

Service

Engine

Engine Model:

General Motors 3.0 L Powertrain

Generator Models:
30 kW

CAUTION

Caution: In order to reduce the chance of personal injury and/or property damage, carefully observe the instructions that follow.

The service manual of General Motors Powertrain is intended for use by professional, qualified technicians. Attempting repairs or service without the appropriate training, tools, and equipment could cause injury to you or others, damage the equipment, or cause the equipment to operate improperly.

Proper equipment and repair are important to the safety of the service technician and to the safe, reliable operation of the equipment. If you need to replace a part, use the same part number or an equivalent part. Do not use a replacement part of lesser quality.

The service procedures we recommend and describe in this service manual are effective methods of performing service and repair. Some of the procedures require the use of tools that are designed for specific purposes.

Accordingly, any person who intends to use a replacement part, a service procedure, or a tool that is not recommended by General Motors Powertrain must first establish that there is no jeopardy to personal safety or the safe operation of the equipment.

This manual contains various *Cautions* and *Notices* that you must observe carefully to reduce the risk of personal injury during service or repair. Improper service or repair may damage the equipment or render the equipment unsafe. These *Cautions* and *Notices* are not exhaustive. General Motors Powertrain cannot possibly warn of all the potentially hazardous consequences of failure to follow these instructions.

Table of Contents

Caution	Inside Front Cover
Introduction	1
Cautions and Notices	2
Fastener Tightening Specifications	7A-12B-4
Sealers, Adhesives, and Lubricants	7A-12B-4
Engine Mechanical Specifications	7A-12B-5
Diagnostic Information and Procedures	7A-12B-7
Base Engine Noise Diagnosis	7A-12B-7
Engine Identification	7A-12B-10
Repair Instruction	7A-12B-16
Draining Fluids and Oil Filter Removal	7A-12B-16
Engine Flywheel Removal	7A-12B-17
Distributor Removal	7A-12B-18
Ignition Coil Removal	7A-12B-18
Lift Bracket Removal	7A-12B-19
Spark Plug Removal	7A-12B-19
Intake/Exhaust Manifold Removal	7A-12B-19
Intake/Exhaust Manifold Disassemble and Assemble	7A-12B-20
Intake/Exhaust Manifold Clean and Inspect	7A-12B-20
Water Pump Removal	7A-12B-20
Crankshaft Pulley Removal	7A-12B-21
Valve Rocker Arm Cover Removal	7A-12B-21
Pushrod Cover Removal	7A-12B-21
Valve Rocker Arm and Pushrod Removal	7A-12B-22
Measuring Camshaft Lobe Lift	7A-12B-22
Valve Train Components Inspect (Cylinder Head)	7A-12B-23
Valve Lifter Removal	7A-12B-23
Cylinder Head Removal	7A-12B-24
Oil Pan Removal	7A-12B-24
Oil Pump Removal	7A-12B-24
Oil Level Indicator and Tube Removal	7A-12B-25
Engine Front Cover Removal	7A-12B-25
Measuring Crankshaft and Camshaft Sprocket Runout	7A-12B-26
Measuring Timing Sprocket Teeth Backlash	7A-12B-26
Crankshaft Sprocket Removal	7A-12B-26
Camshaft Removal	7A-12B-27
Crankshaft and Camshaft Sprocket Inspect	7A-12B-27
Timing Gear Oil Nozzle Removal	7A-12B-28
Piston, Connecting Rod, and Bearing Removal	7A-12B-28
Crankshaft and Bearings Clean and Inspect (Connecting Rod Bearing Clearance)	7A-12B-29
Crankshaft Rear Oil Seal and Housing Removal	7A-12B-31
Crankshaft, Bearings and Bearing Cap Removal	7A-12B-32
Crankshaft and Bearings Clean and Inspect	7A-12B-33
Crankshaft and Bearings Clean and Inspect (Main Bearing Clearance)	7A-12B-35
Camshaft Bearing Removal	7A-12B-37
Distributor Lower Bushing and Thrust Washer Removal	7A-12B-38
Oil Filter Bypass Valve Removal and Installation	7A-12B-38
Cylinder Block Clean and Inspect	7A-12B-39
Cylinder Bore Measurements	7A-12B-39
Cylinder Boring and Honing	7A-12B-40
Distributor Lower Bushing and Thrust Washer Installation	7A-12B-41
Piston and Connecting Rod Disassemble	7A-12B-41
Piston and Connecting Rod Clean and Inspect	7A-12B-42
Piston Selection	7A-12B-44
Piston and Connecting Rod Assemble	7A-12B-45

Table of Contents, continued

Camshaft and Bearings Clean and Inspect	7A-12B-46
Camshaft Sprocket and Retainer Removal and Installation	7A-12B-48
Camshaft Bearing Installation	7A-12B-49
Oil Pump Disassemble	7A-12B-50
Oil Pump Clean and Inspect	7A-12B-51
Oil Pump Assemble	7A-12B-52
Cylinder Head Disassemble	7A-12B-53
Cylinder Head Clean and Inspect	7A-12B-54
Valve Guide Reaming/Valve and Seat Grinding	7A-12B-57
Rocker Arm Stud Removal and Installation	7A-12B-58
Cylinder Head Assemble	7A-12B-59
Service Prior to Assembly	7A-12B-60
Installation	7A-12B-60
Crankshaft, Bearings and Bearing Cap Installation	7A-12B-60
Crankshaft Rear Oil Seal and Housing Installation	7A-12B-61
Piston, Connecting Rod and Bearing Installation	7A-12B-62
Timing Gear Oil Nozzle Installation	7A-12B-64
Crankshaft Sprocket Installation	7A-12B-64
Camshaft Installation	7A-12B-64
Engine Front Cover and Oil Seal Installation	7A-12B-65
Oil Pump Installation	7A-12B-66
Oil Pan Installation	7A-12B-66
Crankshaft Pulley Installation	7A-12B-67
Cylinder Head Installation	7A-12B-67
Valve Lifter Installation	7A-12B-68
Valve Rocker Arm and Push Rod Installation	7A-12B-68
Pushrod Cover Installation	7A-12B-70
Valve Rocker Arm Cover Installation	7A-12B-71
Oil Level Indicator and Tube Installation	7A-12B-71
Water Pump Installation	7A-12B-71
Intake/Exhaust Manifold Installation	7A-12B-72
Spark Plug Installation	7A-12B-72
Lift Bracket Installation	7A-12B-72
Ignition Coil Installation	7A-12B-73
Distributor Installation	7A-12B-73
Engine Flywheel Installation	7A-12B-74
Engine Block Coolant Plug/Oil Filter Installation	7A-12B-74
Description and Operation	7A-12B-76
Engine Component Description	7A-12B-76
Lubrication	7A-12B-77
Thread Repair	7A-12B-77
Cleanliness and Care	7A-12B-78
Replacing Engine Gaskets	7A-12B-78
Use of RTV and Anaerobic Sealer	7A-12B-78
Separating Parts	7A-12B-79
Tools and Equipment	7A-12B-79
Special Tools and Equipment	7A-12B-80

This manual provides the technician with information to service the General Motors Powertrain engine.

In general, this manual covers the service of the engine and associated standard equipment. In some cases the engine is supplied with accessories and equipment that are unique to the application. If service information is required on such unique accessories or equipment, contact the generator set manufacturer who will forward the proper information or advise the service technician where it can be obtained.

The information in this manual is grouped in sections according to the type of work being performed. The various sections are indicated in the Table of Contents of the manual.

This manual has been reprinted by the generator set manufacturer with the permission of General Motors Powertrain.

This manual is a reproduction of a General Motors Powertrain publication and contains information pertaining to industrial generator set engines. Some information pertains to other applications of the engine. The accuracy and completeness of information is the sole responsibility of General Motors Powertrain.

The descriptions and specifications contained in this manual were in effect at the time the book was released by General Motors Powertrain. The generator set manufacturer and General Motors Powertrain reserve the right to discontinue models or change specs or design at any time without notice and without incurring obligation.

Cautions and Notices

Definition of Caution, Notice, and Important

The diagnosis and repair procedures in the GM Powertrain Service Manual contain both general and specific Cautions, Notices, and Important. GM Powertrain is dedicated to the presentation of service information that helps the technician diagnose and repair the systems necessary for the proper operation of the equipment; however, certain procedures may present a hazard to the technician if they are not followed in the recommended manner. Cautions, Notices, and Important are elements designed to prevent these hazards; however, not all hazards can be foreseen. This information is placed at strategic locations within the service manual and is designed to prevent the following:

- Serious bodily injury to the technician.
- Damage to the equipment.
- Unnecessary equipment repairs.
- Unnecessary component repairs.
- Improper repair or replacement equipment components. Any caution or notice that appears in general information is referenced from the individual service categories.

Caution Defined

When encountering a Caution, you will be asked to take a necessary action or avoid a prohibited action. Cautions are designed to prevent:

- Serious bodily injury to the technician.
- Serious bodily injury to other technicians in the workplace area.
- Serious bodily injury to the equipment operator if the equipment has been improperly repaired.

Notice Defined

Notices call special attention to a necessary action or to a prohibited action. Notices are designed to prevent:

- Damage to the equipment.
- Unnecessary equipment repairs.
- Unnecessary component replacement.
- Improper operation or performance of the system or component under repair.
- Damage to any systems or components that are dependent upon the proper operation of the system or component under repair.
- Improper operation or performance of any systems or components that are dependent upon the proper operation or performance of the system or component under repair.
- Damage to fasteners, basic tools, or special tools.
- Leaks of coolant, lubricant, or other vital fluids.

Important Defined

Important statements emphasize a necessary characteristic of a diagnostic or repair procedure. *Important* statements are designed to do the following:

- Clarify a procedure.
- Present additional information for accomplishing a procedure.
- Give insight into the reason or reasons for performing a procedure in the manner recommended.
- Present information that will help to accomplish a procedure in a more effective manner.
- Present information that gives the technician the benefit of past experience in accomplishing a procedure with greater ease.

Moving Parts and Hot Surfaces Caution

Caution: Avoid contact with moving parts and hot surfaces while working around a running engine in order to prevent physical injury.

Safety Glasses Caution

Caution: Always wear safety glasses to avoid eye damage.

Belt Drive Notice

Notice: Do not use belt dressing on the drive belt. Belt dressing causes the breakdown of the composition of the drive belt. Failure to follow this recommendation will damage the drive belt.

Component Fastener Tightening Notice

Notice: Replacement components must be the correct parts for the application. The service procedure identifies components requiring the use of the thread-locking compound, lubricants, corrosion inhibitors, or sealants. Some replacement components may come with these coatings already applied. Do not use these coatings on components unless specified. These coatings can affect the final torque, which may affect the operation of the component. Use the correct torque specifications when installing components in order to avoid damage.

Fastener Notice

Notice: Use the correct fastener in the correct location. Replacement fasteners must be the correct parts for that application. The service procedure identifies fasteners requiring replacement or fasteners requiring the use of thread-locking compound or sealant. Do not use paints, lubricants, or corrosion inhibitors on fasteners or fastener joint surfaces unless specified. These coatings affect fastener torque and joint clamping force and may damage the fastener. Use the correct tightening sequence and specifications when installing fasteners in order to avoid damage to parts and systems.

