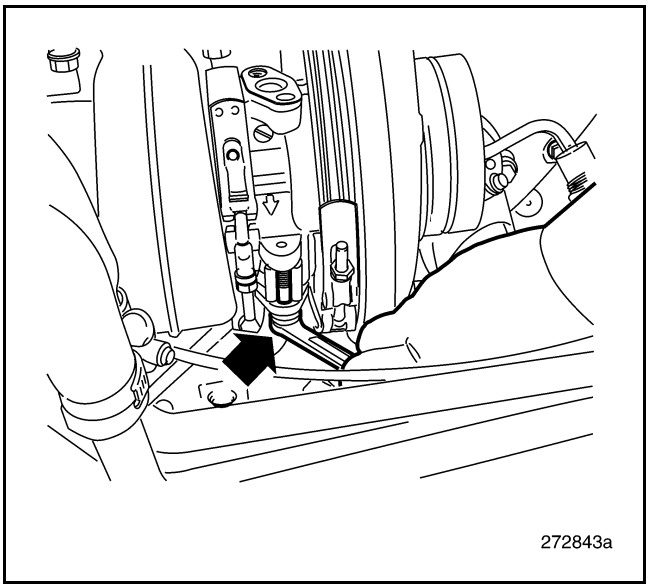


Figure 337 — Turbo Oil Return

9. Install the oil supply line (upper) with a **new** gasket. Torque-tighten the bolts to specification.

⚠ CAUTION

Pre-fill the turbocharger with clean engine oil. Starting the engine without oil pressure and a "dry" turbocharger can damage the turbo.

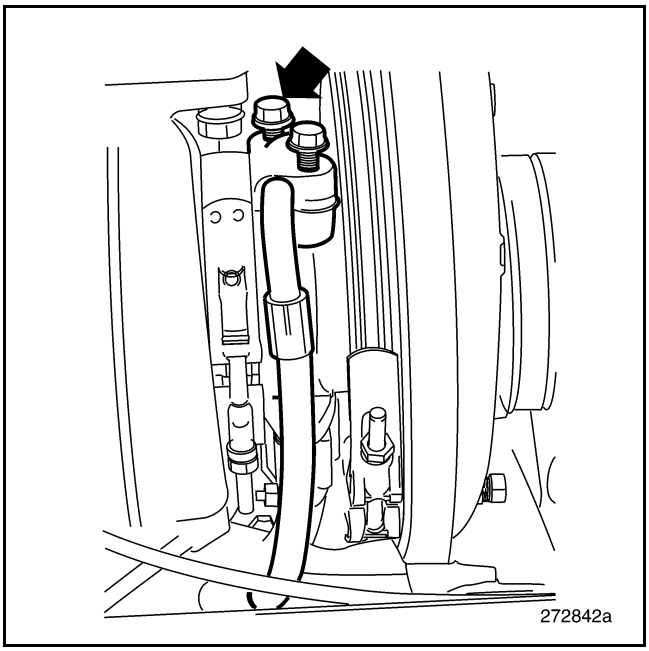


Figure 338 — Turbo Oil Supply

Exhaust Pressure Governor (EPG) Installation

234 BD

1. Lower the EPG housing into position between the exhaust pipe and turbocharger.
2. Install a **new** high-temperature gasket EPG housing and exhaust pipe.

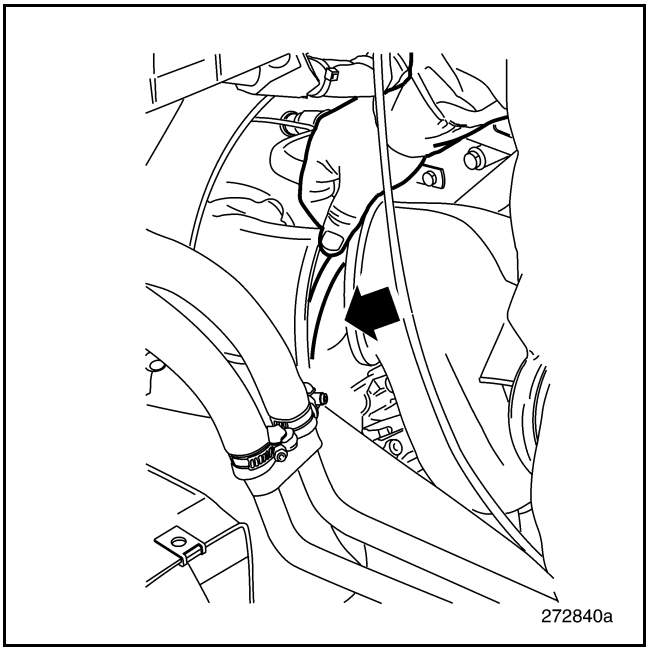


Figure 339 — EPG Housing Gasket

3. Tighten the clamp attaching the exhaust pipe-to-EPG housing.

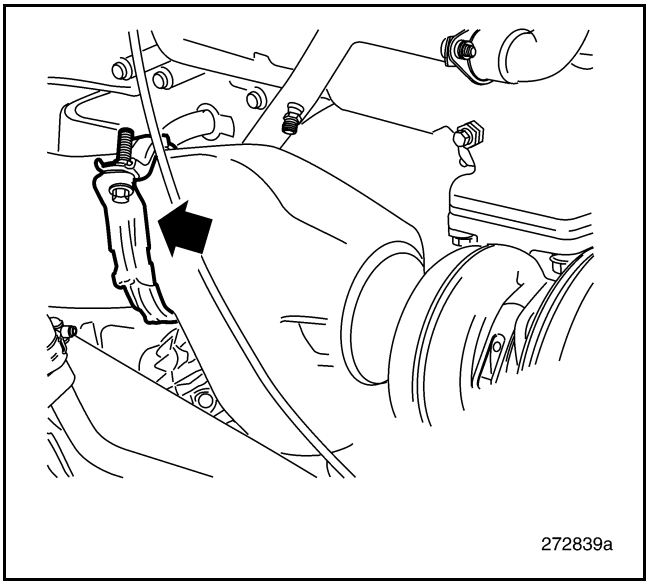


Figure 340 — Exhaust Pipe-to-EPG Housing

4. Install the exhaust clamp from the EPG-to-turbocharger.

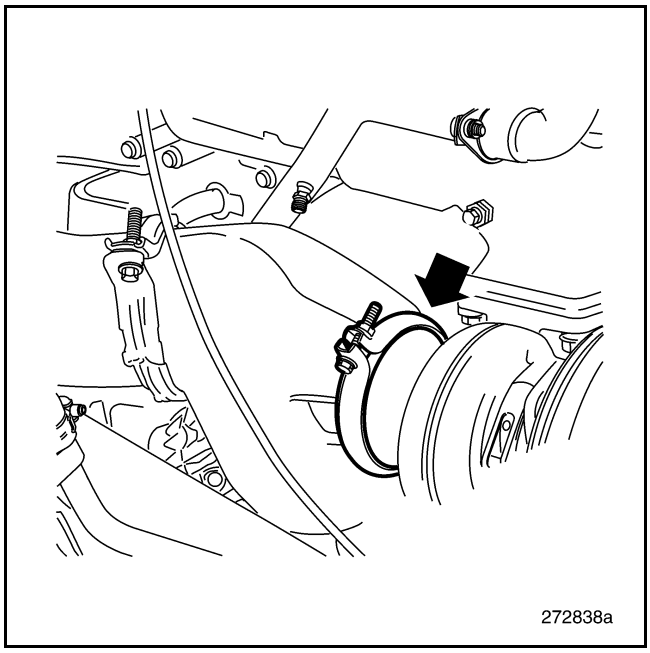


Figure 341 — EPG-to-Turbo Clamp

5. Connect the air supply line to the EPG.

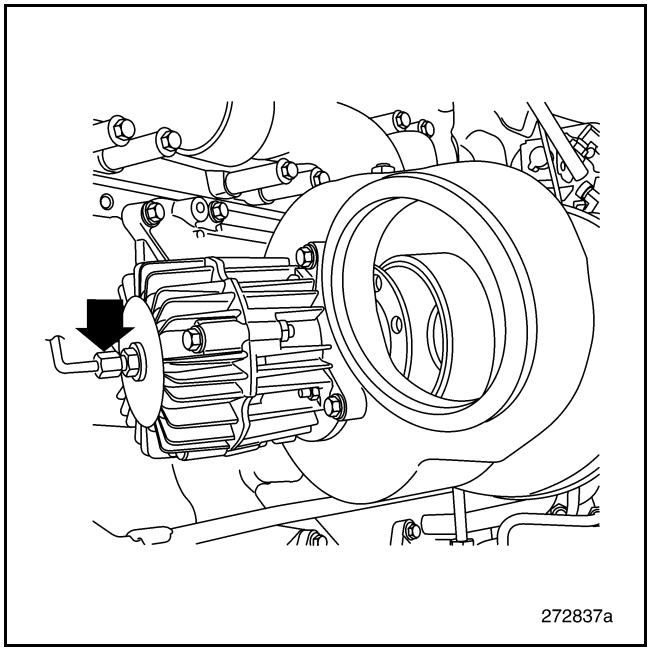


Figure 342 — EPG Air Line Attachment

Starter Installation

[272 DH]

The starter is held in place by nuts assembled over studs inserted in the block. If a stud is missing, replace it.

1. Using a torque wrench, tighten replacement studs according to specification.
2. Assemble the starter on the studs in the flywheel housing.

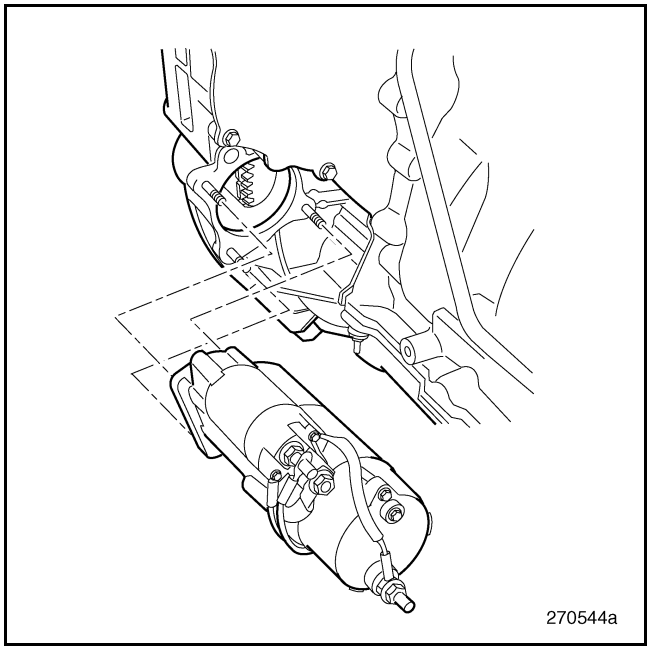


Figure 343 — Starter Installation

3. Using a torque wrench, tighten the nuts according to specification.

Air Compressor Installation

[261 CK]

1. Install a **new** seal in the air compressor housing mounting flange.

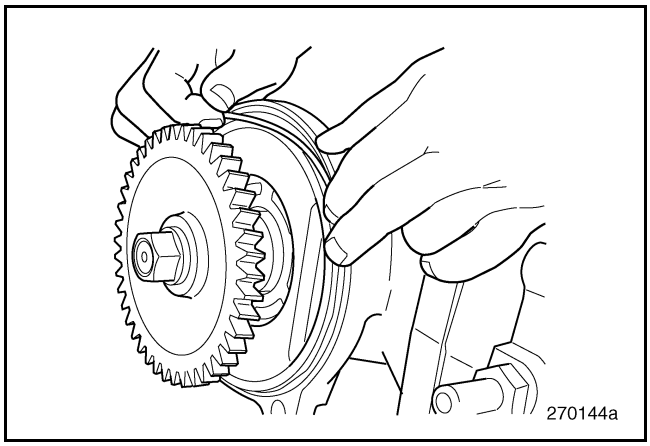


Figure 344 — Installing Air Compressor Mounting Seal

2. Assemble the air compressor on the mounting flange of the timing gear plate.

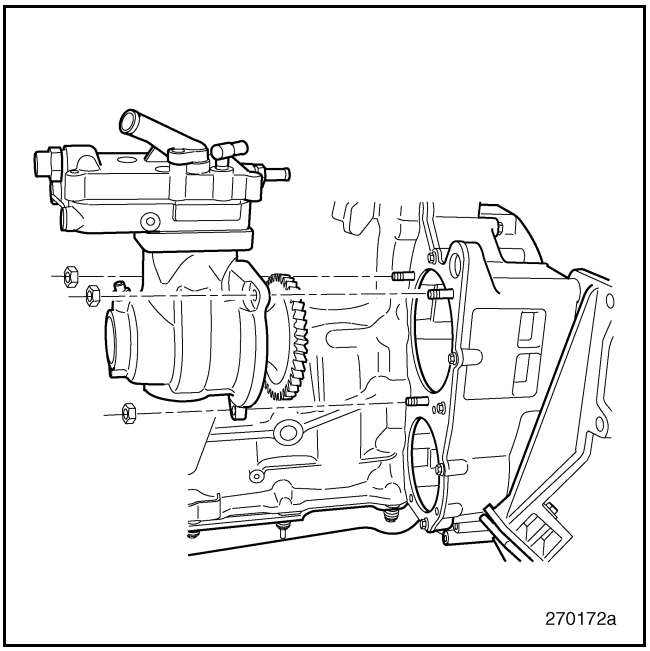


Figure 345 — Air Compressor Installation

3. Using a torque wrench, tighten the attaching nuts in two stages according to specification.

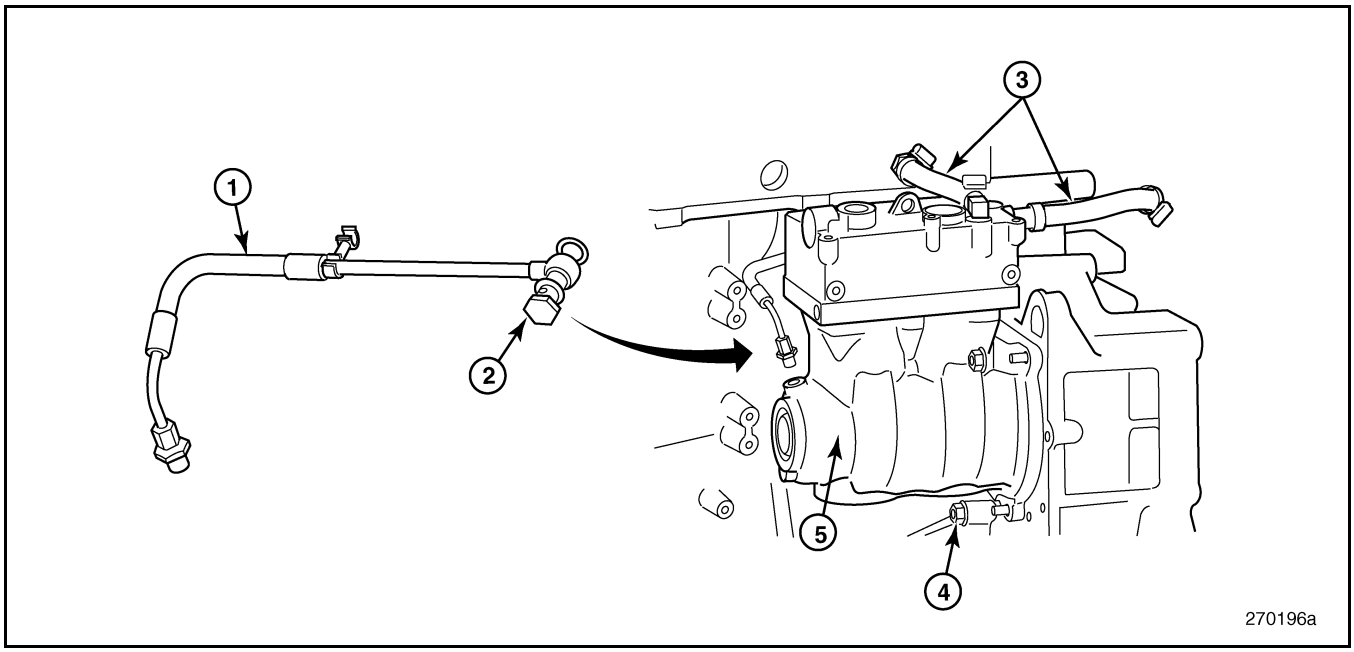


Figure 346 — Air Compressor Coolant and Lubrication Fittings

1. Lubrication Line 2. Banjo Fitting 3. Coolant Lines	4. Attaching Stud and Nut 5. Air Compressor

4. Install the coolant lines to the air compressor.
5. Install the lubrication lines to the air compressor.

Tandem Pump (Fuel and Power Steering) Installation

[231 AA, 262 EB]

1. Install a **new** O-ring in the groove on the tandem pump mounting flange.
2. Assemble the tandem pump on the flywheel housing.

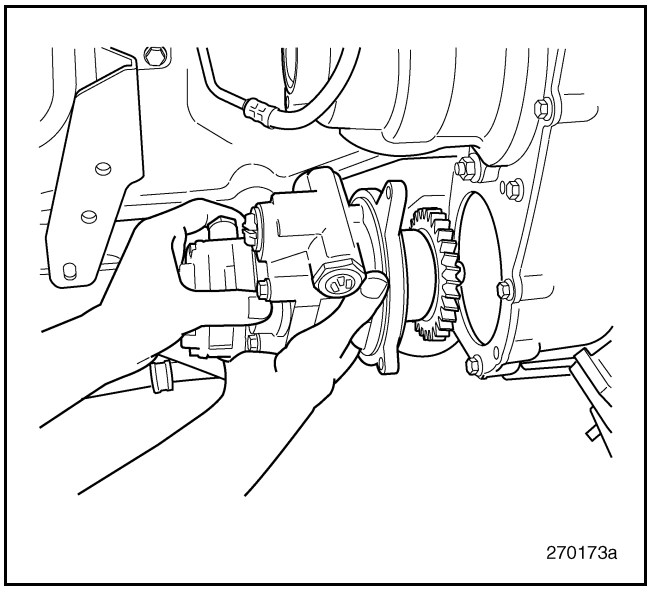


Figure 347 — Tandem Pump (Fuel and Power Steering) Installation

3. Using a torque wrench, tighten the attaching fasteners according to specification.

Inlet Manifold Installation

[214 HD]

1. Using a sharp pick, carefully remove the rubber seal (molded gasket) from the groove in the intake manifold, if not already done. Clean the manifold of any dirt, adhesives and inspect for any damage to the sealing surface. Also, inspect the cylinder head and ensure the sealing surface is clean and undamaged.
2. Install a **new** rubber seal (molded gasket) into the groove of the intake manifold.

N O T E

Apply a minimal amount of silicone sealant in the seal groove to hold the seal in place during assembly. Install the manifold within 20 minutes of applying sealant.

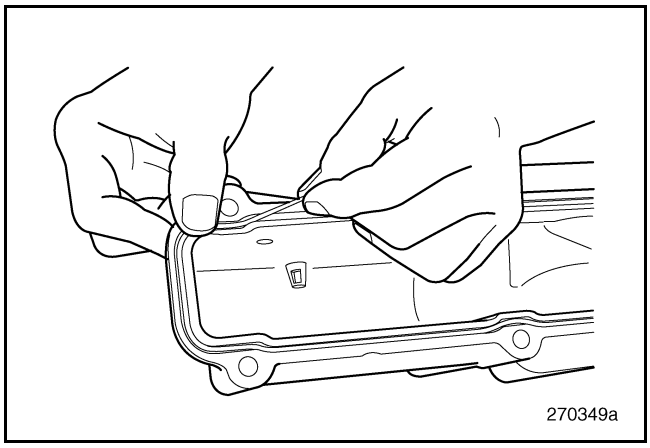


Figure 348 — Installing Inlet Manifold Seal

3. Position the intake manifold onto the two previously installed alignment pins. Start two mounting bolts with mounting spacers to hold the manifold in place, then remove the alignment pins and install the remaining manifold bolts with spacers.

N O T E

Use **new** screws with mounting spacers when installing the intake manifold.

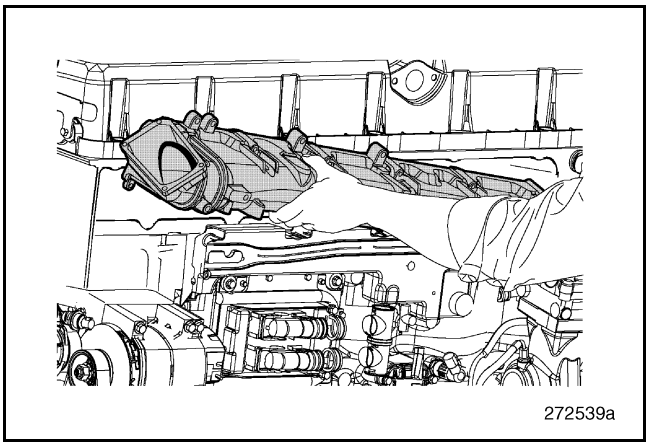


Figure 349 — Intake Manifold

4. Torque-tighten the intake manifold bolts in sequence to specification.
5. Secure the engine harness to the intake manifold using previously removed P-clamps.
6. Install the electrical connector to the charge air temperature sensor located on the top of the intake and secure the harness with tie straps.

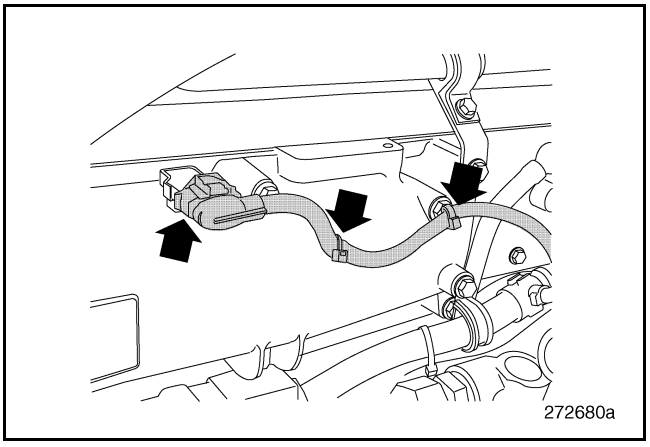


Figure 350 — Charge Air Temperature and Pressure (Boost) Sensor

7. Using a torque wrench, tighten the sensor according to specification.

Engine Preheater/Spacer Installation

[214 HL]

1. Clean the forward sealing surface on the intake manifold, air preheater or spacer, and inlet adapter.
2. Position the inlet adapter and inlet air preheater (if equipped), or spacer block with **new** gaskets onto the intake manifold. Next, start the bolts to hold the assembly to the intake manifold.

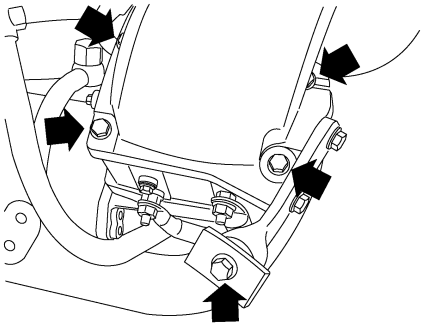


Figure 351 — Inlet Adapter

3. Using a torque wrench, tighten the fasteners in a cross pattern according to specification.
4. Install the fan ring support bracket mounting fastener. Torque-tighten the bolt to specification.
5. If equipped, position and install the inlet air preheater relay bracket (with relay attached) to the mounting surface on the intake manifold. Connect and secure the power and ground cables as marked at disassembly.

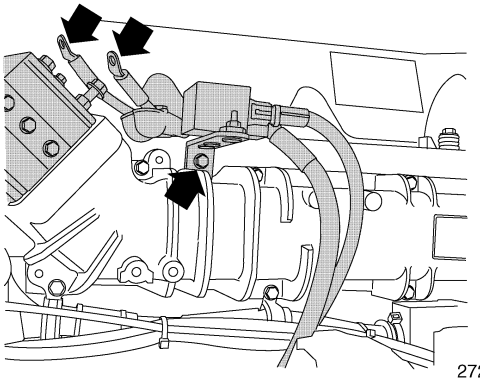


Figure 352 — Inlet Air Preheater Relay

EECU and Cooler Installation

[230 EK]

NOTE

The sequence in which the fuel filter valve housing, fuel lines and EECU are assembled on the engine depends on the type of engine stand used. For engine stands that use an adapter plate attached to the left side of the engine, these components cannot be installed until after the engine has been removed from the repair stand.

Fuel fresh from the tank serves as coolant for the EECU. The cooler connects into the line carrying the fuel from the tank into the fuel pump.

NOTE

Make sure the cooling plate and EECU mating surfaces are clean.

1. Position the EECU on the engine block and install the mounting fasteners.

NOTE

Make sure that rubber isolators are correctly installed and that the ground strap is grounded to the engine block.

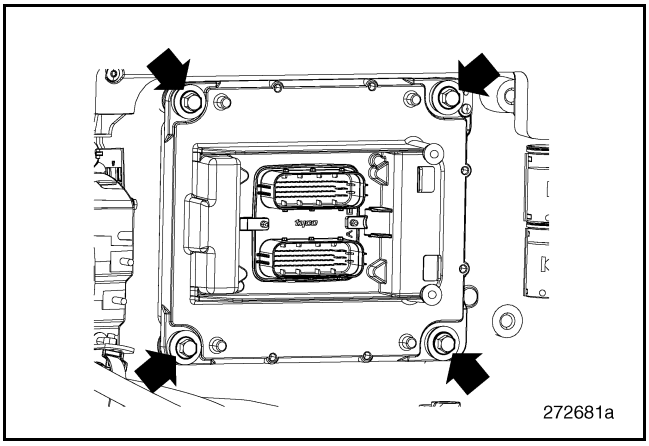


Figure 353 — EECU Installation

2. Using a torque wrench, tighten the fasteners according to specification.
3. Assemble the cooler on the EECU. When positioning the module, make sure that the small ground strap at the upper right of the unit is properly secured and pressed in close.

NOTE

If the EECU is painted in the region contacting the cooler, remove the paint to provide for the most efficient cooling.

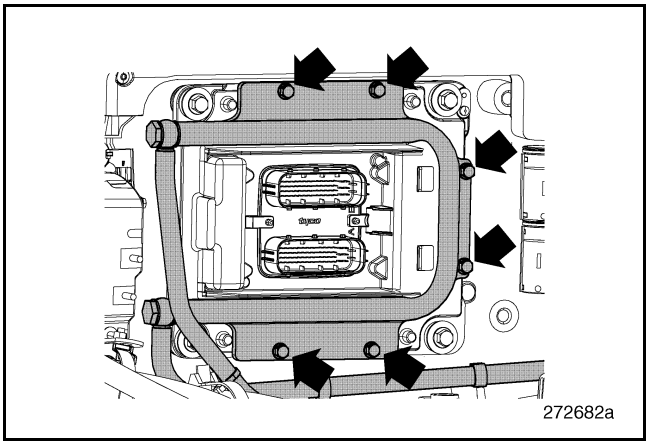


Figure 354 — EECU Cooling Plate

4. Using a torque wrench, tighten the fasteners in sequence according to specification.

Fuel Lines and Filter Housing Installation

NOTE

The sequence in which the fuel filter housing, fuel lines and EECU are assembled on the engine depends on the type of engine stand used. For engine stands that use an adapter plate attached to the left side of the engine, these components cannot be installed until after the engine has been removed from the repair stand.

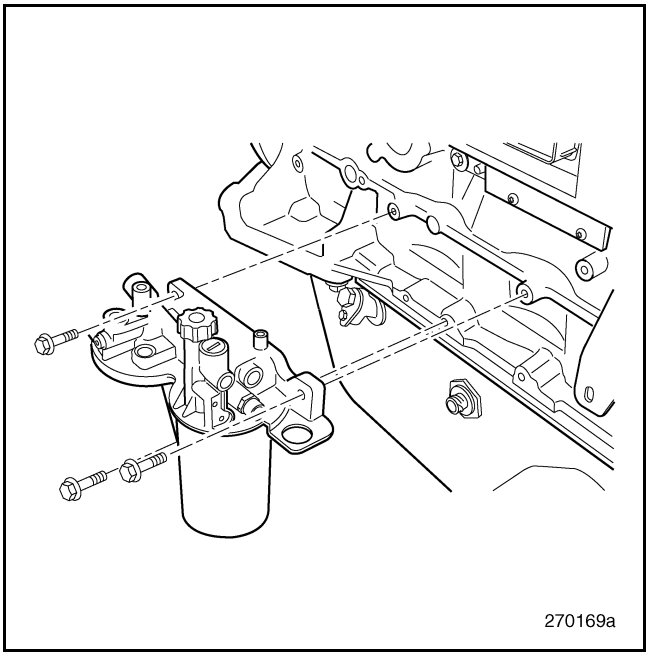


Figure 355 — Fuel Filter and Housing Assembly

1. Assemble the fuel filter housing on the block.
2. Using a torque wrench, tighten the fasteners according to specification.
3. Attach the pipe between the side of the head at the rear and the filter housing.

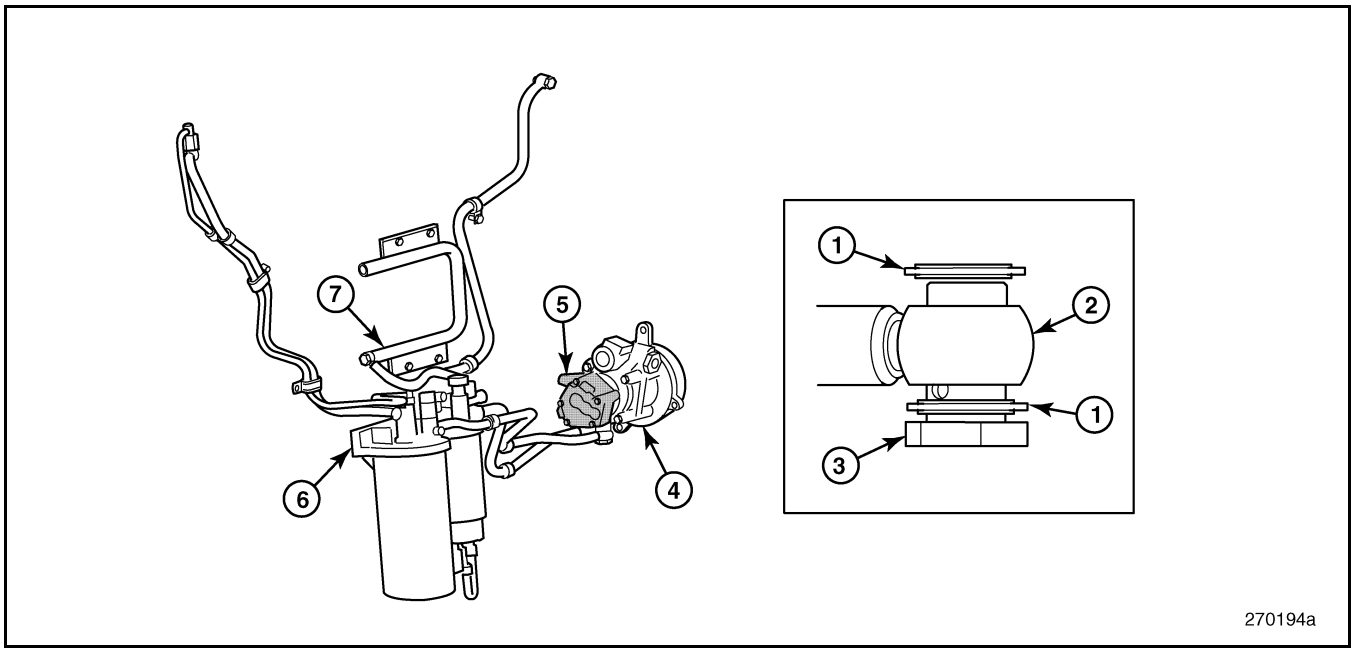


Figure 356 — Fuel Supply Pump, Filter Assembly and Lines

1. Seal Rings 2. Banjo Coupling 3. Hollow Screw 4. Power Steering Pump	5. Low-Pressure Fuel Supply Pump (Mounted to Power Steering Pump) 6. Filter Valve Housing 7. EECU Cooler

4. Attach the line to the block with a P-clamp.
5. Install the fuel return line between the cylinder head at the front and the filter valve housing.
6. Install the line to the block with P-clamps.
7. Install the fuel return line connecting the filter valve housing to the EECU cooler.
8. Install the fuel supply and return lines between the fuel pump and the filter housing.
9. Using a torque wrench, tighten the banjo fittings according to specification.

Crankcase Ventilation Separator

1. Clean the crankcase ventilation separator mating surface on the engine block. Install a **new** rubber gasket into the separator housing groove.

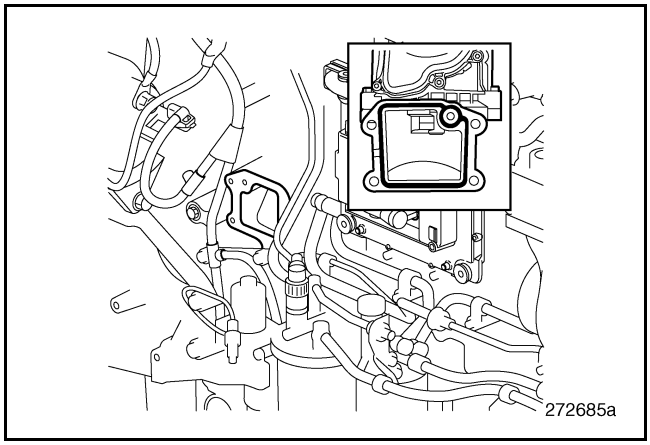


Figure 357 — Separator Mating Surface

2. Assemble the separator on the block and install fasteners.

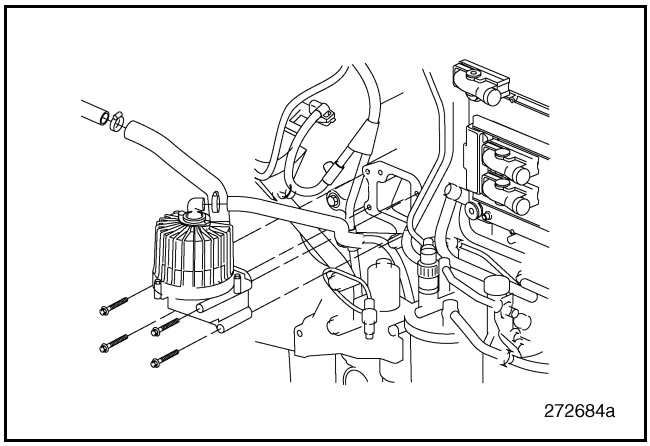


Figure 358 — Separator Installation

3. Using a torque wrench, tighten the fasteners according to specification.
4. Assemble the outlet hose on the separator outlet connector and install hose clamps.
5. Using a torque wrench, tighten the hose clamp fasteners according to specification.
6. Assemble the inlet hose on the separator inlet and prepare for valve cover connection in a future step. Install hose clamps.
7. Using a torque wrench, tighten the hose clamp fasteners according to specification.

Crankshaft Vibration Damper and Fan Pulley Installation

[212 RB, 216 1A]

⚠ CAUTION

When handling a vibration damper, be careful not to damage the housing. Dents in the outer housing will render the damper ineffective. The vibration damper cannot be repaired. Failure to heed this caution may result in severe engine damage.

Inspect the vibration damper for dents, nicks or fluid leaks in the outer housing. If any of these are evident, the damper must be replaced. Due to the close clearance between the damper housing and the rotor inside, dents or nicks may cause contact between the two components. Fluid loss will deteriorate the dampening effect of the damper.

1. Assemble the crankshaft vibration damper and fan pulley on the crankshaft hub using **new** fasteners.

NOTE

Fasteners are one-time use only. Do **NOT** reuse fasteners.

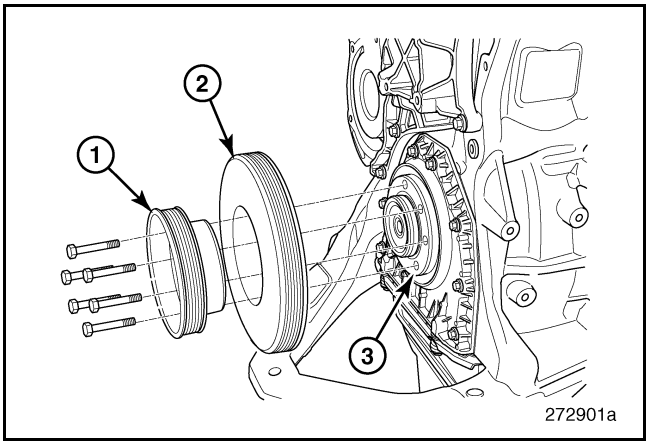


Figure 359 — Fan Drive Pulley and Crankshaft Damper Assembly

1. Fan and Coolant Pump Drive Pulley	2. Vibration Damper 3. Crankshaft Hub

2. Using a torque wrench, tighten the attaching fasteners in sequence in two steps according to specification.
3. Assemble the front engine power take-off (FEPTO) if equipped. Tighten the attaching fasteners in sequence in two steps according to specification.

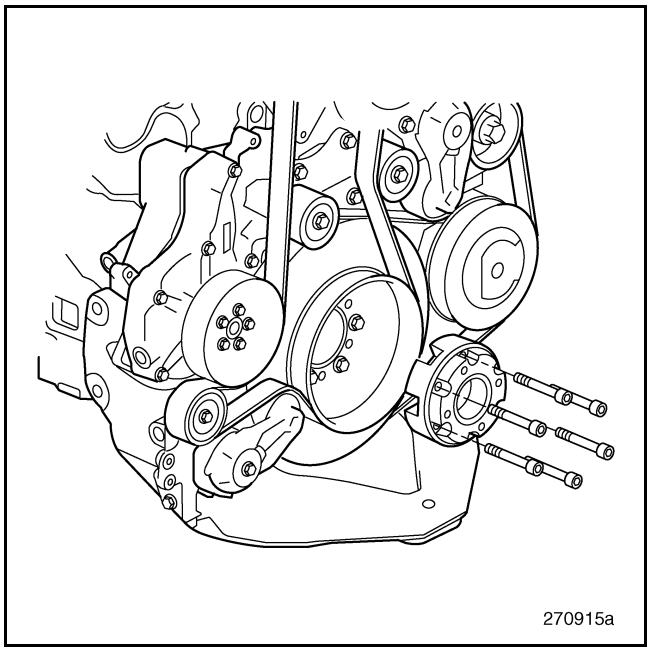


Figure 360 — Front Engine Power Take-Off (FEPTO) Assembly

Alternator and Refrigerant Compressor Installation

[271 CB, 264 DP]

1. Assemble the alternator mounting bracket onto the cylinder block. Tighten the fasteners according to specification.
2. If removed and not previously installed, assemble the front engine support mounting bracket on the cylinder block. This bracket also provides the mounting points for the A/C compressor.
3. Using a torque wrench, tighten the fasteners for the bracket and mount according to specification.
4. If removed, assemble the belt tension idler on the bracket.
5. Using a torque wrench, tighten the fasteners according to specification.
6. Assemble the alternator and refrigerant compressor on their pads.

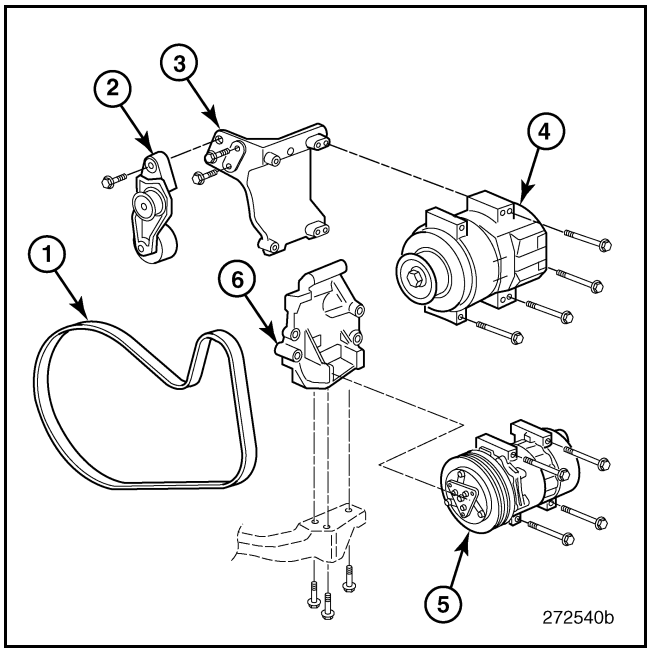


Figure 361 — Alternator and A/C Compressor

1. Drive Belt	4. Alternator
2. Belt Tensioner	5. A/C Compressor
3. Alternator Mounting Bracket	6. Mounting Bracket, Front Engine Support

7. Using a torque wrench, tighten the fasteners according to specification.
8. If a harness is installed, securely connect the electrical wiring as tagged during disassembly.
9. Assemble the belt pulleys on the alternator and compressor hubs, if removed.