Special Fastener Notice

Notice: This bolt is designed to permanently stretch when tightened. The correct fastener must be used to replace this type of fastener. Do not use a bolt that is stronger than the original in this application. If the correct bolt is not used, the parts will not be tightened correctly. The system or the components may be damaged.

Engine Mechanical - 3.0L

Specifications

Fastener Tightening Specifications

Application	N•m	Lb Ft	Lb In
Camshaft Retainer Bolts	9		80
Connecting Rod Cap Nuts	61	45	
Crankshaft Bearing Cap Bolts	75-95	55-70	
Crankshaft Rear Oil Seal Retainer Nuts	17-20		150-180
Cylinder Head Bolts	122	90	
Distributor Hold Down Bolt	27	20	
Flywheel Bolts	88	65	
Front Cover Bolts	3-4		27-35
Ignition Coil Bracket Attaching Bolts	22	16	
Intake to Exhaust Manifold Attaching Nuts and Bolt	27-34	20-25	
Intake/Exhaust Manifold to Head (2 center)	27-34	20-25	
Intake/Exhaust Manifold to Head (outer)	20-27	15-20	
Lift Bracket Bolts	27-41	20-30	
Oil Pan Nuts (rear)	19		165
Oil Pan Bolts (to crankcase)	9		80
Oil Pan Bolts (to front cover)	5		45
Oil Pan Studs to Oil Seal Retainer or Crankcase	2		15
Oil Pump Cover	8		72
Oil Pump to Block	14		120
Oil Pump Pickup	7		60
Pushrod Cover Bolts	5		40
Rocker Arm Cover Bolts	5		40
Spark Plugs	30	22	
Water Pump Bolts	20	15	

Sealers, Adhesives and Lubricants

GM Part Number	Type of Material	Application
1052080	Sealant	Rear camshaft bearing hole plug
1052080	Sealant	Cylinder head bolt threads
1052914	Sealant	Oil pan sealing surfaces
1052365	Lubricant	Valve train component prelube
1052080	Sealant	Valve rocker arm stud threads
1052080	Sealant	Oil level indicator tube

Engine Mechanical Specifications (1 of 2)

Application	Metric	English
General Data		
Engine Type	L4	
Displacement	3.0L	181 CID
Bore	101.60 mm	4.000 in
Stroke	91.44 mm	3.60 in
Compression Ratio	9.25:1	
Firing Order	1-3-4-2	
Spark Plug Gap	0.9 mm	0.035 in
Lubrication System		
Oil Pressure (Minimum - Hot)	41.4 kPa at 1,000 engine rpm 124.1 kPa at 2,000 engine rpm 165.5 kPa at 4,000 engine rpm	6.0 psig at 1,000 engine rpm 18.0 psig at 2,000 engine rpm 24.0 psig at 4,000 engine rpm
Oil Capacity (With Oil Filter Change)	3.81	4.00 qts
Oil Pump Type	Gear Driven	
Cylinder Block		
Bore Diameter	101.5873-101.6635 mm	3.9995-4.0025 in
Bore Out-of-Round Production	0.0254 mm (Maximum)	0.001 in (Maximum)
Bore Out-of-Round Service Limit	0.0508 mm (Maximum)	0.002 in (Maximum)
Bore Taper Thrust Side Production	0.0127 mm (Maximum)	0.0005 in (Maximum)
Bore Taper Thrust Side Service Limit	0.0254 mm (Maximum)	0.001 in (Maximum)
Bore Taper Relief Side Production	0.0127 mm (Maximum)	0.0005 in (Maximum)
Bore Taper Relief Side Service Limit	0.0254 mm (Maximum)	0.001 in (Maximum)
Runout - Rear Face of Block to Crankshaft Center Line	0.05 mm (Maximum)	0.002 in (Maximum)
Piston		
Piston-To-Bore Clearance Production	0.0635-0.0889 mm	0.0025-0.0035 in
Piston-To-Bore Clearance Service Limit	0.0889 mm	0.0035 in (Maximum)
Piston Rings		
Piston Compression Ring Groove Clearance Production Top	0.03048-0.07366 mm	0.0012-0.0029 in
Piston Compression Ring Groove Clearance Production 2nd	0.03048-0.07366 mm	0.0012-0.0029 in
Piston Compression Ring Groove Clearance Service Limit	0.09906 mm (Maximum)	0.0039 in (Maximum)
Piston Compression Ring Gap Top Production *	0.254-0.508 mm	0.01-0.02 in
Piston Compression Ring Gap 2nd Production *	0.4318-0.635 mm	0.017-0.025 in
Piston Compression Ring Gap Top Service Limit *	0.88 mm (Maximum)	0.035 In (Maximum)
Piston Compression Ring Gap 2nd Service Limit *	0.88 mm (Maximum)	0.035 in (Maximum)
Piston Oil Ring Groove Clearance Production	0.0254-0.1524 mm	0.001-0.006 in
Piston Oil Ring Groove Clearance Service Limit	0.1778 mm (Maximum)	0.007 in (Maximum)
Piston Oil Ring Gap Production *	0.25-0.76 mm	0.01-0.03 in
Piston Oil Ring Gap Service Limit *	1.016 mm (Maximum)	0.04 in (Maximum)
Piston Pin		
Diameter	23.545-23.548 mm	0.9270-0.927 in
Clearance in Piston Production	0.00762-0.01651 mm	0.0003-0.00065 in
Clearance in Piston Service Limit	0.0254 mm (Maximum)	0.001 in (Maximum)
Fit in Connecting Rod	0.02032-0.050292 mm (Interference)	0.0008-0.00198 in (Interference)

* Measured in cylinder bore

Engine Mechanical Specifications (2 of 2)

Crankshaft		
Crankshaft Journal Diameter (All)	58.3666-58.4047 mm	2.2979-2.2994 in
Crankshaft Journal Taper Production	0.005 mm (Maximum)	0.0002 in (Maximum)
Crankshaft Journal Taper Service Limit	0.0254 mm (Maximum)	0.001 in (Maximum)
Crankshaft Journal Out-of-Round Production	0.005 mm (Maximum)	0.0002 in (Maximum)
Crankshaft Journal Out-of-Round Service Limit	0.0254 mm (Maximum)	0.001 in (Maximum)
Crankshaft Bearing Clearance Production #1 - #4	0.0254-0.06096 mm	0.001-0.0024 in
Crankshaft Bearing Clearance Production #5	0.0406-0.0889 mm	0.0016-0.0035 in
Crankshaft Bearing Clearance Service Limit #1 - #4	0.0254-0.0635 mm	0.001-0.0025 in
Crankshaft Bearing Clearance Service Limit #5	0.0381-0.0889 mm	0.0015-0.0035 in
Crankshaft End Play	0.05-0.1524 mm	0.002-0.006 in
Crankshaft Sprocket Runout	0.07 mm (Maximum)	0.003 in (Maximum)
Connecting Rod		
Connecting Rod Journal Diameter	53.2892-53.3273 mm	2.0980-2.0995 in
Connecting Rod Journal Taper Production	0.00762 mm (Maximum)	0.0003 in (Maximum)
Connecting Rod Journal Taper Service Limit	0.0254 mm (Maximum)	0.001 in (Maximum)
Connecting Rod Journal Out-of-Round Production	0.005 mm (Maximum)	0.0002 in (Maximum)
Connecting Rod Journal Out-of-Round Service Limit	0.0254 mm (Maximum)	0.001 in (Maximum)
Rod Bearing Clearance Production	0.04318-0.06858 mm	0.0017-0.0027 in
Rod Bearing Clearance Service Limit	0.0762 mm (Maximum)	0.003 in (Maximum)
Rod Side Clearance	0.1524-0.4318 mm	0.006-0.017 in
Camshaft		
Journal Diameter	47.440-47.490 mm	1.8677-1.8697 in
End Play	0.0762-0.2032 mm	0.003-0.008 in
Camshaft Sprocket Runout	0.1 mm (Maximum)	0.004 in (Maximum)
Timing Sprocket Teeth Backlash	0.10-0.15 mm	0.004-0.006 in
Lobe Lift Intake	6.4247 mm	0.25294
Lobe Lift Exhaust	6.4247 mm	0.25294
Lobe Lift Service Limit	±0.0254 mm	±0.001 in
Valve System		
Valve Lifter	Hydraulic	
Valve Rocker Arm Ratio	1.75:1	
Valve Lash	Half to One Turn Down From Zero Lash	
Face Angle	45 Degrees	
Seat Angle	46 Degrees	
Seat Runout	0.05 mm (Maximum)	0.002 in (Maximum)
Seat Width Intake	1.27-1.778 mm	0.050-0.070 in
Seat Width Exhaust	1.524-2.032 mm	0.060-0.080 in
Stem Clearance Intake Production	0.0254-0.06858 mm	0.001-0.0027 in
Stem Clearance Exhaust Production	0.01778-0.06858 mm	0.0007-0.0027 in
Stem Clearance Intake Service Limit	0.09398 mm (Maximum)	0.0037 in (Maximum)
Stem Clearance Exhaust Service Limit	0.1193 mm (Maximum)	0.0047 in (Maximum)
Valve Spring Free Length	52.324 mm	2.06 in
Valve Spring Pressure Closed	444-490 N at 40.89 mm	100-110 lb at 1.61 in
Valve Spring Pressure Open	925-987 N at 30.99 mm	208-222 lb at 1.22 in
Valve Spring Installed Height Intake	41.91 mm	1.65 in
Valve Spring Installed Height Exhaust	41.91 mm	1.65 in
Valve Lift Intake	11.25 mm	0.443 in
Valve Lift Exhaust	11.25 mm	0.443 in
Cylinder Head Warpage		
Cylinder Head Deck (measured within a 152.4 mm (6.0 in) area)	0.0762 mm	0.003 in
Cylinder Head Deck (measuring the overall length of the cylinder head)	0.1778 mm	0.007 in

Diagnostic Information and Procedures**Base Engine Noise Diagnosis**

Step	Action	Value	Yes	No
1	1. With the engine running, try to determine if the noise is timed to the crankshaft speed or the camshaft speed. 2. Using a timing light, two knocks per flash is the crankshaft or one knock per flash is the camshaft. Is the noise timed to the crankshaft speed?	—	Go to Step 2	Go to Step 3
2	1. Remove the rod bearings and inspect the bearings and the journals for wear. 2. If the parts are OK, remove the crankshaft and inspect the main bearings and journals for wear. 3. Replace the parts as necessary. Does the engine continue to knock?	—	Go to Step 3	System OK
3	Check to see if the noise is timed to the camshaft speed. Is the noise timed to the camshaft speed?	—	Go to Step 5	Go to Step 4
4	1. Inspect for loose accessory attachments, the flywheel. 2. Tighten or adjust as necessary. Does the engine continue to knock?	—	Go to Step 5	System OK
5	1. Remove the pushrod cover. • Refer to <i>Pushrod Cover Removal</i> . 2. Rotate the engine and measure the lifter movement in the bore. 3. Compare the measurement with the specifications in <i>Engine Mechanical Specifications</i> . Is the camshaft within specifications?	—	Go to Step 7	Go to Step 6
6	Replace the camshaft. Refer to <i>Camshaft Removal and Installation</i> . Does the engine continue to knock?	—	Go to Step 7	System OK
7	1. Remove the rocker arms, the pushrods and the lifters. 2. Inspect the parts for excessive wear or damage. 3. Replace the parts as necessary. Are the repairs complete?	—	System OK	—

Engine Compression Test

Perform the following steps in order to conduct a compression test:

1. Conduct the following steps in order to check cylinder compression:
 - 1.1. Engine should be at room temperature.
 - 1.2. Disconnect the two electrical connectors from the distributor.
 - 1.3. Remove the spark plugs.
 - 1.4. Throttle plates should be wide open.
 - 1.5. Battery should be at or near full charge.
2. For each cylinder, crank engine through four compression strokes.
3. The lowest cylinder reading should not be less than 70% of the highest.
4. No cylinder reading should be less than 689 kPa (100 psi).

Important: The results of a compression test will fall into the following categories:

1. Normal — Compression builds up quickly and evenly to specified compression on each cylinder.
2. Piston Rings — Compression low on first stroke. Tends to build up on the following strokes but does not reach normal. Improves considerably with addition of oil.
3. Valves — Compression low on first stroke. Does not tend to build up on the following strokes. Does not improve much with addition of oil. Use approximately three squirts from a plunger-type oiler.

Engine Noise Diagnosis

There are four steps to diagnosing engine noise. You must determine the following conditions:

- Type of noise.
- The exact operating condition under which the noise exists.
- Determine the rate and location of the noise.
- Compare the sounds in other engines to make sure you are not trying to correct a normal condition.

Identify the type of noise. For example, a light rattle or low rumble.

Remember, engine noises are generally synchronized to either engine speed (caused by the crankshaft, pistons or connecting rods) or one-half engine speed (valve train noise). Try to determine the rate at which the noise is occurring.

Knocks Cold and Continues for 2 to 3 Minutes

- Engine flywheel contacting the splash shield. Reposition the splash shield.
- Loose or broken crankshaft balancer or drive pulleys. Tighten or replace as necessary.
- Excessive piston to bore clearance. Replace the piston.

- Cold engine knock usually disappears when the specific cylinder secondary ignition circuit is grounded out. Cold engine piston knock which disappears in 1.5 minutes should be considered acceptable.

Knocks on Start-Up but Only Lasts a Few Seconds

- Improper oil viscosity. Install recommended oil viscosity for expected temperatures.
- Excessive piston to bore clearance.
- Excessive piston pin to piston clearance.
- Excessive crankshaft end clearance.
- Excessive crankshaft bearing clearance.

Knocks at Idle Hot

- Detonation or spark knock. Check operation of ignition controls or knock sensor circuit.
- Loose flywheel bolts.
- Exhaust leak at manifold. Tighten the exhaust manifold bolts and/or replace the gasket.
- Excessive connecting rod bearing clearance. Replace the bearings as necessary.
- Excessive piston pin clearance.
- Excessive crankshaft thrust bearing clearance.
- Bent connecting rod.

Valve Train Diagnosis

A light tapping at one-half engine speed or any varying frequency, can indicate a valve train problem. These tapping noises increase with engine speed.

Before attempting to judge the valve train noises, thoroughly warm up the engine. By doing this you will bring all engine components to a normal state of expansion. Also, run the engine at various speeds and listen for engine noise. The causes of the valve train noise include the following conditions:

- Incorrectly adjusted valve lash.
- Low oil pressure.
- Loose valve rocker arm attachments.
- Worn valve rocker arm and/or pushrod.
- Broken valve spring.
- Sticking valves.
- Lifters worn, dirty or faulty.
- Camshaft lobes worn.
- Worn valve guides.
- Worn or damaged valve keys.
- Bent pushrods.

Oil Consumption Diagnosis

Excessive oil consumption (not due to leaks) is the use of 1.9L (2 qts.) or more of engine oil within 50 hours of use. The causes of excessive oil consumption include the following conditions:

- External oil leaks. Tighten bolts and/or replace gaskets and oil seals as necessary.
 - Incorrect oil level or improper reading of oil level indicator. With the engine at a level surface, allow adequate drain down time and check for the correct oil level.
 - Improper oil viscosity. Use a recommended SAE viscosity for the prevailing temperatures.
 - Continuous high speed operation and/or severe usage.
 - Crankcase ventilation system restrictions or malfunctioning components. Possible improper PCV valve.
 - Valve guides and/or valve stem oil seals worn, or the seal omitted. Ream guides and install oversize service valves and/or new valve stem oil seals.
 - Piston rings broken, improperly installed, worn or not seated properly. Allow adequate time for rings to seat. Replace broken or worn rings as necessary.
 - Piston improperly installed or mis-fitted.
3. Visually check around the suspected component. Check around the gasket mating surfaces for leaks. A mirror is useful for finding leaks in areas that are hard to reach.
 4. If the leak still cannot be found, it may be necessary to clean the suspected area with a degreaser, steam or spray solvent. Clean the area well, then dry the area. Run the engine for several minutes at normal operating temperature and varying speeds. After running the engine, visually check the suspected area. If you still cannot locate the leak, try using the powder or black light and dye method.

Perform the following steps in order to perform the powder method:

1. Clean the suspected area.
2. Apply an aerosol-type powder (such as foot powder) to the suspected area.
3. Run the engine under normal operating conditions.
4. Visually inspect the suspected area. You should be able to trace the leak path over the white powder surface to the source.

Perform the following steps in order to use the black light and dye method:

Tools Required

J 39400 Leak Detector

1. Pour specified amount of dye into the leaking component.
2. Run the engine under normal operating conditions as directed by the J 39400.
3. Direct the light toward the suspected area. The dyed fluid will appear as a yellow path leading to the source.

Repairing the Leak

Once the origin of the leak has been pinpointed and traced back to its source, the cause of the leak must be determined in order for it to be repaired properly. If a gasket is replaced, but the sealing surface is damaged, the new gasket will not repair the leak. Before attempting to repair a leak, be sure that the gasket and sealing surfaces are correct.

Perform the following steps in order to check for gasket leaks:

1. Inspect the fluid level/pressure for being too high.
2. Check the crankcase ventilation system for restrictions or malfunctioning components.
3. Inspect for improperly tightened fasteners or dirty/damaged threads.
4. Look for warped flanges or sealing surfaces.
5. Check for scratches, burrs or other damage to the sealing surface.
6. Look for a damaged or worn gasket.
7. Check for cracking or porosity of the component.
8. Check for use of an improper sealant used (where applicable).

Low or No Oil Pressure Diagnosis and Testing

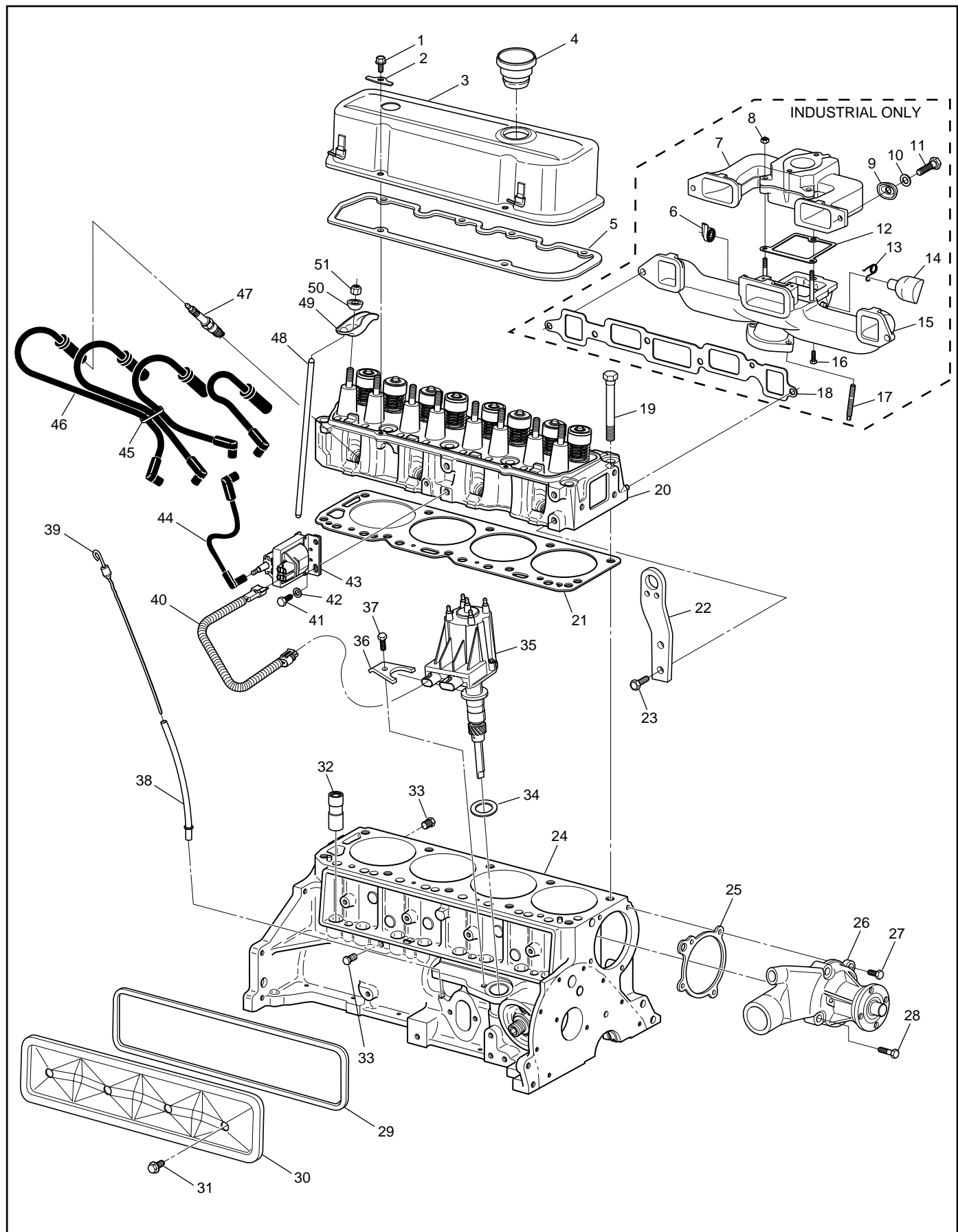
- Low oil level. Fill to full mark on oil level indicator.
- Incorrect or malfunctioning oil pressure switch.
- Incorrect or malfunctioning oil pressure gauge.
- Improper oil viscosity for the expected temperature.
- Oil pump worn or dirty.
- Malfunctioning oil pump pressure regulator valve.
- Plugged oil filter.
- Oil pump screen loose, plugged or damaged.
- Excessive bearing clearance. Replace as necessary.
- Cracked, porous or restricted oil galleries. Repair or replace the engine block.
- Oil galley plugs missing or incorrectly installed. Install the plugs or repair as necessary.
- Oil diluted by moisture or unburned fuel mixtures.

Oil Leak Diagnosis

Most fluid oil leaks are easily located and repaired by visually finding the leak and replacing or repairing the necessary parts. On some occasions a fluid leak may be difficult to locate or repair.