Wiring Harness Installation

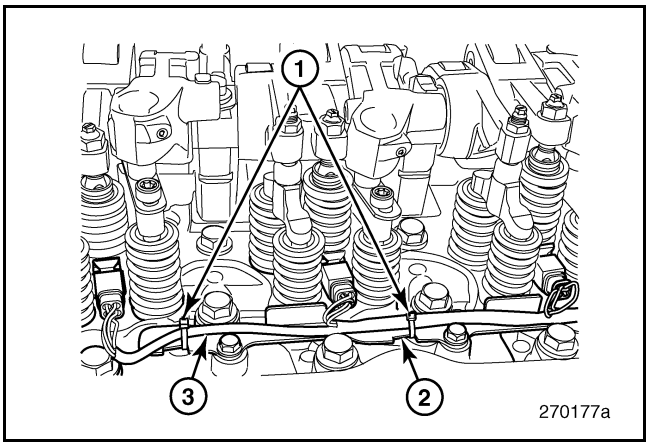


Figure 362 — Internal Wiring Harness

1. Tie Straps 2. Tie Bar Notch	3. Wiring Harness

1. Route and position the harness on the engine as noted during disassembly.
2. Insert the unit injector portion of the harness through the hole in the timing gear housing.
3. Connect the harness to each injector.
4. Connect the harness to the engine brake control valve if installed.
5. Using high-temperature wire ties, 983472, attach the harness to the cylinder head.
6. If not previously done, carefully route the wiring harness over the engine brake control valve. Secure the harness to the control valve as shown in Figure 363. Make sure that the harness is positioned to the side of the boss at the top of the valve assembly.

⚠ CAUTION

Do NOT route the harness over the boss at the top of the engine brake control valve. There is not enough clearance between the valve and the valve cover for the harness when the cover is installed. The harness must be positioned to the side of the boss to avoid damage to the harness.

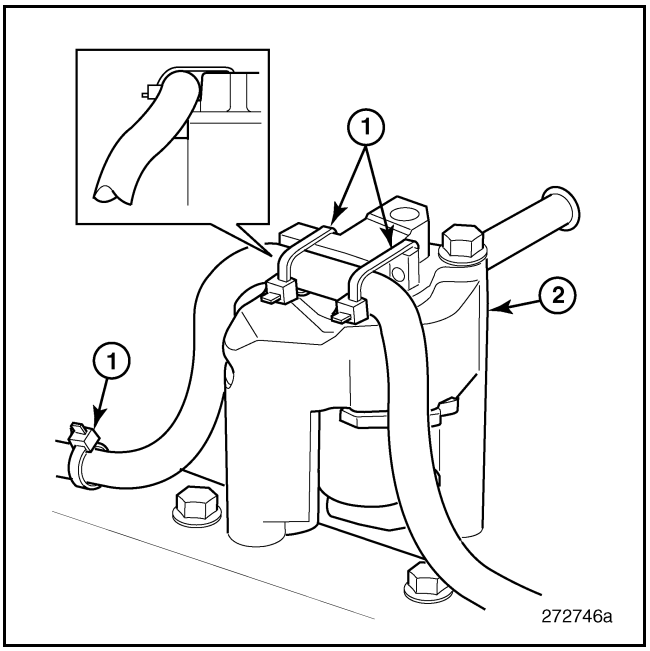


Figure 363 — Harness Routing Over Engine Brake Control Valve

1. Tie Straps	2. Control Valve

The external portion of the wiring harness is encased in accordion tubing. There are several units each of which is fitted with end connectors that permit convenient stringing, joining and attachment to the block in various locations.

CONNECTING THE EECU

1. Check the tension of the terminal connector pins using the test pins tool kit 9990008.

NOTE

If terminal pins are damaged or corroded, replace as necessary.

2. Carefully engage the upper and lower wiring harness connectors to the EECU. Verify that the connectors are latched and properly locked in position.

⚠ CAUTION

Use care to ensure that the EECU terminal pins are straight and undamaged.

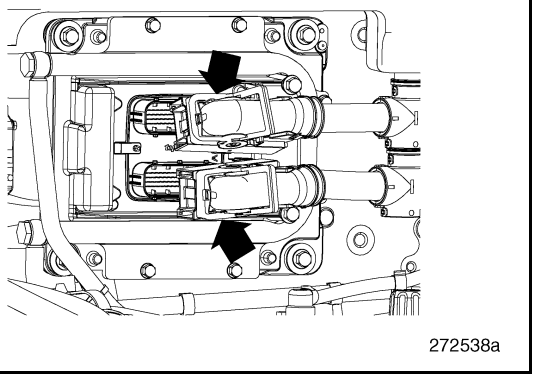


Figure 364 — EECU Harness Connectors

3. Install the bolts to secure the wiring harness clamps to the EECU.

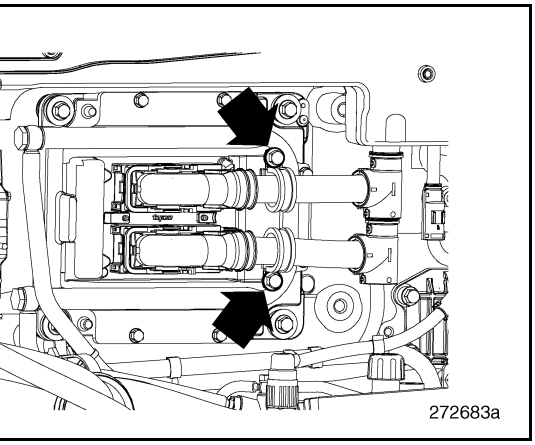


Figure 365 — EECU Harness Clamps

4. Connect the various terminals as tagged at disassembly to all sensors, relays and components such as the starter, alternator and refrigerant compressor among others.
5. Attach the clamps to hold the harness on the block.

Cylinder Head (Valve) Cover Installation

[211 JB]

1. Clean the gasket sealing surface of the cylinder head. The surfaces should be clear of any dirt or debris and free of any oil.
2. Inspect the gasket for damage. If replacement is necessary, carefully place a **new** gasket into the channel, making sure that it is properly seated and follows the contour of the channel.

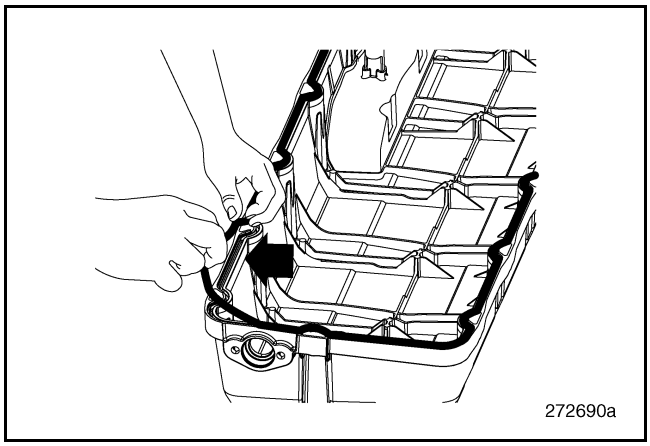


Figure 366 — Cylinder Head Cover Gasket

3. Apply a 2 mm (0.079 inch) bead of MACK sealant to the area where the timing cover and the cylinder head meet. This parting line is on both sides of the cylinder head. Carefully position the valve cover on the cylinder head and make sure that the seal remains properly seated.

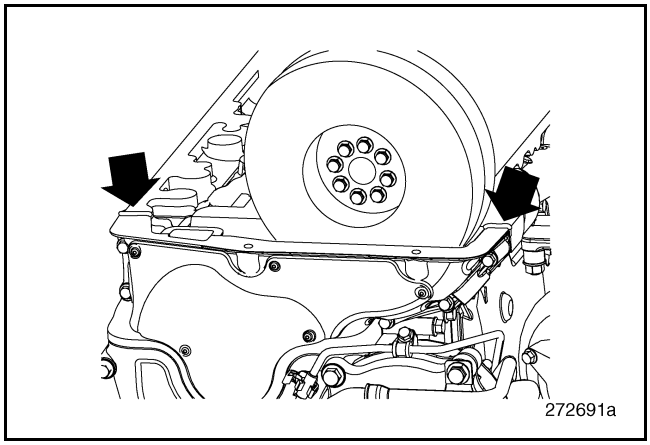


Figure 367 — Sealant Application

4. Install the spring-loaded bolts in the valve cover. Torque-tighten the valve cover bolts in sequence to specification.

NOTE

- The cylinder head cover must be installed within 20 minutes of the sealant being applied.
- The bolt springs provide even tension on the valve cover gasket.

5. Install the fasteners securing the crankcase ventilation tube and bracket to the valve cover and intake manifold. Torque-tighten the fasteners to specification.

NOTE

Inspect the crankcase ventilation tube O-ring and replace if necessary.

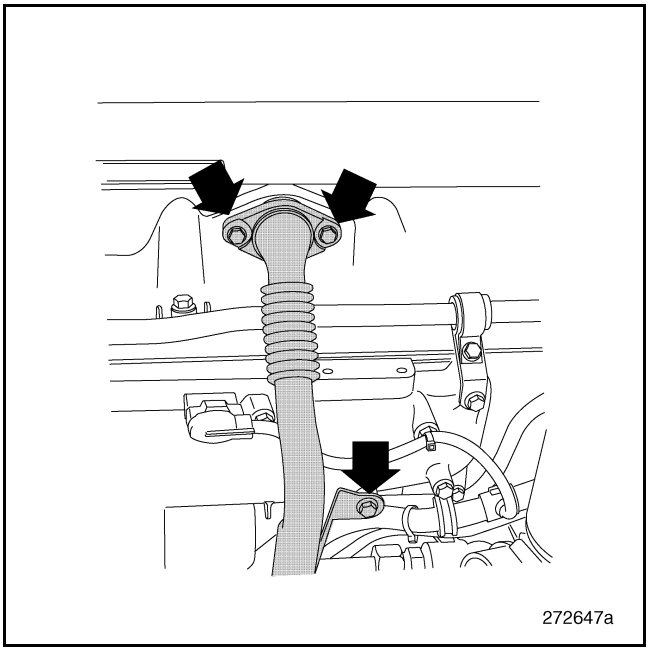


Figure 368 — Crankcase Ventilation Tube

Fan Hub and Drive Belt Installation [216 AA]

1. Place the fan hub bracket assembly in position at the front of the cylinder head and block. Install the mounting fasteners and tighten to specification.

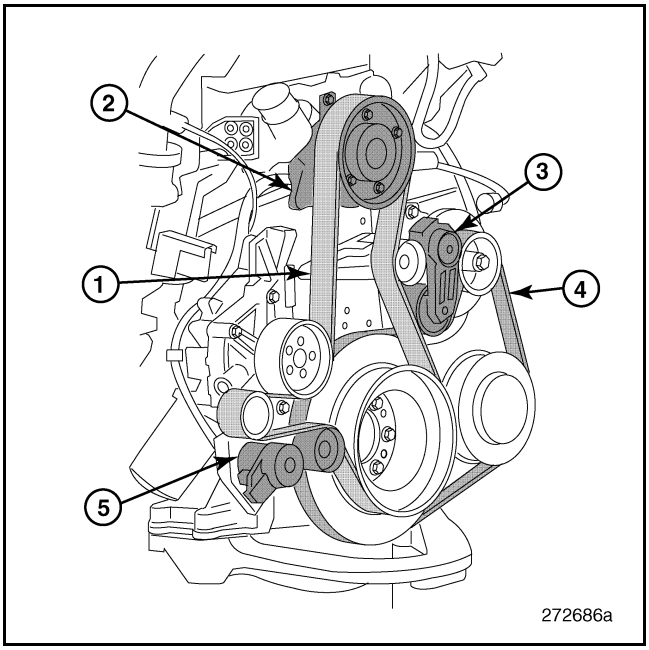


Figure 369 — Fan Hub and Accessory Drive System

1. Fan Drive Belt 2. Fan Hub Bracket 3. Accessory Drive Belt Tensioner	4. Accessory Drive Belt 5. Fan Drive and Coolant Pump Belt Tensioner

2. Place the fan drive and pump drive belt tensioner in position on the coolant pump housing. Install the fasteners and tighten to specification.
3. If not already done, place the accessory drive belt tensioner in position on the cylinder block. Install the fasteners and tighten to specification.
4. Check the condition of both of the original A/C/alternator and water pump/fan belts. Check for dry cracks or scuff marks and replace with new belts if any of these conditions are present.
5. Per the accessory routing decal, route the A/C/alternator and fan/water pump belts.

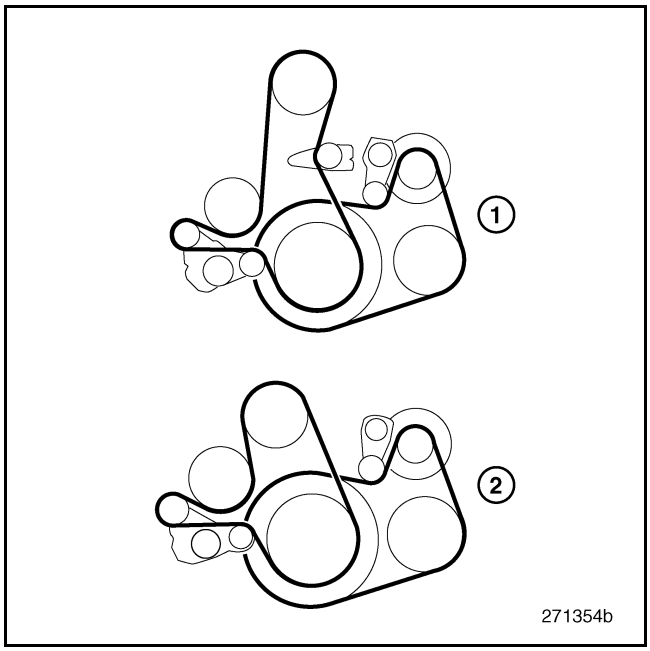


Figure 370 — Drive Belt Arrangement

1. Conventional	2. LCF

6. Place a 1/2-inch ratchet or special tool J 44392 in the accessory drive belt tensioner notch. Install the drive belt by prying the tensioner away from the belt to relieve the tension on the adjuster and allow the belt to slip onto the A/C compressor pulley. Release the tension and remove the tool.

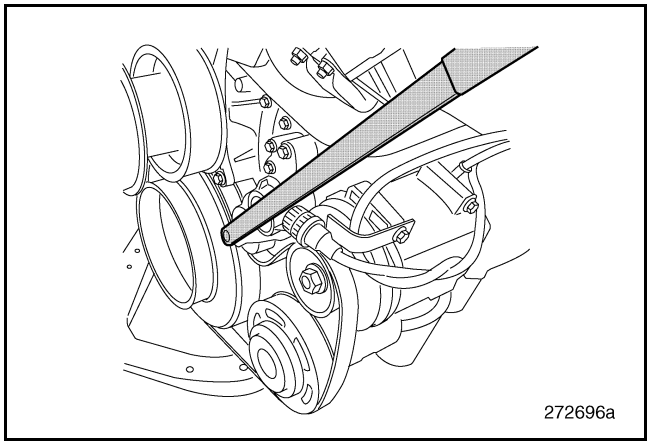


Figure 371 — Accessory Drive Belt Installation

7. Using tool J 44392, pry the belt tensioner away from the fan and water pump drive belt and install the belt. Release the tension and remove the tool.

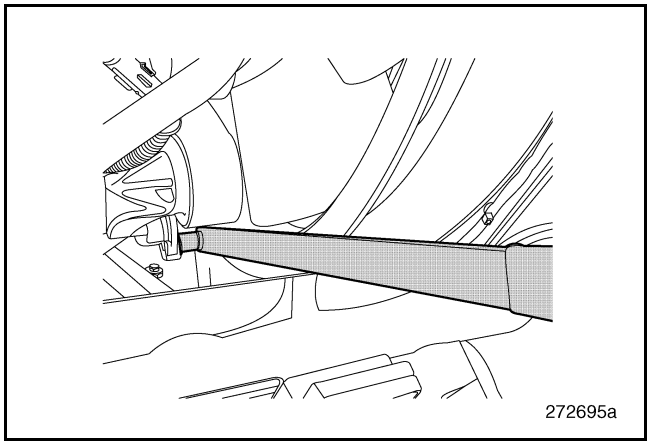


Figure 372 — Fan and Water Pump Drive Belt Installation

Removing Engine from Engine Stand

[200 EB]

⚠ DANGER

The engine is very heavy and extreme caution must be exercised while it is being lifted from the stand. Failure to use proper equipment and failure to keep your body clear may result in serious personal injury or death if the engine should fall or suddenly shift out of position.

1. Attach engine lifting tools J 47038-1, J 47038-6 and J 47038-8 as follows:
   a. Slide the center engine lifting bar over the cylinder head cover and install the clevis pin. Connect the center lifting bar clevis to the chain on the hoist.
   b. Place the lifting chain to the engine lift eyes and secure the chain to the bracket.
   c. Slide the rear lifting plate into the center lifting bar and install the pin.
   d. Bolt on the front section of the engine lifting bracket to the cylinder head and install the pin in the bar.
   e. Torque-tighten lifting bracket fasteners to specification.

⚠ DANGER

Use only the chains, clevis and lifting plate provided with these special tools. Failure to use the correct special tool components may allow the engine to fall, causing serious personal injury or death.

2. Support the weight of the engine using a mobile floor crane such as OTC 16-1813 or equivalent crane capable of lifting the engine. Position the crane and hook up to the bar as close as possible. Raise the crane slightly to apply tension to the chain.
3. With the lifting device now supporting the engine weight, remove the mounting fasteners from the engine stand.
4. Using the engine hoist, place the engine in a suitable support rack or install the engine in the vehicle (see *Engine Installation* in the **REPAIR INSTRUCTIONS, PART 1** section).

Filters and Miscellaneous Components Installation

[219 EV, 215 LD]

This section covers installation of filters and other components that might get in the way of other assembly operations and to which nothing is assembled.

NOTE

The sequence in which the fuel filter valve housing, fuel lines and EECU are assembled on the engine depends on the type of engine stand used. For engine stands that use an adapter plate attached to the left side of the engine, these components cannot be installed until after the engine has been removed from the repair stand.

1. If not already done, assemble the following components on the engine using the procedures covered earlier in this section.
   - Engine wiring harness
   - Crankcase ventilation tubing
   - EECU and cooling plate
   - Fuel filter valve housing and fuel lines
   - Crankcase ventilation separator

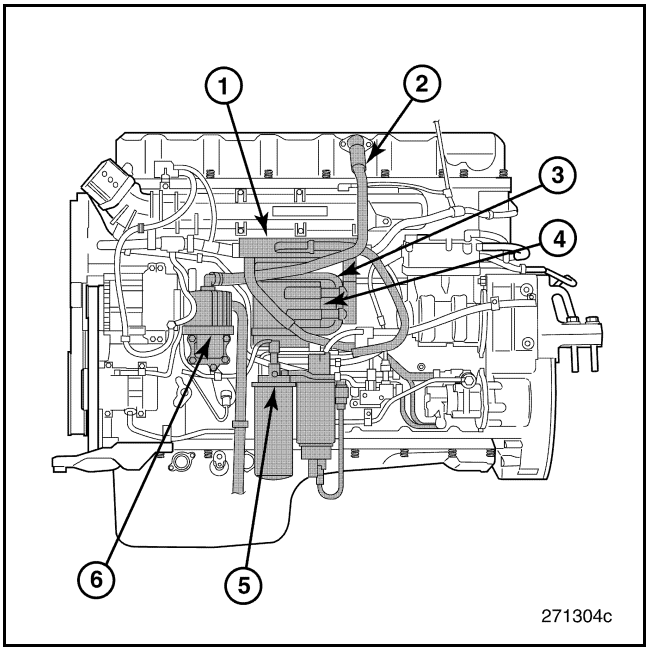


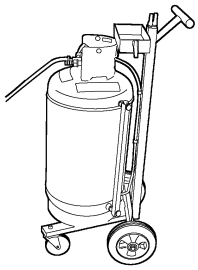
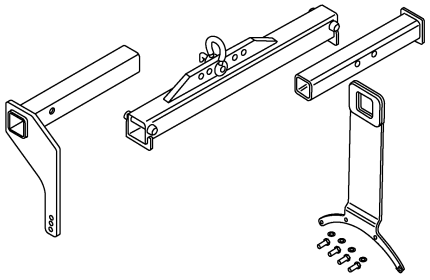
Figure 373 — Components for Installation After Removal from Repair Stand

1. Engine Wiring Harness	4. EECU
2. Crankcase Ventilation Tubing	5. Fuel Filters
3. EECU Cooler	6. Crankcase Ventilation Separator

2. Assemble the full-flow oil filters and tighten to contact plus 3/4 to 1 turn.
3. Assemble the bypass oil filter and tighten to contact plus 3/4 to 1 turn.
4. Assemble the coolant filter and tighten to contact plus 3/4 to 1 turn.

ENGINE INSTALLATION

Special Tools

Tool No.	Description	Image
DBT2V700	Coolant Extractor/Injector	 006940a
J 47038-3 J 47038-4 J 47038-6 J 47038-8	Engine Lifting Tool Set	 006927b

General Instructions

Details of the engine installation procedure vary from one vehicle to another. This section provides general guidelines for installing an MP8 engine in a vehicle.

NOTE

Before installing the engine, make sure tools and equipment are inspected for safety and available for use.

1. Position the vehicle on a flat, level surface with ample work space.
2. Apply the parking brake and block the wheels. Observe all safety precautions.

NOTE

Refer to the **SPECIFICATIONS** section for information about the fasteners mentioned below. Some groups of fasteners must be tightened in a specific sequence. Patterns of sequence are also specified in the torque specification section.

Installation

⚠ WARNING

The engine is obviously heavy and difficult to handle. Obtain a helper and provide a suitable lifting device to support it safely during installation. Failure to heed this warning may result in severe personal injury.

⚠ CAUTION

While installing the engine, watch for obstructions that may interfere, such as engine and chassis components, brackets, clamps and other parts attached to the frame and cab. Failure to heed this caution may result in severe damage to the engine and other components.

1. Remove the valve cover.
2. Cover the valve mechanism and gear train with a suitable cloth or similar covering to prevent dirt and debris from entering the engine.
3. Attach the engine lifting tool, J 47038, to the engine. Secure the engine lifting tool to the front of the cylinder head and to the rear at the flywheel housing. Adjust the tool to assume the load.

⚠ DANGER

Ensure all bolts and pins are correctly positioned prior to removing the engine from the engine stand. Failure to properly install all bolts and pins of the engine lifting tool can result in personal injury and/or death.

4. Using the engine lifting tool, J 47038, and with the aid of the helper, lift and lower the engine into position.
5. Align the engine with the transmission.
6. Install and, using a torque wrench, tighten the rear engine support attaching screws according to specification.
7. Install and, using a torque wrench, tighten the front engine support attaching screw according to specification.
8. Remove the engine lifting tool from the engine.
9. Apply an even 2 mm (5/64 inch) bead of sealant at the joint lines between the cylinder head and the timing cover.

NOTE

Install the valve cover within 20 minutes of applying the sealant.

10. Install the valve cover.
11. Install the transmission and, using a torque wrench, tighten the transmission attaching screws according to specification.
12. Withdraw the transmission jack.
13. As applicable:
    a. If manual transmission, attach the clutch linkage and bracket retaining screws.
    b. If automatic transmission, attach the torque converter access panel and torque converter.
14. Attach the hood rest crossmember if applicable.
15. Connect starter wires and cables.
16. Attach the power steering hoses and reservoir if applicable.
17. Attach the exhaust system brackets.
18. Attach the exhaust system to the turbocharger.

⚠ WARNING

The radiator and CAC assembly is heavy and difficult to handle. Provide a suitable lifting device and a helper to support it safely during installation. Failure to heed this warning may result in severe personal injury.

19. Attach the radiator and CAC assembly.
20. Attach the fan assembly.

NOTE

To allow for chassis articulation in severe service applications, the fan ring rubber seal does not fit flush against the shroud on GU model chassis. A gap of 15–20 mm (0.59–0.79 inch) exists between the front face of the aluminum fan ring to the back face of the fan shroud.

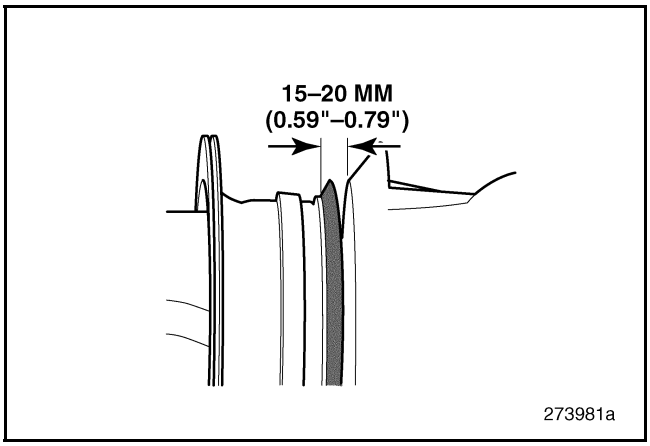


Figure 374 — Fan Ring-to-Shroud Clearance

21. Connect the fan actuator.
22. Connect the engine coolant temperature sensor.
23. Attach the charge air cooler outlet components.
24. Attach the charge air cooler inlet components.
25. Attach the coolant expansion tank.
26. Attach the lower radiator tube.
27. Connect the cab heater and fuel heater coolant return lines to the lower radiator tube.
28. Attach the upper radiator tube.
29. If the vehicle is equipped with air conditioning:
    a. Connect the A/C compressor discharge hose.
    b. Connect the A/C line at the receiver/dryer.
    c. Connect the pressure switch on the receiver/dryer.
    d. Connect the low pressure cutout switch.
    e. Recharge the A/C system with refrigerant using refrigerant recovery and recycling equipment for R134A.
30. Install the inlet air system components including the filter.
31. Connect the inlet air heater if present.
32. Attach the oil and fuel filters and the coolant conditioner.
33. Close all drains and drain valves.
34. Connect all sensors and actuators.
35. Install the drive belts.
36. Add oil and coolant. If available, use coolant extractor/injector when adding coolant.
37. Attach the hood, or replace the tilted cab.

REPAIR INSTRUCTIONS, PART 2

IN-CHASSIS PART/COMPONENT PROCEDURES

This section presents standalone replacement operations which can be done in-chassis without a complete engine overhaul. These operations include:

- CAMSHAFT BEARING BRACKETS, REPLACEMENT
- OIL THERMOSTAT AND PRESSURE SAFETY VALVE REPLACEMENT
- CRANKSHAFT FRONT SEAL REPLACEMENT
- CRANKSHAFT REAR SEAL REPLACEMENT
- CRANKCASE VENTILATION (CCV) SEPARATOR REPLACEMENT
- OIL PUMP REPLACEMENT
- INJECTOR COPPER SLEEVE REPLACEMENT
- UNIT INJECTOR CLEANING
- VALVE STEM HEIGHT MEASUREMENT PROCEDURE
- VALVE STEM SEAL REPLACEMENT

Due to the Engine Electronic Control Unit (EECU) self-learning capability, it is necessary to reset learned EECU parameters after servicing some engine-related components. This allows the EECU to learn the new component's behavior. After servicing is complete, perform the “Learned Data Reset” located in VCADS/PTT.

CAMSHAFT BEARING BRACKETS, REPLACEMENT (MACK MP8 ENGINE) [213 CJ]

This information covers guidelines when replacing factory or aftermarket camshaft bearing brackets (lower journals) on the MACK MP8 engine.

Preliminary Steps

The following components need to be removed for access to the camshaft bearing brackets:

- Valve Cover
- Compression Brake Solenoid Valve
- Rocker Arm Shaft
- Camshaft Assembly

General Information

Camshaft bearing journals are numbered 1–7, with matching upper and lower halves. Be sure to note and mark the corresponding journal numbers and install them in the correct sequence with matched upper and lower halves.

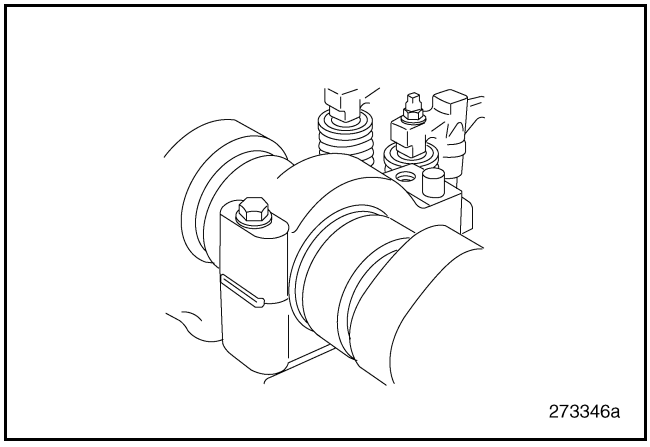


Figure 375 — Camshaft Bearing Bracket Installed

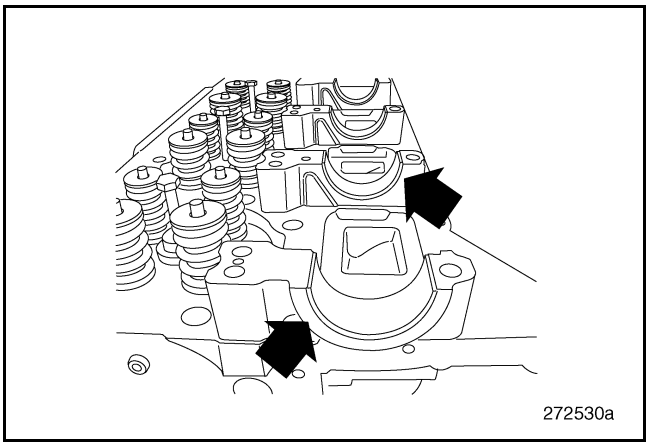


Figure 376 — Camshaft Bearing Bracket Lower Half

WHEN REPLACING FACTORY-INSTALLED JOURNALS

- If a camshaft journal has seized, DO NOT MIX a replacement bearing bracket with the original factory-installed bearing brackets. This is because the original bearing brackets were align-bored when the engine was manufactured. All seven brackets must be replaced.
- When replacing a cylinder head, do not mix new bearing brackets with original bearing brackets from the old cylinder head. Use only new bearing brackets on a new cylinder head.

WHEN REPLACING/INSTALLING AFTERMARKET JOURNALS

- If there are already replacement bearing bracket assemblies on the engine, and one or more assemblies are damaged, all seven assemblies must be replaced. Replacement bracket assemblies can be identified by the oval-shaped alignment pin holes.
- For replacement bracket assemblies used in locations 2 through 6, both alignment pin holes are oval-shaped for side-to-side adjustment. For brackets used in locations 1 and 7, one alignment pin hole is oval-shaped for front-to-rear adjustment; the second pin hole is round with an alignment pin preassembled in it.
- Mark the bearing caps to indicate that aftermarket bearing bracket and cap assemblies have been installed.

Camshaft Inspection

To avoid unnecessary overhauling, conduct a thorough inspection of the camshaft before reinstalling it after replacing the bearing bracket assemblies.

Bracket Replacement Procedure

1. Remove the lower bearing brackets using a pry bar. The rearmost No. 7 bracket can be removed by using a soft-faced mallet and tapping side to side. (The alignment pins should come off the cylinder head with the brackets. If not, remove the pins.)

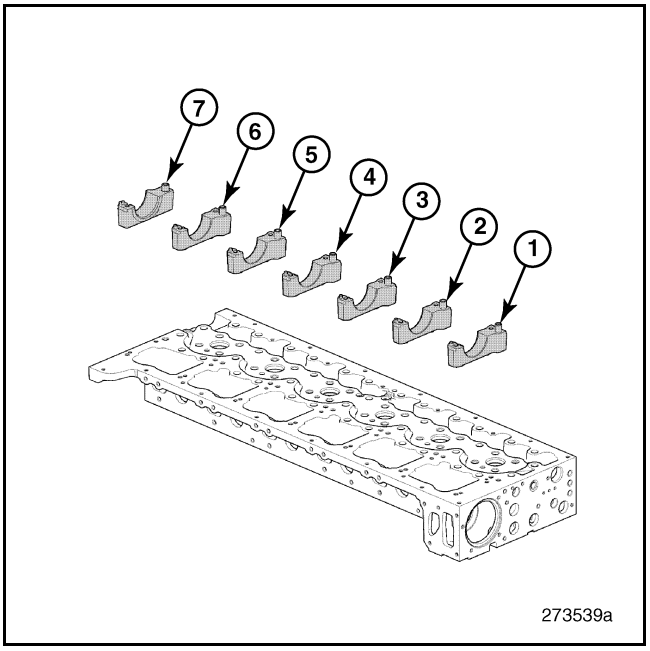


Figure 377 — Camshaft Lower Bearing Brackets

2. Clean the contact surfaces of the cylinder head and the lower bearing brackets.
3. Using a metal stamp or electric etching tool, mark the **new** bearing brackets and caps with the numbers, 1 through 7, indicating the location at which each assembly will be installed.

⚠ CAUTION

Do not use excessive force to punch the bracket assemblies when marking their position on the cylinder head. Damage to components can result.

4. Install 12 **new** locating pins from the parts kit at the cylinder head locations illustrated (Figure 378). Use a plastic mallet so as not to damage the locating pins.

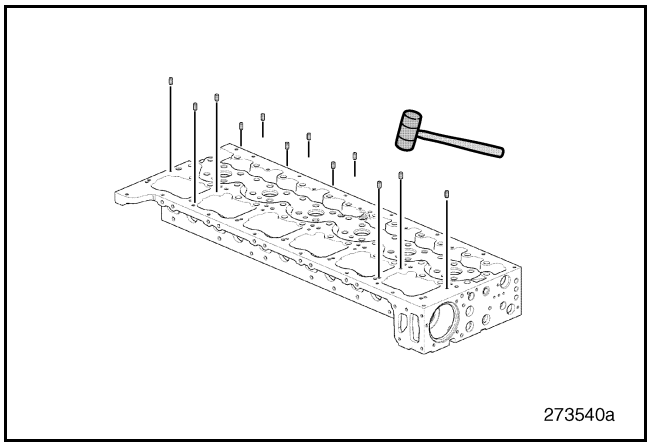


Figure 378 — Locating Pin Installation

5. Install the **new** lower bearing brackets at their respective marked positions on the cylinder head.
6. Check that the bearing brackets can move slightly on the locating pins.
   - Bracket Nos. 1 and 7 should turn slightly forward and back at one side.
   - Bracket Nos. 2 through 6 should move slightly side to side.

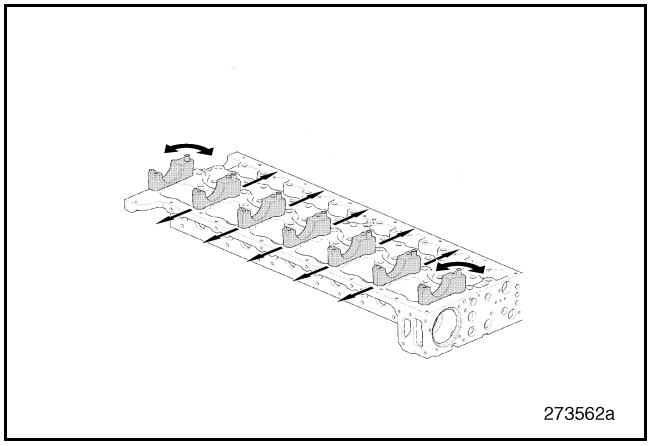


Figure 379 — Bracket Movement on Alignment Pins

Final Steps

Install the following components which were removed for access to the camshaft bearing brackets (see appropriate component for installation procedures):

- Camshaft Assembly
- Rocker Arm Shaft
- Compression Brake Solenoid Valve
- Valve and Unit Injector Adjustment
- Valve Cover Assembly

1. Install all previously removed cables to the ground (negative) battery terminals.
2. Start the engine, check for leaks and proper operation.

OIL THERMOSTAT AND PRESSURE SAFETY VALVE REPLACEMENT

Pressure Safety Valve Removal

Before attempting to remove the oil pressure safety valve, apply the parking brake, shift into neutral and thoroughly clean around the safety valve cover.

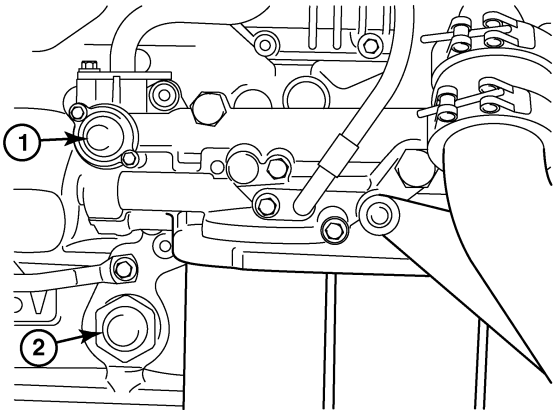


Figure 380 — Oil Valves — Thermostat and Pressure Safety

1. Thermostat Valve	2. Oil Pressure Safety Valve

1. Using the oil valve socket, J 43051, remove the safety valve cover and valve as a unit. Ensure that the seal is also removed with the cover and valve. Dispose of the valve.

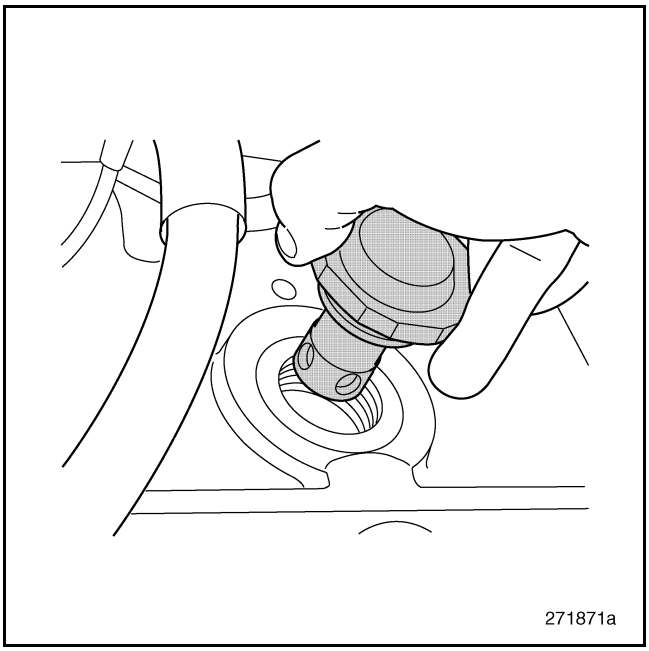


Figure 381 — Oil Pressure Safety Valve and Cover

2. Clean the cover and cylinder block sealing surface.
3. Replace the O-ring on the cover.

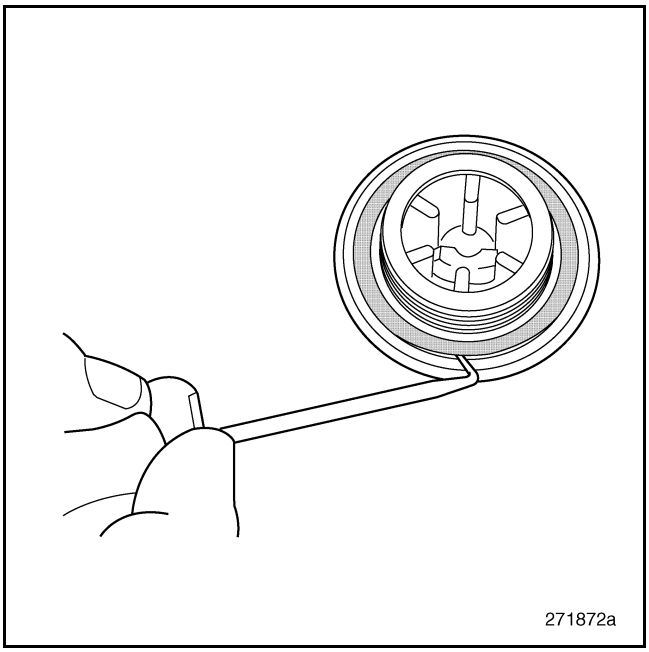


Figure 382 — Removing Safety Valve Cover O-Ring

4. Install a **new** valve in the cover.
5. Install the **new** valve and cover into the cylinder block.
6. Using a torque wrench, tighten the valve according to specification.

Oil Thermostat Valve Replacement

Before attempting to remove the thermostat valve, apply the parking brake, shift into neutral and thoroughly clean around the valve head.