Use the following steps in order to find the leak:

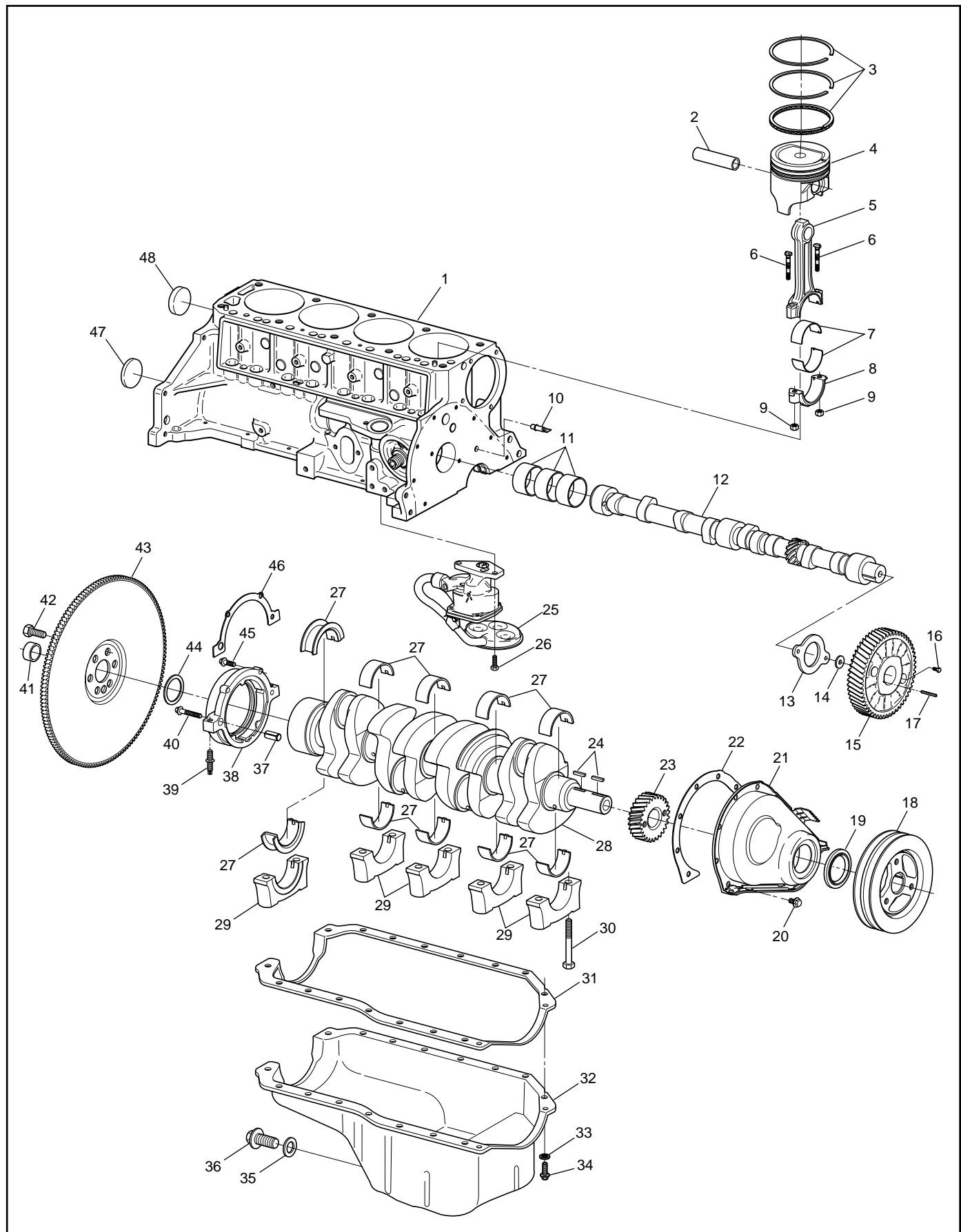
1. Identify the fluid, determine whether it is engine oil, transmission fluid or power steering fluid.
2. At what point is the fluid leaking from? After running the engine at normal operating temperature, place a large sheet of paper under the engine. After a few minutes, you should be able to find the approximate location of the leak by the drippings on the paper.



Block Explode #1

Disassembled View (1 of 4)

- 1 VALVE ROCKER ARM COVER BOLT
- 2 VALVE ROCKER ARM COVER REINFORCEMENT
- 3 VALVE ROCKER ARM COVER
- 4 OIL FILLER CAP
- 5 VALVE ROCKER ARM COVER GASKET
- 6 EFE VALVE THERMOSTAT
- 7 INTAKE MANIFOLD
- 8 INTAKE MANIFOLD NUT
- 9 INTAKE/EXHAUST MANIFOLD CLAMP
- 10 INTAKE/EXHAUST MANIFOLD WASHER
- 11 INTAKE/EXHAUST MANIFOLD BOLT
- 12 INTAKE/EXHAUST MANIFOLD GASKET
- 13 EFE VALVE SPRING
- 14 EFE VALVE BUSHING
- 15 EXHAUST MANIFOLD
- 16 INTAKE/EXHAUST MANIFOLD BOLT
- 17 EXHAUST MANIFOLD STUD
- 18 INTAKE/EXHAUST MANIFOLD GASKET
- 19 CYLINDER HEAD BOLT
- 20 CYLINDER HEAD
- 21 CYLINDER HEAD GASKET
- 22 LIFT BRACKET
- 23 LIFT BRACKET BOLT
- 24 ENGINE BLOCK
- 25 WATER PUMP GASKET
- 26 WATER PUMP
- 27 WATER PUMP BOLT
- 28 WATER PUMP BOLT
- 29 PUSHROD COVER GASKET
- 30 PUSHROD COVER
- 31 PUSHROD COVER BOLT
- 32 VALVE LIFTER
- 33 ENGINE BLOCK COOLANT PLUG
- 34 DISTRIBUTOR GASKET
- 35 DISTRIBUTOR
- 36 DISTRIBUTOR HOLD DOWN
- 37 DISTRIBUTOR HOLD DOWN BOLT
- 38 OIL LEVEL INDICATOR TUBE
- 39 OIL LEVEL INDICATOR
- 40 PRIMARY IGNITION HARNESS
- 41 IGNITION COIL BOLT
- 42 IGNITION COIL WASHER
- 43 IGNITION COIL
- 44 IGNITION COIL WIRE
- 45 SPARK PLUG WIRE RETAINER
- 46 SPARK PLUG WIRE HARNESS
- 47 SPARK PLUG
- 48 VALVE PUSHROD
- 49 VALVE ROCKER ARM
- 50 VALVE ROCKER ARM BALL
- 51 VALVE ROCKER ARM NUT

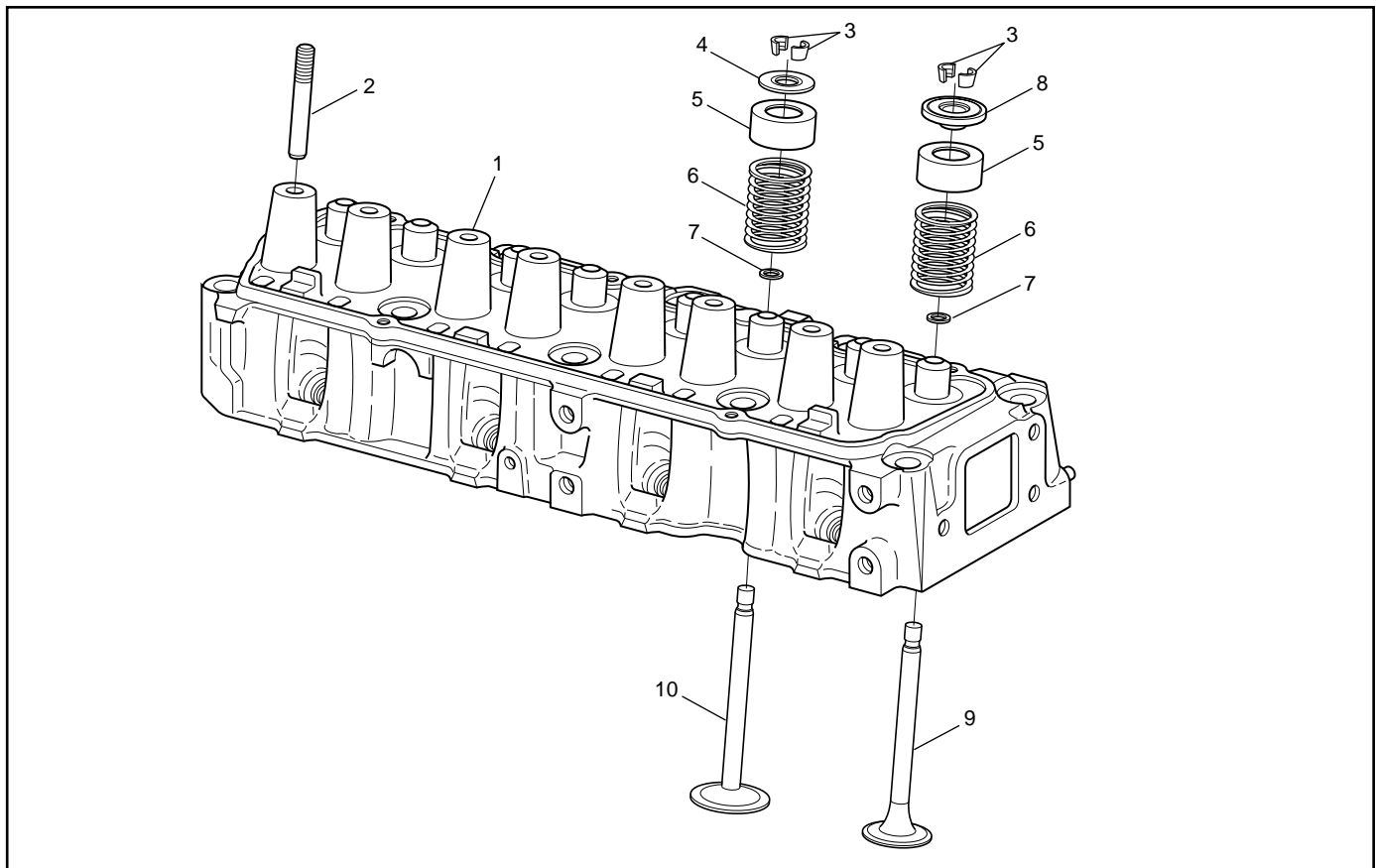


Block Explode #2

VE002-3L

Disassembled View (2 of 4)

- 1 ENGINE BLOCK
- 2 PISTON PIN
- 3 PISTON RING KIT
- 4 PISTON
- 5 CONNECTING ROD
- 6 CONNECTING ROD BOLT
- 7 CONNECTING ROD BEARING KIT
- 8 CONNECTING ROD CAP
- 9 CONNECTING ROD NUT
- 10 OIL NOZZLE
- 11 CAMSHAFT BEARINGS
- 12 CAMSHAFT
- 13 CAMSHAFT RETAINER
- 14 CAMSHAFT RETAINER WASHER
- 15 CAMSHAFT SPROCKET
- 16 CAMSHAFT RETAINER BOLT
- 17 CAMSHAFT WOODRUFF KEY
- 18 CRANKSHAFT PULLEY
- 19 ENGINE FRONT COVER SEAL
- 20 ENGINE FRONT COVER BOLT
- 21 ENGINE FRONT COVER
- 22 ENGINE FRONT COVER GASKET
- 23 CRANKSHAFT SPROCKET
- 24 CRANKSHAFT KEYWAY
- 25 OIL PUMP
- 26 OIL PUMP BOLT
- 27 CRANKSHAFT BEARING KIT
- 28 CRANKSHAFT
- 29 CRANKSHAFT BEARING CAP
- 30 CRANKSHAFT BEARING CAP BOLT
- 31 OIL PAN GASKET
- 32 OIL PAN
- 33 OIL PAN WASHER
- 34 OIL PAN BOLT
- 35 OIL DRAIN PLUG WASHER
- 36 OIL DRAIN PLUG
- 37 CRANKSHAFT REAR OIL SEAL HOUSING PIN
- 38 CRANKSHAFT REAR OIL SEAL HOUSING
- 39 CRANKSHAFT REAR OIL SEAL HOUSING STUD
- 40 CRANKSHAFT REAR OIL SEAL HOUSING BOLT
- 41 CLUTCH PILOT BEARING
- 42 ENGINE FLYWHEEL BOLT
- 43 ENGINE FLYWHEEL
- 44 CRANKSHAFT REAR OIL SEAL
- 45 CRANKSHAFT REAR OIL SEAL HOUSING BOLT
- 46 CRANKSHAFT REAR OIL SEAL HOUSING GASKET
- 47 CAMSHAFT REAR BEARING HOLE PLUG
- 48 ENGINE BLOCK CORE PLUG

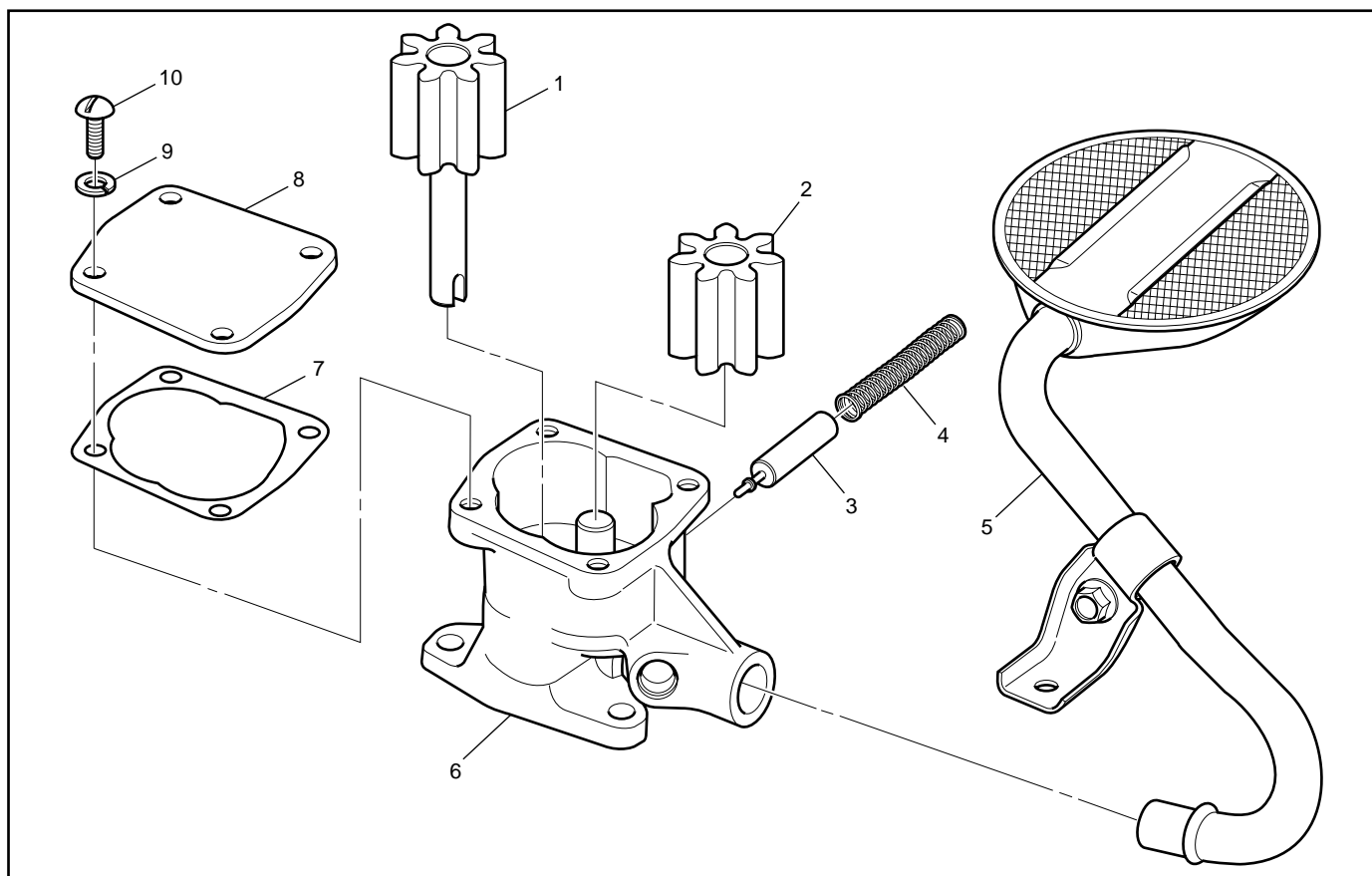


Head Explode

VE003-3L

Disassembled View (3 of 4)

- 1 CYLINDER HEAD
- 2 VALVE ROCKER ARM STUD
- 3 VALVE STEM KEY
- 4 VALVE SPRING CAP INTAKE
- 5 VALVE STEM OIL SHIELD
- 6 VALVE SPRING
- 7 VALVE STEM OIL SEAL
- 8 VALVE SPRING CAP EXHAUST
- 9 EXHAUST VALVE
- 10 INTAKE VALVE

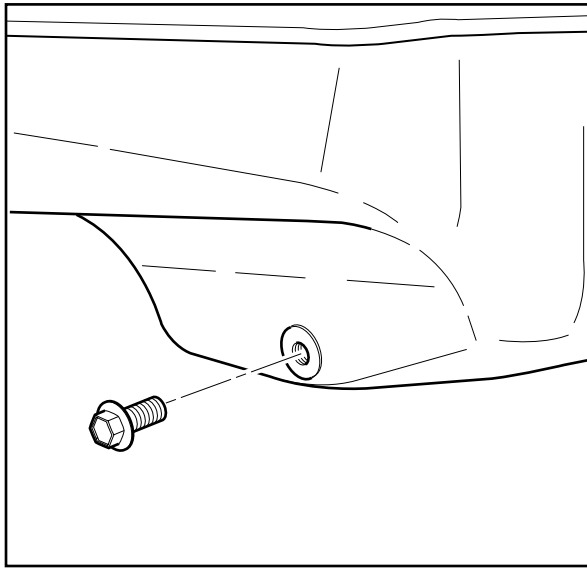


Oil Pump Explode

VE004-3L

Disassembled View (4 of 4)

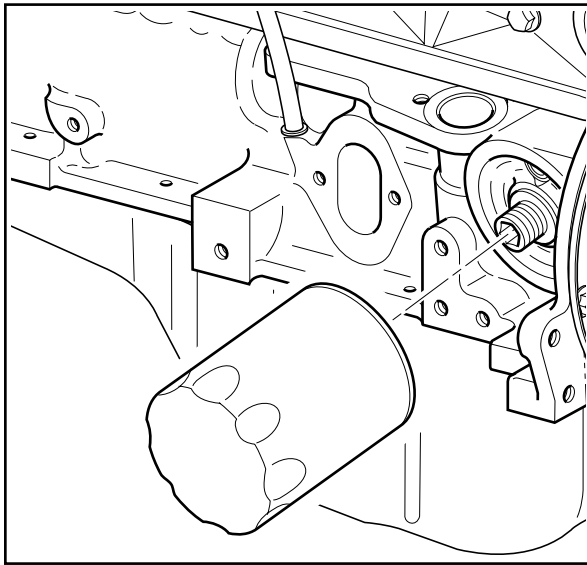
- 1 DRIVE GEAR
- 2 DRIVEN GEAR
- 3 OIL PRESSURE RELIEF VALVE
- 4 OIL PRESSURE RELIEF VALVE SPRING
- 5 OIL PUMP SCREEN
- 6 OIL PUMP
- 7 OIL PUMP COVER GASKET
- 8 OIL PUMP COVER
- 9 OIL PUMP COVER WASHER
- 10 OIL PUMP COVER BOLT



VE005-3L

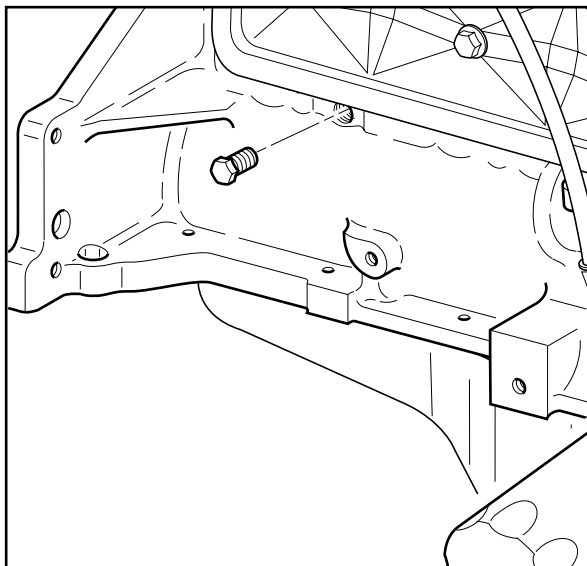
Draining Fluids and Oil Filter Removal

1. Remove the oil pan drain plug and allow the oil to drain.



VE006-3L

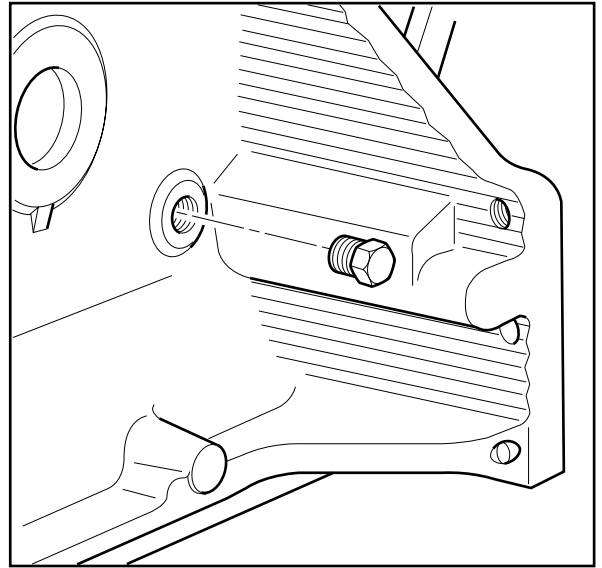
2. Remove the oil filter.