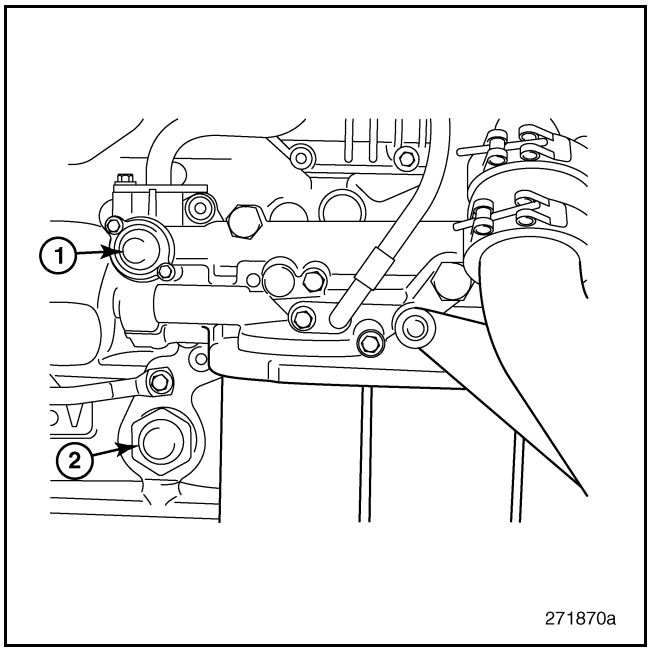


Figure 383 — Oil Valves — Thermostat and Pressure Safety

1. Thermostat Valve	2. Oil Pressure Safety Valve

1. Remove the thermostat valve from the oil filter housing and discard.
2. Replace the O-ring.

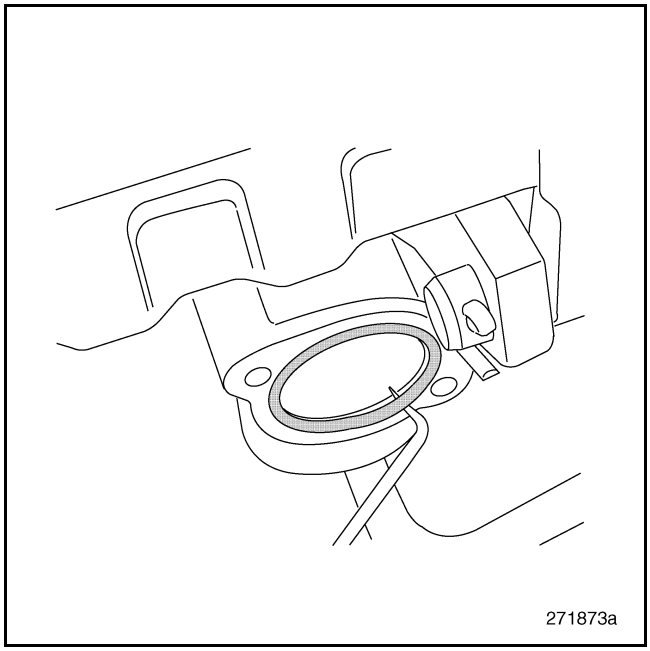
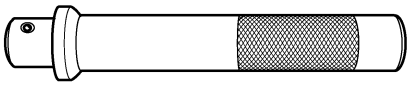
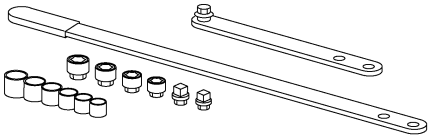
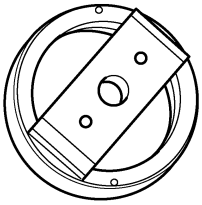


Figure 384 — Thermostat Valve O-Ring

3. Install a **new** thermostat valve with a **new** gasket.
4. Start the engine and check for leaks.

CRANKSHAFT FRONT SEAL REPLACEMENT

Special Tools

Tool No.	Description	Image
9992000	Handle with various uses (fits 25 mm hole) (Essential)	 006785a
J 44392	Drive Belt Tensioner Tool	 272697a
88800021	Front Main Seal Remover/Installer (Essential)	 006774a

Seal Removal

1. Remove the fan blade from the fan clutch hub.
2. Compress the belt tensioner (using J 44392) to release pressure on the fan and coolant pump drive belt and remove the belt.

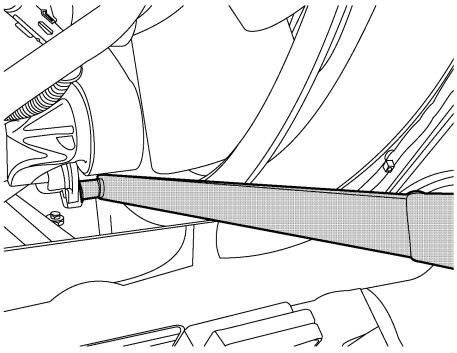


Figure 385 — Drive Belt Tensioner Tool

3. Compress the accessory belt tensioner (using J 44392) and remove the drive belt from the vibration damper pulley, refrigerant compressor pulley and alternator pulley.
4. If equipped, remove the front engine PTO fasteners and PTO.
5. Remove the mounting fasteners that secure the drive belt pulley and vibration damper to the crankshaft hub. Separate the pulley and damper from the hub.

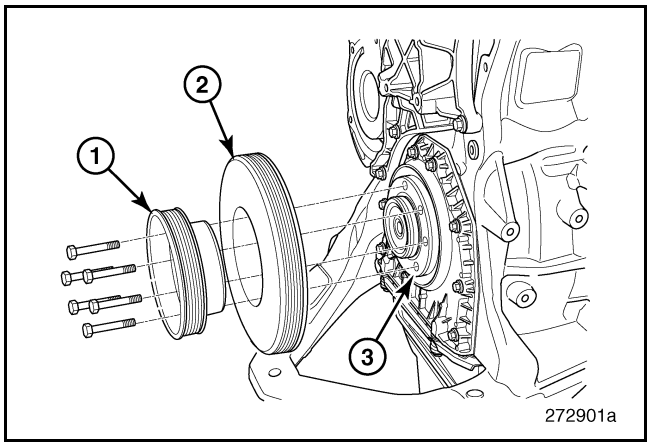


Figure 386 — Vibration Damper and Pulley Removal

1. Fan and Coolant Pump Drive Pulley 2. Vibration Damper	3. Crankshaft Hub

⚠ CAUTION

When handling a vibration damper, be careful not to damage the housing. Dents in the outer housing can render the damper ineffective. If damaged, the vibration damper cannot be repaired and must be replaced.

6. Remove the crankshaft seal as follows:
   A. Drill two 3.5 mm (0.138 inch) holes in the metal rim of the crankshaft front seal. Use the holes in the rim of the front main seal remover/installer (88800021) as a guide.

NOTE

Apply grease on the end of the drill bit to prevent chips from getting into the engine.

   B. Using two self-tapping M5 screws of suitable length, attach the crankshaft front seal remover/installer to the seal.
   C. Using two M10 fasteners threaded into the crankshaft front seal remover/installer, remove the crankshaft front seal.

Seal Installation

1. Clean the seal seating surface in the crankshaft front cover and the sealing surface of the crankshaft hub.
2. Assemble the handle (9992000) and front main seal remover/installer (88800021).
3. Place a **new** crankshaft front seal on the crankshaft front seal remover/installer.

NOTE

The crankshaft front seal should be installed dry. No sealant or lubricant is necessary.

4. Position the crankshaft front seal remover/installer and new seal over the crankshaft hub and crankshaft front cover. Carefully drive the seal into the cover until the tool bottoms against the crankshaft hub and front cover.

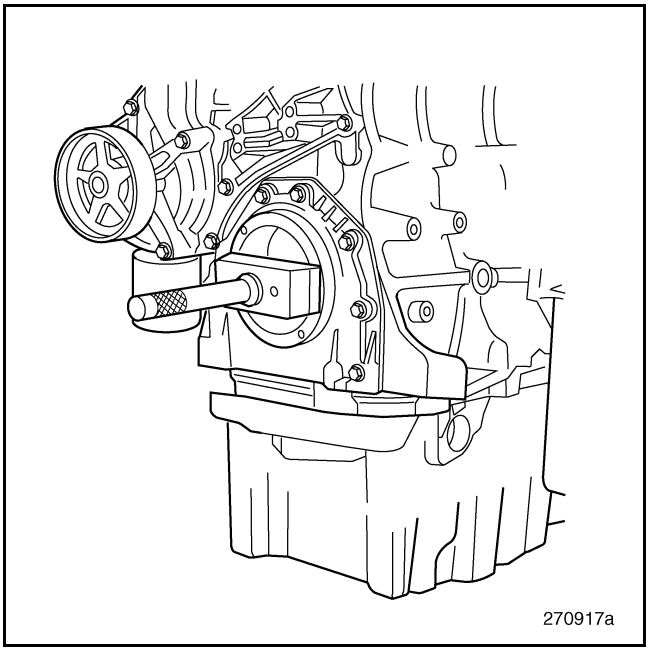


Figure 387 — Seal Installation

5. Remove the tool and inspect the seal to make sure that it is properly installed.
6. Place the vibration damper and fan pulley on the crankshaft hub and align the fastener holes. Install and tighten the mounting fasteners in two steps to specification.

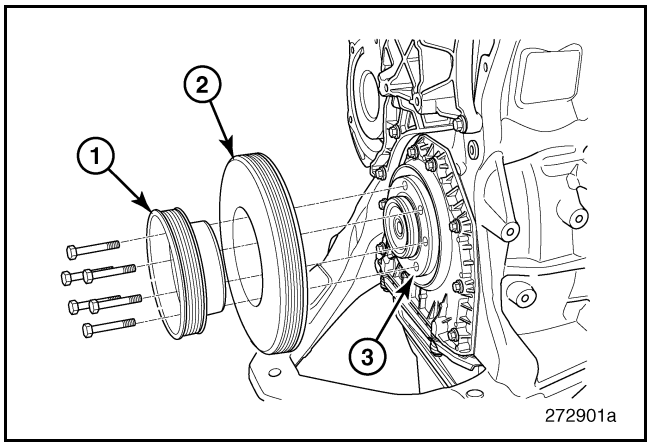


Figure 388 — Vibration Damper and Pulley Installation

1. Fan and Coolant Pump Drive Pulley 2. Vibration Damper	3. Crankshaft Hub

7. If equipped, install the front engine PTO and fasteners. Tighten the mounting fasteners to specification.

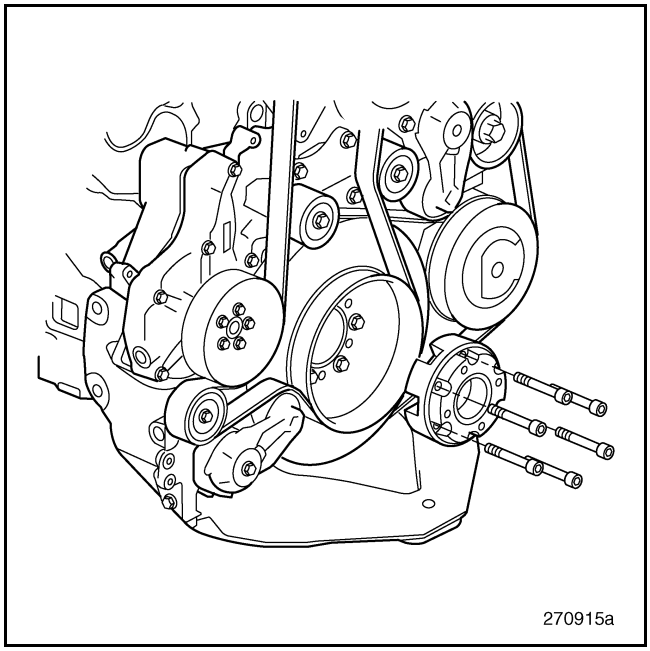


Figure 389 — Front Engine PTO Installation

8. Compress the accessory drive belt tensioner (using J 44392) and install the drive belt over the crankshaft pulley, fan drive pulley and coolant pump pulley.
9. Compress the lower belt tensioner (using J 44392) and install the drive belt over the crankshaft pulley, fan drive pulley and coolant pump pulley.

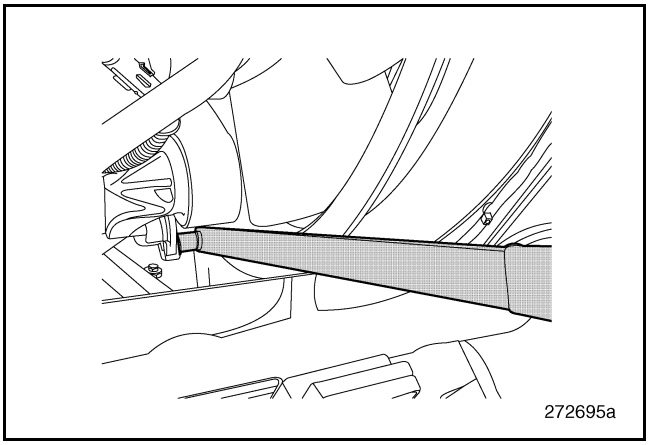
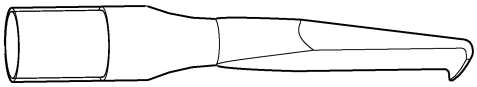
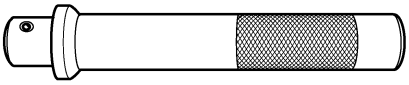
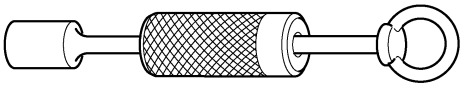
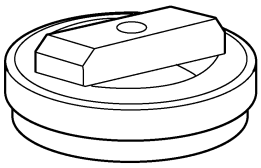


Figure 390 — Drive Belt Tensioner Tool

10. Place the fan blade on the fan clutch hub, install the mounting fasteners and tighten to specification.

CRANKSHAFT REAR SEAL REPLACEMENT

Special Tools

Tool No.	Description	Image
9990192	Crankshaft Seal Puller	 006896a
9992000	Handle with various uses (fits 25 mm hole) (Essential)	 006785a
9996400	Slide Hammer	 006897a
9998238	Rear Main Seal Remover/Installer, for neoprene type seal (Essential)	 006780a

Neoprene Seal Removal

⚠ CAUTION

The flywheel is heavy. Do not attempt to remove the flywheel without the help of an assistant or a suitable lifting device. Failure to heed this caution may result in severe personal injury and property damage.

1. Carefully remove the flywheel sensor.
2. Install two M10 screws to use as handles to aid in removal.
3. Remove the flywheel.
4. Using the puller, 9990192, and the slide hammer, 9996400, carefully remove the seal.

Neoprene Seal Installation

1. Clean the flywheel, housing and crankshaft sealing surfaces.
2. Align properly and assemble the new seal on the seal installer, 9998238.

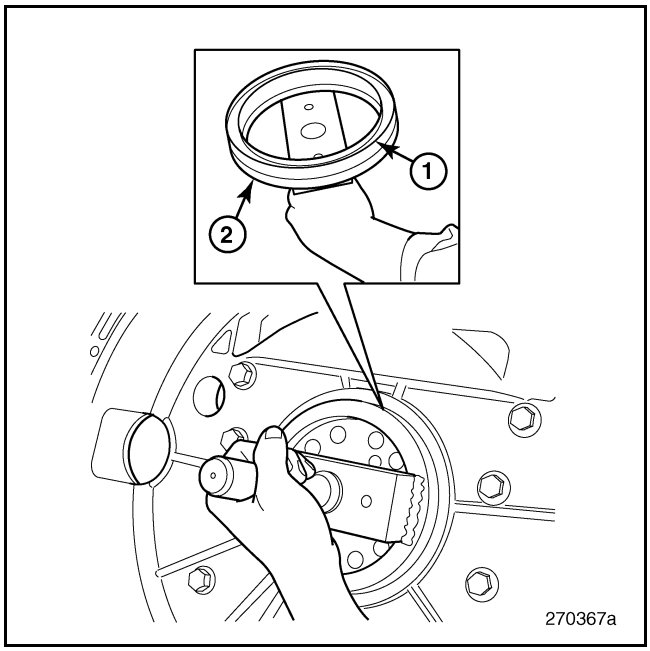


Figure 391 — Seal Installation

1. Rear Main Seal	2. Seal Installer, 9998238

3. Using the handle, 9992000, and the seal installer, carefully tap the seal into the flywheel housing until there is even contact.
4. Using the M10 screws as handles, with the help of an assistant or a lifting device, assemble the flywheel over the dowel and alignment studs on the mounting surface.

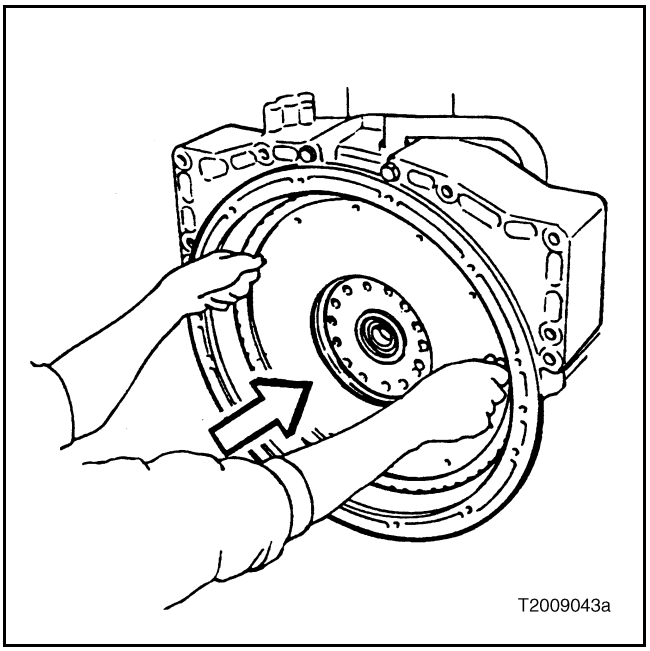


Figure 392 — Flywheel Installation

5. Insert the flywheel mounting screws finger tight. Remove the M10 screws to insert the remaining mounting screws.
6. Using a torque wrench, tighten the mounting screws in sequence according to specification.
7. Carefully install the flywheel sensor and connect it to the harness.

Teflon® Seal Removal

⚠ CAUTION

The flywheel is heavy. Do not attempt to remove the flywheel without the help of an assistant or a suitable lifting device. Failure to heed this caution may result in severe personal injury and property damage.

1. Remove the clutch assembly.
2. Carefully remove the flywheel sensor.
3. Install two M10 screws to use as handles to aid in removal.
4. Remove the flywheel.
5. Using the puller, 9990192, and the slide hammer, 9996400, carefully remove the seal. Make sure that the tools are free of burrs and dirt.

NOTE

Take care not to damage the crankshaft or flywheel sealing surfaces. Slant the tools inward to get a good grip on the crankshaft rear seal.

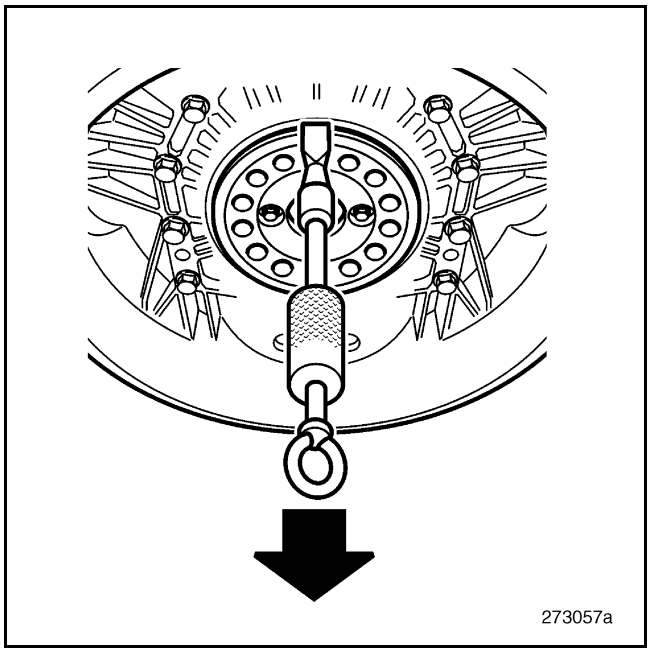


Figure 393 — Removing Crankshaft Rear Seal

6. Tap out the crankshaft rear seal.
7. Thoroughly clean the sealing surfaces of the flywheel, flywheel housing and crankshaft.

Teflon® Seal Installation

1. Install the plate and thrust screw part of tool, 9990166, to the crankshaft. Tighten the assembly screws securely.

NOTE

Make sure that the plate of the tool is positioned properly in the crankshaft internal guide and is flat against the crankshaft before tightening the screws.

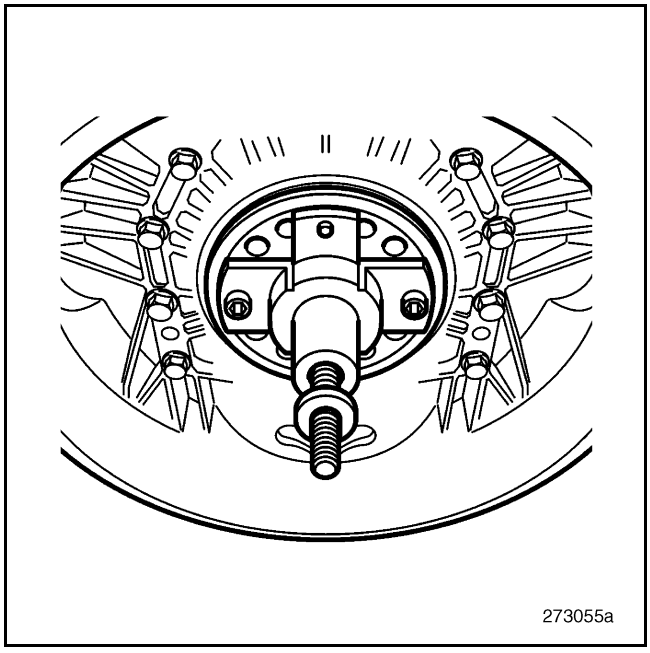


Figure 394 — Install Plate and Thrust Screw Assembly

2. Install the spacer, 88880013, of tool, 9990166, on the thrust screw.

NOTE

The spacer is important because it determines the installation depth of the crankshaft rear seal.

3. The sealing ring is supplied with a plastic installation ring that should be left in place during installation.

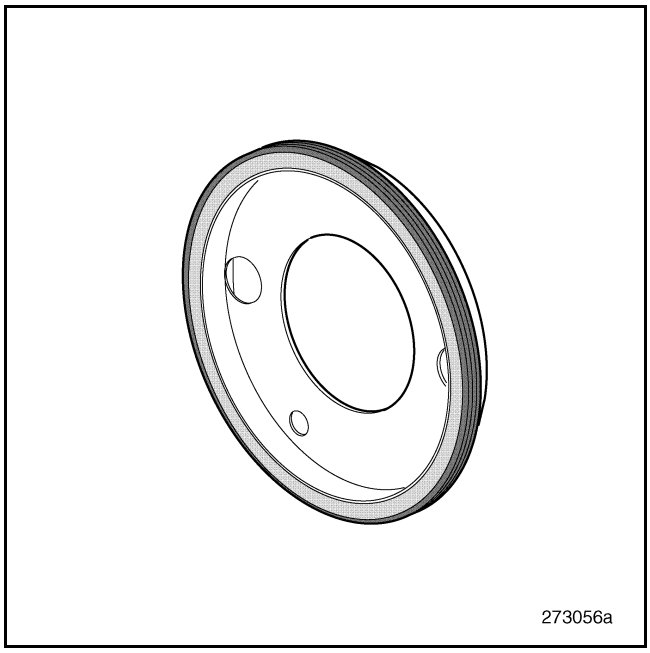


Figure 395 — Crankshaft Rear Seal

4. Install the seal without removing the installation ring over the thrust screw, spacer and plate assembly.

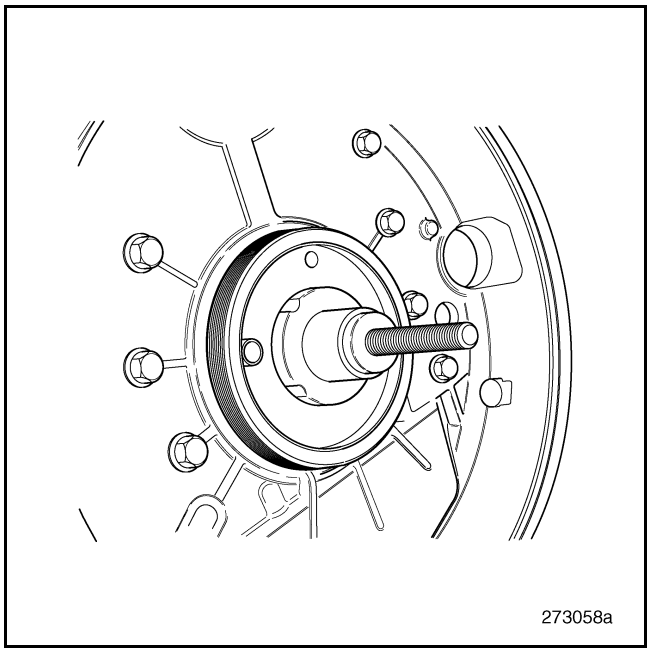


Figure 396 — Crankshaft Rear Seal Positioned on Tool

5. Install the cover and handle over the assembly. Center the cover over the crankshaft rear seal and thread the handle to keep the cover in position.

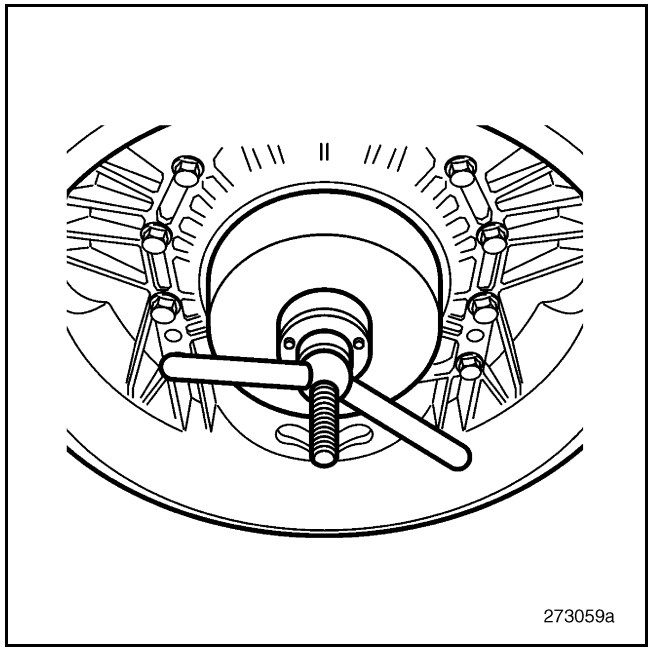


Figure 397 — Cover and Handle Installed

6. Turn the handle to press the crankshaft rear seal over the crankshaft and into the flywheel housing. When the cover bottoms out against the spacer, the rear seal is in proper position.
7. Remove the crankshaft rear seal installation tools.

8. Using the M10 screws as handles, with the help of an assistant or a lifting device, assemble the flywheel over the dowel and alignment studs on the mounting surface.

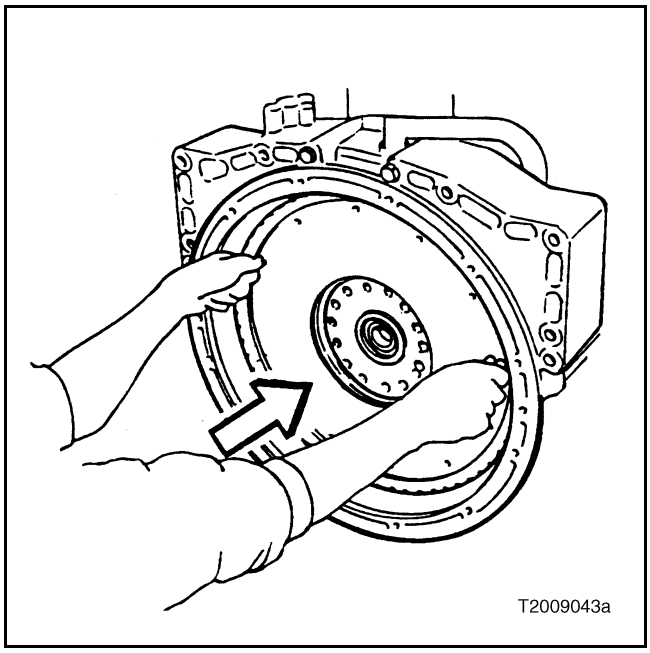


Figure 398 — Flywheel Installation

9. Insert the flywheel mounting screws finger tight. Remove the M10 screws to insert the remaining mounting screws.
10. Using a torque wrench, tighten the mounting screws in sequence according to specification.
11. Carefully install the flywheel sensor and connect it to the harness.

CRANKCASE VENTILATION (CCV) SEPARATOR REPLACEMENT

CCV Separator Removal

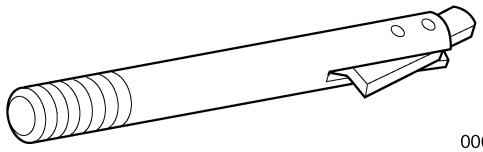
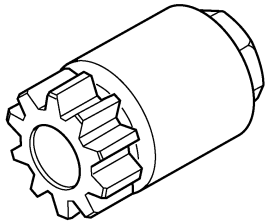
1. Disconnect the batteries, or turn off the main switch.
2. Clean the cylinder block around the CCV separator mounting.
3. Detach the CCV hoses.
4. Remove the CCV separator from the cylinder block.

CCV Separator Installation

1. Clean the mounting surfaces on the cylinder block and the CCV separator.
2. Using a **new** gasket, assemble the CCV separator on the cylinder block.
3. Using a torque wrench, tighten the screws according to specification.
4. Attach the CCV hoses.
5. Turn on the main switch, or reconnect the batteries.
6. Start the engine and check for leaks.

OIL PUMP REPLACEMENT (IN CHASSIS) [219 MU]

Special Tools

Tool No.	Description	Image
9998649	Block Stiffener Plate Assembly Tool	 006894a
88800014	Flywheel Turning Tool (Essential)	 271485a

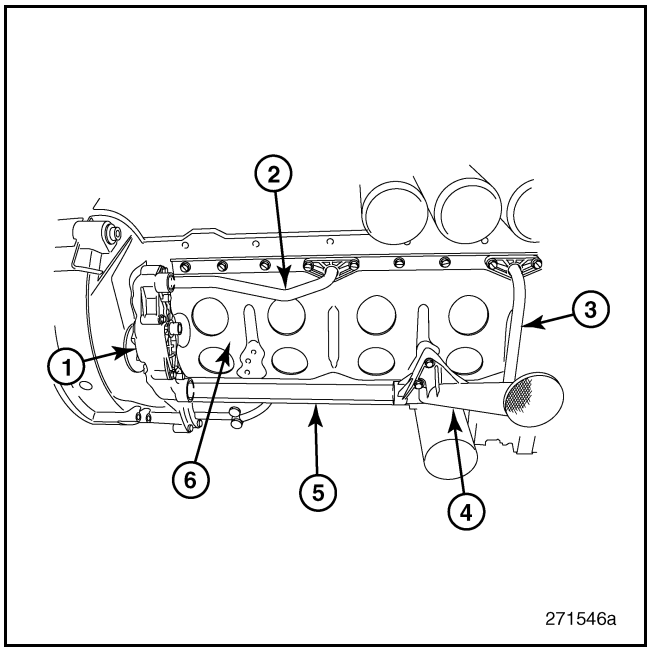


Figure 399 — Oil Pump, Pickup and Distribution System

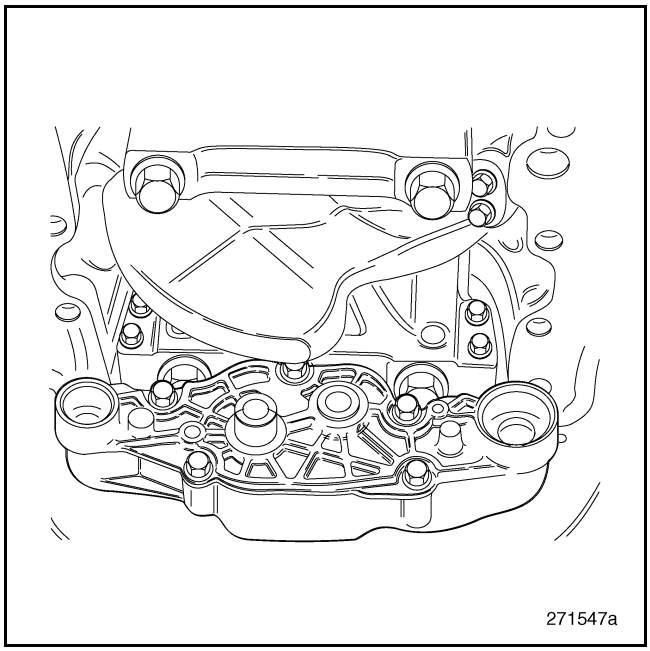


Figure 400 — Oil Pump

1. Oil Pump	4. Strainer
2. Pump Outlet Pipe	5. Pump Inlet Pipe
3. Crossover Pipe	6. Block Stiffener Plate

Oil Pump Removal

1. If not already done, remove the oil pan.
2. Remove the pump inlet pipe and strainer.
3. Remove the pump outlet pipe.
4. Remove the crossover pipe.
5. Remove the block stiffener plate.

⚠ CAUTION

Wear gloves when handling the block stiffener plate. It has sharp edges. Failure to heed this caution could result in severe personal injury.

6. If necessary, rotate the crankshaft out of the way using flywheel turning tool, 88800014.
7. Remove the oil pump from the bearing cap.

Oil Pump Installation

1. Clean all parts to be reused.
2. Attach the oil pump to the No. 7 main bearing cap.
3. Using a torque wrench, tighten the screws according to specification.

⚠ CAUTION

Make certain that the bearing insert is in good condition and properly installed on the bearing cap. Failure to heed this caution may result in severe component damage.

4. Using **new** screws and assembly tool, 9998649, attach the block stiffener plate to the block. Do NOT torque-tighten the screws at this time.
5. Lubricate and assemble **new** O-rings on the inlet, crossover and outlet pipes.

6. Assemble the crossover and outlet pipes in the pump housing and install the mounting screws to secure the pipe flanges to the stiffener plate and block.
7. Using a torque wrench, tighten the stiffener plate screws (including pipe flange screws) in sequence according to specification.
8. Assemble the inlet pipe and strainer.
9. Assemble the pipe and strainer in the pump housing and on the block.
10. Using a torque wrench, tighten the screws according to specification.
11. Inspect the oil pan seal and replace it if necessary. Lubricate and assemble the seal on the oil pan.

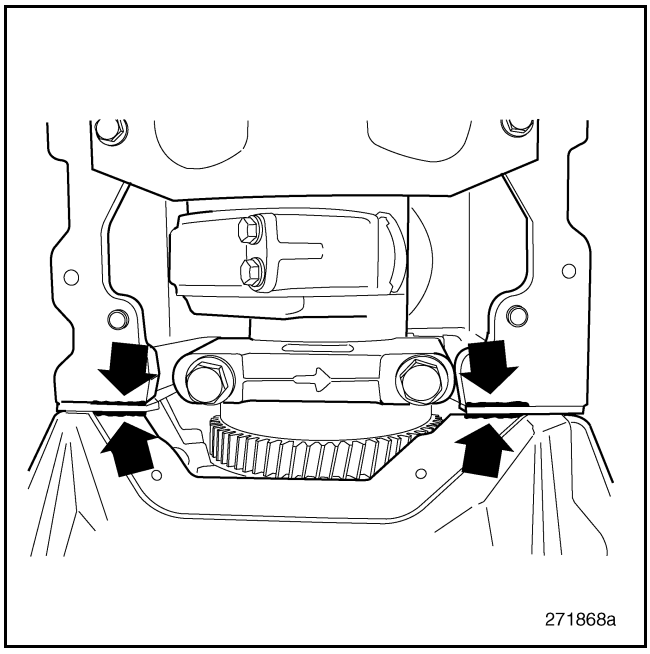


Figure 401 — Sealant Points — Flywheel Housing to Timing Gear Plate and Plate to Block

12. Apply a 2 mm (5/64 inch) bead of 342SX33 MACK-approved sealant to the seams between the flywheel housing and timing gear plate and between the mounting plate and the cylinder block.

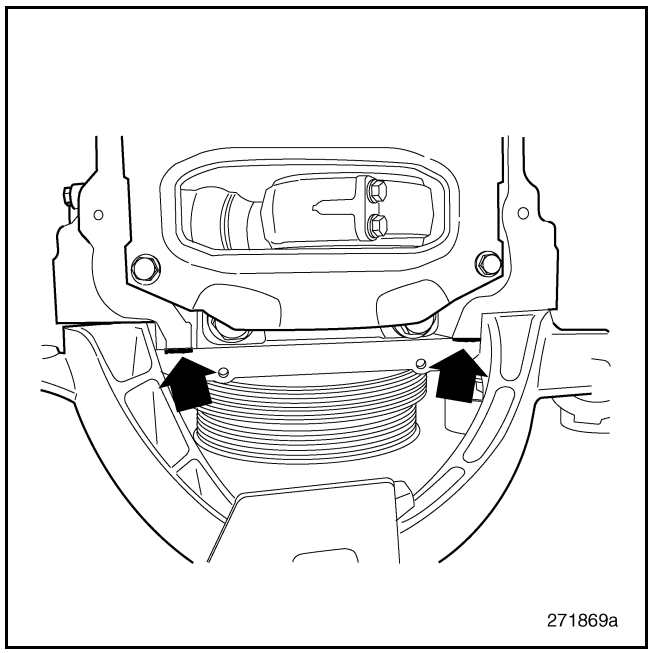


Figure 402 — Sealant Points — Front Seal Cover to Block

13. Apply a 2 mm (5/64 inch) bead of 342SX33 MACK-approved sealant to the seams between the front seal cover and the cylinder block.
14. Attach the oil pan to the cylinder block.
15. Using a torque wrench, tighten the screws in sequence according to specification.

⚠ CAUTION

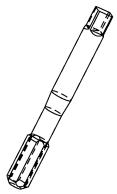
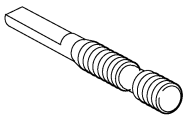
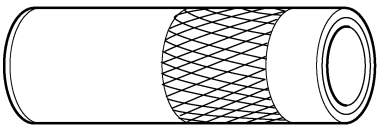
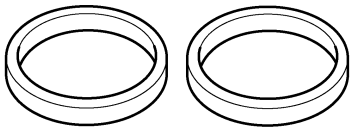
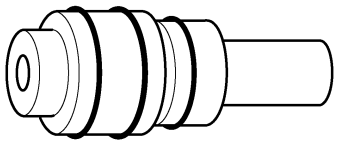
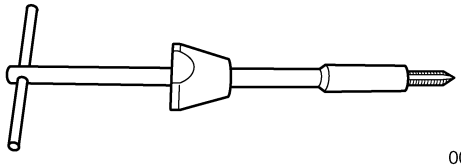
Use a steel washer. Do not use a copper washer. Do not use an impact wrench to install the drain plug. Failure to heed this caution may result in property damage.

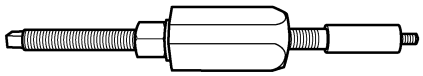
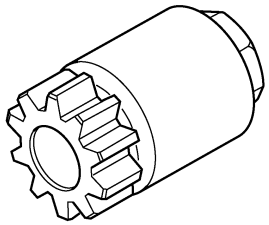
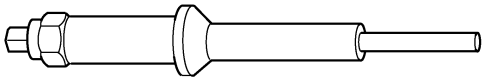
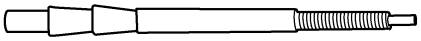
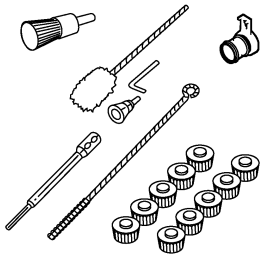
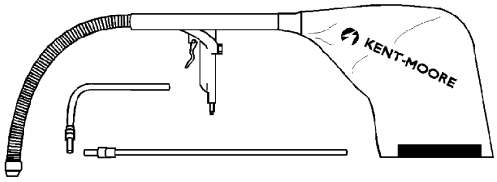
16. Install the drain plug.
17. Check system oil pressure through the pressure sensor port in the oil filter housing.