VE007-3L

3. Remove right rear engine block coolant plug and allow the coolant to drain.

4. Remove the left rear engine block coolant plug and allow the coolant to drain.

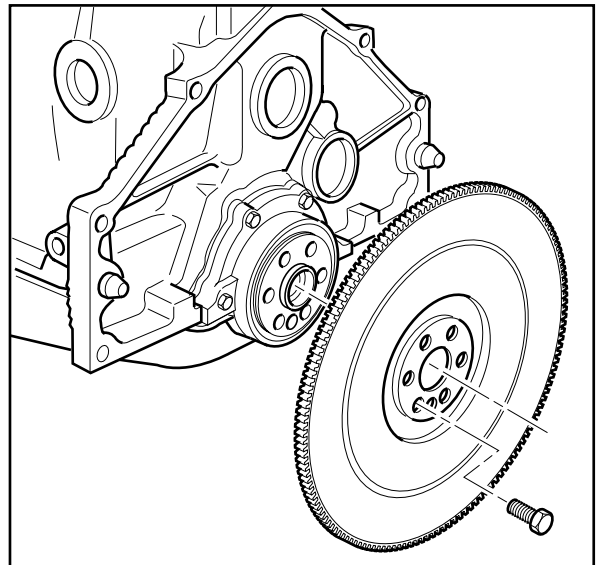


VE008-3L

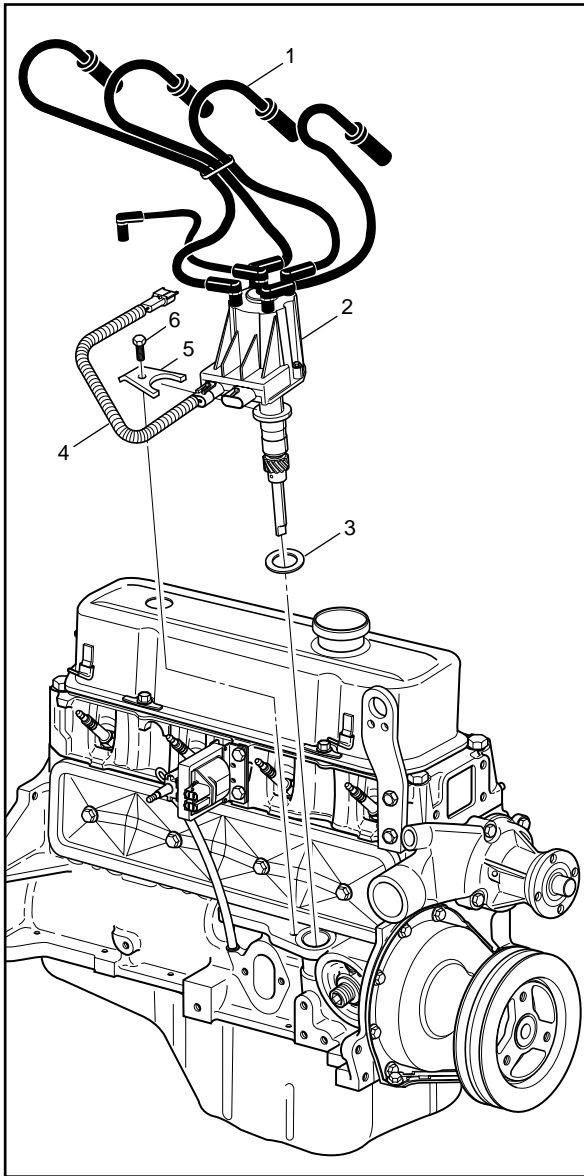
Engine Flywheel Removal

Important: Note the position and direction of the engine flywheel before removal. The flywheel center alignment hole is a tapered fit to the crankshaft. The engine flywheel must be reinstalled to the original position and direction.

1. Remove the engine flywheel bolts.
2. Remove the engine flywheel.



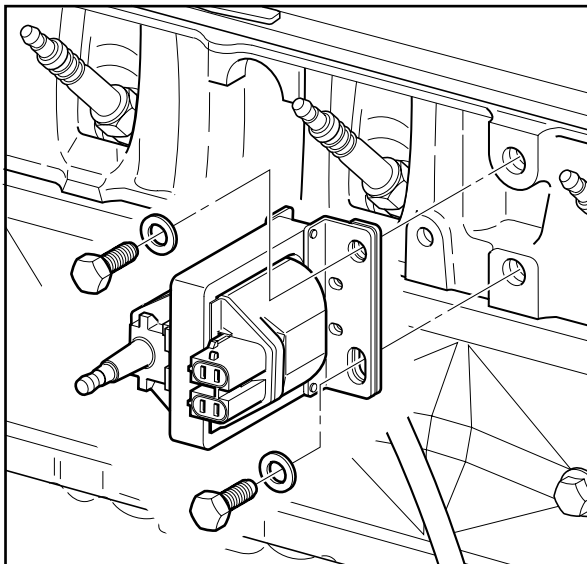
VE009-3L



VE010-3L

Distributor Removal

1. Disconnect the secondary ignition wires (1) from the spark plugs and the ignition coil.
2. Disconnect the primary ignition harness (4) from the ignition coil. Do not remove the wires from the distributor unless it is necessary.
3. Remove the distributor hold down bolt (6).
4. Remove the distributor (2) and gasket (3).



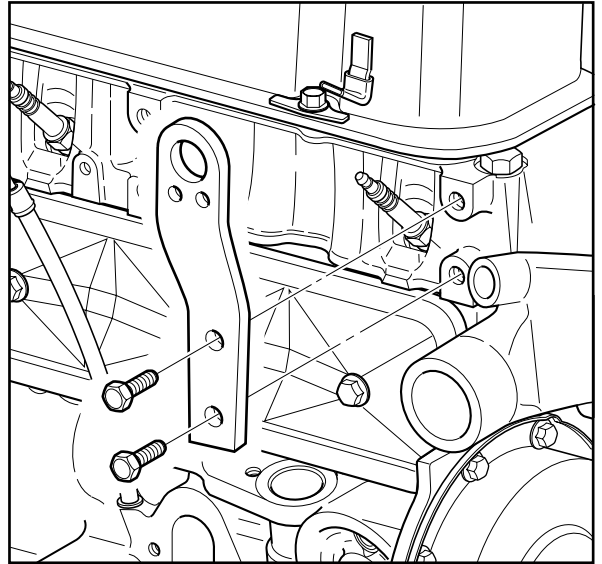
VE011-3L

Ignition Coil Removal

1. Remove the ignition coil bracket attaching bolts.
2. Remove the ignition coil.

Lift Bracket Removal

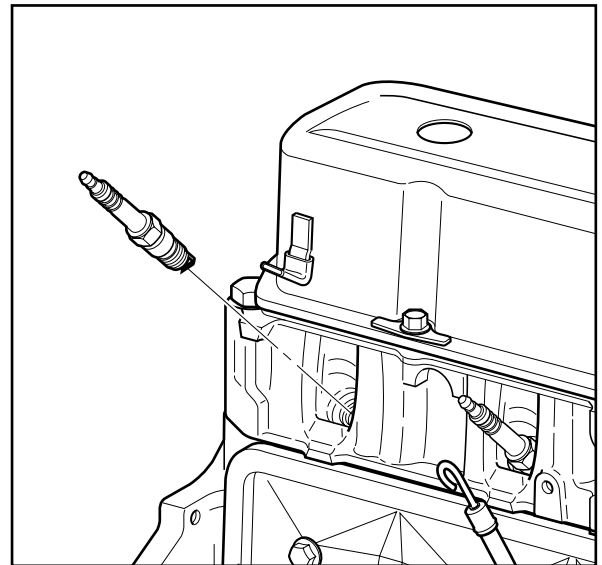
1. Remove the lift bracket bolts.
2. Remove the lift bracket.



VE012-3L

Spark Plug Removal

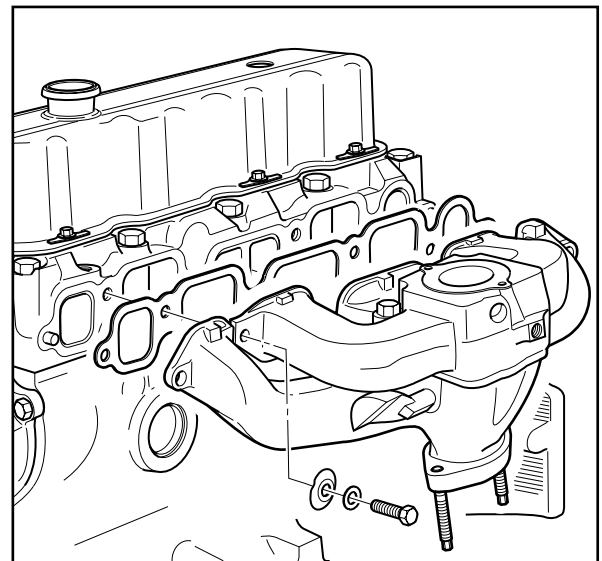
1. Remove the spark plugs.



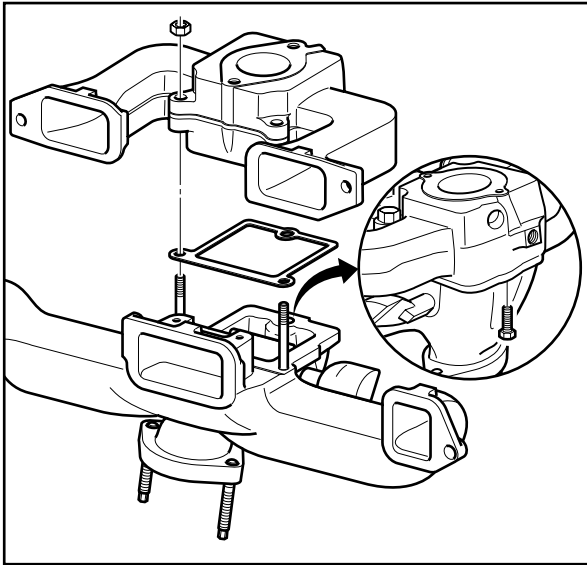
VE013-3L

Intake/Exhaust Manifold Removal

1. Remove the intake/exhaust manifold bolts.
2. Remove the intake/exhaust manifold.
3. Remove the intake/exhaust manifold gaskets.



VE014-3L



VE015-3L

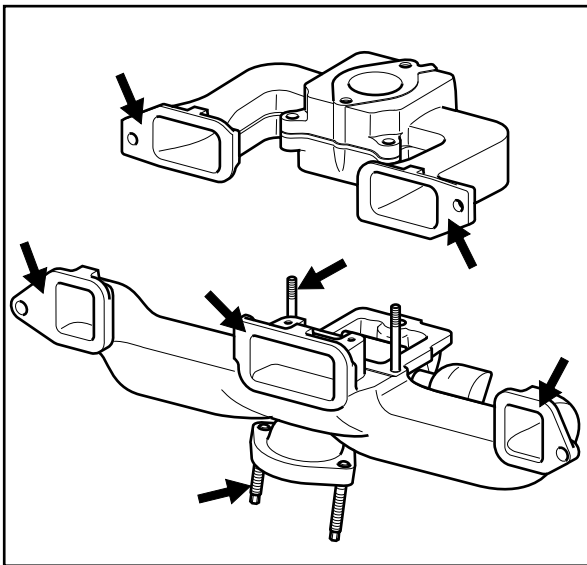
Intake/Exhaust Manifold Disassemble and Assemble

If necessary to replace either the intake or exhaust manifold, separate them as follows:

1. Remove the one attaching bolt and the two nuts at the center of the assembly.
2. Reassemble manifolds using a new gasket.