INJECTOR COPPER SLEEVE REPLACEMENT [213 EV]

Tools and Equipment

SPECIAL TOOLS

Tool No.	Description	Image
9809667	Injector Copper Sleeve Tap (Essential)	 006961a
9809668	Injector Copper Sleeve Extractor (Essential)	 006916a
9998249	Unit Injector Protection Sleeves (Essential)	 006798a
9998250	Unit Injector Bore Gallery Sealing Rings (Available)	 006799a
9998251	Unit Injector Bore Sealing Plug (Essential)	 006800b
9998252	Unit Injector Sleeve Tap (Essential)	 006801a

Tool No.	Description	Image
9998253	Unit Injector Sleeve Remover (Essential)	 006802a
88800014	Flywheel Turning Tool (Essential)	 271485a
88800196	Swedging Tool for Installing Unit Injector Copper Sleeve (Essential)	 006805a
88880010	Swedging Tip for Copper Sleeve Swedging Tool (Available separately)	 006842a
J 42885	Unit Injector Bore Cleaning Kit (Essential)	 006926a
PT-2900	Chip Vacuum (Essential)	 006962a

Preliminary Steps

The following components need to be removed for access to the injector copper sleeves (see ENGINE DISASSEMBLY for procedures):

- Cylinder Head Cover
- Rocker Arm Shaft
- Unit Injector(s)

Copper Sleeve Removal

1. If the injector sleeve is not being removed immediately, install the protective plug into the unit injector bore of the cylinder head to protect it from debris.

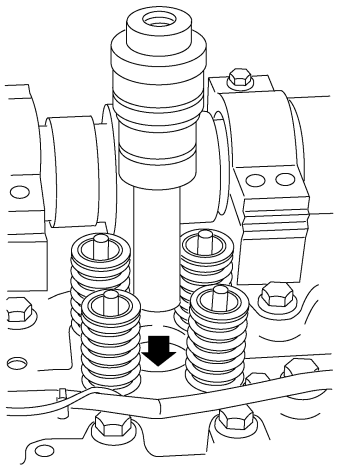


Figure 403 — Unit Injector Bore Protective Plug

2. Install two sealing rings to prevent dirt from entering the fuel gallery when the copper sleeve is removed.

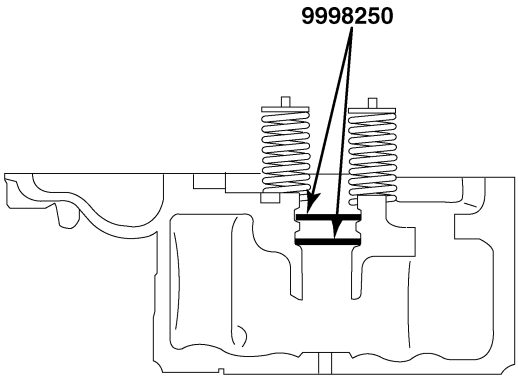


Figure 404 — Fuel Gallery Sealing Rings

NOTE

Two sealing rings are required to cover the fuel gallery.

3. Remove the plug from the lower front side of the flywheel housing and install the flywheel turning tool. Turn the flywheel until the piston is at its lowest position in the cylinder.

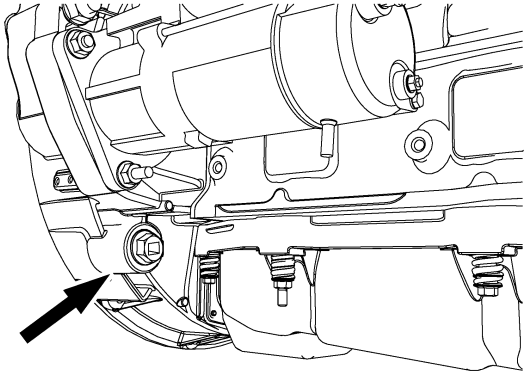


Figure 405 — Flywheel Turning Tool

NOTE

This is to ensure that the copper sleeve tapping tool does not damage the piston due to tool length.

Ensure the turning tool is well greased before attempting to turn the flywheel.

4. Adjust the 9 mm tap so that it extends a minimum of 25 mm or 1 inch (dimension A) from the end of the tapping tool.

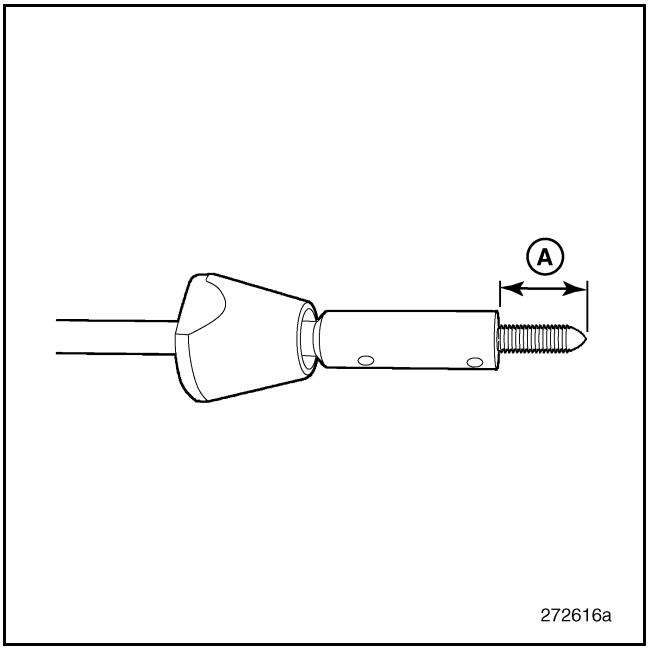


Figure 406 — Copper Sleeve Tapping Tool

NOTE

This ensures that the tip of the copper sleeve is tapped all the way through.

⚠ CAUTION

If the copper sleeve is not completely tapped through to the opening of the tip, an end piece of the tip can break off and fall into the cylinder during removal.

5. Lubricate the tip of the 9 mm tap with grease.

NOTE

Applying grease will capture copper cuttings and prevent them from falling down into the cylinder.

6. Thread the tap in small increments. Remove the tap and wipe off the grease and copper sleeve shavings. Apply fresh grease, reinstall the tapping tool and thread more of the copper sleeve. Continue this process to thread the tap all the way through the copper sleeve until no resistance is felt and the tap turns freely. Tapping in small increments and removing the shavings minimizes the chance of shavings falling into the cylinder and the sleeve turning in the cylinder head. Ensure that the tap is completely through the copper sleeve.

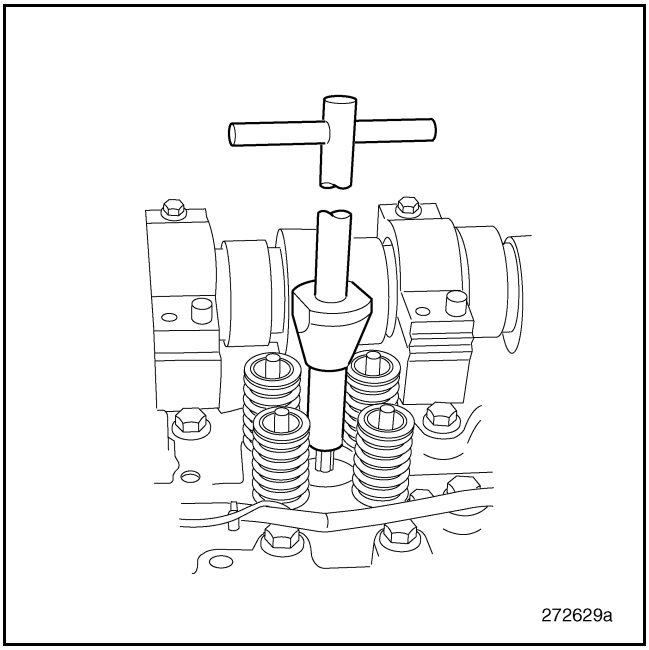


Figure 407 — Tapping Tool Installation

⚠ CAUTION

If threads are not cut completely through the tip of the copper sleeve, the tip can break off and fall into the cylinder. This can result in damage to the cylinder, piston, valves or turbocharger.

7. Remove the tap and tapping tool.
8. Using the chip vacuum, remove any remaining shavings from the copper sleeve.

9. Install the extractor bolt into the end of the extractor tool. Adjust the bolt until it extends approximately 22 mm (0.9 inch) beyond the end of the tool (dimension A).

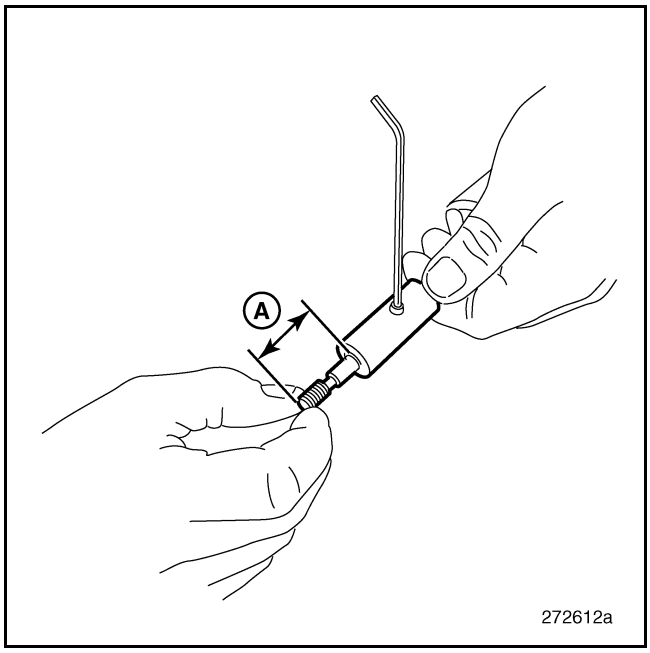


Figure 408 — Adjusting Copper Sleeve Extractor Bolt

10. Tighten the set screw of the extractor tool to secure the bolt. Make sure that the set screw is seated against the flat part of the extractor bolt.
11. Place the extractor tool with the bolt into the injector bore. Make sure the nut on the spindle is backed off so that the threaded end can be completely installed through the copper sleeve tip. Hand tighten until the bolt bottoms out in the sleeve.

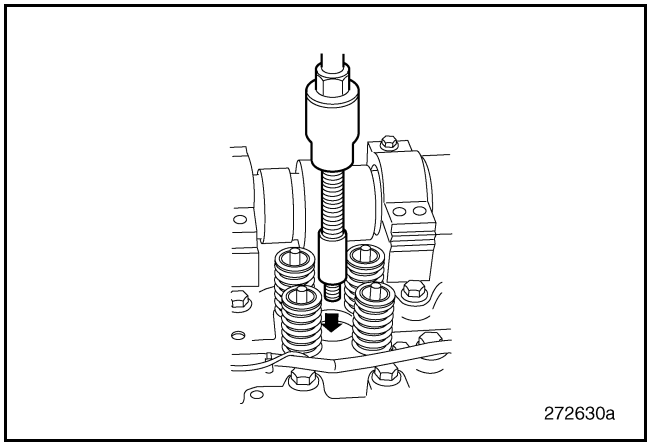


Figure 409 — Extractor Tool Installation

⚠ CAUTION

Make sure the extractor bolt is threaded completely into the copper sleeve before attempting to remove it or the tip of the sleeve may break off as it is removed. This broken sleeve tip can seriously damage the piston, valves or turbocharger.

12. While holding the top of the tool stationary, turn the large nut clockwise to extract the copper sleeve.

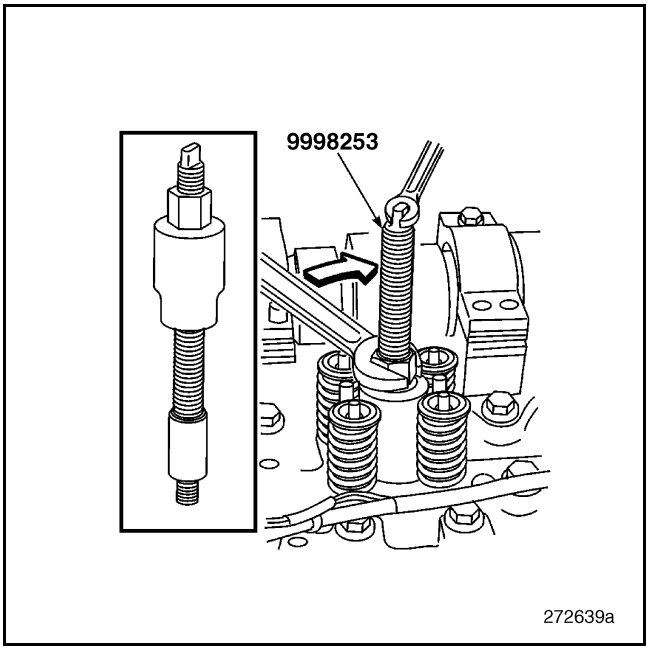


Figure 410 — Copper Sleeve Extraction

NOTE

When the copper sleeve is removed, make sure that the extractor bolt is extended at least one thread beyond the copper sleeve. If not, make sure that no part of the copper sleeve has broken off and fallen into the cylinder.

⚠ CAUTION

Do not use air tools to remove copper sleeves, or damage to the injector bore can result.

13. Remove the two sealing rings from the fuel passage. Using the chip vacuum, remove any remaining debris from the injector bore.

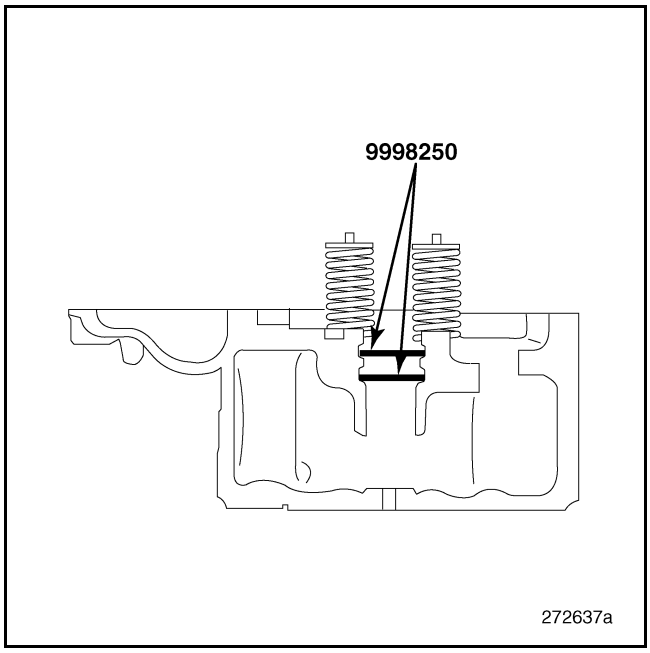


Figure 411 — Fuel Gallery Sealing Rings

14. Install the injector bore sealing tool (J 42885-25) to protect the fuel passage area and prevent debris from entering. Use the unit injector hold down bolt to secure the tool in the cylinder head.
15. Using the injector bore cleaning kit, clean the copper sleeve seat of the cylinder head.

NOTE

The injector bore sealing tool must be used to prevent dirt from entering the fuel passage.

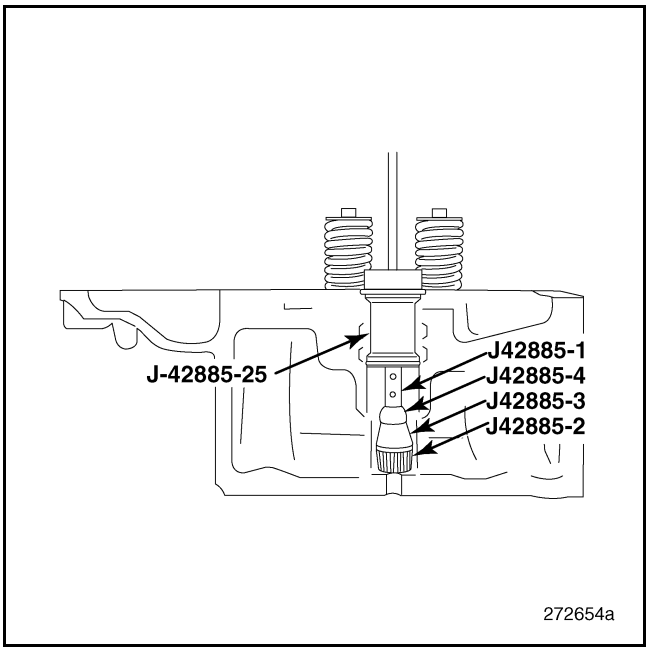


Figure 412 — Cleaning Copper Sleeve Seat

16. Using the brush, clean the cylinder head injector bore walls for the copper sleeve.

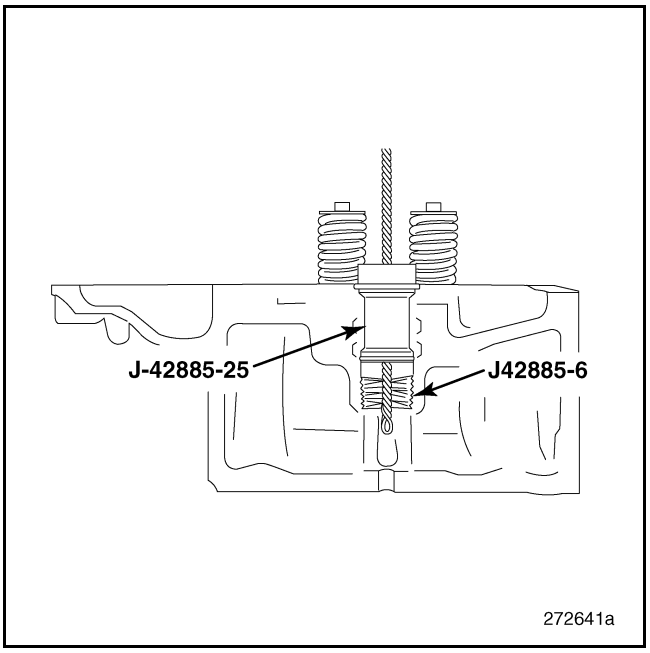


Figure 413 — Cleaning Copper Sleeve Bore Walls

NOTE

The injector bore sealing tool must be used to prevent debris from entering the fuel passage.

17. Using the brush, clean the copper sleeve opening in the cylinder head.

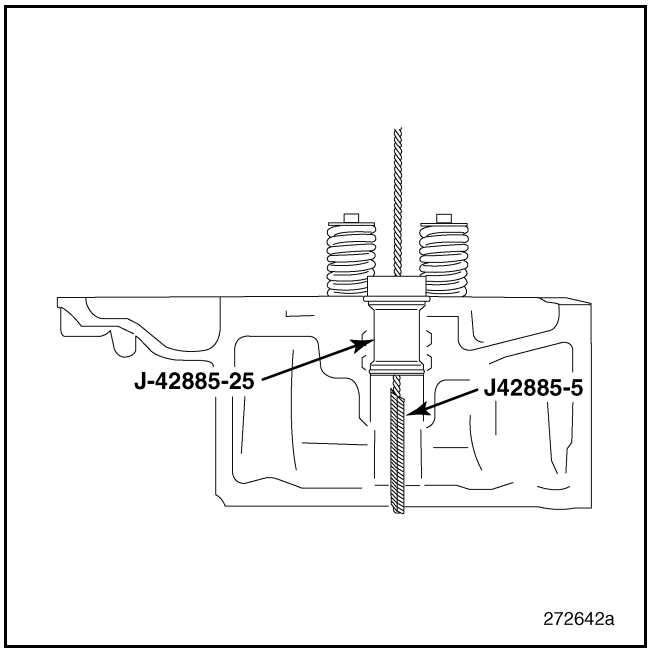


Figure 414 — Cleaning Injector Tip Bore

NOTE

The injector bore sealing tool must be used to prevent debris from entering the fuel passage.

When replacing the copper sleeves, it is important to check that the sleeve bore in the cylinder head is free from any carbon deposits or other residue (i.e., pieces of O-ring, etc.) before installing a new copper sleeve. Reclean if necessary.

18. Using the chip vacuum, remove all debris from the copper sleeve bore.

SERVICE HINT

Do not attempt to blow away debris using compressed air. Doing so can result in eye injury.

19. Remove the injector bore sealing tool from the cylinder head. Using the chip vacuum, remove any remaining debris.

Copper Sleeve Installation

1. Ensure the piston is at the lowest position in the cylinder. If not, use the flywheel turning tool to place the piston at its lowest position.

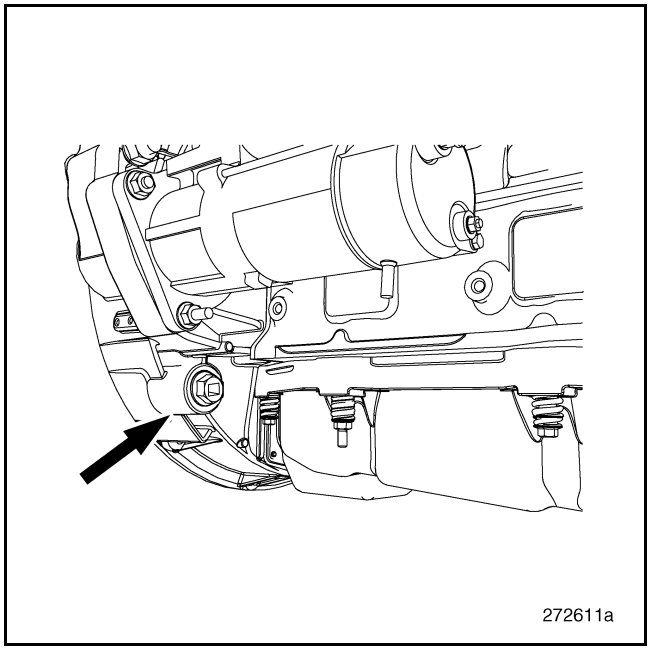


Figure 415 — Flywheel Turning Tool

NOTE

This is to ensure that the copper sleeve installation tool does not damage the piston due to tool length.

2. Before installing the copper sleeve, inspect it to ensure that it is the correct part.

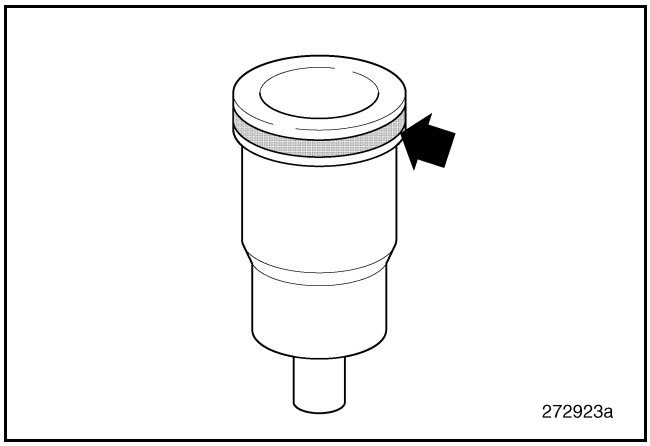


Figure 416 — Copper Sleeve and O-Ring

3. Lubricate a **new** copper sleeve O-ring with coolant. Install the O-ring on the copper sleeve and lubricate again with coolant. Always use a **new** O-ring.
4. Place the **new** copper sleeve on the installation tool.

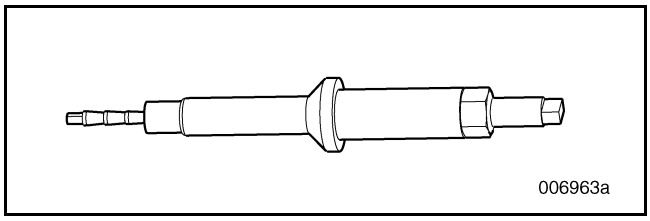


Figure 417 — Installation Tool Identification

⚠ CAUTION

Before installing the sleeve on the installation tool, inspect the tool to ensure that it is the correct tool. The correct tool is identified by a bottom surface that has a machined circular recess. Use of a tool with a perfectly flat bottom may result in damage to the copper sleeve.

5. Using calipers, measure the swedging bit to make sure that the proper swedging tool is used. Measurement should read approximately 7.8 mm. Also, verify that the length of the swedging bit is 108 mm.

⚠ CAUTION

Failure to use the proper bit can result in the bit breaking off into the cylinder head.

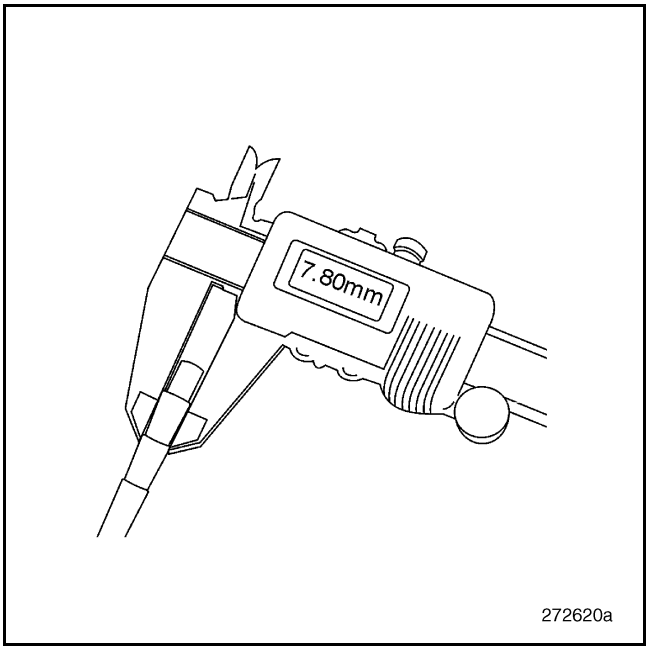


Figure 418 — Swedging Bit Verification

6. Thread the swedging bit completely into the flaring tool until it stops (finger tight).

NOTE

Swedging bit can be ordered as a spare part if the bit is worn or broken.

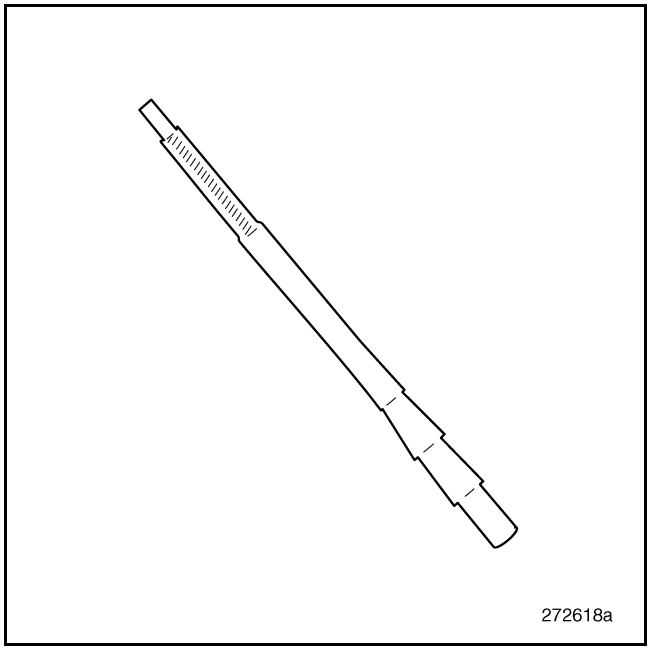


Figure 419 — Swedging Bit

7. Loosen the swedging bit 180 degrees before installing the tool in the cylinder head.

⚠ CAUTION

Failure to loosen the swedging bit can result in the bit being twisted or broken.

8. Lubricate the swedging bit and the threads on the tool with oil.

9. Carefully place the sleeve installation tool (with new copper sleeve attached) into the unit injector bore of the cylinder head. Carefully move the copper sleeve downward into the injector bore so that the swedging bit is guided into the injector tip bore in the cylinder head. Push downward on the installation tool using hand force to move the copper sleeve downward until it bottoms out on the injector sleeve seat in the bottom of the injector bore. Use the unit injector hold down and bolt to hold the tool in position. To ensure that the copper sleeve is bottomed in the cylinder head, tighten the unit injector hold down bolt to specification.

NOTE

Remove any oil from the injector hold down bolt holes to avoid hydraulic lock for this step and when the injector is installed.

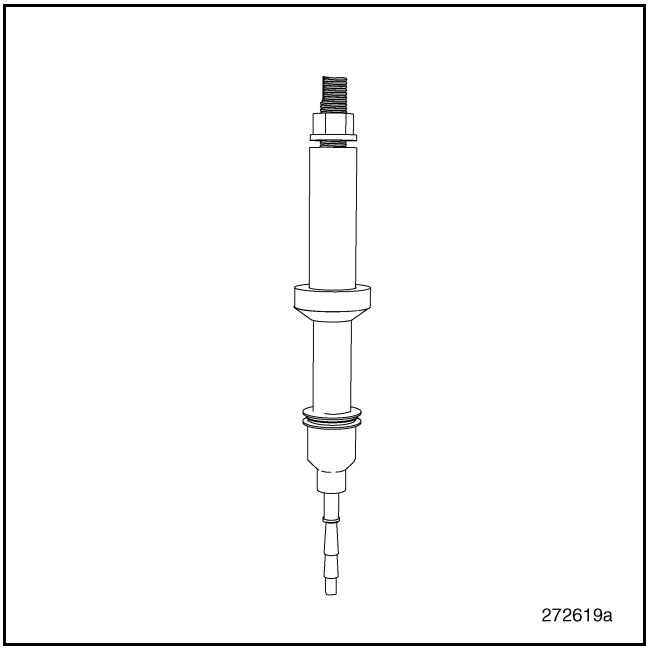


Figure 420 — Copper Sleeve Installation Tool

10. Flare the copper sleeve by turning the nut (1) clockwise while holding the spindle until the swedging bit has been pulled completely through the copper sleeve.

⚠ CAUTION

Failure to hold the spindle can result in a twisted or broken swedging bit.

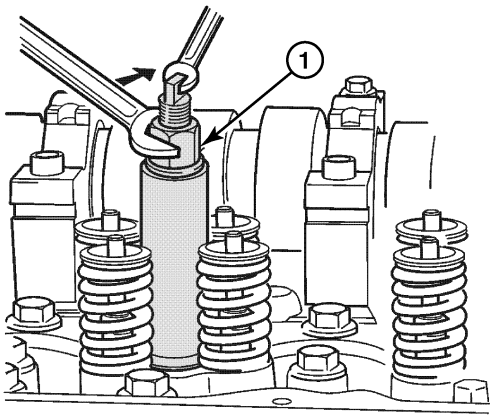


Figure 421 — Flaring Copper Sleeve Using Installation Tool

11. Remove the sleeve installation tool from the injector bore.

NOTE

If the injector is not being installed immediately, install the protective plug into the injector bore to protect it from debris.

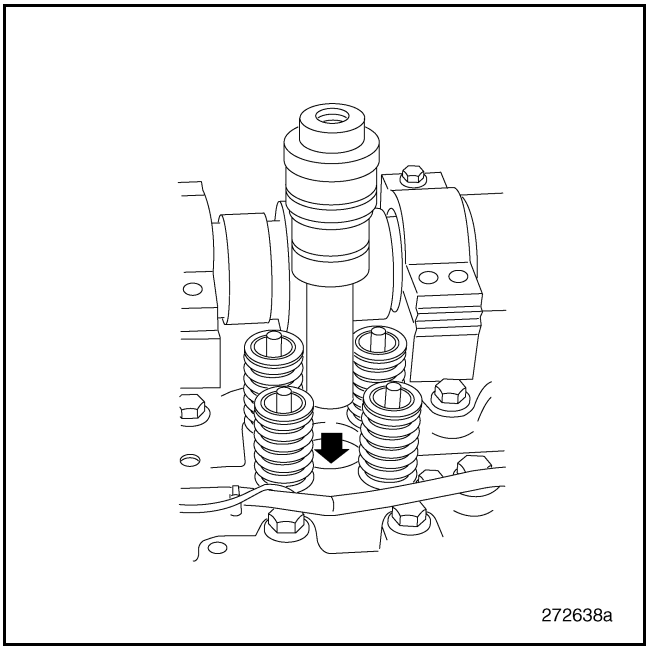


Figure 422 — Unit Injector Bore Protective Plug

Final Steps

Install the following components which were removed for access to the injector copper sleeves (see ENGINE REASSEMBLY for procedures):

- Unit Injector(s)
- Rocker Arm Shaft
- Cylinder Head Cover

UNIT INJECTOR CLEANING

Preliminary Steps

Remove the following components from the engine (see ENGINE DISASSEMBLY for procedures):

- Cylinder Head Cover
- Rocker Arm Shaft Assembly
- Unit Injectors

Install the sealing plug, 9998251, into the unit injector bore of the cylinder head to prevent dirt and debris from entering the bore.

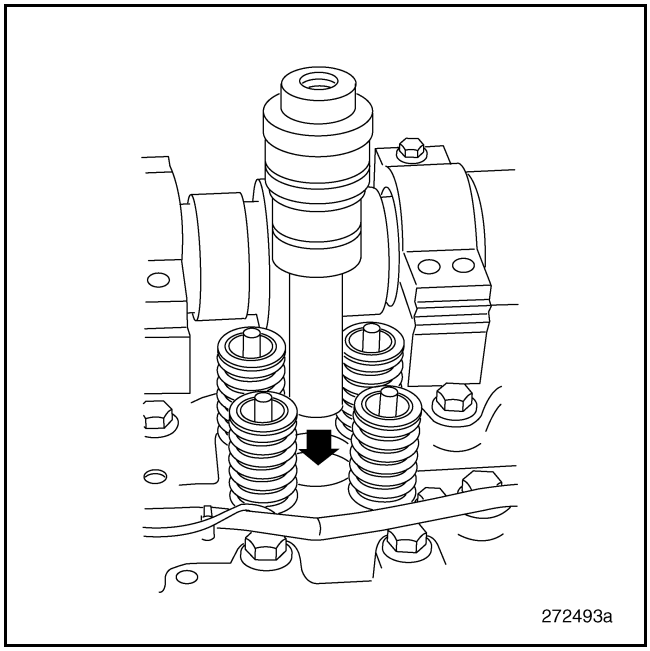


Figure 423 — Installing Injector Bore Sealing Plug, 9998251

Cleaning and Inspection

NOTE

Since the unit injectors operate at very high fuel injection pressures, the nozzle tip spray holes and the immediate area around the spray holes remain clean and free of carbon deposits. This leaves the cap nut seat surface as the only surface which requires a thorough cleaning.

Clean the injector **cap nut surface** as follows:

1. Remove the two O-rings from the injector and discard the O-rings.
2. Cover the O-ring grooves and the complete area between the grooves with tape or equivalent to prevent contaminants from getting into the injector.
3. Cover the opening for the electrical connection.
4. Slide a short section of 6 mm (0.25 inch) ID hose over the injector nozzle tip until it covers approximately half the nozzle tip length. This is necessary to protect the nozzle spray holes from damage when cleaning the cap nut seat surface.

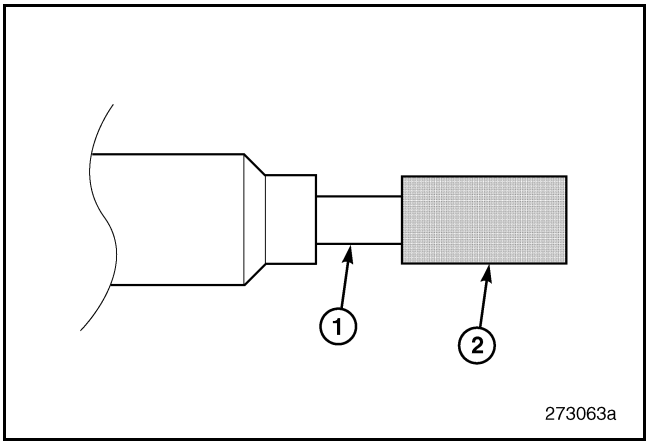


Figure 424 — Injector Nozzle Tip Cover

1. Injector Cap Nut Seat Surface	2. Hose (covering Nozzle Tip)

5. With the unit injector nozzle tip spray holes protected, carefully clean the cap nut seat surface of hard carbon deposits using a wire wheel. Apply only light nominal pressure to hold the wire wheel against the injector surface for short periods of time.

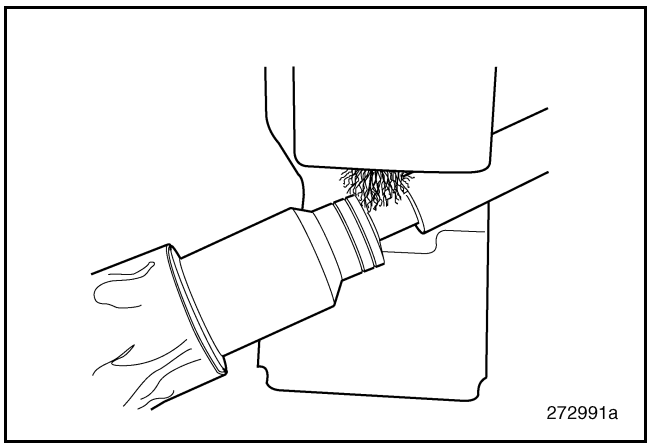


Figure 425 — Cleaning Injector Cap Nut Seat Surface

⚠ CAUTION

The carbon will be very hard and difficult to remove. Avoid the tendency to use excessive pressure in holding the wire wheel against the injector cap nut surface. Excessive force can damage the cap nut surface, making the injector unacceptable for reuse.

6. Clean any remaining carbon using hand tools such as a hand scraper or medium grit emery cloth.
7. After cleaning, inspect the injector nozzle cap nut seat surface for pitting or related damage. If there is pitting or other damage, replace the injector.

NOTE

Pitting on surfaces other than the cap nut seat does not affect the function of the unit injector and is acceptable.

8. Install **new** O-rings in the grooves on the injector.
9. Lubricate the injector O-rings with clean engine oil.

Final Steps

Install the following components on the engine (see ENGINE REASSEMBLY for procedures):

- Unit Injectors
- Rocker Arm Shaft Assembly
- Cylinder Head Cover

VALVE STEM HEIGHT MEASUREMENT PROCEDURE [213 FB]

On engines exhibiting poor performance, smoke (at times) and a noticeable engine miss (with the symptoms getting worse as the engine gets hotter), may be an indication of valve seat recession. A decrease in clearance (valve lash) between the valve rocker and valve yoke (bridge) can be measured at the valves to determine if seat recession is occurring. If valve seat recession is suspected, the following procedure can be used to measure valve stem height. To perform this measurement, a valve stem height measurement gauge (tool No. 85112461) and a depth micrometer are required.

NOTE

For detailed information on rocker arm shaft removal and installation procedures, refer to the applicable section of this service manual.

1. Remove components as necessary to gain access to the cylinder head (valve) cover.
2. Remove the cylinder head cover and rocker arm shaft assembly.

⚠ CAUTION

On engines equipped with an engine brake, use suitable tie straps or mechanics wire to retain the pistons in the rocker arms. The match between the pistons and rocker arms must be maintained. Failure to secure the engine brake pistons before removing the rocker shaft assembly, allows the pistons to drop from the bore of the rocker arms. If a piston drops out, it might not be noticed, or it may be difficult to push the piston fully back into the bore of the rocker arm. Also, pistons are a match-fit to the rocker arm, and so inadvertent mix-up of components must be avoided. Assembling the rocker arm shaft to the engine, or operating an engine with the engine brake pistons not fully retracted (or missing), results in breakage of valve train components and significant engine damage.

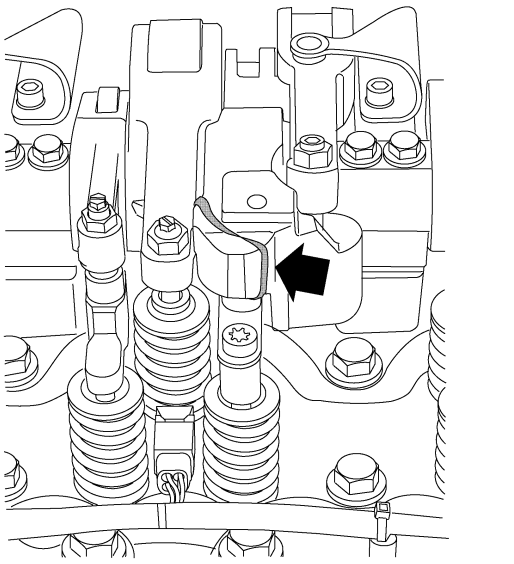


Figure 426 — Engine Brake Piston Retained

3. Remove the valve yokes (bridges).

NOTE

The valve yokes must be installed on the same set of valves that they were removed from. Before removing the valve yokes, mark them to identify their location and orientation. An incorrectly installed valve yoke causes severe engine damage due to a dropped valve. For proper valve yoke removal and installation, refer to the appropriate sections in this service manual.