Tighten

Tighten the bolts to 27-34 N•m (20-25 lb ft).

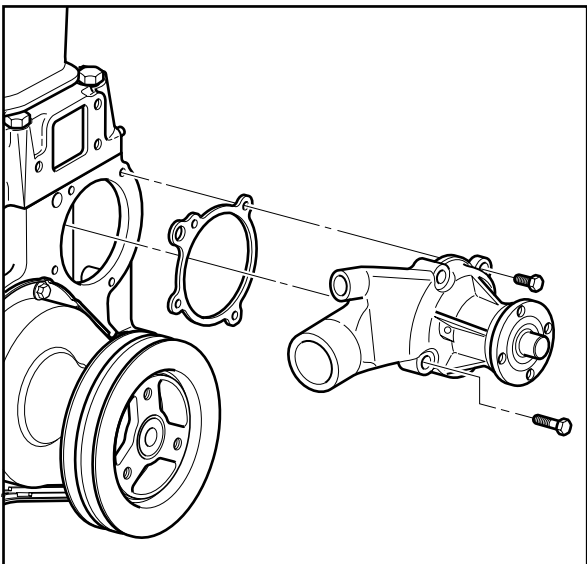


VE016-3L

Intake/Exhaust Manifold Clean and Inspect

Clean and inspect the following areas:

- The manifold bolts and studs.
- All manifold sealing surfaces.
- Any old RTV from the manifold.



VE017-3L

Water Pump Removal

Make sure the coolant is drained.

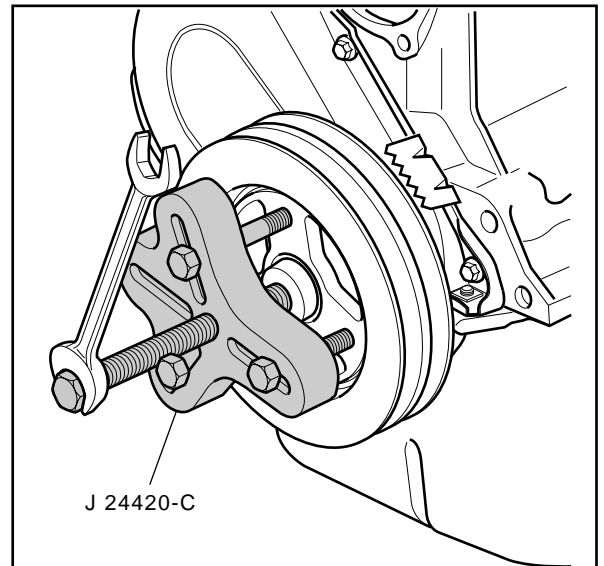
1. Remove the water pump bolts.
2. Remove the water pump and gasket.
3. Discard the water pump gasket.
4. Inspect the water pump for the following:
 - Gasket sealing surfaces for excessive scratches or gouges.
 - Excessive side-to-side play in the pulley shaft.
 - Leakage at the water inlet housing or rear cover gaskets areas.
 - Leakage at the water pump vent hole.

A stain around the vent hole is acceptable. If leakage occurs at the vent hole with the engine running and the cooling system pressurized, replace the pump.

Crankshaft Pulley Removal

Tools Required

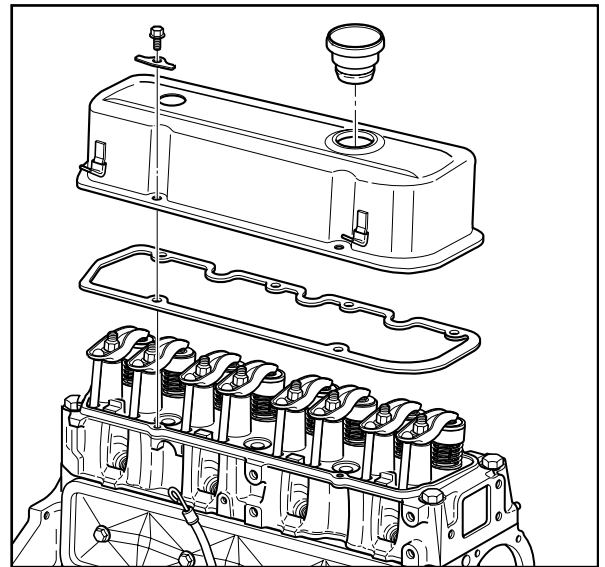
- J 24420-C Universal Crankshaft Pulley Remover
1. Use the J 24420-C in order to remove the crankshaft pulley.



VE018-3L

Valve Rocker Arm Cover Removal

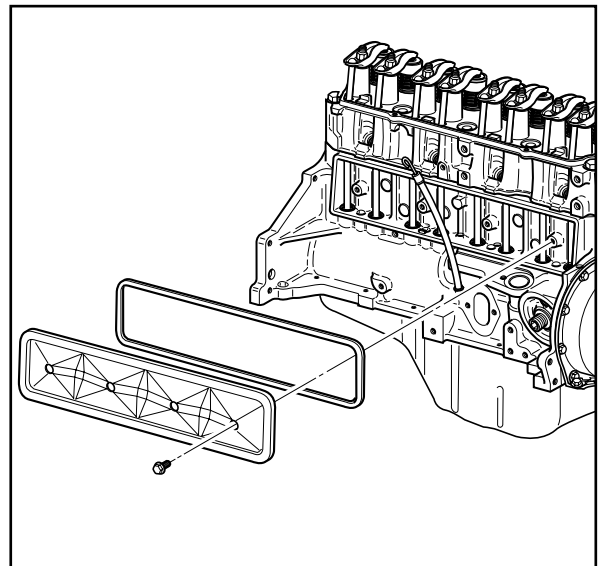
1. Remove the valve rocker arm cover bolts.
2. Remove the valve rocker arm cover.
3. Remove the gasket.



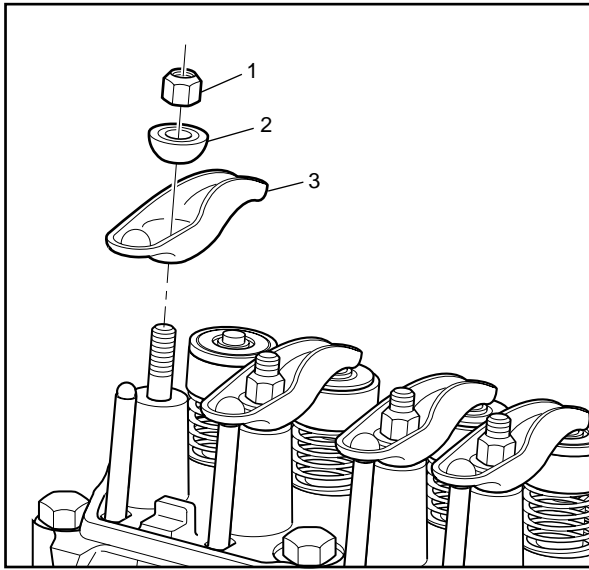
VE019-3L

Pushrod Cover Removal

1. Remove the pushrod cover bolts.
2. Remove the pushrod cover.
3. Remove the gasket.



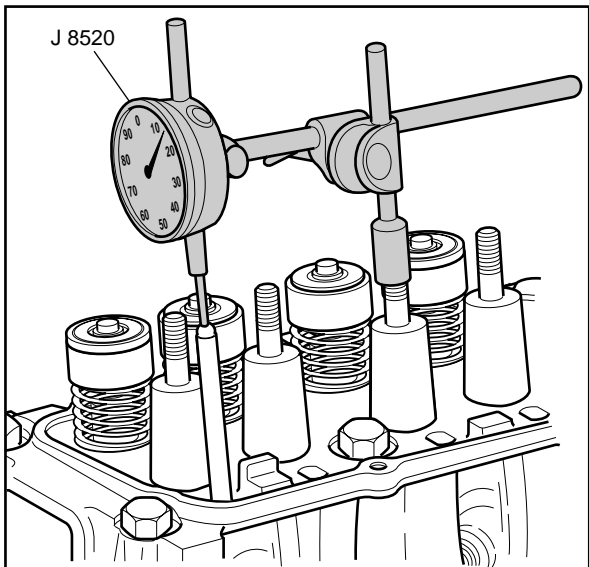
VE020-3L



VE021-3L

Valve Rocker Arm and Pushrod Removal

1. Remove the following components from the cylinder head:
 - 1.1. The valve rocker arm nuts (1).
 - 1.2. The valve rocker arm balls (2).
 - 1.3. The valve rocker arms (3).

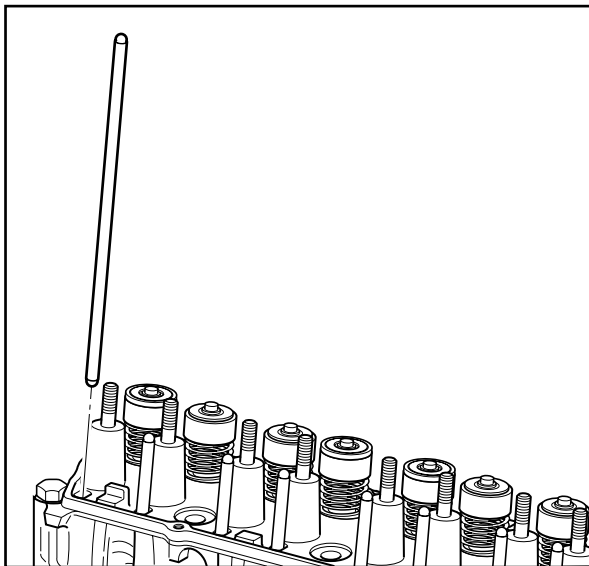


VE022-3L

Measuring Camshaft Lobe Lift

Tools Required

- J 8520 Camshaft Lobe Lift Indicator
1. Position the J 8520 with the ball socket adapter on the valve pushrod. Be sure that the valve pushrod is in the valve lifter socket.
 2. Slowly rotate the crankshaft until the valve lifter roller is on the heel of the cam lobe. The valve pushrod will be in its lowest position.
 3. Set the J 8520 on zero.
 4. Slowly rotate the crankshaft until the valve pushrod is raised fully.
 5. Compare the total lift shown on the J 8520 with the specifications. Refer to *Engine Mechanical Specifications*.
 6. Remove the J 8520.



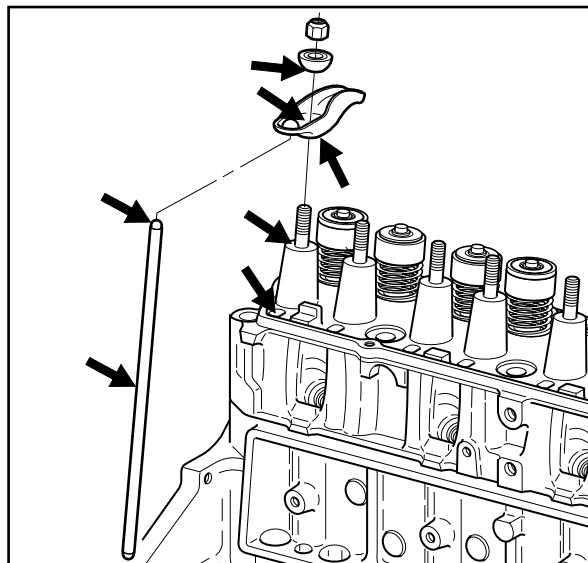
VE023-3L

2. Remove the valve pushrods.
3. Place the following parts in a rack so that they can be reinstalled in their original locations:
 - The valve rocker arms.
 - The valve rocker arm balls.
 - The valve pushrods.