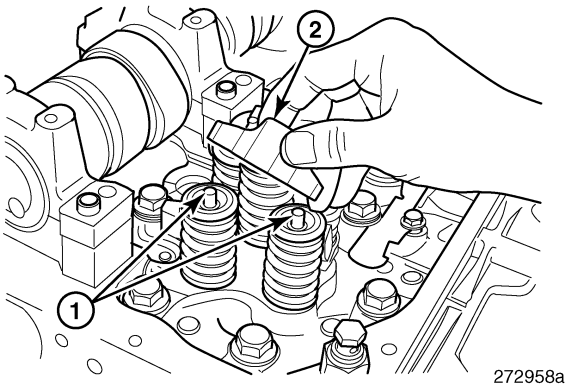


Figure 427 — Removing the Valve Yoke

1. Inlet Valve Stem Tips	2. Inlet Valve Yoke

4. Remove the screws securing the unit injector harness tie bar to the cylinder head. Slide the tie bar outward to provide sufficient clearance for the valve stem height measurement gauge to be installed over the valve springs. Do not disconnect the harness connectors from the unit injectors or cut the tie straps that secure the harness to the tie bar.

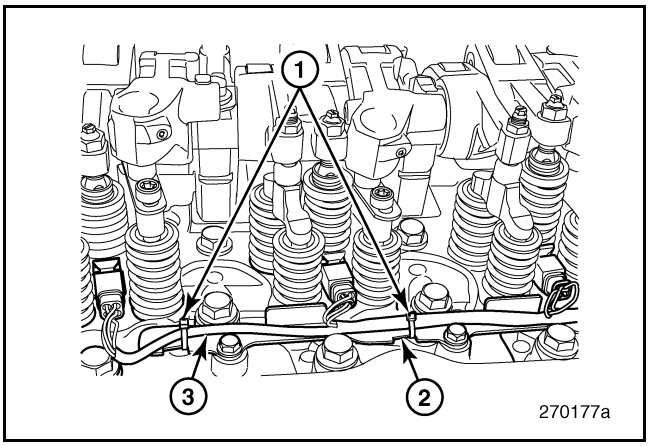


Figure 428 — Move Harness Tie Bar Outward

1. Tie Straps 2. Tie Bar Notch	3. Wiring Harness

5. Set the depth micrometer to 8.10 mm (0.319 inch) to measure stem protrusion.

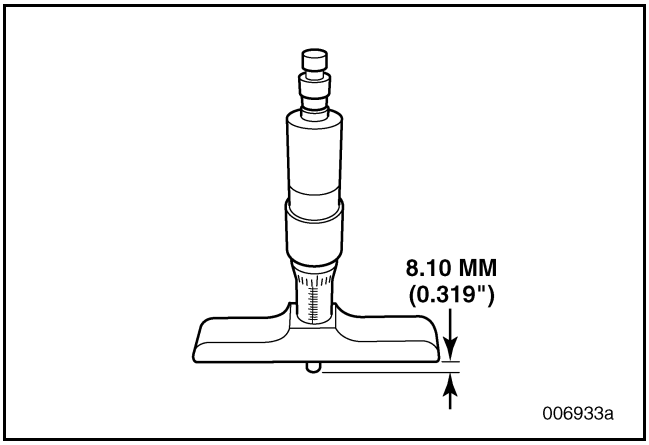


Figure 429 — Set Depth Micrometer

6. Place the valve stem height measurement gauge (tool No. 85112461) over the valve spring of the valve to be measured. Make sure the tool is fully seated on a clean surface.

NOTE

Make sure there are no particles of any kind between the bottom of the valve stem height measurement gauge and the cylinder head surface. Particles between the gauge and the cylinder head surface results in an inaccurate measurement.

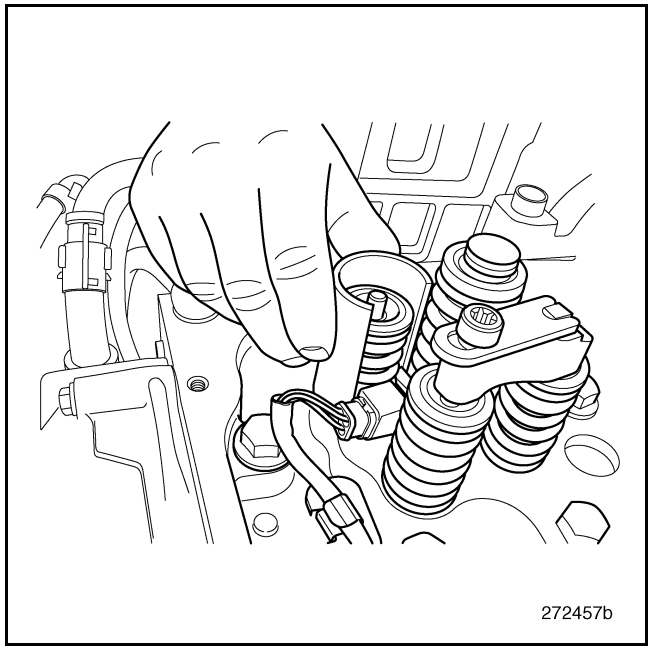


Figure 430 — Place Measurement Gauge over Valve Spring

7. Place the depth micrometer on top of the valve stem height measurement gauge and note if there is clearance between the end of the micrometer spindle and the tip of the valve stem.

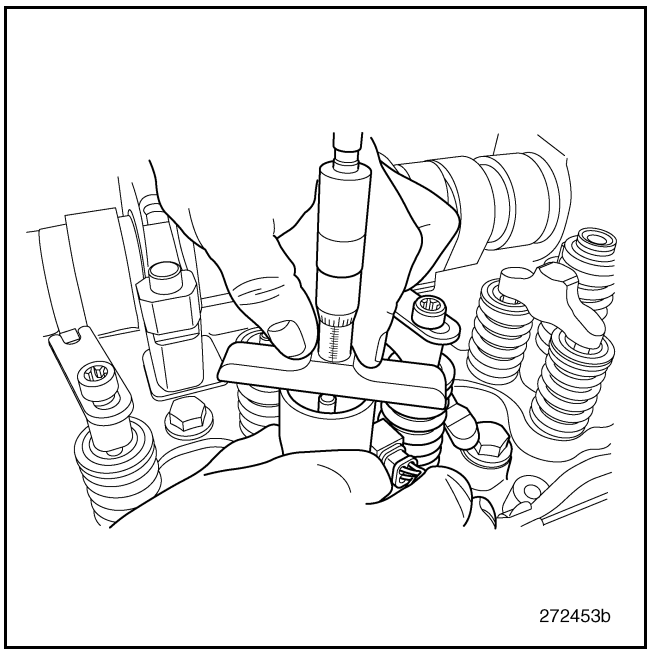


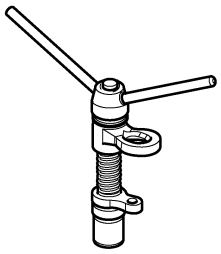
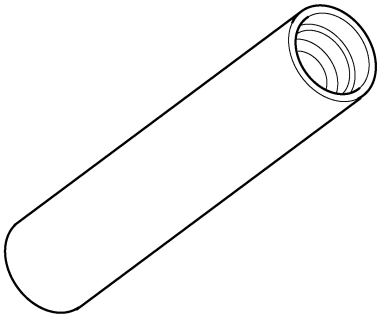
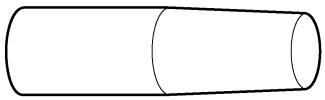
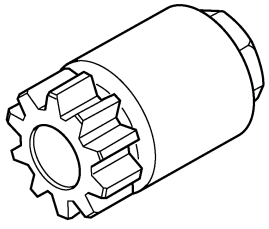
Figure 431 — Measuring Valve Stem Height

- If there is clearance between the tip of the valve stem and the tip of the depth micrometer spindle, valve height is within specification. Measure the next valve stem height using the same method.
- If valve stem height is less than 8.10 mm (0.319 inch), as indicated by the tip of the depth micrometer spindle contacting the tip of the valve stem, the valve seat is recessed. Replacement of the cylinder head is necessary.

8. Position the unit injector harness tie bar to the cylinder head, install the screws and tighten according to specification.
9. Install the valve yokes to their original location.
10. Install the rocker arm shaft assembly and remove the retainers securing the engine brake pistons. Adjust valve lash as necessary.
11. Install the cylinder head cover.
12. Install the components that were removed to gain access to the cylinder head cover.

VALVE STEM SEAL REPLACEMENT [213 MV]

Special Tools

Tool No.	Description	Image
9990210	Valve Spring Compressor (Essential)	 006782a
85112460	Valve Stem Seal Installation Tool	 006966a
88800011	Valve Stem Seal Protection Tool (Essential)	 006773a
88800014	Flywheel Turning Tool (Essential)	 271485a

Preliminary Steps

The following components need to be removed for access to the valve stem seals (see ENGINE DISASSEMBLY for procedures):

- Cylinder Head Cover
- Rocker Arm Shaft Assembly
- Unit Injectors

Seal Removal

NOTE

When replacing the valve stem seals, the pistons must be at TDC when the valves are released so that the valves do not drop into the cylinder.

1. Using the flywheel turning tool, 88800014, rotate the crankshaft so that the pistons are at TDC for the appropriate pair of cylinders where stem seals are being replaced.

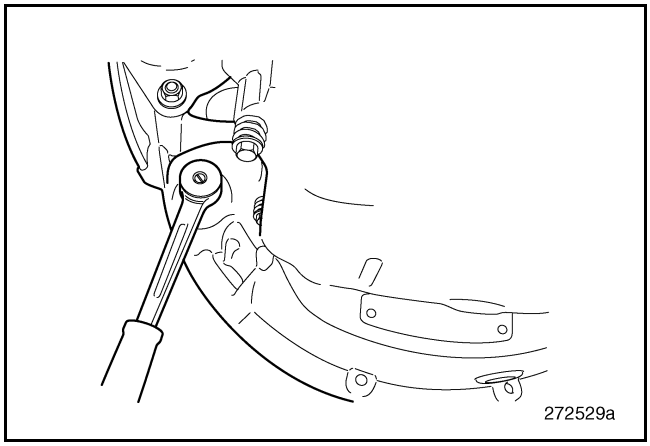


Figure 432 — Rotating Crankshaft

2. Using the valve spring compressor tool, 9990210, press down on the springs (one at a time) and remove the valve retainers and springs for the cylinder.

⚠ WARNING

Use protective goggles or eye injury could occur.

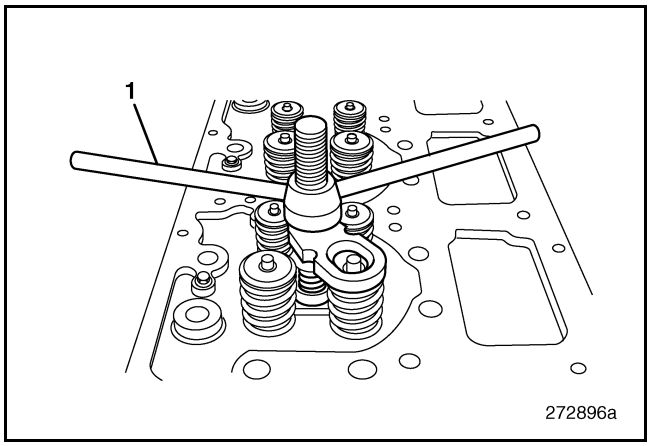


Figure 433 — Compressing Valve Springs

1. Valve Spring Compressor 9990210

3. Remove and discard the valve stem seals.
4. Using a clean cloth, thoroughly clean all engine oil off the valve stem and valve guide.

Seal Installation

1. Apply a thin film of clean engine oil to the outside diameter of the valve seal guide tool and to the sealing lips of the **new** valve stem seal to avoid damage to the seal as it is installed.

NOTE

Do NOT apply oil to the inner surfaces of the seal that contact the valve guide. These surfaces must be dry.

2. Place the seal guide tool, 88800011, in position on the valve stem.
3. Place a **new** valve stem seal in position over the guide tool and onto the valve stem.
4. Using the appropriate end of the seal installation tool, 85112460, seat the valve stem seal on the valve guide by gently tapping the installation tool with a light plastic or rubber mallet. When the seal is fully seated, a normal “spring-back” of the seal will occur, leaving a maximum gap of approximately 0.5 mm (0.02 inch) between the bottom of the seal and the shoulder surface on the valve guide.

⚠ CAUTION

Use only gentle taps with the hammer when seating the seal to avoid damage to the seal casing as well as the top rubber portion of the seal.

NOTE

Seal installation tool, 85112460, is designed for use on MP7, MP8 and MP10 engines. Use the appropriate end of the tool for the engine being serviced.

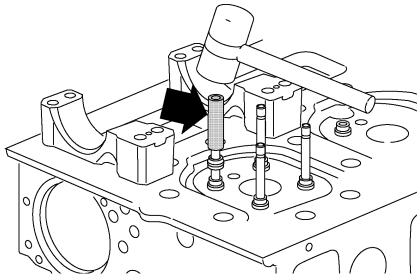


Figure 434 — Seating the Valve Stem Seal

5. Using the valve spring compressor, 9990210, install the valve spring and valve retainers. Carefully tap on the valve stem with a plastic or rubber hammer to ensure that the valve keepers are positioned correctly.

⚠ WARNING

Use protective goggles or eye injury could occur.

6. Move the valve spring compressor to the next cylinder of the cylinder pair and repeat the procedure. Rotate the crankshaft so that the pistons are at TDC for the next cylinder pair and repeat the procedure. Continue on and repeat the procedure for the final cylinder pair.

Final Steps

Install the following components which were removed for access to the valve stem seals (see ENGINE REASSEMBLY for procedures):

- Unit Injectors
- Rocker Arm Shaft Assembly
- Cylinder Head Cover

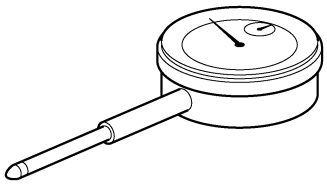
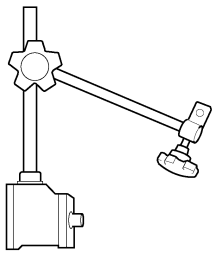
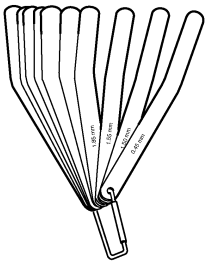
REPAIR INSTRUCTIONS, PART 3

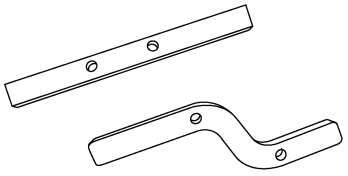
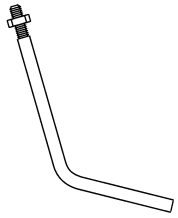
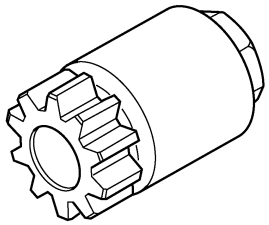
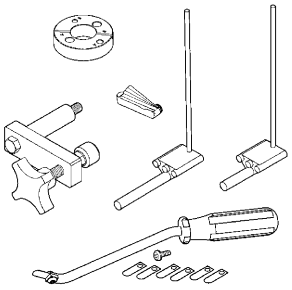
MP8 EURO 3 ENGINE SETUP AND ADJUSTMENT [200 EA]

NOTE

Due to the Engine Electronic Control Unit (EECU) self-learning capability, it is necessary to reset learned EECU parameters after servicing some engine-related components. This allows the EECU to learn the new component's behavior. After servicing is complete, perform the “Learned Data Reset” located in VCADS.

Special Tools

Tool No.	Description	Image
9989876	Dial Indicator (Available)	 006899a
9999696	Magnetic Base (Available)	 006900a
85111377	Feeler Gauge Set	 006844a

Tool No.	Description	Image
85111422 (A, B)	Timing Gear Cover Alignment Tool	 006924a
85111493	Angled Extension (Available)	 006898a
88800014	Flywheel Turning Tool	 271485a
J 44514-B	Engine Timing Kit (Essential)	 006889a

Valve and Unit Injector Adjustment [213 NB, 222 KG]

GENERAL INFORMATION

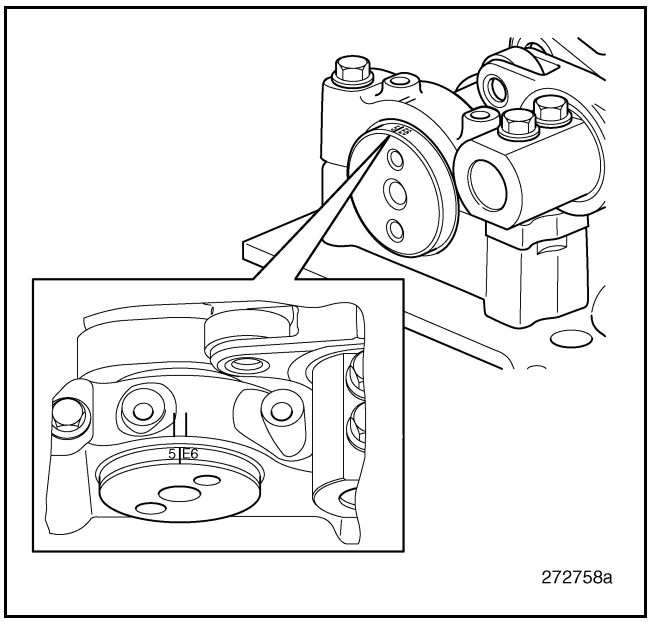


Figure 435 — Camshaft Timing Marks — Front Bearing Cap (4 Rocker Shown)

Timing marks for basic camshaft timing and adjustment of the valves and unit injectors are located at the front of the camshaft just forward of the No. 1 front bearing journal. Two lines at the top of the front bearing cap mark the alignment point for positioning of the camshaft and making the adjustments.

The top dead center (TDC) mark is used for basic camshaft timing. The TDC mark must be between the two lines on the front camshaft bearing cap when the flywheel is at 0° (top dead center for cylinder No. 1).

The engine must be cold, 60°C (140°F) or less, before making these adjustments.

Camshaft markings for setting of valves and unit injectors:

- **Without PowerLeash™**: Markings 1–6 apply to adjustment of inlet valves, exhaust valves and injectors.
- **With PowerLeash™**: Markings 1–6 apply to adjustment of inlet valves and injectors. Markings E1–E6/V1–V6 apply to adjustment of exhaust valves.

NOTE

— **4 Rocker** — Marked as E1–E6.

— **3 Rocker** — Marked as V1–V6.

INLET VALVE ADJUSTMENT

⚠ WARNING

Apply the parking brake before barring the engine over. Remove the EMS power supply fuse to avoid starting the engine unintentionally. Make sure that the transmission is not in gear.

With the engine cold, 60°C (140°F) or less, check and adjust the valves and injector as required for each cylinder before moving to the next. Follow this sequence of cylinders when adjusting clearances: 5, 3, 6, 2, 4 and 1.

1. Using the flywheel turning tool, 88800014, bar the engine over manually to the appropriate camshaft marking for adjustment of the inlet valves and injector for that cylinder.
2. Using a feeler gauge, check the clearance between the rocker arm adjusting screw and the valve yoke (bridge) of the inlet valves. Refer to Figure 436.

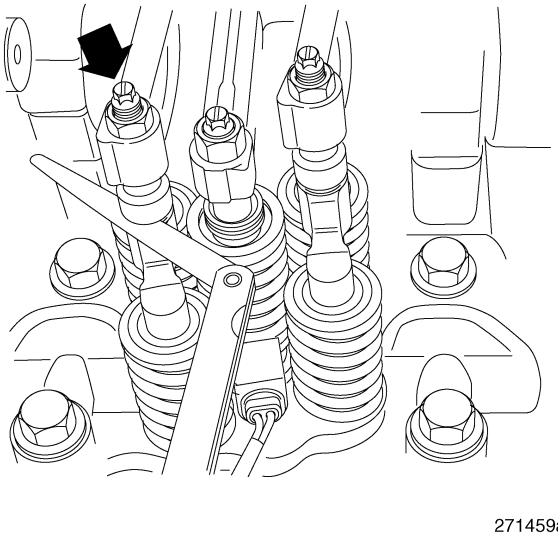


Figure 436 — Checking Inlet Valve Clearance

3. If the clearance is not within specification, loosen the locknut and adjust the clearance as required.
4. Hold the adjusting screw to prevent it from turning and tighten the locknut to specification.
5. Recheck the clearance after tightening the locknut.
6. Mark the rocker arm when adjustment is complete.

UNIT INJECTOR ADJUSTMENT

The unit injector adjustment is done with the engine and camshaft in the same position as for the inlet valve adjustment on each cylinder.

1. Loosen the injector rocker arm adjusting screw jam nut and turn the adjusting screw out (counterclockwise) to relieve the preload.
2. Turn the adjusting screw in (clockwise) until it firmly contacts the injector. Do not compress the spring.
3. Turn the adjusting screw in a further 240° (four flats on the hex head).

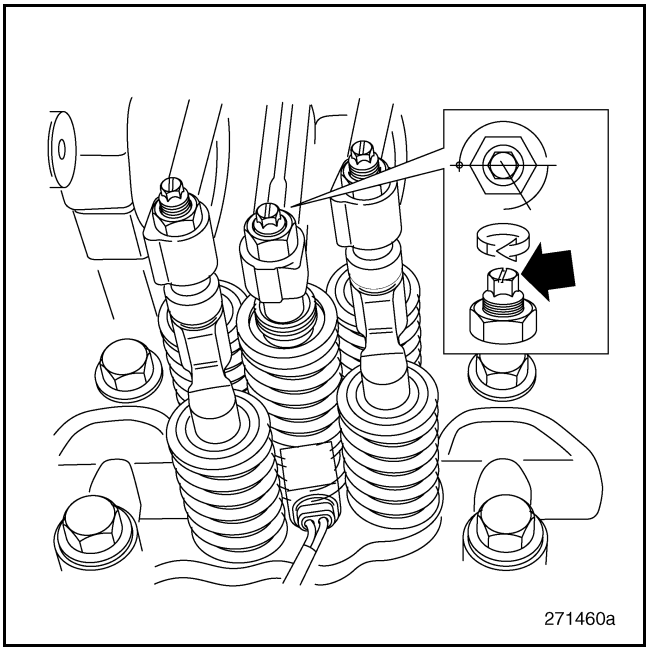


Figure 437 — Adjusting Unit Injector Clearance

4. Hold the adjusting screw to prevent it from turning further and, using a torque wrench, tighten the jam nut to specification.
5. Mark the rocker arm when adjustment is complete.

EXHAUST VALVE ADJUSTMENT (WITHOUT POWERLEASH™)

1. At the current camshaft setting used for the inlet valves, adjust the exhaust valves following the same procedure described for adjustment of the inlet valves. However, the valve clearance specification is different.

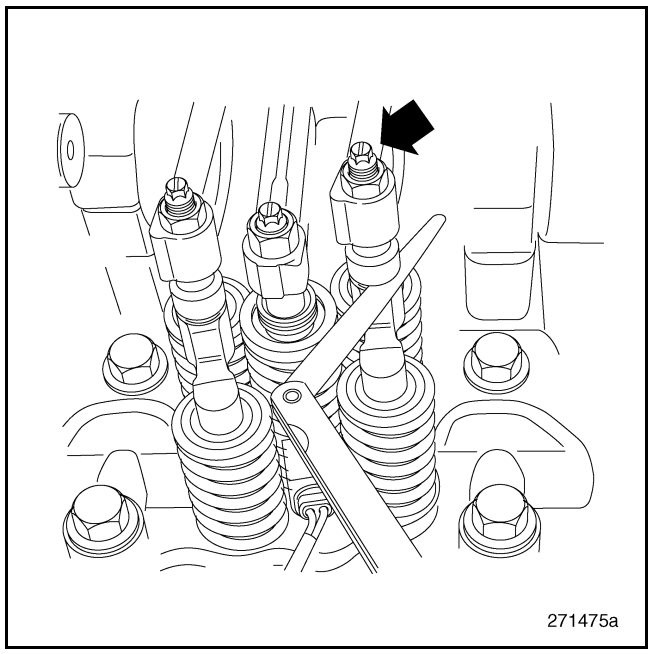


Figure 438 — Checking Exhaust Valve Clearance

2. Mark the rocker arm when adjustment is complete.
3. Using the flywheel turning tool, bar the engine over manually to the appropriate marking for the next cylinder. Adjust the inlet valves, unit injector and exhaust valves at that cylinder.

EXHAUST VALVE ADJUSTMENT (WITH 3-ROCKER POWERLEASH™)

NOTE

The numbers on the camshaft preceded by a **V** are used to adjust the exhaust valves when the engine is equipped with PowerLeash™.

1. Using the flywheel turning tool, 88800014, bar the engine over so that the appropriate **V** number marking for the respective exhaust valve is between the lines on the camshaft bearing cap.
2. Press down on the rocker arm as shown in Figure 439. If the rocker arm "springs," the brake piston spring should be pulled outward at the same time as the rocker arm is pressed down to make and ensure contact with the valve stem. Use a strong wire with a hooked end to catch and compress the spring. When the piston spring is loosened from its seat, the residual oil film retaining the spring is punctured, allowing the adjustment setting to be more accurate.

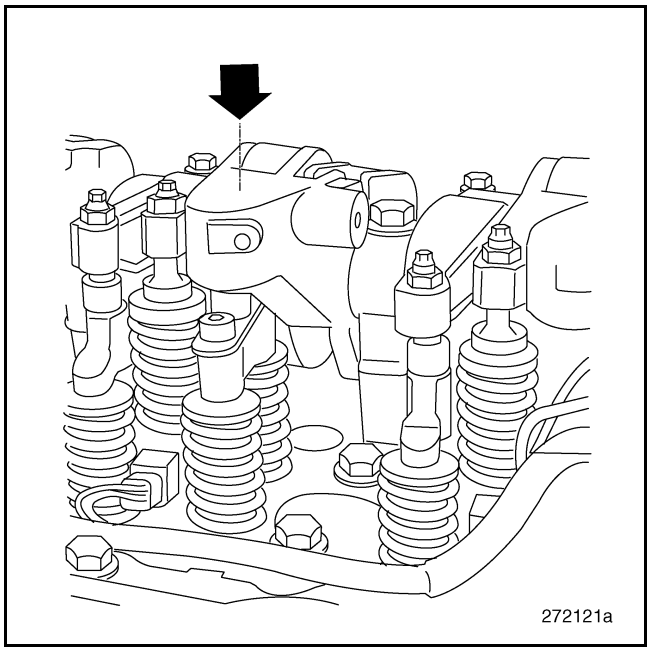


Figure 439 — Releasing Engine Brake Piston Pressure

3. Measure the clearance between the rocker arm piston and the shim on top of the yoke (bridge) as shown in Figure 440.

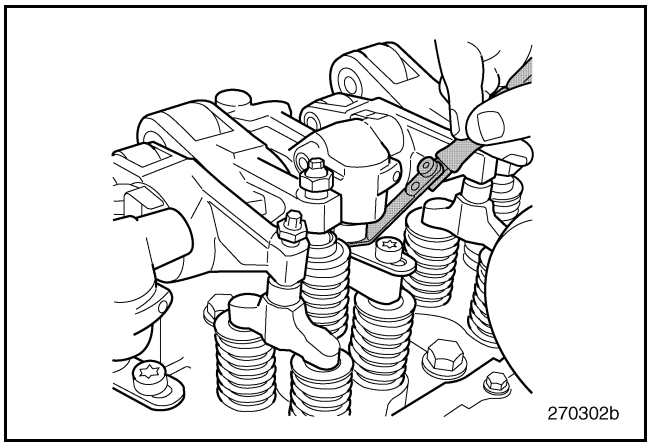


Figure 440 — Measuring Exhaust Valve Clearance

4. If clearance is not within specification, adjust the clearance as required, using shims (Figure 441) placed on top of the valve yoke (bridge).
   a. Remove the shim retaining screw and remove the shim(s).
   b. Determine the thickness of the shim(s) required to match the measured clearance.
   c. Make sure that the valve yoke and shim(s) are clean. Place the shim(s) in position on the valve yoke.

NOTE

DO NOT use more than two shims. Shims are available in 0.05 mm (0.002 inch) increments with the thickness marked on the surface. If two shims are required to take up the clearance, the shims should be of nearly equal thickness.

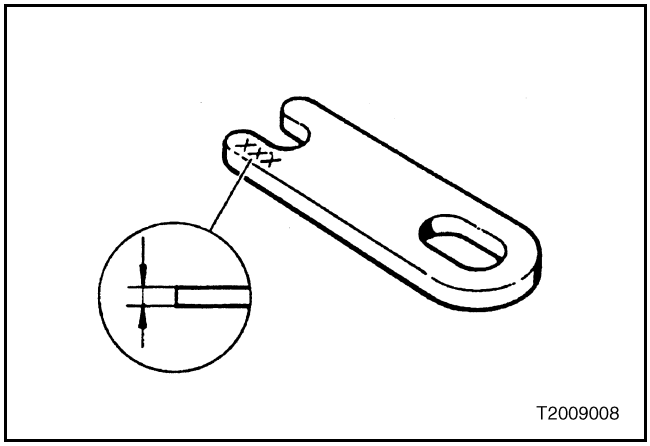


Figure 441 — Engine Compression Brake Adjustment Shim

5. With the required shim(s) in place, install the retainer screw securing the shim(s) to the valve yoke and tighten to specification. Hold the yoke securely while tightening the retaining screw.
6. Recheck the clearance between the exhaust valve rocker arm and the valve yoke.

SERVICE HINT

Mark the respective rocker arm as each valve adjustment is completed.

EXHAUST VALVE ADJUSTMENT (WITH 4-ROCKER POWERLEASH™)

NOTE

The numbers on the camshaft preceded by an ***E*** are used to adjust the exhaust valves when the engine is equipped with PowerLeash™.

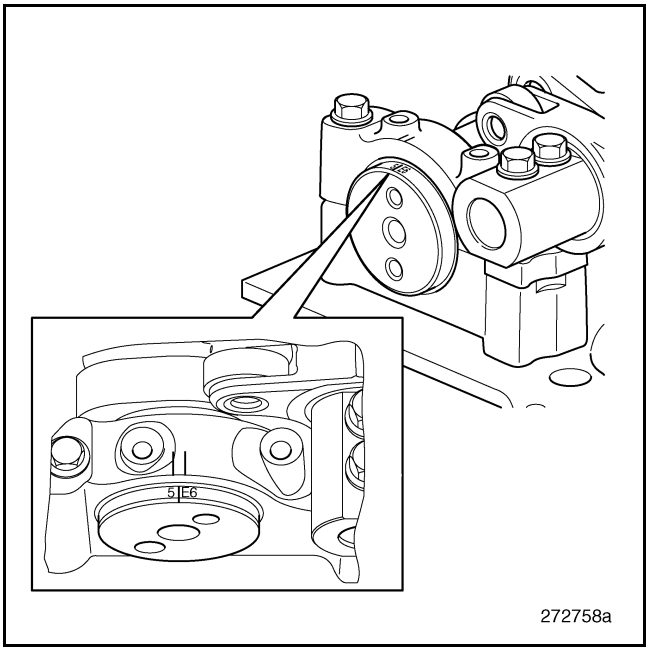


Figure 442 — Camshaft Timing Marks

Engines equipped with the PowerLeash™ engine brake have two rocker arms working in combination to control the exhaust valves. They are the **exhaust rocker arm** and the **brake rocker arm** which are adjusted separately as described in the following procedure.

1. Loosen the screws holding the plate springs to release the spring tension against the engine brake rocker arms.

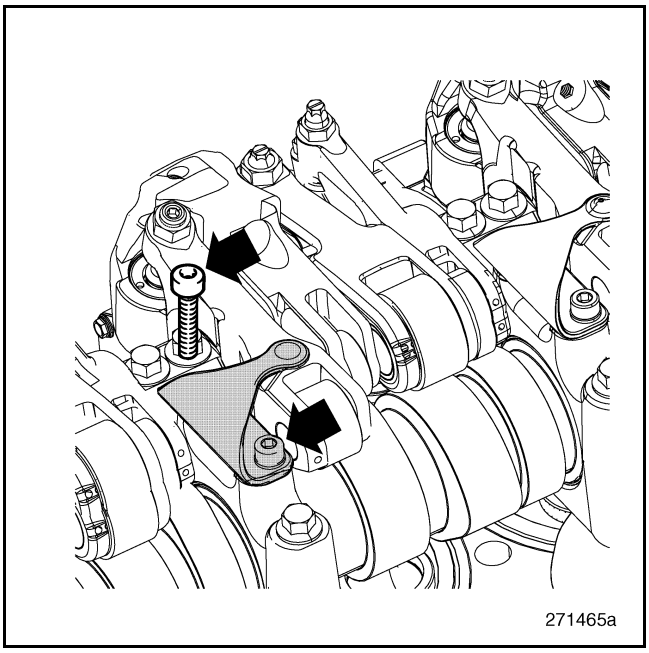


Figure 443 — Plate Spring Attaching Screws

2. Using the flywheel turning tool, 88800014, bar the engine over so that the appropriate ***E*** number marking is between the lines on the front camshaft bearing cap.
3. Measure the clearance between the exhaust rocker arm piston and the shim on top of the valve yoke (bridge) as shown in Figure 444.

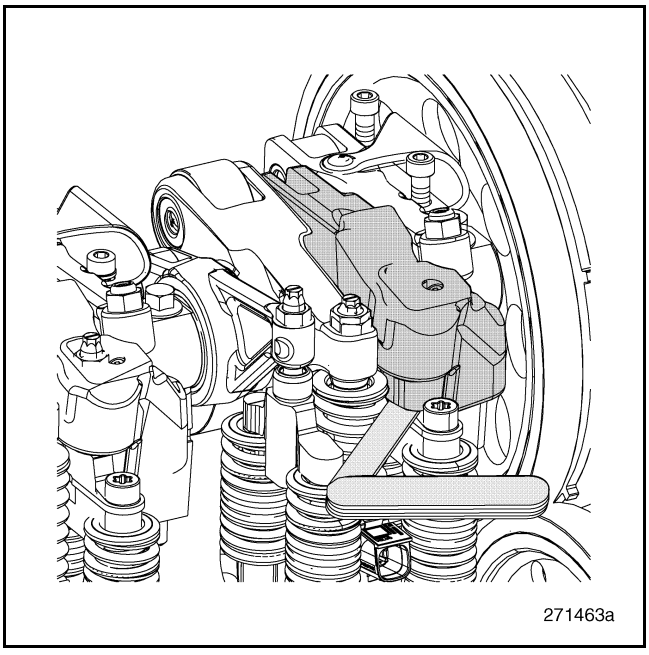


Figure 444 — Measuring Exhaust Valve Clearance

4. If clearance is not within specification, adjust the clearance as follows, using shims (Figure 441) placed on top of the valve yoke (bridge).

Adjusting Exhaust Rocker Arm Clearance

a. Remove the shim retaining screw and remove the shim(s).

b. Determine the thickness of the shim(s) required to provide the specified clearance.

c. Make sure that the valve yoke and shim(s) are clean. Place the shim(s) in position on the valve yoke and install the retaining screw. Tighten the screw to specification.

NOTE

DO NOT use more than two shims. Shims are available in 0.05 mm (0.002 inch) increments with the thickness marked on the surface. If two shims are required to take up the clearance, the shims should be of nearly equal thickness.

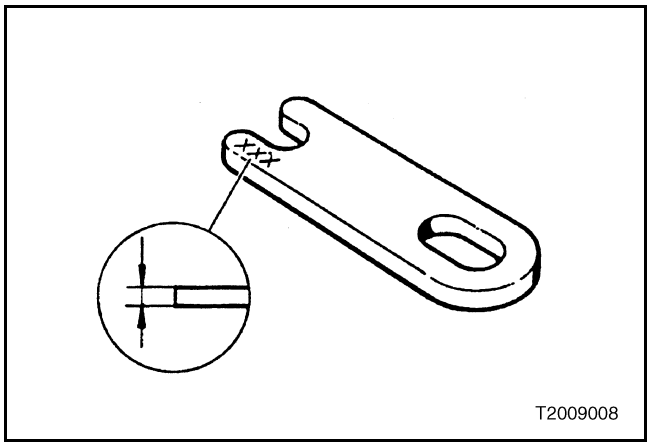


Figure 445 — Engine Compression Brake Adjustment Shim

5. Leave the feeler gauge in place between the exhaust rocker arm piston and the valve yoke shim and adjust the brake rocker arm clearance.

Adjusting Brake Rocker Arm Clearance

a. Loosen the locknut **A** on the brake rocker arm adjusting screw.

b. Using the dial indicator with angled extension and base (9989876, 85111493 and 9999696), place the tip of the dial gauge on the yoke as close as possible to the rocker arm yoke pad. Zero the gauge.

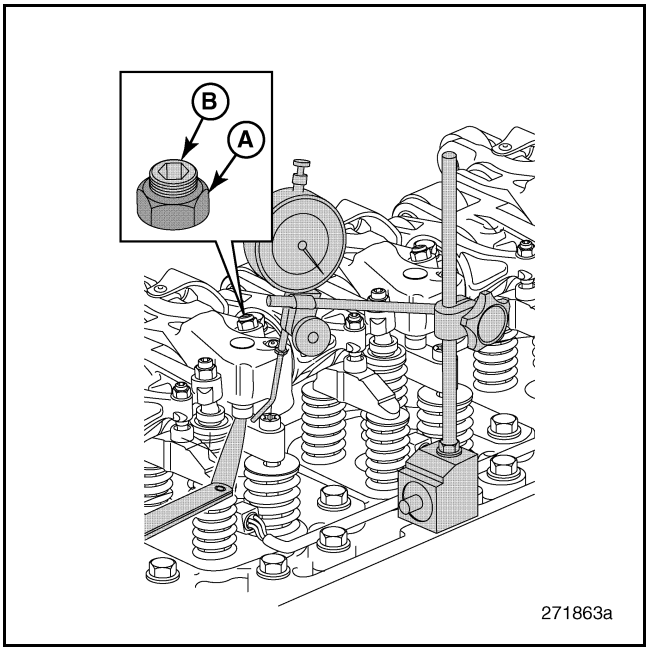


Figure 446 — Brake Rocker Arm Adjustment with Dial Indicator

A. Locknut	B. Adjusting Screw

c. Tighten the rocker arm adjusting screw **B** until the dial shows that the yoke has been pushed downward to specification.

d. Loosen the rocker arm adjusting screw according to specification.

e. Hold the adjusting screw to prevent it from turning further and, using a torque wrench, tighten the locknut to specification.

6. Remove the dial indicator and the feeler gauge.

7. Using a feeler gauge, check the clearance between the brake rocker arm roller and the cam lobe. If the clearance is incorrect, repeat the brake rocker arm clearance adjustment.

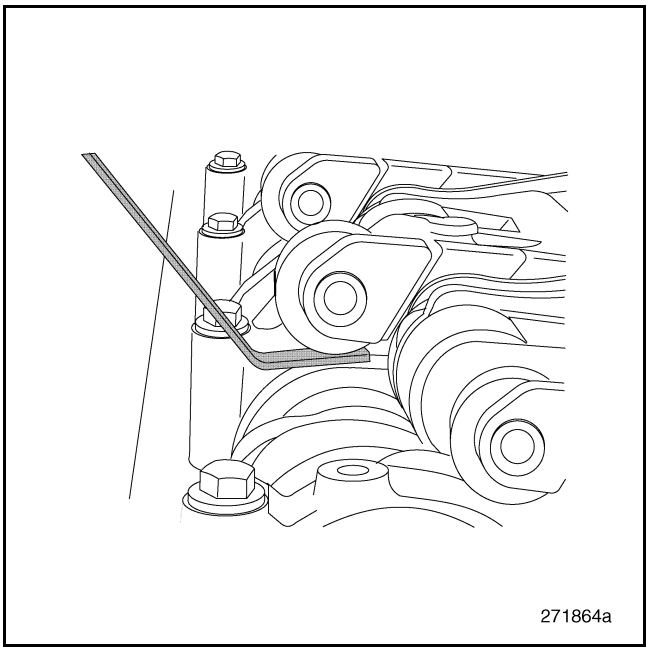


Figure 447 — Checking Brake Rocker Arm Roller to Cam Lobe Clearance

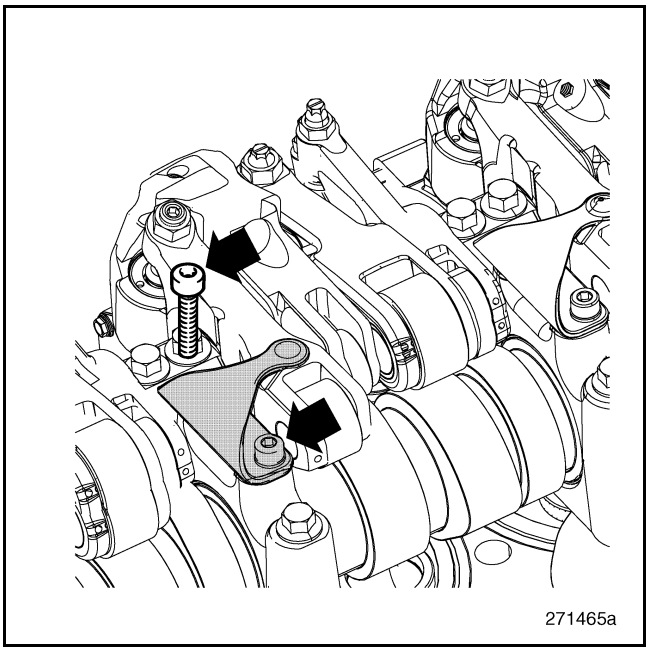


Figure 448 — Plate Spring Attaching Screws

8. Mark the respective rocker arm as each valve adjustment is completed.

CONTINUATION OF ADJUSTMENTS

Continue the procedure by barring the engine to the appropriate timing marks and adjusting the valves and unit injectors at each of the remaining cylinders. Follow the steps described above to adjust the inlet and exhaust valves, and unit injector at each cylinder.

For engines equipped with the 4-rocker PowerLeash™ engine brake, tighten the plate spring attaching screws to specification after the valve and unit injector adjustments have been completed.

OPERATIONAL CHECK

After the valve and unit injector adjustments have been completed, check engine operation as follows:

1. Using the flywheel turning tool, bar the engine over manually two complete revolutions to ensure that no piston-to-valve contact occurs. If contact does occur, readjust the valves as needed BEFORE starting the engine.
2. Start the engine and bring it up to normal operating temperature.
3. Once normal operating temperature is attained, let the engine idle for an additional five minutes. During this time, the electronic engine management system (EMS) will perform its own cylinder balancing, resulting in smooth engine idling.

NOTE

DO NOT use any form of power consuming equipment, such as PTO or air conditioning, when cylinder balancing is being carried out.

Checking and Adjusting Timing Gear Backlash

(Camshaft Gear to Idler Gear)

⚠ WARNING

Apply the parking brake before barring the engine over. Remove the EMS power supply fuse to avoid starting the engine unintentionally. Make sure that the transmission is not in gear.

1. Remove the 16 retaining screws and springs and remove the valve cover from the cylinder head.
2. Disconnect the wiring harness leads at the unit injectors and camshaft sensor connector. Pull the harness out through the cover.
3. Remove the compressor coolant lines.
4. Loosen and remove the capscrews securing the timing gear cover to the cylinder head.
5. Remove the timing gear cover from the engine. Use care when removing the cover to avoid the rubber seals falling into the flywheel housing. Remove the rubber seals from the cover and discard.

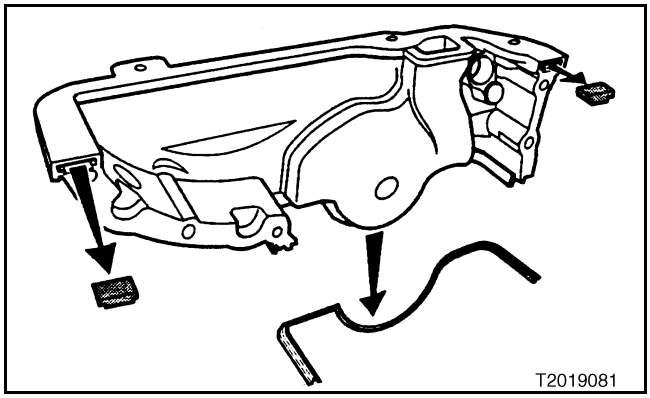


Figure 449 — Timing Gear Cover

6. Using the flywheel turning tool, bar the engine over manually so that the camshaft is positioned at top dead center (TDC) by aligning the TDC mark on the camshaft with the timing marks on the No. 1 camshaft bearing cap.

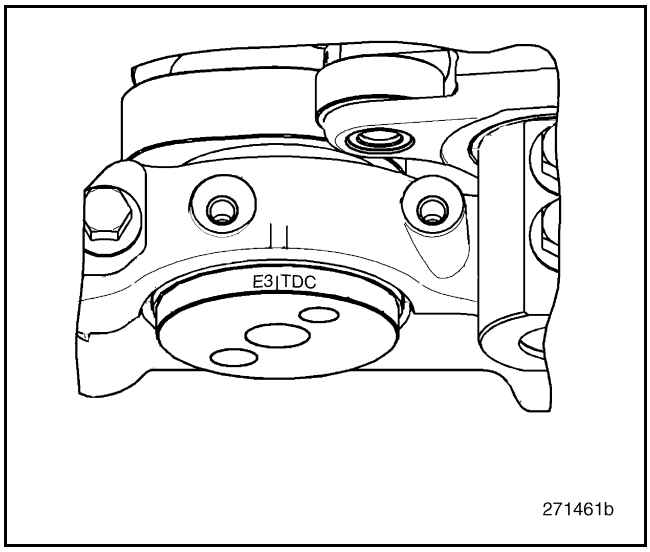


Figure 450 — Camshaft Positioning

7. Loosen and remove the six screws securing the vibration damper and gear to the camshaft. Remove the damper from the camshaft, but DO NOT remove the camshaft gear.
8. Install the gauge plate tool, J 44514-1A.

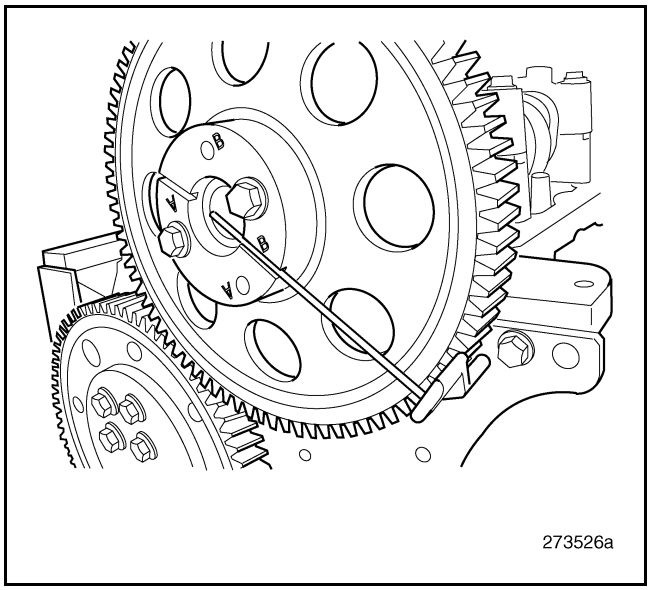


Figure 451 — Camshaft Gear Timing Marks Alignment

9. Insert the alignment tool in the hole in the timing gear plate to engage the camshaft gear teeth with the rod of the tool in the slot of the clamp tool. Rotate the camshaft until this occurs.

10. Tighten the bolts to specification. With the camshaft set at TDC, the double timing marks on the gear should be aligned with the marking hole in the gear plate.
11. Install the clamp assembly tool, J 44514-5.
12. Install a dial gauge against a tooth on the camshaft gear (Figure 452). With the idler gear locked in position, rotate the camshaft gear back and forth to measure backlash. The backlash reading should be within specification.

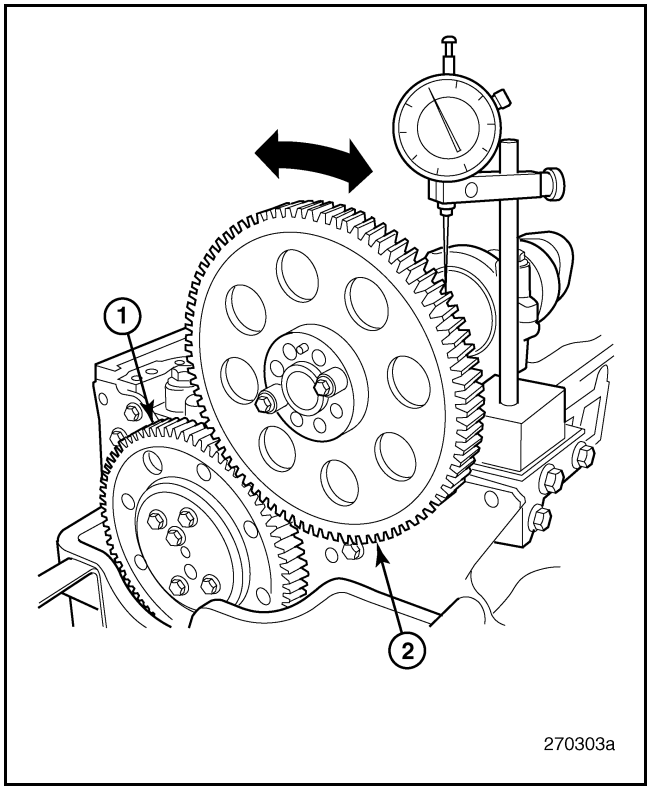


Figure 452 — Camshaft Gear Backlash Measurement

1. Idler Gear	2. Camshaft Gear

13. If the backlash measurement is out of specification, adjust the gear flank clearance as follows:
    a. Loosen the clamp assembly tool.
    b. Loosen the camshaft idler gear hub screws. Loosening the hub screws will allow the idler gear to be moved slightly in/out from the camshaft gear.
    c. Insert a 0.1 mm (0.004 inch) thickness gauge on the pressure side of the idler and camshaft gear teeth (Figure 453).
    d. While holding the idler gear in against the thickness gauge and camshaft gear, tighten, but DO NOT torque, the idler gear hub screws.
    e. Tighten the clamp assembly tool.
    f. Recheck the backlash. With the specified backlash attained, replace each adjustable idler gear hub screw with **new** and tighten the screws to specification.

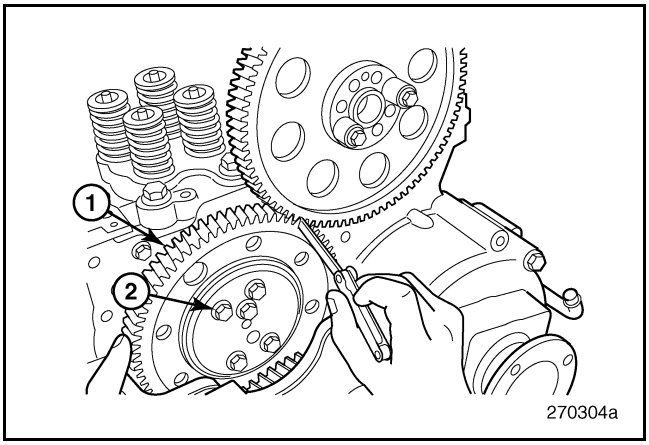


Figure 453 — Idler Gear Flank Clearance Adjustment

1. Idler Gear	2. Hub Screws

14. Remove the gauge plate tool securing the camshaft gear. Use care to ensure that the gear remains in place and properly aligned on the camshaft.
15. Reinstall the vibration damper on the gear and camshaft. Install the six **new** mounting screws and tighten to specification.
16. Apply a 2 mm (5/64 inch) bead of MACK-approved sealant on the timing gear cover mounting surface and install **new** rubber seals (Figure 454).

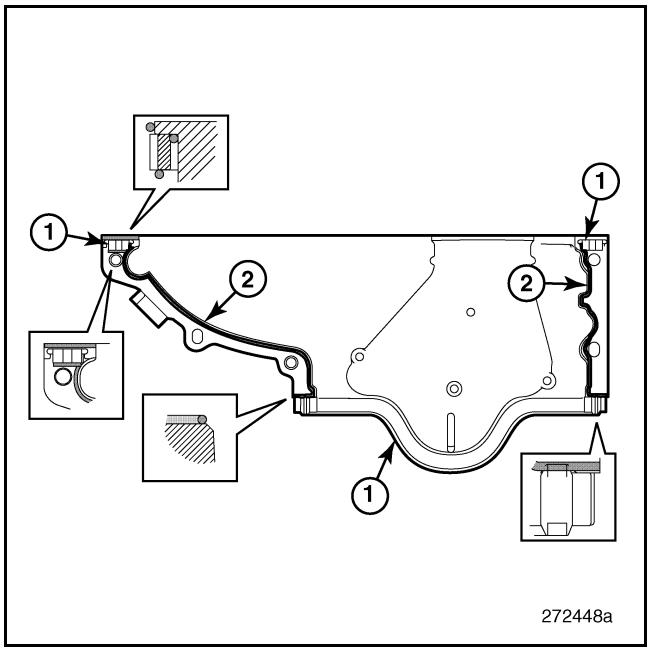


Figure 454 — Timing Cover Seals and Sealant Application

1. Rubber Seals	2. Sealant

17. Place the timing gear cover in position on the engine. Install two capscrews (item 1 in Figure 455) and hand tighten.

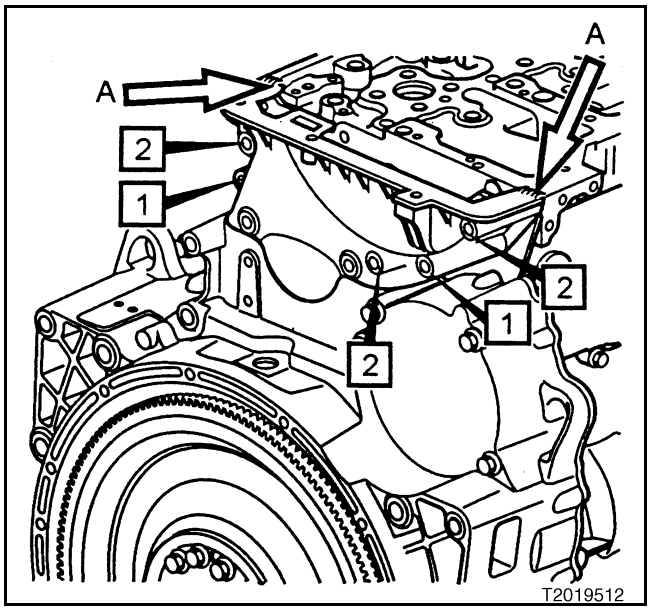


Figure 455 — Timing Gear Cover Installation

18. Using alignment tools, 85111422A and 85111422B, ensure that the upper and lower seals are properly seated and that the upper surface of the cover is flush with the top of the cylinder head (points A in Figure 455).
19. Install the three remaining capscrews (item 2 in Figure 455) and tighten to specification.
20. Reconnect the wiring harness leads at the unit injectors and camshaft sensor connector.
21. Apply an even 2 mm (5/64 inch) bead of sealant at the joint lines (point A) between the cylinder head and the timing cover.
22. Install the valve cover and the 16 retaining screws and springs. Tighten the screws to specification.

ENGINE FINAL PREPARATION AND OPERATIONAL CHECK

After Engine Overhaul Procedures

Filter Element Installation

All filters and coolant conditioners must meet MACK specifications.

1. Install a **new** air filter in the air filter housing.
2. Using a torque wrench, tighten the attaching screw to specification.
3. Lubricate the gaskets.
4. Using a filter wrench, tighten the filters to specification.
5. Attach the filters to the valve housing.
6. Using a filter wrench, tighten the filters to specification.

Engine Lubrication System

An oil film coats rotating parts and bearings of an overhauled engine, but this may not provide sufficient lubrication when the engine is started for the first time. Following is the recommended procedure for providing adequate lubrication.

⚠ CAUTION

Do not mix brands or types of lubricants. Chemical additives may be incompatible and may contribute to the formation of sludge, acid and hardening.

Failure to heed this caution may result in severe engine damage.

SERVICE HINT

Usually there are various points on the engine where a pressure line may be opened, but if no other is apparent, use the oil pressure sensor port.

PRIMING THE LUBRICATION SYSTEM

1. Fill the engine crankcase with the specified quantity of the specified engine oil.
2. Using a pressure prelubricator filled with the specified oil, prime the engine lubrication system for a minimum of five minutes.
3. Check the crankcase oil level.
4. If necessary, add oil to reach the FULL mark on the dipstick.

NOTE

Do NOT overfill.

Oil Pressure

Engine Speed/RPM	Temperature	Pressure
600	90–110°C (195–230°F)	>250 kPa (36 psi)
>1100	90–110°C (195–230°F)	300–550 kPa (44–80 psi)
>1100	Cold Engine	650 kPa (95 psi)

Rocker Shaft Engine Brake	Engine Speed/RPM	Oil Pressure
Inactive	—	80–120 kPa (12–17 psi)
Active	900–2300	220 kPa (32 psi)

Turbocharger

⚠ CAUTION

It is necessary to perform the system pre-lubrication procedure anytime the vehicle has not been operated for a period exceeding 30 days to avoid damage to the turbocharger. During this extended period, all oil will have drained away from the bearing and shaft surfaces.

1. Remove and flush the turbocharger oil supply line with a suitable, clean, non-flammable solvent.

SERVICE HINT

Allow solvent to run through the line to flush any debris, then blow the line dry with clean compressed air.

⚠ CAUTION

A turbocharger failure can result in debris contaminating the turbocharger oil supply line. It is EXTREMELY IMPORTANT to remove, flush and thoroughly clean the line prior to starting the engine. Failure to heed this caution may result in severe component and engine damage.

2. Reinstall the oil supply line.
3. Prime the lubrication system following the procedure described earlier in this section.
4. Following engine overhaul, use the diagnostic computer to calibrate the variable geometry turbocharger.

Cooling System

1. Check the cooling system. Make sure all plugs and coolant drain quick disconnects are installed and are tight.
2. Make sure the thermostat is installed.
3. Install a **new** coolant filter.
4. Fill the system with the recommended coolant.

NOTE

Make sure that all air is purged from the cooling system.

Fuel System

⚠ DANGER

Before working on or inspecting a vehicle, set the parking brake, place the transmission in neutral and block the wheels. Failure to heed this warning can result in unexpected vehicle movement and cause severe personal injury or death.

⚠ DANGER

To avoid potential fire hazard, do not service any part of the fuel system while smoking or in the presence of flames, sparks or hot surfaces, or when working on an operating engine. Failure to heed this warning can result in fire which can produce severe personal injury or death.

⚠ DANGER

Wear adequate protective clothing (face shield, heavy gloves, apron, etc.) when working on a hot engine to guard against burns from direct contact with hot fuel. Failure to heed this warning can result in severe personal injury or death.

⚠ WARNING

Do not work near the fan with the engine running. The engine fan can become active at any time without warning. Failure to heed this warning can result in severe personal injury.

⚠ WARNING

Before turning the ignition on, make sure no one is near the fan. Failure to heed this warning can result in severe personal injury.

1. Check the fuel system to make sure that all connections are tight.
2. Start the engine and run it at idle for approximately 5 minutes to remove air trapped in the fuel system.

PRIMING THE FUEL SYSTEM

Using the hand priming pump is usually only necessary when the fuel system has air in it, or when replacing filters. If hand priming is needed, use the following procedure.

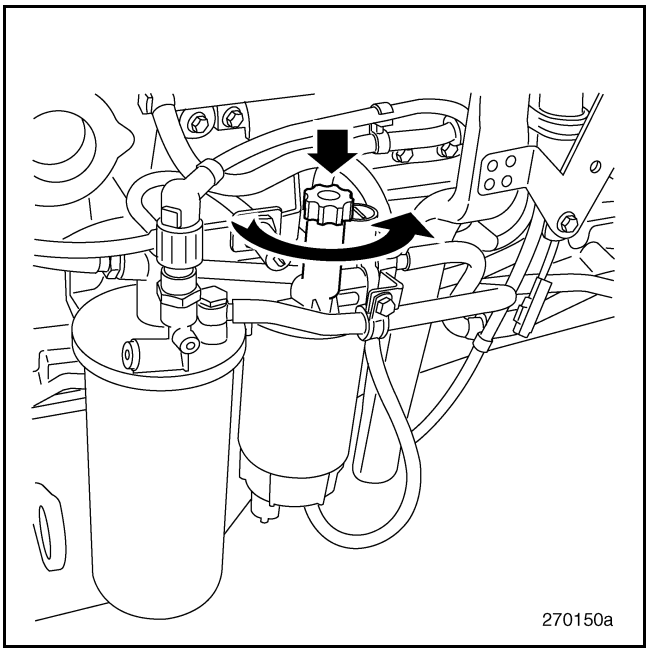


Figure 456 — Unlocking the Hand Primer Pump

1. Unlock the hand primer pump by pushing the handle in and turning it counterclockwise.
2. Pump the hand primer until the force of pumping increases.

NOTE

When the fuel system is completely empty, 200 or more strokes may be needed to prime the system properly.

NOTE

There are NO bleed nipples to be opened in order to prime the fuel system.

3. Lock the pump by pushing the handle into the housing, turning it clockwise and releasing it.
4. Start the engine and run it at an increased idle for approximately 5 minutes to remove air trapped in the fuel system.
5. Check the fuel system to make sure that all connections are tight.

NOTE

If the engine does not start following this procedure, contact your local MACK Truck dealer.

NOTE

Do not crank the engine continuously for more than 30 seconds without allowing the starter to cool for 2 minutes between cranks.

Some starters are equipped with starter protection. If the starter temperature is too high, starter engagement is inhibited to prevent starter damage. Wait until the starter has cooled to crank the engine.

⚠ CAUTION

The only acceptable method of priming the fuel system is the hand primer pump. Applying air pressure to the fuel tank or using an auxiliary pump to prime the fuel system is PROHIBITED. These priming techniques may cause fuel to leak past the supply pump seal into the crankcase. Failure to heed this caution may result in severe engine damage.

⚠ WARNING

After running for 5 minutes, the engine, all its components and fluids will be hot. Contact with hot components and fluids can cause severe burns. Failure to heed this warning can result in severe personal injury.

Engine Operational Check

1. Remove all tools from the engine compartment.
2. Connect the battery cables (negative cable last).
3. Clear the work area of debris and personnel.

NOTE

The following step is important to proper break-in for all new parts at initial startup of the engine.

4. Start the engine and immediately increase the speed to 1200–1600 rpm. During the break-in period, check for leaks and monitor gauges for satisfactory oil pressure, etc.
5. Operate the engine within the 1200–1600 rpm range for 15 minutes.

NOTE

DO NOT allow the engine to drop to idle speed until the 15 minute break-in period at 1200–1600 rpm has been completed.

6. Shut down the engine.
7. Check the fluid levels and fill to capacity before restarting the engine.
8. Refer to *Rebuilt Engine Run-In Procedures* for inspections to be sure of proper engine operation before releasing the vehicle for service.

REBUILT ENGINE RUN-IN PROCEDURES

General

The durability and service life of a rebuilt engine is directly related to its initial run-in following overhaul. After a complete overhaul or any major repair job involving installation of piston rings, pistons, cylinder liners or bearings, the engine must be run-in prior to release for service.

Run-in procedures vary depending on method used (i.e., engine dynamometer, chassis dynamometer or highway run-in). Regardless of method, however, always prepare the engine properly before starting it for the first time.

Run-In Check

NOTE

Install any additional instrumentation needed for the run-in method selected.

The operator should be familiar with the correct, established procedure for checking chassis power *before* using the chassis dynamometer method for run-in. Refer to applicable chassis dynamometer operating procedures.

The operator must be observant throughout the entire run-in procedure in order to detect any problems.

Constantly monitor the instrument display of engine functions and support systems and record all readings.

If the engine develops any of the following abnormal characteristics during run-in, shut it down immediately.

Discover and correct problems before continuing the run-in procedure.

Always investigate the following conditions:

- Unusual noises, such as knocking, scraping, etc.
- A significant drop in engine oil pressure
- A significant rise in coolant temperature, exceeding 116°C (240°F)
- A significant rise in oil temperature that exceeds 116°C (240°F)
- An exhaust temperature that exceeds maximum acceptable limits for the engine involved, as measured by a pyrometer (if applicable)
- Any oil, coolant, fuel or air inlet system leaks

SPECIFICATIONS

MP8 EURO 3 ENGINE MECHANICAL SPECIFICATIONS

Material and Dimensional Data

GENERAL DATA, WEIGHTS AND DIMENSIONS

Item	Specification
Engine Type	In-line, direct injection, diesel
Number of Cylinders	6
Displacement	12.8 L
Bore and Stroke	131 x 158 mm (5.16 x 6.22 in.)
Compression Ratio	18.1:1
Emissions Level	Euro 3
Fuel System	Electronic Unit Injector
Valve Actuation	Single Overhead Cam, 4 valves per cylinder
Aspiration	Turbocharger
Power Cylinder	Wet sleeve; one-piece steel pistons
Electronic Controls	Electronic Management System (EMS)
Peak Power Ratings	254–324 kW (346–440 hp)
Peak Torque Ratings	1800–2200 N•m (1328–1623 lb-ft)
Weight, Dry	1145 kg (2524 lb.)
Firing Order	1–5–3–6–2–4
Length Overall	1359 mm (53.5 in.)
Width Overall	813 mm (32.0 in.)
Height Overall	1171 mm (46.1 in.)

COMPONENT FEATURES AND MATERIALS

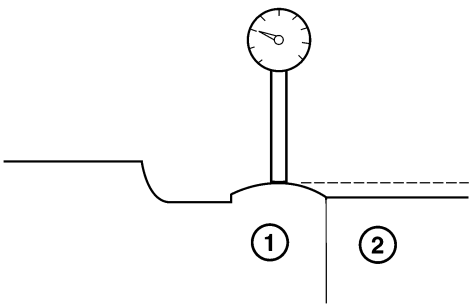
Item	Description
Air Compressor	Flange mounted, oil lubricated, coolant cooled
Camshaft	Induction hardened, gear driven
Coolant Conditioner	Spin-on type, disposable
Coolant Pump	Centrifugal rotor impeller, belt driven
Connecting Rods	Forged steel, cracked cap design
Crankshaft	Drop forged steel, induction hardened, seven main bearings
Cylinder Block	In-line six cylinder; wet, replaceable cylinder sleeves; cast iron, machined with bearing caps, stiffener plate added at bottom, timing gear train mounting plate added at rear
Cylinder Head	One-piece cast iron alloy; supports overhead camshaft, four valve system, unit injectors; replaceable cast iron valve guides with oil seals; replaceable steel valve seats; copper unit injector sleeves; integral fuel passages; integral thermostat housing
Cylinder Head (Valve) Cover	Plastic, 20 spring tension attaching screws
Cylinder Head — Valve Springs	Double springs on exhaust valves, single on inlet

Item	Description
Cylinder Head — Valve Guides	Cast iron, replaceable; with oil seals
Cylinder Head Gasket	One-piece steel stamping; elastomer seals added; one-time bosses to aid head installation
Cylinder Head Bolts	M16 (38)
Cylinder Liner	Wet; replaceable; with EDPM rubber and Viton seals
Fasteners and Threads	Metric
Flywheel Housing	Die-cast aluminum
Fuel Filters	Two: primary and pre-filter with water separator
Fuel Injection	Individually programmed unit injectors (6): EMS module controlled; common fuel gallery in head; constant supply pressure; over-pressure return
Fuel Supply Pump	Gear type pump integral with power steering pump; crankshaft idler gear driven
Lubrication System	Crankshaft gear driven lubrication pump; system integrated within block and head; serves camshaft, rocker arm shaft, pistons, crankshaft, air compressor; three filters, 1 bypass and 2 full-flow; lubricant level and temperature sensor in oil pan
Main Bearing Caps	Nodular iron; machined with block; No. 7 mounts lubrication pump; 1–3, 5 and 6 numbered for consistent reassembly; cast and drilled for consistent reassembly; thrust washers at No. 4 main bearing journal
Manifold — Exhaust	Three-piece, six port
Pistons	Steel; one-piece; 3 ring grooves
Piston Rings — Compression	2: 1 trapezoidal cross section, 1 rectangular cross section
Piston Ring — Oil	1 garter spring type; scraping
Oil Filters	2 full flow; 1 bypass Filter capacity, 2 full flow: • 4.0–4.5 L (4.2–4.8 qts.)
Oil Pan	Plastic or steel; 22 spring-tension screws Sump capacity: • 25 L (26.4 qts.) minimum • 30 L (31.7 qts.) maximum
Thermostat, Coolant	Piston-type; 82°C (180°F)
Thermostat Housing	Integrated in head
Timing Gear Cover	Die-cast aluminum, elastomer seals
Turbocharger	Exhaust gas driven, radial flow, engine oil lubricated
Valve Rocker Arms	Roller followers
Valve Seat Inserts	Pressed in head, replaceable
Vibration Damper, Crankshaft	Internal fluid-filled ring

FITS AND LIMITS

The specifications as listed are for new parts and, therefore, maximum wear must be established by good judgment, experience and sound shop practice.

Tolerances Are Shown Low to High	Standard Size or Fit	
Component	**Metric**	**English**
CAMSHAFT		
Camshaft Journal Diameter	70 mm	2.75 in.
Inlet Valve Lobe Nominal Lift	13.1 mm	0.516 in.
Exhaust Valve Lobe Nominal Lift (EPG)	12.3 mm	0.484 in.
Exhaust Valve Lobe Nominal Lift (3-Rocker)	13.1 mm	0.516 in.
Exhaust Valve Lobe Nominal Lift (4-Rocker)	12.3 mm	0.484 in.
Camshaft End Play	0.24 mm max.	0.0094 in. max.
CONNECTING ROD		
Length between Centers	267.5 mm	10.5 in.
CRANKSHAFT		
Crankpin Journal OD (Inspection only: not for machining)	99 mm	3.9 in.
Main Journal OD (Inspection only: not for machining)	108 mm	4.25 in.
CYLINDER BLOCK		
Main Bearing Bore in Block	113 mm	4.449 in.
Cylinder Sleeve Flange Bead to Block Deck (Top of Bead to Block Deck)	0.15–0.21 mm	0.0059–0.0083 in.



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1. Cylinder Liner	2. Cylinder Block

Tolerances Are Shown Low to High	Standard Size or Fit	
Component	**Metric**	**English**
CYLINDER HEAD		
⚠ CAUTION *Do **NOT** machine the cylinder head. This will change the extension of the injector/valves and upset injector timing.* *Do **NOT** grind copper injector sleeves.*		
Overall Height	135 mm	5.315 in.
Valve Guide Height Above Cylinder Head Spring Face — Inlet	24.5 mm	0.965 in.
Valve Guide Height Above Cylinder Head Spring Face — Exhaust	24.5 mm	0.965 in.
Valve Seat Insert (Inlet)	45 mm	1.77 in.
Valve Seat Insert (Exhaust)	43 mm	1.69 in.
Valve Seat Height (Inlet)	7.55 mm	0.2972 in.
Valve Seat Height (Exhaust)	7.5 mm	0.2953 in.
Valve Seat Counterbore Depth (Inlet)	11.8 mm	0.4646 in.
Valve Seat Counterbore Depth (Exhaust)	11.2 mm	0.4409 in.
INJECTORS		
Preload	240° (4 flats on the hex head)	
PISTON		
Wrist Pin Diameter	58 mm	2.2835 in.
Wrist Pin Length	76 mm	2.9921 in.
PISTON RINGS		
Compression Ring End Gap — Upper: Wear Tolerance	0.9 mm max.	0.0354 in. max.
Compression Ring End Gap — Lower: Wear Tolerance	1.3 mm max.	0.0512 in. max.
Oil Control Ring End Gap — Wear Tolerance	1.0 mm max.	0.0394 in.
OIL PUMP		
Crankshaft Gear to Oil Pump Gear Backlash	0.1–0.4 mm	0.004–0.016 in.
TIMING GEARS		
Adjustable Idler Gear to Camshaft Gear Backlash	0.05–0.15 mm	0.0020–0.0059 in.
VALVES		
Head Diameter (Inlet Valve)	42 mm	1.654 in.
Head Diameter (Exhaust Valve)	40 mm	1.575 in.
Inlet Rocker Arm Clearance (cold engine)	0.2 ±0.05 mm	0.008 ±0.002 in.

Tolerances Are Shown Low to High	Standard Size or Fit	
Component	**Metric**	**English**
Exhaust Rocker Arm Clearance (cold engine)		
— without PowerLeash™	0.8 ±0.05 mm	0.031 ±0.002 in.
— with PowerLeash™ 3-Rocker	1.6 ±0.05 mm	0.063 ±0.002 in.
— with PowerLeash™ 4-Rocker	0.8 ±0.05 mm	0.031 ±0.002 in.
Brake Rocker Arm Clearance, PowerLeash™ 4-Rocker (cold engine) **Note:** After setting exhaust arm clearance		
— Brake rocker press down using adjusting screw	0.25 ±0.05 mm	0.010 ±0.002 in.
— Brake rocker adjusting screw loosening	720° counterclockwise	—
— Clearance check (camshaft to brake rocker arm roller)	3.8 ±0.1 mm	0.150 ±0.004 in.
Valve Face to Cylinder Head Deck (Inlet)	1.0 mm min. 1.6 mm max.	0.0394 in. min. 0.0630 in. max.
Valve Face to Cylinder Head Deck (Exhaust)	1.35 mm min. 2.0 mm max.	0.0531 in. min. 0.0787 in. max.
Note: Replacing valve seats requires replacing valves.		
VALVE SEAT ANGLE		
Inlet Valve Head	24.5°	
Exhaust Valve Head	39.5°	
Inlet Valve Seat	25.0°	
Exhaust Valve Seat	40.0°	
VALVE SPRINGS		
Outer Spring:		
Free Length (approximate)	73.8 mm	2.91 in.
Inner Spring:		
Free Length (approximate)	70.5 mm	2.78 in.

Exhaust Pressure Governor

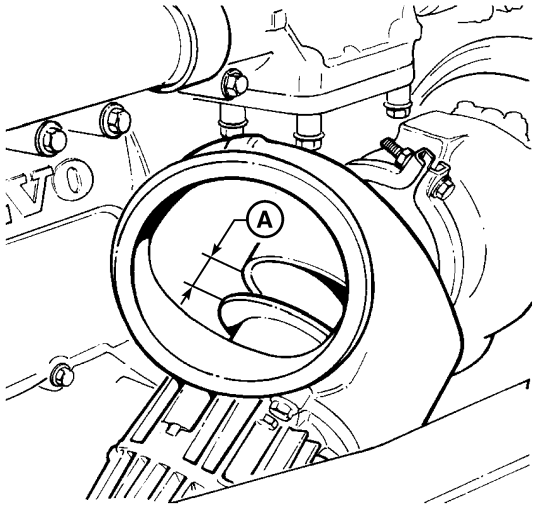


Figure 457 — Exhaust Pressure Governor

Stroke, shutter (A)	29 mm min.	1.14 in. min.

Engine Component Torque Specifications (Critical Fasteners)

NOTE

All components are to be clean and free from foreign material or corrosion. Assemblies are to be made using suitable tools and procedures so that no permanent damage will occur as a result of the assembly.

Threads, washers, under head of screw and washer face of nuts should be lubricated with clean engine oil unless otherwise specified.

The following listed fasteners require the use of a calibrated manual torque wrench. If an adapter is required in combination with a torque wrench, a correction factor **must be** applied to the torque wrench readings in order to obtain accurate fastener torque values.

Fasteners noted by an asterisk (*) require retorque after engine run-in.

FASTENER REUSE

⚠ CAUTION

Repeated tightening of fasteners and threaded components reduces their capacity to function adequately. The following table describes the various items and the limits of their reusability. Failure to conform to these limits may result in severe component damage.

Fasteners	Examples	Reusable Limit	Reuse Recommendations
Highly loaded screws (Phosphating plus oil)	Cylinder head Cylinder block Injector yoke Camshaft bearing housing Transmission (except adjustable idler gear) Flywheel	5 times	Apply engine oil on threads and under screw head. Mark bolt head with an indentation. Dry mounting for new screws (delivered with oil pre-applied and anti-rust treatment for spare parts). If a part is replaced, e.g., cylinder head, also replace the screws.
	Connecting rods	5 times	Apply clean engine oil.
	Adjustable idler gear	Do not reuse	
Special screws (specific shape)	Oil pan and valve cover	No limit	No limit if no cracks, corrosion or damage to the flat surfaces.
Flange head screws	Exhaust manifold	5 times	If exhaust manifold is replaced, also replace the screws.
Stainless steel fasteners and spacers	Turbocharger	5 times	If turbocharger or the exhaust manifold is replaced, also replace the fasteners and spacers and apply anti-seize.
Prevailing torque feature screws (Dri-Loc Plastic or Tuflock)	Piston cooling jets	Do not reuse	
Standard screws	Property class 8.8 Property class 10.9 Property class 12.9	No limit	No limit if no cracks, corrosion or damage to the flat surfaces.

Fasteners	Examples	Reusable Limit	Reuse Recommendations
V-nipples with taper thread	With locking fluid pre-applied	Do not reuse	Before fitting the new nipple, clean the hole with a nipple tap and apply sealant on the nipple thread, or use a new, coated nipple.
Taper plugs or nipples	With sealer fluid pre-applied	Do not reuse	Before fitting the new nipple, clean the hole with a nipple tap and apply sealant on the nipple thread, or use a new, coated nipple.

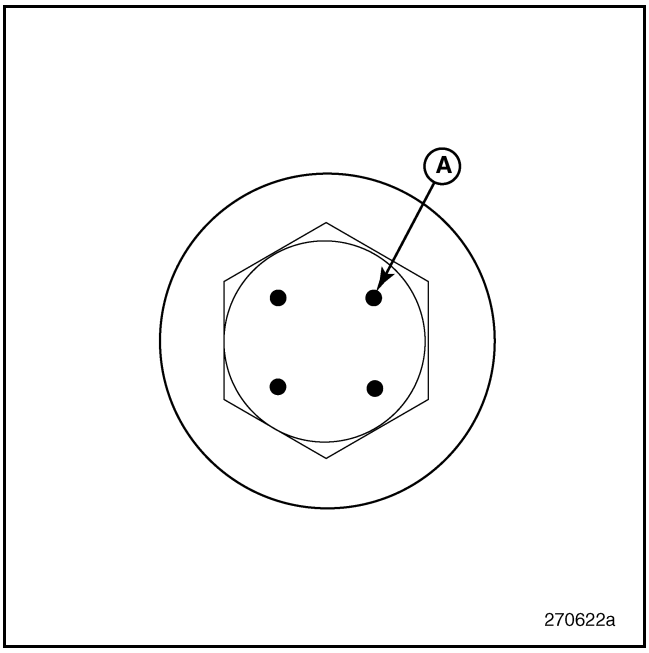


Figure 458 — Usage Marks on Head of Fastener

Bolts and screws that have limited reusability specified in the table above must be marked with a punch **(A)** each time they are installed in service. Bolts and screws with four punch marks when removed have been tightened five times and must be discarded.

⚠ CAUTION

Do not reuse timing gear mounting plate bolts.

Do not reuse timing gear mounting bolts.

SENSORS AND WIRING HARNESS

⚠ CAUTION

Overtorquing a sensor or sensor mounting screw can result in sensor breakage or thread damage.

Sensors	
Camshaft Position (timing gear cover)	8 ±2 N•m (6 ±1 lb-ft)
Charge Air Pressure/Temperature (inlet manifold)	3.3 N•m (29 lb-in)
Coolant Level (surge tank)	Plug-in
Coolant Temperature (front, right side cylinder head)	22 ±3 N•m (16 ±2 lb-ft)
Crankcase Pressure (block, front of air compressor)	30 ±5 N•m (22 ±3 lb-ft)
Flywheel Position/Speed (top of flywheel housing)	8 ±2 N•m (6 ±1 lb-ft)
Fuel Pressure (fuel filter housing)	25 ±3 N•m (18.5 ±2 lb-ft)
Humidity (fresh air pipe)	27 ±3 N•m (20 ±2 lb-ft)
Oil Level/Temperature (inside sump)	Standard Torque
Oil Pressure (block, front of air compressor)	30 ±5 N•m (22 ±4 lb-ft)
Wiring Harness	
Attaching Screws	24 ±4 N•m (18 ±3 lb-ft)

MP8 ENGINE COMPONENTS — TOP OF ENGINE

Valve (Cylinder Head) Cover

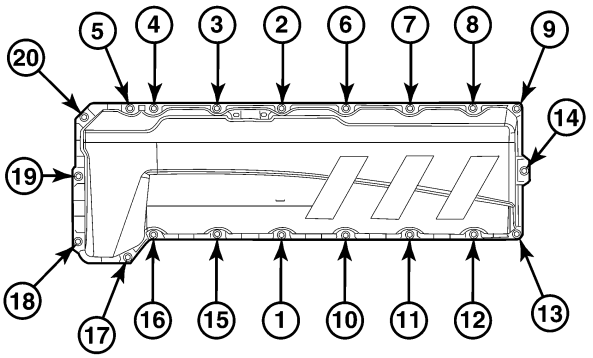


Figure 459 — Valve Cover Torque Sequence

Install two alignment pins and bushings in the head before assembling the valve cover.	
Tighten screws in the order indicated to . . .	24 ±4 N•m (18 ±3 lb-ft)

Camshaft Bearing Caps and Rocker Arm Shaft Assembly

The rocker arm shaft assembly is installed on top of the camshaft bearing caps (inboard side) using the long screws, numbers 8 through 21. The rocker arm shaft and camshaft bearing cap retaining screws are tightened to specification as listed below in the table.

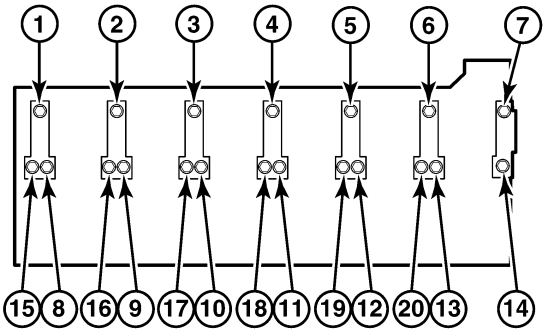


Figure 460 — Camshaft Cap Torque Sequence Screw Numbers

Preliminary steps: • Discard screws with four punch marks when removed and replace with **new** screws. • If not already loose, loosen screws 1–7 before proceeding with the tightening sequence.	
Step 1. Screws 1–7	25 ±3 N•m (18 ±2 lb-ft)
Step 2. Screws 8–14	60 ±5 N•m (44 ±4 lb-ft)
In step 2, tighten the screws progressively beginning with screw No. 11.	
In steps 3–7, tighten the screws progressively from the center to the outer ends.	
Step 3. Screws 1–7, angle tighten	90 ±5°
Step 4. Screws 15–20	25 ±3 N•m (18 ±2 lb-ft)
Step 5. Screws 15–20, angle tighten	120 ±5°
Step 6. Screws 8–13	Loosen completely
Step 7. Screws 8–13	25 ±3 N•m (18 ±2 lb-ft)
Step 8. Screws 8–14, angle tighten	120 ±5°

Cylinder Head

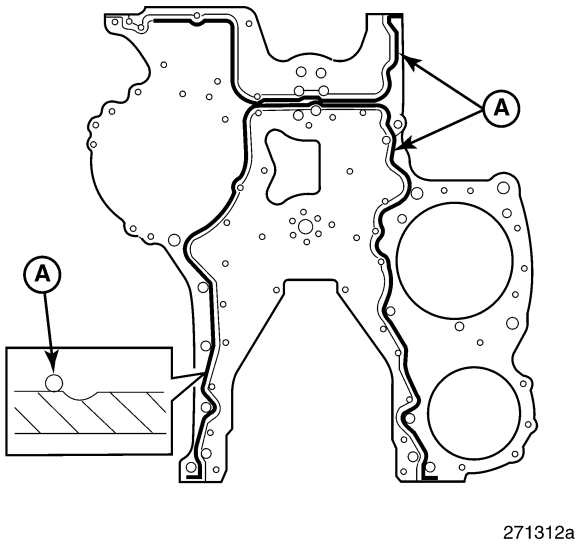


Figure 461 — Sealant Application Pattern — Head to Plate

Remove all old sealant before attempting to apply new sealant.
Apply a 2 mm (0.079 inch) bead of sealant to the timing gear plate following the pattern shown.
Attach the head to the timing gear plate within 20 minutes of applying the sealant.

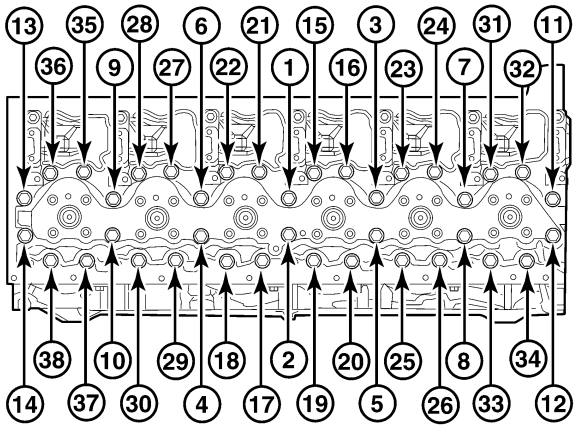


Figure 462 — Torque Sequence Screw Numbers — Head to Block

Discard screws with four marks when removed and substitute new screws. Tighten the screws in the order indicated by the numbers in the graphic.	
Step 1.	100 ±5 N•m (74 ±4 lb-ft)
Step 2. Verify	100 ±5 N•m (74 ±4 lb-ft)
Step 3. Angle tighten	120° ±5°
Step 4. Angle tighten	90° ±5°

Additional Top of Engine Components

Cylinder Head Plugs	
Plug, M10 x 1.00	25 ±3 N•m (18 ±2 lb-ft)
Plug, M10 x 1.00, coated	10 ±2 N•m (7.5 ±1.5 lb-ft)
Plug, M14 x 1.50, coated	30 ±3 N•m (22 ±2 lb-ft)
Plug, M16 x 1.50	50 ±3 N•m (37 ±2 lb-ft)
Cylinder Head Connectors	
Right side, coated	10 N•m (7.5 lb-ft)
Rocker Arm Components	
Locknut, Valve Adjustment (Inlet and Exhaust without Engine Brake)	38 ±4 N•m (28 ±3 lb-ft)
Locknut, Valve Adjustment (Exhaust with Engine Brake)	52 ±4 N•m (38 ±3 lb-ft)
Locknuts, Injector Adjustment	52 ±4 N•m (38 ±3 lb-ft)
Retainer Screw, Shim (Exhaust Yoke)	38 ±4 N•m (28 ±3 lb-ft)
Engine Brake	
Attaching Screws, Solenoid Valve See *Engine Brake Valve* under **Rocker Arm Components**.	24 ±4 N•m (18 ±3 lb-ft)
Engine Brake Plate Spring (PowerLeash™, 4-Rocker)	25 ±3 N•m (18 ±2 lb-ft)
Injector Retainers	
If the copper injector sleeve is new, injector yoke screws must be tightened in five steps. Step 3 requires loosening after steps 1 and 2. If the copper injector sleeve is reused, only steps 4 and 5 below apply.	
Step 1.	20 +5/–0 N•m (15 +4/–0 lb-ft)
Step 2. Angle tighten	180° ±5°
Step 3. Loosen the screws until the torque is 10–15 N•m (7–11 lb-ft).	
Step 4.	20 +5/–0 N•m (15 +4/–0 lb-ft)
Step 5. Angle tighten • With raised-bead design copper sleeve (no injector gasket) • With flat-bottom design copper sleeve and injector gasket	 60° ±5° 90° ±5°

MP8 ENGINE COMPONENTS — FRONT OF ENGINE

Crankshaft Damper

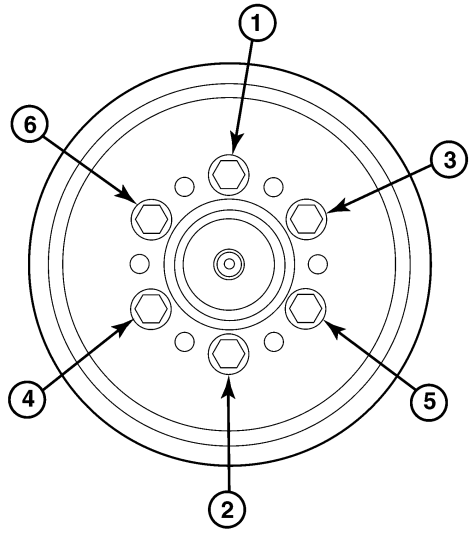


Figure 463 — Torque Sequence Screw Numbers — Damper to Crankshaft

Do **NOT** reuse screws. Use **new** screws in service and tighten in the order indicated.	
Step 1.	35 ±5 N•m (26 ±4 lb-ft)
Step 2.	90 ±10 N•m (66 ±7 lb-ft)

Crankshaft Front Seal Cover

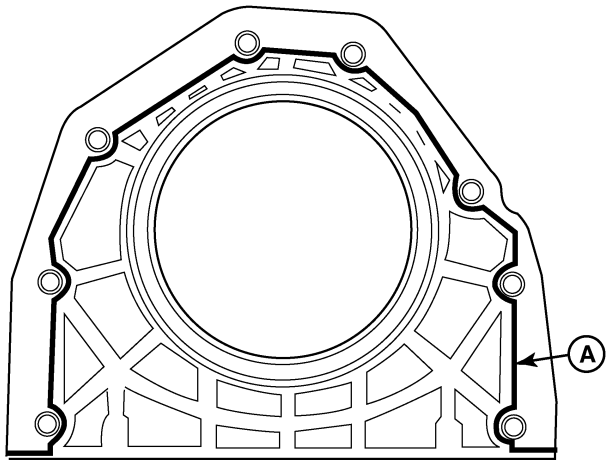


Figure 464 — Sealant Application Pattern — Cover to Block

Remove all old sealant before attempting to apply new sealant. Apply a 2 mm (5/64 inch) bead of 3092340 sealant to the seal cover following the pattern (A) shown. Attach the cover to the cylinder block within 20 minutes of applying the sealant.

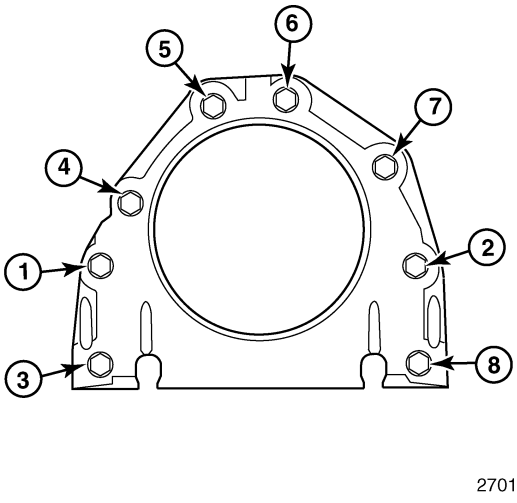


Figure 465 — Torque Sequence Screw Numbers — Cover to Block

Tighten screws in the order indicated according to the following torque specifications.	
Step 1. Secure cover with screws 1 and 2	Hand tighten
Step 2. Screws 1–8	24 ±4 N•m (18 ±3 lb-ft)

Front Engine Support

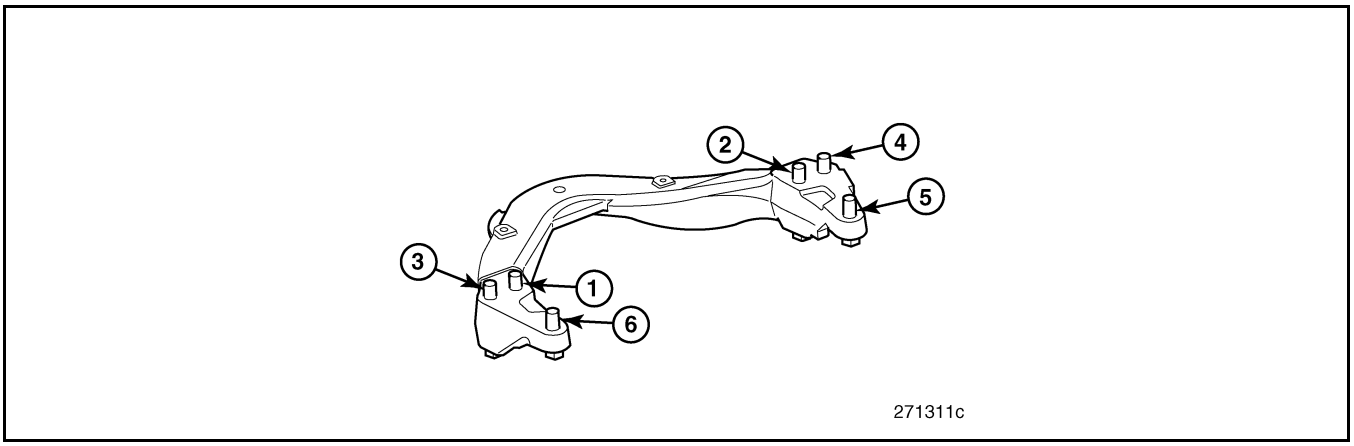


Figure 466 — Torque Sequence Screw Numbers — Support to Brackets

Step 1. Tighten in order: 1, 2, 3, 4, 5 and 6	275 ±45 N•m (203 ±33 lb-ft)
Step 2. Verify in the same order	275 ±45 N•m (203 ±33 lb-ft)

Front Engine Support Mounting Brackets

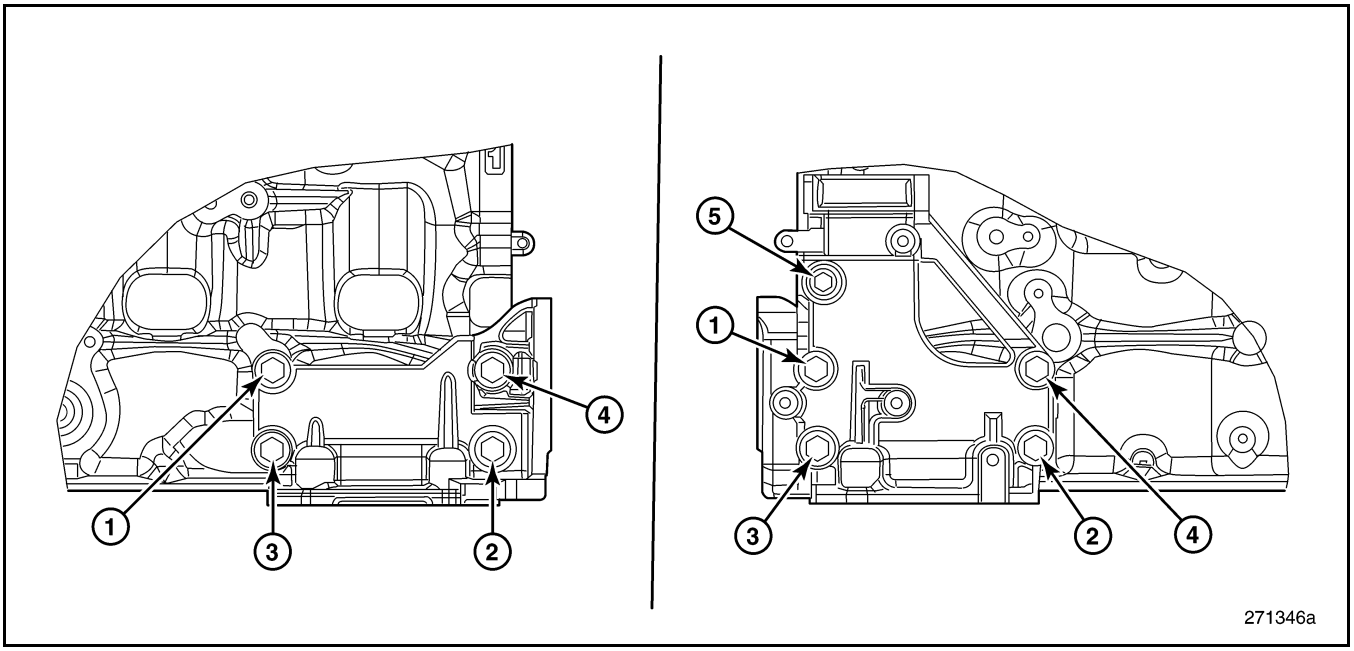


Figure 467 — Engine Support Brackets to Block

Sequence	Torque	Angle Tighten
Step 1. Screw No. 1	80 ±15 N•m (59 ±11 lb-ft)	—
Step 2. Screws No. 2, 3 and 4	105 ±15 N•m (77 ±11 lb-ft)	60 ±5°
Step 3. Screw No. 1	105 ±15 N•m (77 ±11 lb-ft)	60 ±5°
Step 4. Screw No. 5	Standard screw torque	—

Additional Front of Engine Components

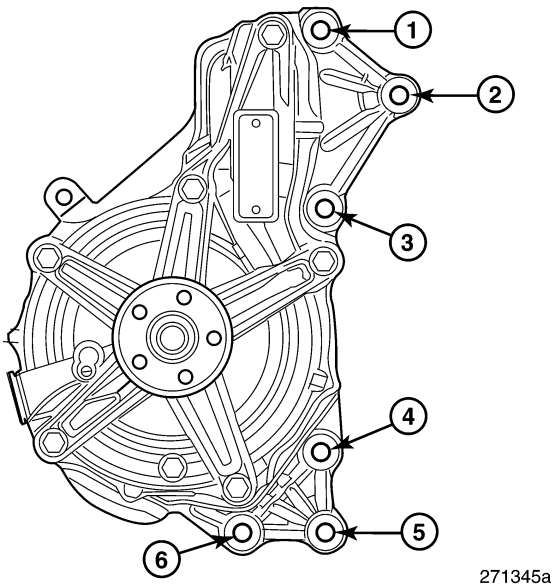


Figure 468 — Coolant Pump Housing

Coolant Pump Housing	
Step 1. Tighten all 6 screws in the following sequence: 2, 5, 6, 4, 3, 1.	48 ±8 N•m (35 ±6 lb-ft)
Step 2. Retighten screws 2 and 5.	48 ±8 N•m (35 ±6 lb-ft)
Viscous Fan Drive	
Attaching Nuts, Drive to Hub	24 ±4 N•m (18 ±3 lb-ft)
Attaching Nuts, Hub to Cylinder Head and Block	48 ±8 N•m (35 ±6 lb-ft)

MP8 ENGINE COMPONENTS — REAR OF ENGINE

Timing Gear Train Plate

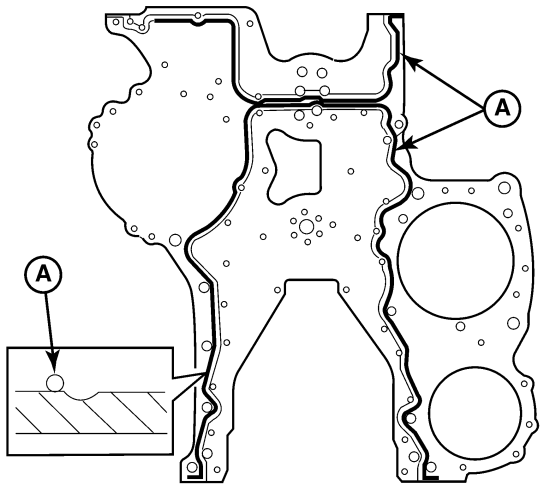


Figure 469 — Sealant Application Patterns — Head and Block to Plate

Remove all old sealant before attempting to apply new sealant. Apply a 2 mm (0.079 inch) bead of sealant to the timing gear plate next to the groove following the patterns shown. Attach the timing gear plate to the head and block within 20 minutes of applying the sealant.

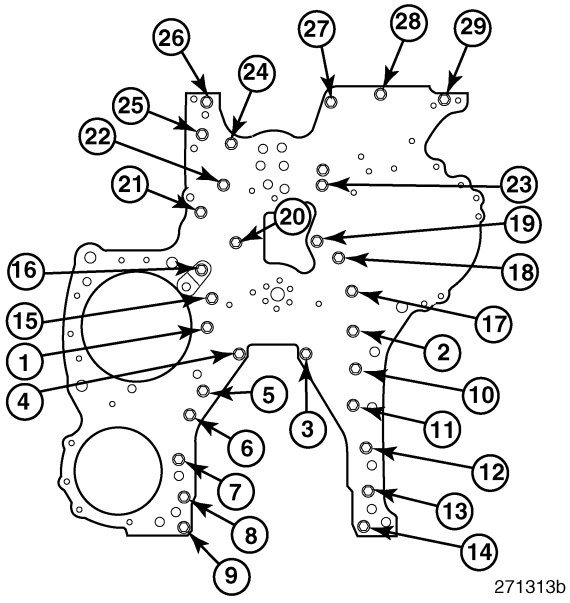


Figure 470 — Torque Sequence — Plate to Cylinder Block and Cylinder Head

Do not reuse mounting plate screws. Do NOT apply sealant to new, coated screws.	
Tighten screws in the order indicated.	28 ±4 N•m (21 ±3 lb-ft)

Timing Gears

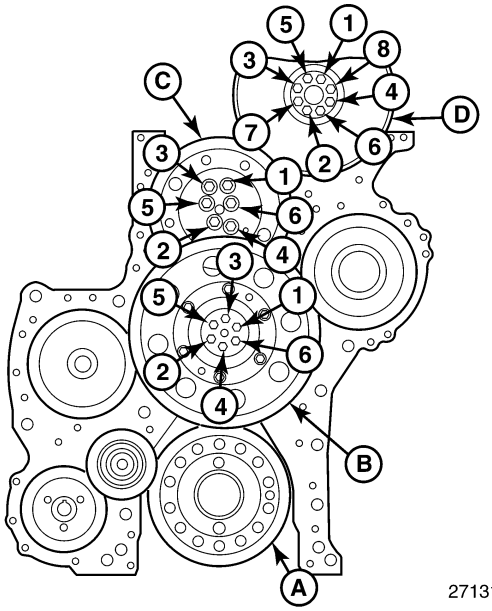


Figure 471 — Torque Sequence Screw Numbers — Gear Mounting

Component	Torque	Plus Angle Tighten
Loosen any screws used to pull the cylinder head into position before beginning this sequence. Tighten screws in the order indicated on each gear.		
(A) Crankshaft Gear (2 screws)	24 ±4 N•m (18 ±3 lb-ft)	
(B) Intermediate Gear Hub (6 screws)	25 ±3 N•m (18 ±2 lb-ft)	110° ±5°
(C) Intermediate Adjustable Gear Hub (5 screws)	35 ±4 N•m (26 ±3 lb-ft)	120° ±5°
(D) Camshaft Gear and Damper (6 screws)	45 ±5 N•m (33 ±4 lb-ft)	90° ±5°

Timing Gear Cover

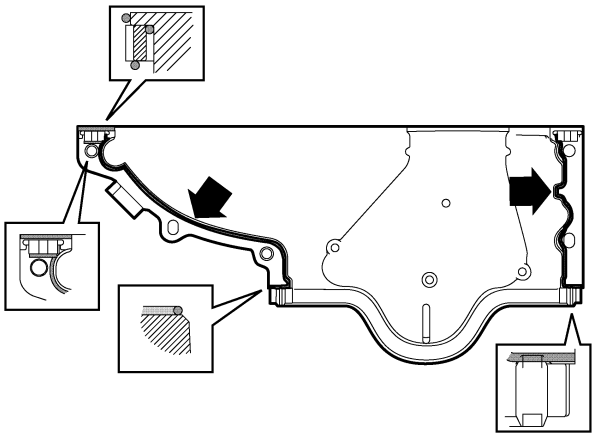


Figure 472 — Sealant Application Pattern — Cover to Plate

Remove all old sealant before attempting to apply new sealant. Apply a 2 mm (0.079 inch) bead of sealant to the timing gear cover following the pattern shown. Attach the cover to the timing gear plate within 20 minutes of applying the sealant.

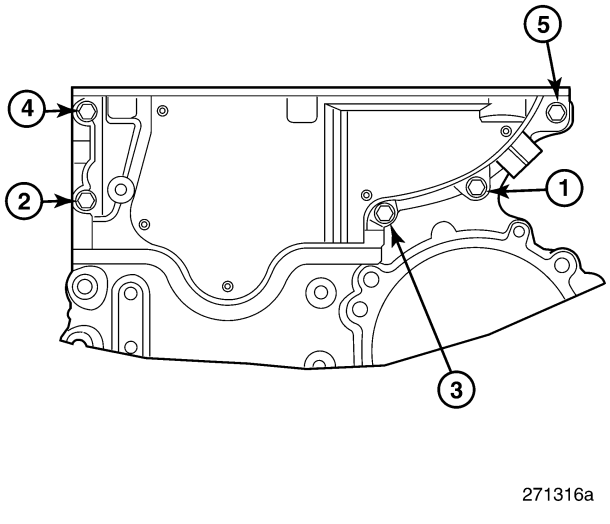


Figure 473 — Torque Sequence Screw Numbers — Cover to Plate

Step 1. Align cover to cylinder head so that sealing surfaces are flush and install screws 1 and 2. Hand tighten screws 1 and 2 to hold alignment.	
Step 2. Tighten screws in the order indicated.	24 ±4 N•m (18 ±3 lb-ft)

Flywheel

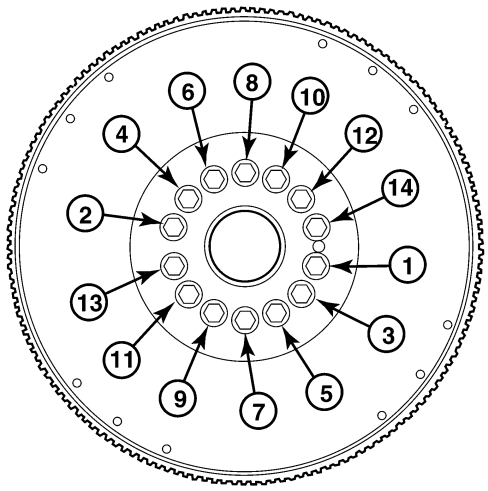


Figure 474 — Torque Sequence Numbers — Flywheel to Crankshaft

Mark the head of each screw after installation. Discard screws with four marks when removed and substitute **new** screws. Lubricate the threads and under the heads of screws to be reused. Do NOT lubricate new screws that are coated.	
Step 1. Tighten screws in the order indicated.	60 ±5 N•m (44 ±4 lb-ft)
Step 2. In the order indicated: angle tighten.	120° ±10°

Flywheel Housing

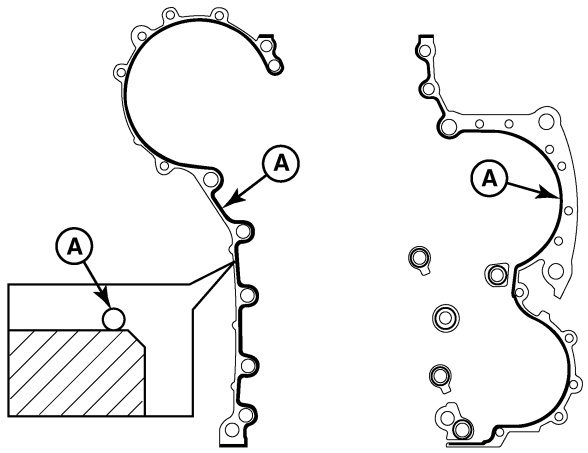


Figure 475 — Sealant Application Pattern — Flywheel Housing to Plate

Remove all old sealant before attempting to apply new sealant.
Apply a 2 mm (5/64 inch) bead of 3092340 sealant to the flywheel housing following the pattern shown.
Attach the housing to the timing gear mounting plate within 20 minutes of applying the sealant.

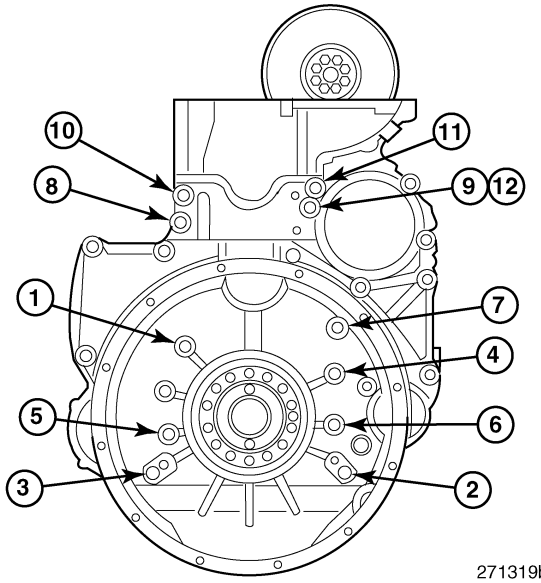


Figure 476 — Torque Sequence — M14 and M10 Screws (Housing to Plate and Block)

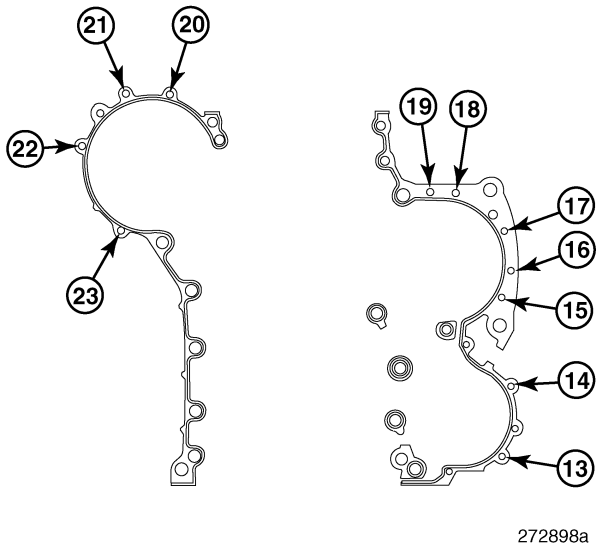


Figure 477 — Torque Sequence — M8 Screws (Plate to Housing)

Tighten the screws in the order indicated according to the following torque values.	
Step 1. M14, M10 and M8 screws	24 ±4 N•m (18 ±3 lb-ft)
Step 2. M14 screws, 1–8	140 ±20 N•m (103 ±15 lb-ft)
Step 3. M10 screws, 9–12	48 ±8 N•m (35 ±6 lb-ft)
Step 4. M8 screws, 13–23 (front of timing gear plate-to-flywheel housing)	24 ±4 N•m (18 ±3 lb-ft)

Additional Rear of Engine Components

Attaching Screws, Rear Engine Support Bracket to Flywheel Housing	300 ±45 N•m (221 ±33 lb-ft)

MP8 ENGINE COMPONENTS — BOTTOM OF ENGINE

Oil Pan

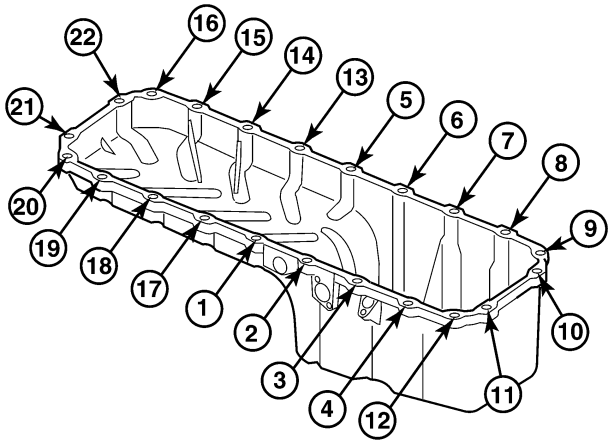


Figure 478 — Torque Sequence Screw Numbers — Oil Pan to Block

Tighten screws in the order indicated to . . .	24 ±4 N•m (18 ±3 lb-ft)

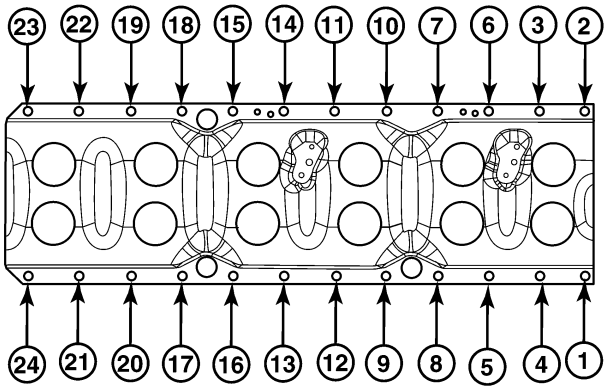
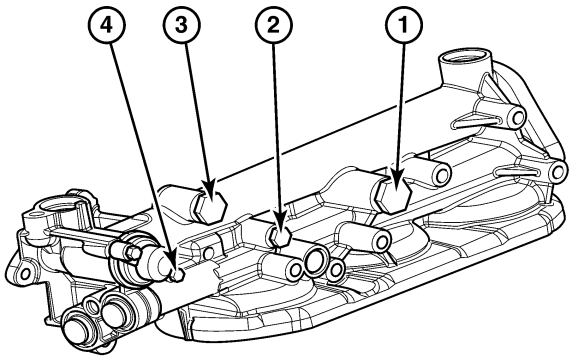


Figure 479 — Torque Sequence — Block Stiffener Plate to Block

Do NOT reuse stiffener plate attaching screws. Always use **new** screws in service. Tighten the screws in the order indicated according to the following torque specifications.	
Step 1. All screws	45 ±5 N•m (33 ±4 lb-ft)
Step 2. Angle tighten	60 ±5°



271349a

Figure 480 — Oil Filter Support Assembly

Filter Support Attaching Screws	24 ±4 N•m (18 ±3 lb-ft)
Oil Filter	25 +5/–0 N•m (18 +3.5/–0 lb-ft)
1. Plug	55 ±5 N•m (40 ±4 lb-ft)
2. Plug	12 ±2 N•m (9 ±1.5 lb-ft)
3. Plug	55 ±5 N•m (40 ±4 lb-ft)
4. M6 Screws	10 ±2 N•m (7 ±1.5 lb-ft)

Additional Bottom of Engine Components

Lube Valve Housing	
Attaching Screws (4)	Hand start all, then tighten to 48 ±8 N•m (35 ±6 lb-ft).
Crankshaft Bearing Caps	
Discard screws with four marks when removed and substitute new screws.	
Attaching Screws Step 1.	 150 ±20 N•m (111 ±15 lb-ft)
Step 2. Angle tighten	120° ±5°
Connecting Rod Bearing Caps	
Discard screws with four marks when removed and substitute new screws. Tighten screws in a cross pattern.	
Attaching Screws Step 1.	 20 ±3 N•m (15 ±2 lb-ft)
Step 2.	60 ±3 N•m (44 ±2 lb-ft)
Step 3. Angle tighten	90 ±5°
Oil Pan Drain Plug	60 ±10 N•m (44 ±7 lb-ft)
Oil Pump Attaching Screws	24 ±4 N•m (18 ±3 lb-ft)
Nozzle Attaching Screws, Piston Cooling Do not reuse.	24 ±4 N•m (18 ±3 lb-ft)

MP8 ENGINE COMPONENTS — RIGHT SIDE

Exhaust Manifold

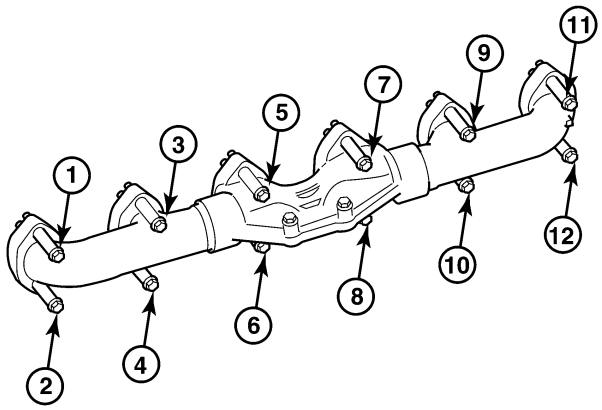


Figure 481 — Torque Sequence Numbers — Manifold to Cylinder Head

Use anti-seize compound on contact surfaces of nuts, bolts and screws when reassembling exhaust system components.	
Step 1. All screws	5 ±1.5 N•m (3.5 ±1 lb-ft)
Step 2. Screws 1, 4, 5, 8, 9 and 12	10 ±1.5 N•m (7.5 ±1 lb-ft)
Step 3. Screws 3, 2, 7, 6, 11, 10, 1, 4, 5, 8, 9 and 12	48 ±8 N•m (35 ±6 lb-ft)

Oil Cooler Cooling Duct Cover

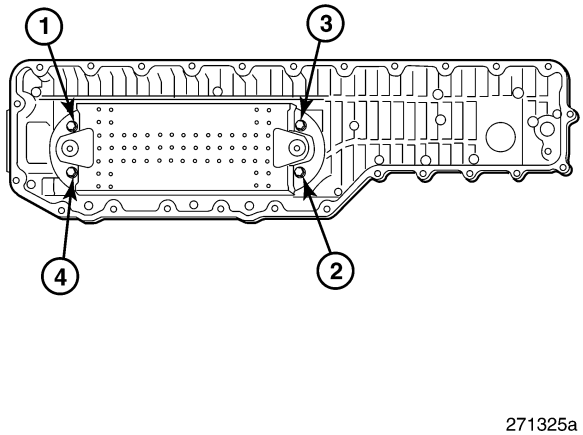


Figure 482 — Oil Cooler to Cooling Duct Cover

Step 1. Screws 1, 2, 3 and 4	5 ±1 N•m (44 ±9 **lb-in**l)
Step 2. Screws 1, 2, 3, 4 and 1	27 ±4 N•m (20 ±3 lb-ft)

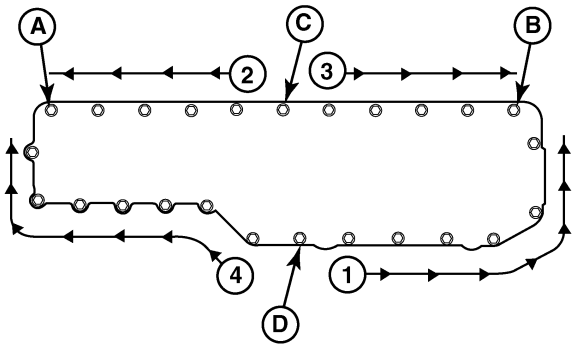


Figure 483 — Torque Sequence Numbers — Cooling Duct Cover to Block

Place the cover in position on the cylinder block and loosely install screw **A**. Press the cover against the coolant pump housing using the assembly tool 88800022 and loosely install screw **B**. Check that the duct cover is properly positioned and install the screws following the step sequence listed below.	
Step 1. Screws C and D	24 ±4 N•m (18 ±3 lb-ft)
Step 2. Starting at the center and moving outward — all screws in sequence 1, followed by sequences 2 (including A), 3 (including B) and 4.	24 ±4 N•m (18 ±3 lb-ft)
Step 3. Verify screws C and D.	24 ±4 N•m (18 ±3 lb-ft)

Turbocharger

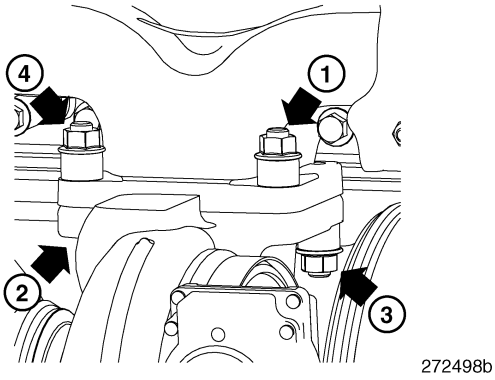


Figure 484 — Torque Sequence — Turbocharger Mounting Fasteners

Fasteners, Turbocharger to Exhaust Manifold (use anti-seize compound at reassembly)	
Step 1.	20 ±4 N•m (15 ±3 lb-ft)
Step 2.	48 ±8 N•m (35 ±6 lb-ft)

Turbocharger Lubrication Fittings

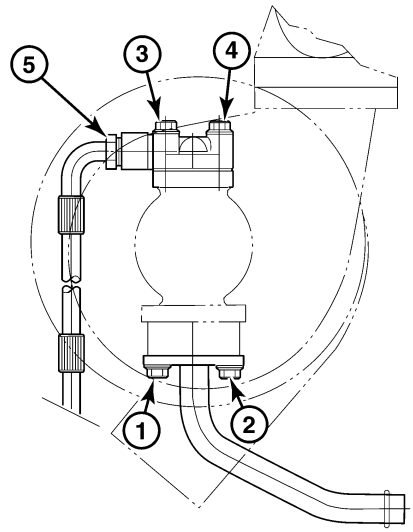


Figure 485 — Torque Sequence — Turbocharger Lubrication Fittings

Step 1. Screws 1 and 3	12 N•m (9 lb-ft)
Step 2. Screws 2, 4, 1 and 3	24 ±2.4 N•m (18 ±1.8 lb-ft)
Connector 5	30 ±5 N•m (22 ±4 lb-ft)

Oil Pressure Safety Valve

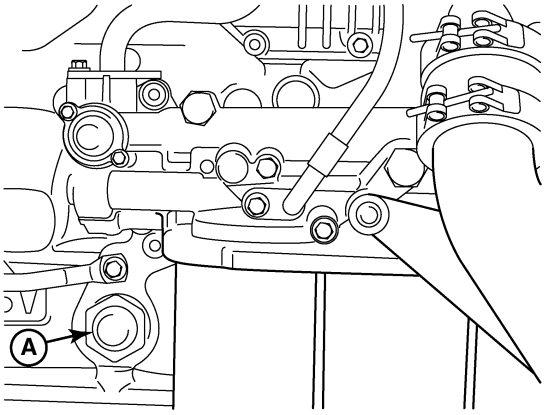


Figure 486 — Oil Pressure Safety Valve

Screws **A**	50 ±5 N•m (37 ±3 lb-ft)

Starter

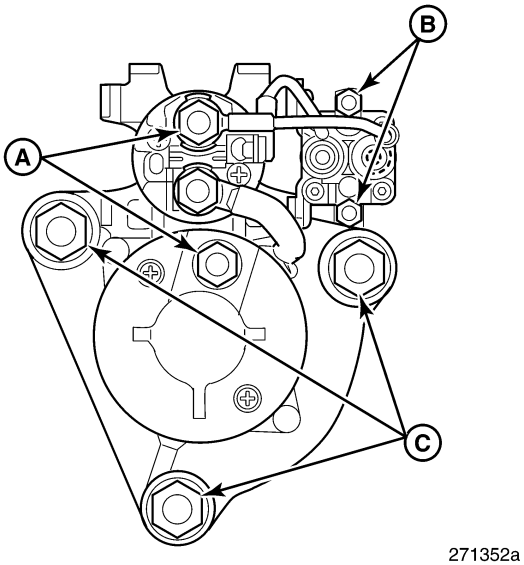


Figure 487 — Starter Attaching Studs

Attaching Studs	24 ±4 N•m (18 ±3 lb-ft)
Screws **A**	18 ±2 N•m (13 ±1.5 lb-ft)
Screws **B**	3 ±0.5 N•m (27 ±4.4 **lb-in**)
Screws **C**	60 ±6 N•m (44 ±4 lb-ft)

Additional Right-Side Engine Components

Oil Filter	
Bracket Attaching Screws	24 ±4 N•m (18 ±3 lb-ft)
Oil Cooler Cooling Duct Cover	
Plug, Oil Cooler Cooling Duct Cover	55 ±8 N•m (40 ±6 lb-ft)
Water Drain Connector	40 ±4 N•m (30 ±3 lb-ft)
Fitting, 90° Elbow	30 ±5 N•m (22 ±4 lb-ft)

MP8 ENGINE COMPONENTS — LEFT SIDE

Inlet Manifold

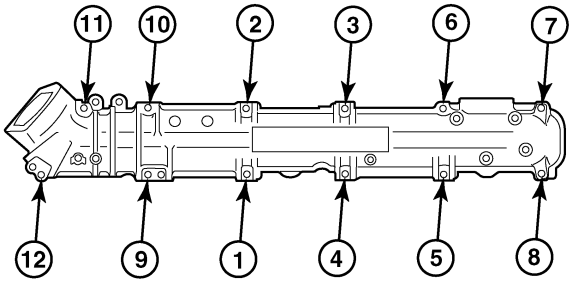


Figure 488 — Torque Sequence — Manifold to Cylinder Head

Tighten screws in the order indicated.	24 ±4 N•m (18 ±3 lb-ft)

Inlet Air Heater

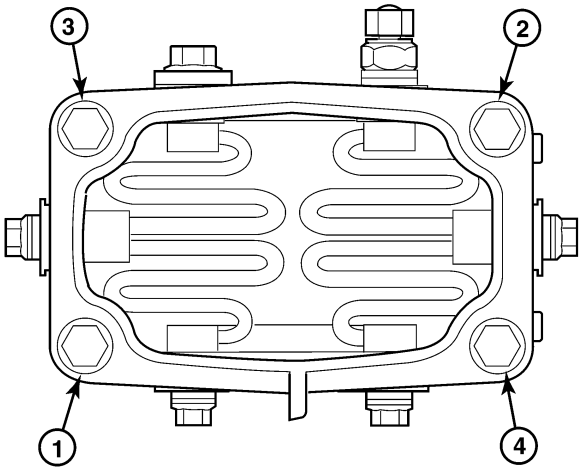


Figure 489 — Torque Sequence Screw Numbers — Inlet Air Heater

Tighten screws in the order indicated.	
Step 1.	10 ±2 N•m (7 ±1.5 lb-ft)
Step 2.	24 ±3 N•m (18 ±2 lb-ft)

Low Pressure Fuel Circuit

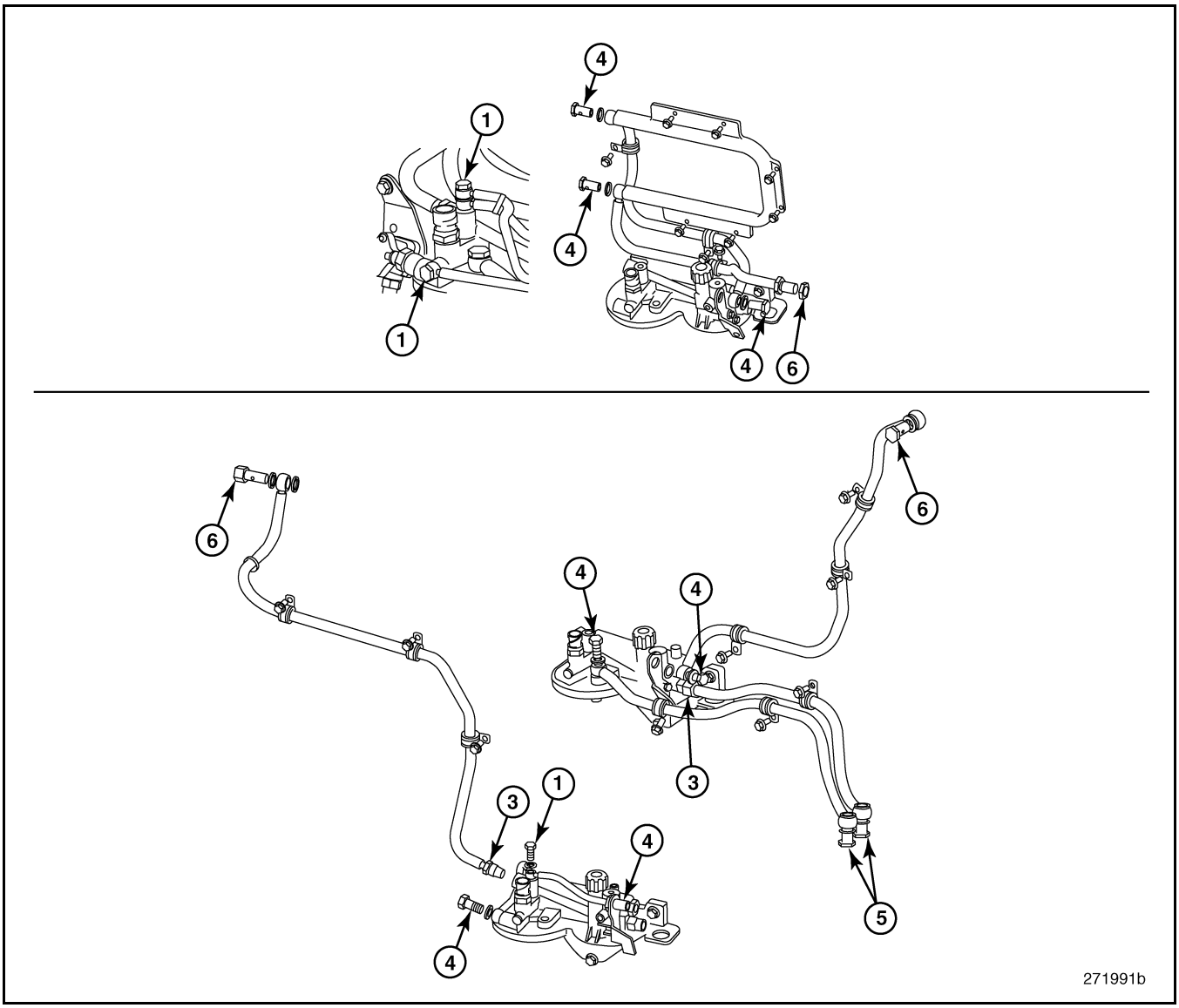


Figure 490 — Screw Number Identification for Torquing — Fuel Circuit

Filter Bracket Attaching Screws, M8 x 1.25	24 ±4 N•m (18 ±3 lb-ft)
No. 1	18 ±3 N•m (13 ±2 lb-ft)
No. 3	30 ±4 N•m (22 ±3 lb-ft)
No. 4	35 ±5 N•m (26 ±4 lb-ft)
No. 5	40 ±5 N•m (29.5 ±4 lb-ft)
No. 6	48 ±5 N•m (35 ±4 lb-ft)

Fuel Filter Support

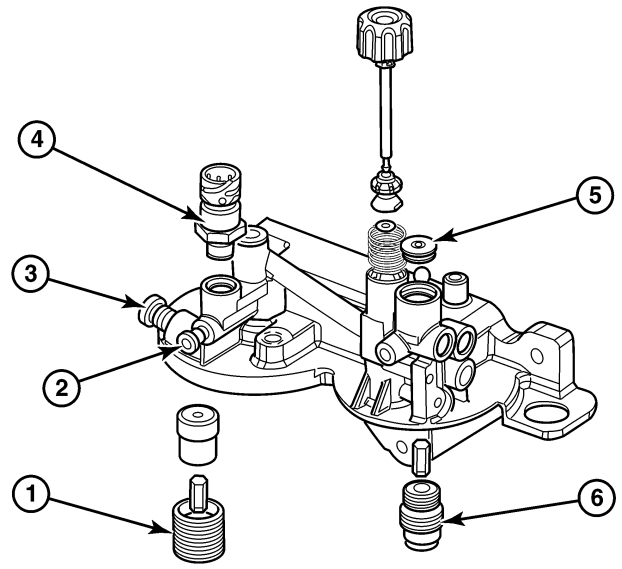


Figure 491 — Fuel Filter Support — Plugs and Valves

Tighten the plugs and valves according to the following specifications.	
No. 1, 40 ±5 N•m (30 ±4 lb-ft)	No. 4, 30 ±5 N•m (22 ±4 lb-ft)
No. 2, 10 ±1.5 N•m (7 ±1 lb-ft)	No. 5, 2 ±0.5 N•m (18 ±4 lb-in) (Note lb-in)
No. 3, 25 ±1.5 N•m (18 ±1 lb-ft)	No. 6, 40 ±1.5 N•m (30 ±1 lb-ft)

Tandem Pump (Fuel and Power Steering)

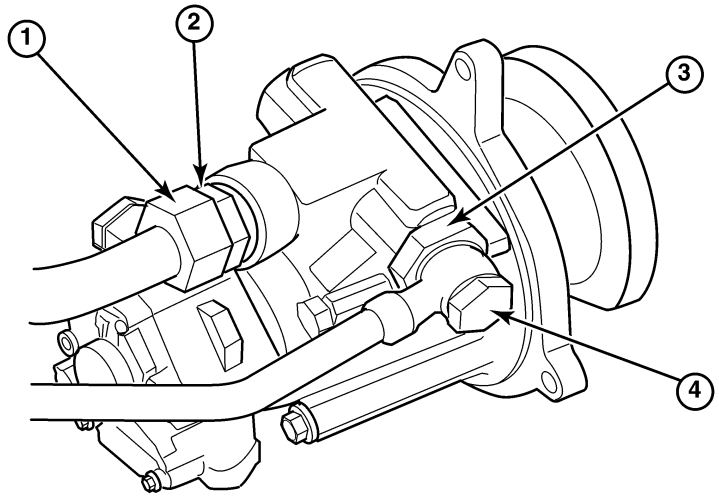


Figure 492 — Power Steering Pump Connectors

Tighten the connectors according to the following specifications.	
No. 1, 80 ±16 N•m (59 ±12 lb-ft)	No. 3, 70 ±10 N•m (52 ±7 lb-ft)
No. 2, 60 ±12 N•m (44 ±9 lb-ft)	No. 4, 37 ±7 N•m (27 ±5 lb-ft)

Additional Left-Side Engine Components

Alternator	
Mounting Bracket Attaching Screws, M10	48 ±8 N•m (35 ±6 lb-ft)
Pad Mount Attaching Screws, M12	85 ±15 N•m (63 ±11 lb-ft)
Attaching Screws, Tension Idler Roller	48 ±8 N•m (35 ±6 lb-ft)
Pulley Nut	101 ±6.5 N•m (75 ±5 lb-ft)
Inlet Manifold	
Plug, Inlet Manifold	20 ±3 N•m (15 ±2 lb-ft)
Air Compressor, Brake System	
Gear Attaching Nut	200 +50/–0 N•m (147 +37/–0 lb-ft)
Compressor Attaching Nuts	85 ±15 N•m (63 ±11 lb-ft)
Grease Connector	25 ±4 N•m (18 ±3 lb-ft)
Attaching Studs	24 ±4 N•m (18 ±3 lb-ft)
Fuel Pump	
Attaching Screws (to Power Steering Pump)	8 +2/–0 N•m (6 +1/–0 lb-ft)
Banjo Bolts	40 ±5 N•m (30 ±4 lb-ft)
Power Steering Pump	
Gear Attaching Nut	100 ±10 N•m (74 ±7 lb-ft)
Attaching Screws	24 ±4 N•m (18 ±3 lb-ft)
Refrigerant Compressor, Air Conditioning	
M8 Attaching Screws	24 ±4 N•m (18 ±3 lb-ft)

Standard Bolt and Nut Torque Values

The torque values in the table below conform to standard STD 5511,15.

	N•m (lb-ft)	
Screw/Bolt (Nut) Metric Size	**Grade 8.8**	**Grade 10.9**
M6 x 1.00	10 ±1.5 (7 ±1)	12 ±2 (9 ±1.5)
M8 x 1.25	24 ±4 (18 ±3)	30 ±5 (22 ±4)
M10 x 1.50	48 ±8 (35 ±6)	60 ±10 (44 ±7)
M12 x 1.75	85 ±15 (63 ±11)	105 ±20 (77 ±15)
M14 x 2.00	140 ±25 (103 ±18)	175 ±30 (129 ±22)
M16 x 2.00	190 ±35 (140 ±26)	275 ±45 (203 ±33)
M18 x 2.50	290 ±45 (214 ±33)	360 ±55 (265 ±40)
M20 x 2.50	430 ±70 (317 ±52)	540 ±90 (398 ±66)
M22 x 2.50	580 ±90 (428 ±66)	730 ±120 (528 ±88)
M24 x 3.00	740 ±120 (546 ±88)	900 ±140 (664 ±103)

ENGINE GASKETS, LUBRICANTS AND SEALANTS

Gasket and Seal Reuse

Some gaskets and seals must be discarded if removed during service. The following table describes the components and their limits.

Components	Examples	Reusable Limit	Reuse Recommendations
Gaskets (steel)	Cylinder head	Do not reuse	Discard the old gasket and substitute new if the head is removed.
Gaskets (hot)	Exhaust manifold Turbocharger	Do not reuse	Discard old gaskets and substitute new if associated components are removed.
Rubber gaskets (special)	Sealing strip (coolant duct cover, valve cover, oil pan, upper timing gear cover and inlet manifold)	No limit if no damage and no leaks	Remove old silicone from the T joints. Clean the surfaces. Apply fresh silicone.
Rubber gaskets (standard)	O-rings and sealing rings	Do not reuse	
Bonded seals, steel/rubber gasket	Nipples, hollow screws and oil filter housing	No limit if no damage and no leaks	
Valve seals	Valve stems	No limit if no damage and no leaks	Discard old seals and substitute new if the gasket is removed.
Crankshaft seals		Do not reuse	Discard old seals and substitute new if removed. Do **not** apply oil on the inside or outside diameters of the seal during assembly. **SEALS MUST BE DRY MOUNTED**.
Sealant agent	Sealing between: Timing Gear Plate and Cylinder Block Flywheel Housing and Timing Gear Plate Timing Gear Cover and Gear Plate	Do not reuse	Remove the old sealant. Clean the surfaces. Apply fresh sealant. **Important**: Remove the old silicone from the T joints and apply fresh.

Lubricants and Sealants

Use only the following recommended sealing compounds and lubricants.

NOTE

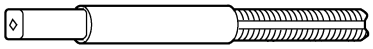
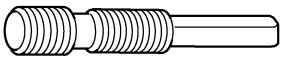
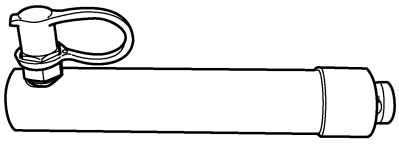
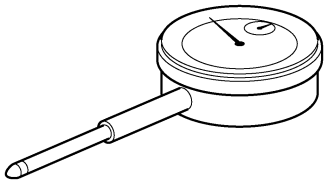
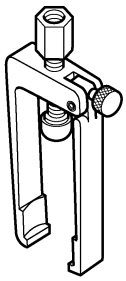
All genuine MACK cylinder head gaskets are precoated and do not require any type of sealing compound. Before installing **new** gaskets, degrease both gasket sealing surfaces to avoid leaks.

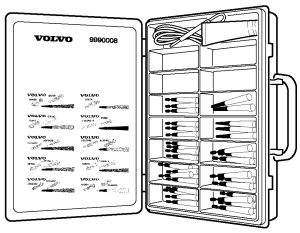
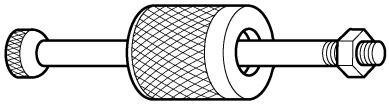
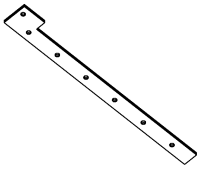
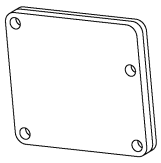
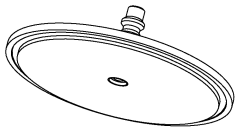
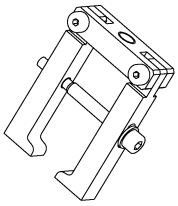
Location	Sealant or Lubricant
Crankshaft front seal cover	Part No. 342SX33 (or Dow Corning® 832)
Cup plugs/threaded plugs	Loctite® 277 or equivalent/Teflon® thread sealer
Cylinder sleeve seats	Part No. 342SX33 (or Dow Corning® 832)
Engine parts, fasteners (sides and threads), and washers	Clean engine oil
Injector sleeve copper seals	Clean coolant
Oil filter sealing gaskets (full-flow filters)	Clean engine oil
O-rings	Use the type of fluid that the O-ring contacts in use.
Sensors with O-ring seals	Assemble dry
Valve stems and guides	SAE 15-40 clean engine oil

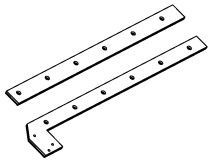
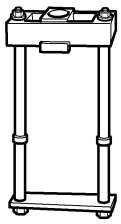
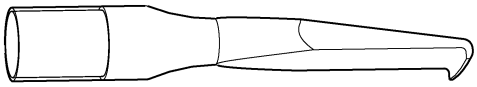
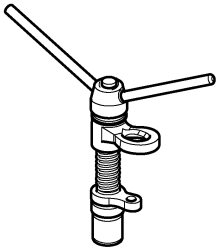
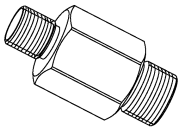
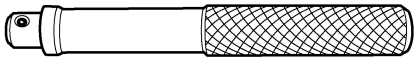
SPECIAL TOOLS & EQUIPMENT

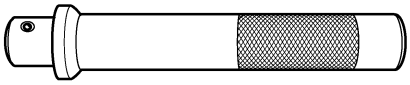
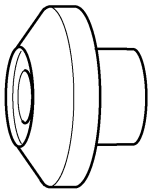
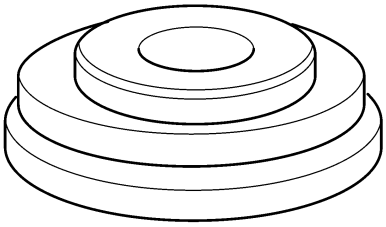
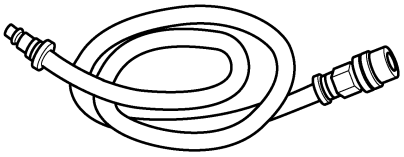
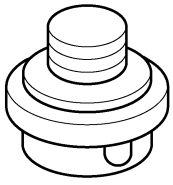
MP8 ENGINE SERVICE TOOLS [200 EA]

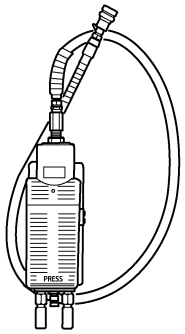
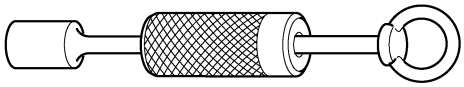
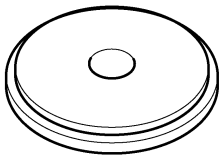
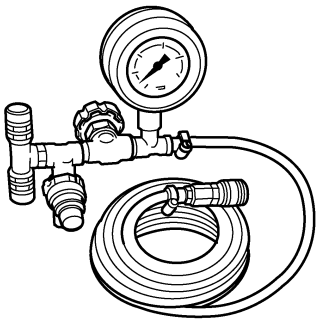
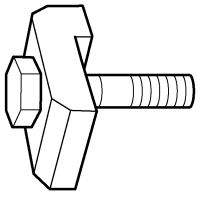
Special Tools for Engine Overhaul

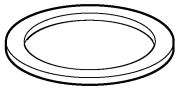
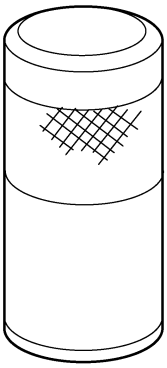
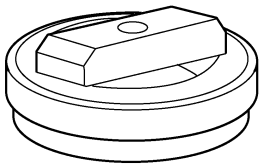
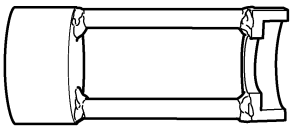
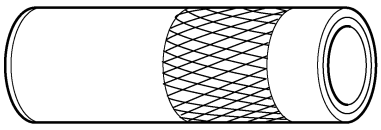
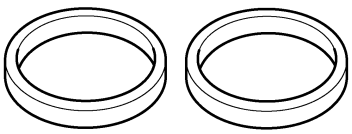
Tool No.	Description	Image
9809667	9 mm Tap, use with 9998252 (Available)	 006840a
9809668	9 mm Bit, use with 9998253 (Available)	 006841a
9809729	Hydraulic Ram (Available)	 006777a
9989876	Dial Indicator (Available)	 006899a
9990006	Two-Jaw Puller for Unit Injector Removal, use with 9990013 (Essential)	 006778a

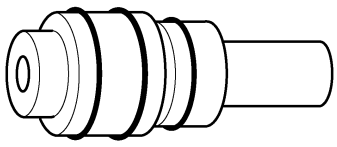
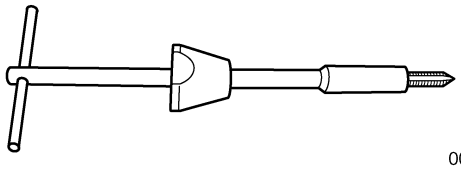
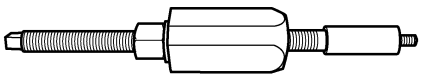
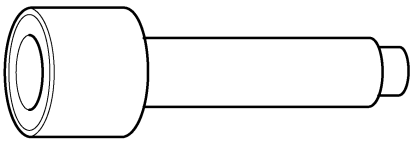
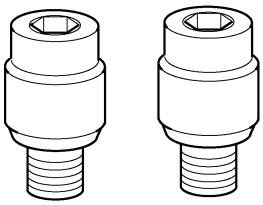
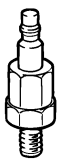
Tool No.	Description	Image
9990008	Set of Test Pins	 006951a
9990013	Slide Hammer for Unit Injector Removal, use with 9990006 (Essential)	 006779a
9990105	Sealing Plate for MP7 Cylinder Head	 274113a
9990106	Sealing Plate for MP7, MP8 and MP10 Cylinder Heads	 274114a
9990107	Connection Disc for MP7, MP8, and MP10 Cylinder Heads	 274115a
9990114	Main Bearing Cap Puller	 007030a

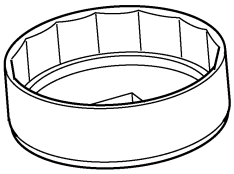
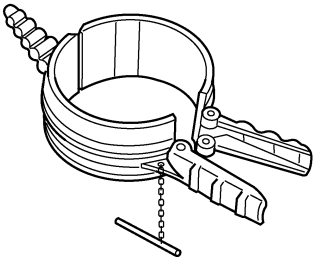
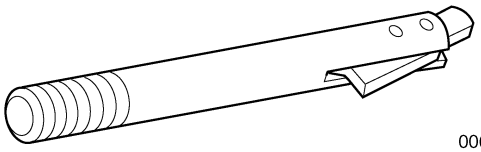
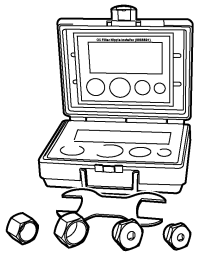
Tool No.	Description	Image
9990164	Sealing Plate for MP10 Cylinder Head	 274116a
9990176	Tool Press for Valve/Valve Guide Replacement (Available)	 006781a
9990192	Crankshaft Seal Puller	 006896a
9990210	Valve Spring Compressor (Essential)	 006782a
9990262	Slide Hammer Adapter	 007031a
9991801	Handle with various uses (fits 18 mm hole), use with 9992564 (Essential)	 006783a
9991821	Slide Hammer for Pilot Bearing Removal and other various uses (Available)	006784a

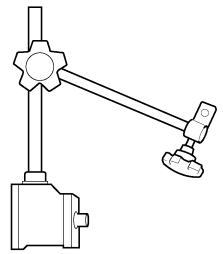
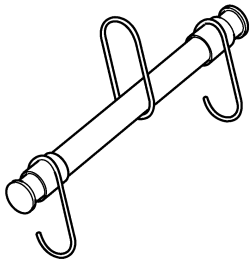
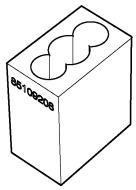
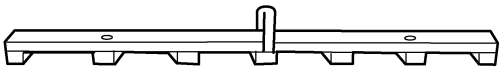
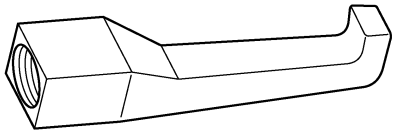
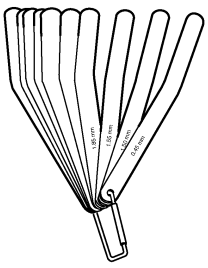
Tool No.	Description	Image
9992000	Handle with various uses (fits 25 mm hole), use with 9990113 (Essential)	 006785a
9992564	Driver for Installation of Pilot Bearing, use with 9991801 (Essential)	 006786a
9992610	Drift (Available)	 006975a
9996049	Coolant Drain Hose (Available)	 006788a
9996159	Adapter (Tool Press for Valve/Valve Guide Replacement) (Available)	 006789a

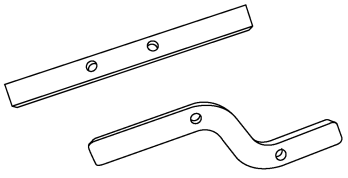
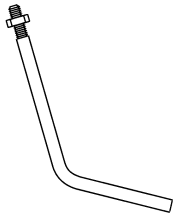
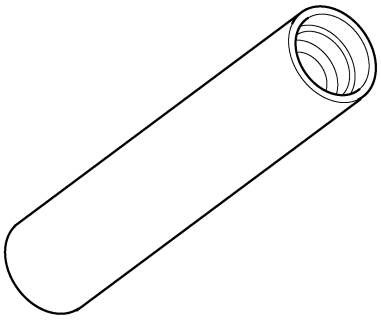
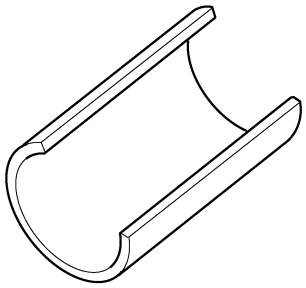
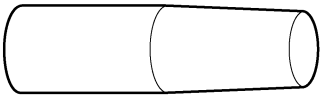
Tool No.	Description	Image
9996222	Hydraulic Pump (Available)	 006790a
9996400	Slide Hammer	 006897a
9996454	Handle for Liner Installation Plate (Available)	006791a
9996599	Liner Installation Plate (Available)	 006792a
9996662	Pressure Gauge and Hoses (Available)	 006793a
9996966	Liner Hold-Down Tools (Essential)	 006796a

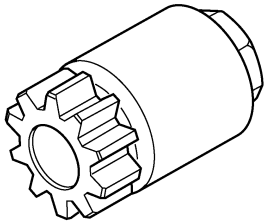
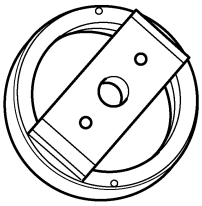
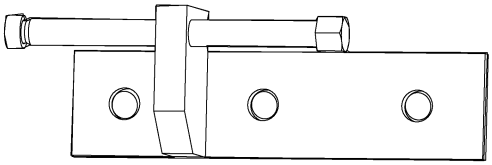
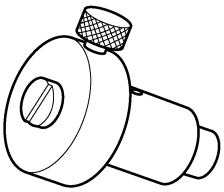
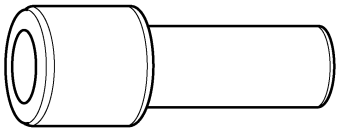
Tool No.	Description	Image
9998170	Seal Spacer (Essential)	 006947a
9998225	Drift (Available)	 006974a
9998238	Rear Main Seal Remover/Installer, use with 9992000 (Essential) **Note:** For Teflon® seals, use tools 9990166, 9990192 and 9996400.	 006780a
9998246	Valve Spring Compressor Adapter (Available)	 006797a
9998249	Unit Injector Protection Sleeves (Essential)	 006798a
9998250	Fuel Gallery Sealing Rings (Available)	 006799a

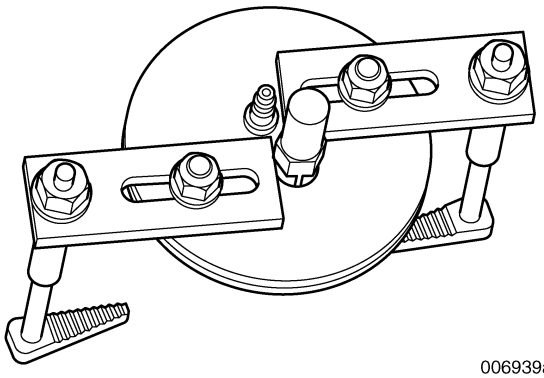
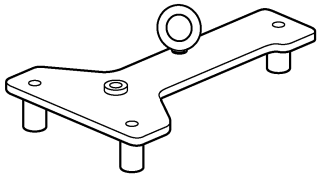
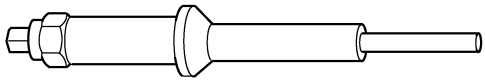
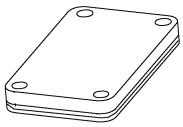
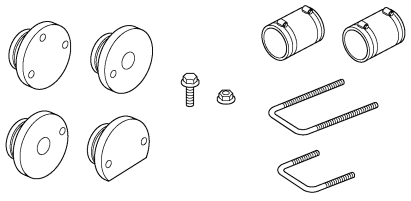
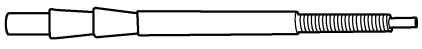
Tool No.	Description	Image
9998251	Unit Injector Bore Sealing Plug (Essential)	 006800b
9998252	Unit Injector Sleeve Tap (to thread nose of cup) (Essential) This tool comes with both M8 x 1.25 (part No. 9987009) and M9 x 1.25 (part No. 9809667) taps. Use the larger of the two taps, M9 x 1.25 (part No. 9809667), when servicing an MP8 engine.	 006801a
9998253	Unit Injector Sleeve Remover (Essential) This tool comes with both M8 (part No. 9809746) and M9 (part No. 9809668) bits. Use the larger of the two bits, M9 (part No. 9809668), when servicing an MP8 engine.	 006802a
9998263	Valve Guide Removal Tool (Available)	 006803a
9998267	Dowels (Locating Tools for the Timing Gear Mounting Plate)	 006887a
9998333	Coupler, for use with EGR Cooler Leak Test Kit 88800216.	 273047a

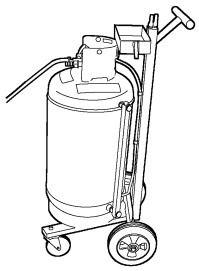
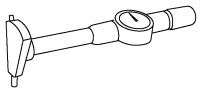
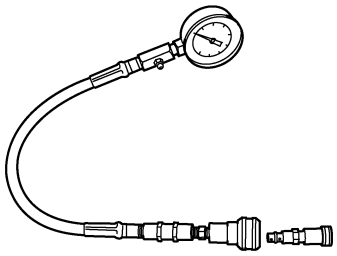
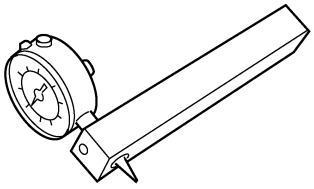
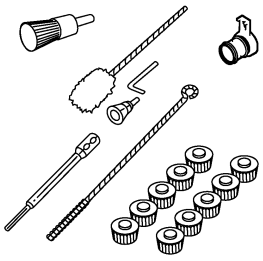
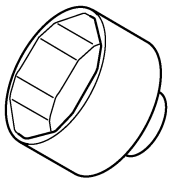
Tool No.	Description	Image
9998487	Oil Filter Wrench (Available)	 006845a
9998511	Lever	007121a
9998531	Piston Ring Compressor (Essential)	 006834a
9998649	Block Stiffener Plate Installation Tool	 006894a
9998691	Oil Filter Nipple (Spud) Installer Kit (Essential)	 007021b
9999683	Sweep Dial Indicator (Essential)	006948a

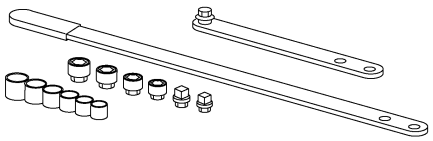
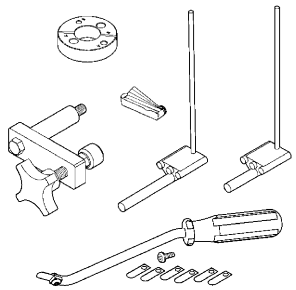
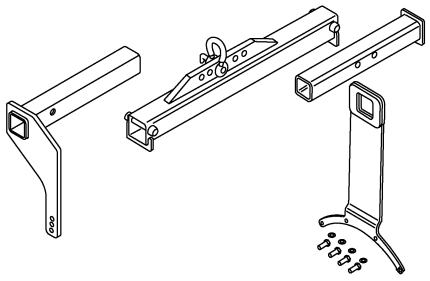
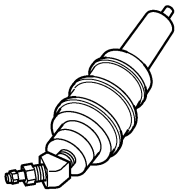
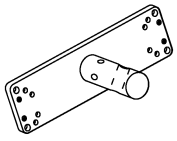
Tool No.	Description	Image
9999696	Magnetic Stand (Available)	 006900a
85109034	Camshaft Lifting Bar (Essential) **Note:** Alternate lifting tool —9998264	 006835a
85109208	Bearing Cap Press Tool (Essential)	 006949a
85109250	Rocker Shaft Assembly Lifting Tool (Essential) **Note:** Alternate lifting tool —9990185	 006770a
85109980	Camshaft Bearing Cap Removal Tool, use with 9990013 (Essential)	 006886a
85111377	Feeler Gauge Set	 006844a

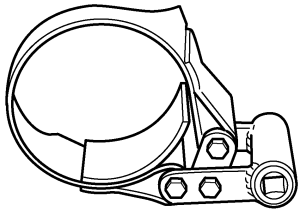
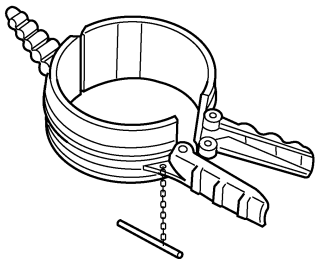
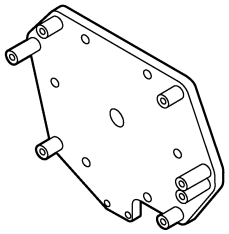
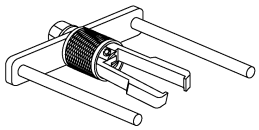
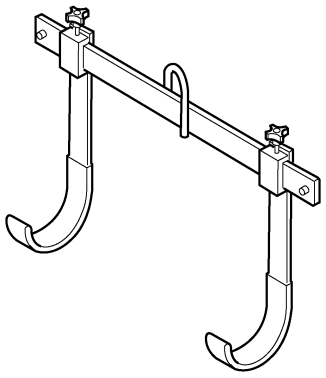
Tool No.	Description	Image
85111422 (A, B)	Timing Gear Cover Alignment Tool (Essential)	 006924a
85111493	Angled Extension (Available)	 006898a
85112460	Valve Stem Seal Installation Tool	 006966a
85112461	Valve Stem Height Measurement Gauge (Essential)	 006944a
88800011	Valve Stem Seal Protection Tool (Essential)	 006773a

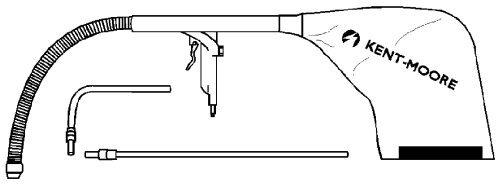
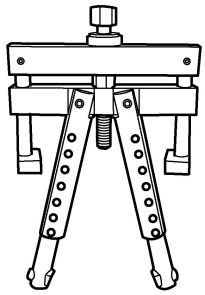
Tool No.	Description	Image
88800014	Flywheel Turning Tool (Essential)	 271485a
88800021	Front Main Seal Remover/Installer (Essential)	 006774a
88800022	Coolant Duct Cover Installation Tool	 006893a
88800031	Camshaft Sensor Depth Gauge (Essential)	 006804a
88800062	Inlet and Exhaust Valve Guide Installation (Available)	 006776a

Tool No.	Description	Image
88800186	Charge Air System Leakage Tester (Essential)	 006939a
88800188	Cylinder Head Lifting Tool (Essential)	 006923a
88800196	Swaging Tool for Installing Unit Injector Copper Sleeve (Essential)	 006805a
88800215	Sealing Plate	 007157a
88800216	EGR Cooler Leak Test Kit (Essential) **Note:** For alternate pressure test method, use tools 9988288, 9996662 and 9998143.	 007002c
88880010	Swaging Bit (Available)	 006842a

Tool No.	Description	Image
DBT 2V700 (2815- 2V700)	Coolant Extractor/Injector	 006940a
J 5347-B	Dial Bore Gauge	 000615b
J 6692-B	Cylinder Compression Gauge (Available)	 006836a
J 26948	Cylinder Liner Height Measurement Tool (Available)	 006846a
J 42885	Unit Injector Bore Cleaning Kit (Essential) **Note:** Alternate tool kit for cleaning — 9998599.	 006926a
J 43051	Oil Valve Socket	 006895a

Tool No.	Description	Image
J 44392	Fan Belt Tensioner Tool (Available)	 272697a
J 44514-B	Engine Timing Kit (Essential)	 006889a
J 47038-3 J 47038-4 J 47038-6 J 47038-8	Engine Lifting Tool (Essential)	 006927b
J 47363	Cylinder Compression Gauge Adapter (Essential) **Note:** Alternate tools — 9998248 with 9988539.	 006837a
J 47364	Cylinder Head Adapter Plate	 007117a

Tool No.	Description	Image
J 48061	Coolant Conditioner Filter Wrench (Available)	 006807a
J 48062	Piston Ring Compressor (Available)	 006834a
J 48662	Engine Stand Adapter Plate for use with stand J 29109-A (Available) **Note:** Alternate tools —88800117 with stand 9986485.	 006925a
J 48922	Heavy-Duty Unit Injector Puller (Essential)	 007000b
J 49002	Crankshaft Lifting Tool (Essential)	 007089a

Tool No.	Description	Image
PT-2900	Chip Vacuum	 006962a
PT-6435 or PT-6400-C	Cylinder Liner Puller (Available) **Note:** Alternate tools for liner removal – 9992955, 9996394, 9996395 and 9996645 in combination.	 006808a

All of the above tools are available through the MACK Parts System with the exception of those beginning with the prefix J or PT-. J and PT- tools are available from Kent-Moore at the following address.

KENT-MOORE
O.E. TOOL AND EQUIPMENT GROUP
SPX CORPORATION
28635 MOUND ROAD
WARREN, MICHIGAN 48092-3499
TEL: 1-800-328-6657
FAX: 1-800-578-7375

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SERVICE MANUAL

(EURO 3 EMISSIONS REGULATIONS)

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