Valve Train Components Inspect (Cylinder Head)

Inspect the following areas:

- The valve rocker arms and ball at the mating surfaces. These surfaces should be smooth and free of scoring or other damage.
- The valve pushrod sockets and valve stem mating surfaces. These surfaces should be smooth with no scoring or exceptional wear.
- The valve pushrods for bends or scored ends.

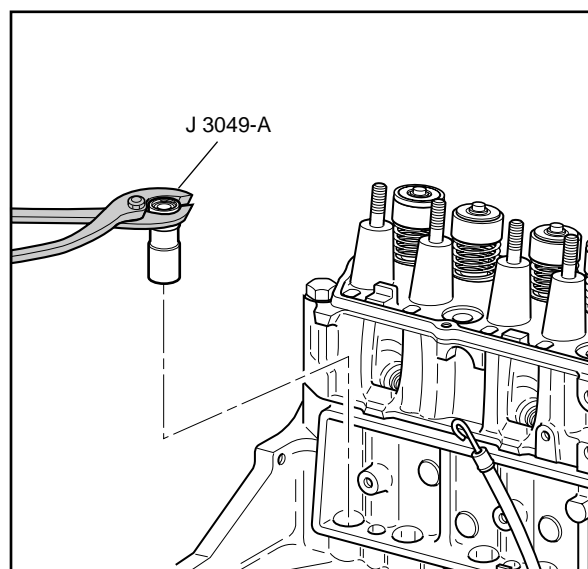


VE024-3L

Valve Lifter Removal

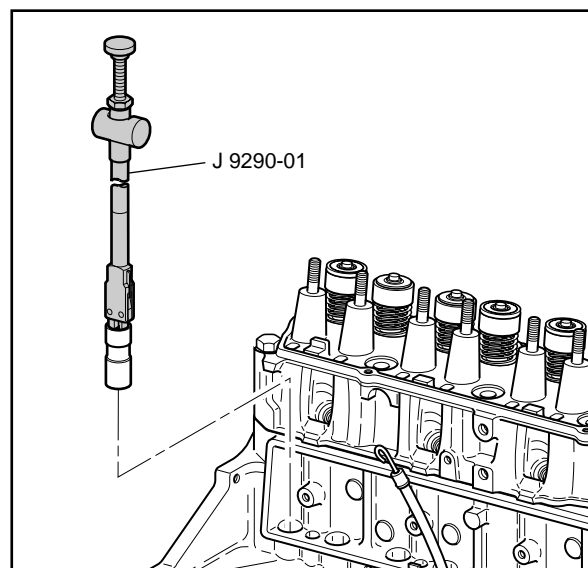
Tools Required

- J 3049 Valve Lifter Remover (Plier Type)
 - J 9290-01 Valve Lifter Remover (Slide Hammer Type)
1. Use the J 3049 in order to remove the valve lifters.

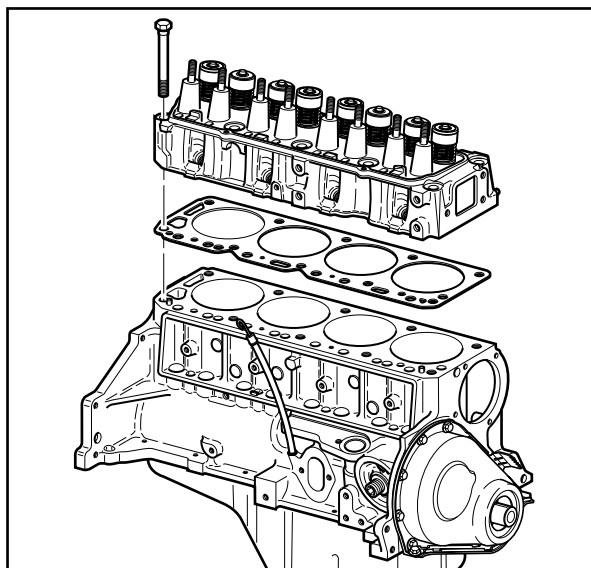


VE025-3L

2. If the valve lifters cannot be removed with the J 3049 use the J 9290-01 in order to remove the valve lifters.



VE026-3L



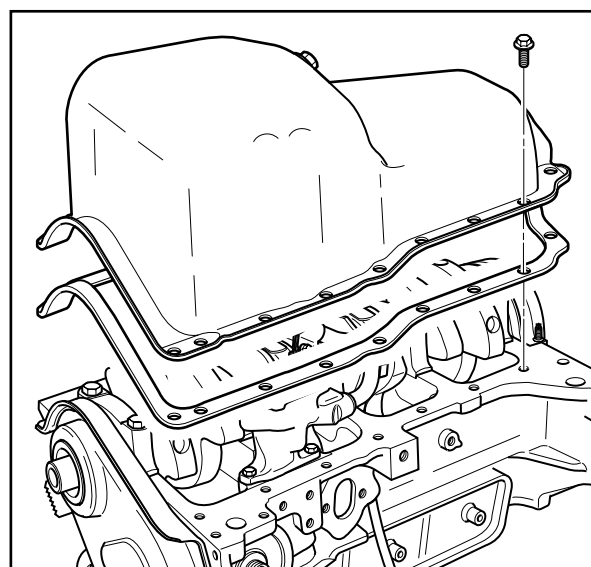
VE027-3L

Cylinder Head Removal

1. Remove the cylinder head bolts.

Notice: After removal, place the cylinder head on two wood blocks to prevent damage.

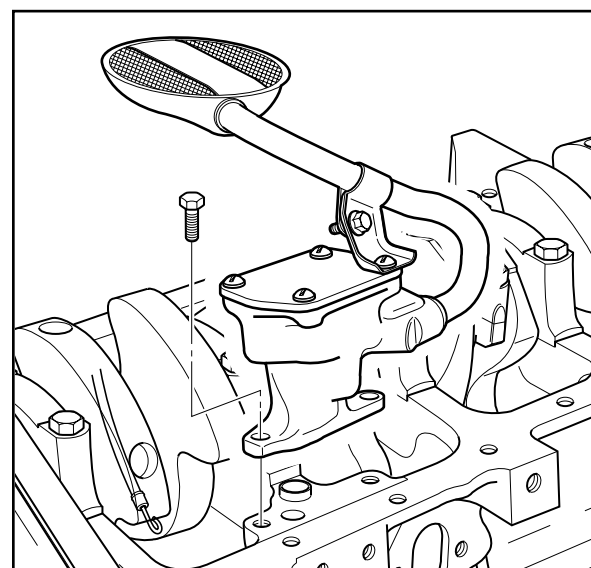
2. Remove the cylinder head.
3. Remove the gasket.
4. Discard the gasket



VE028-3L

Oil Pan Removal

1. Remove the oil pan bolts.
2. Remove the oil pan.
3. Remove the gasket.
4. Discard the gasket.



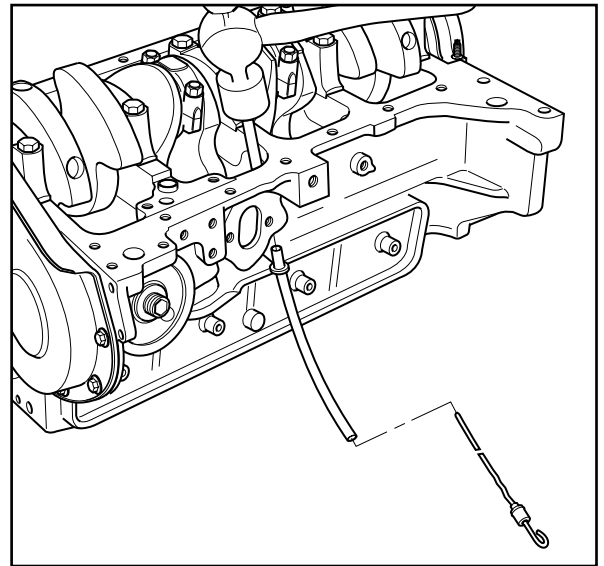
VE029-3L

Oil Pump Removal

1. Remove the bolts that attach the oil pump to the engine block.
2. Remove the oil pump and gasket.
3. Discard the gasket.

Oil Level Indicator and Tube Removal

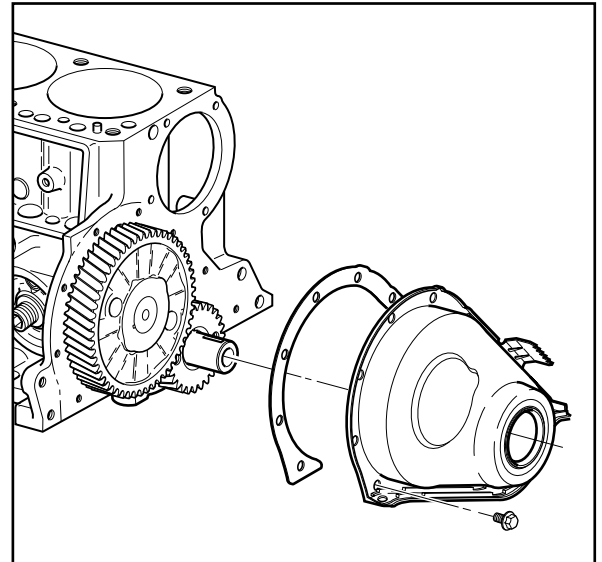
1. Remove the oil level indicator from the tube.
2. Use a drift punch in order to remove the oil level indicator tube from the engine block.



VE128-3L

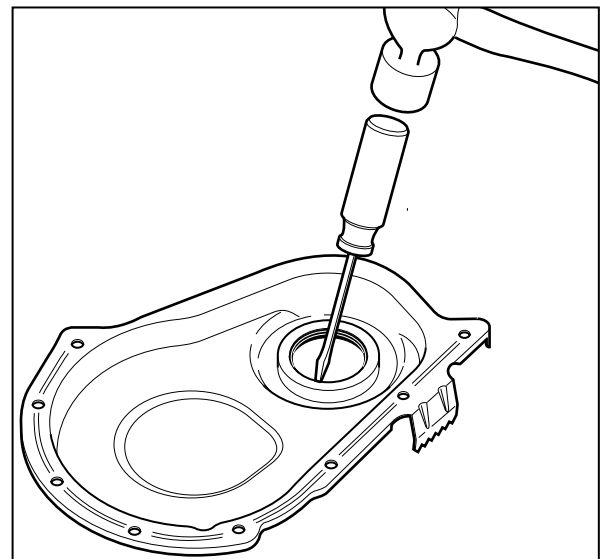
Engine Front Cover Removal

1. Remove the engine front cover bolts.
2. Remove the engine front cover.
3. Remove the gasket.
4. Discard the gasket.

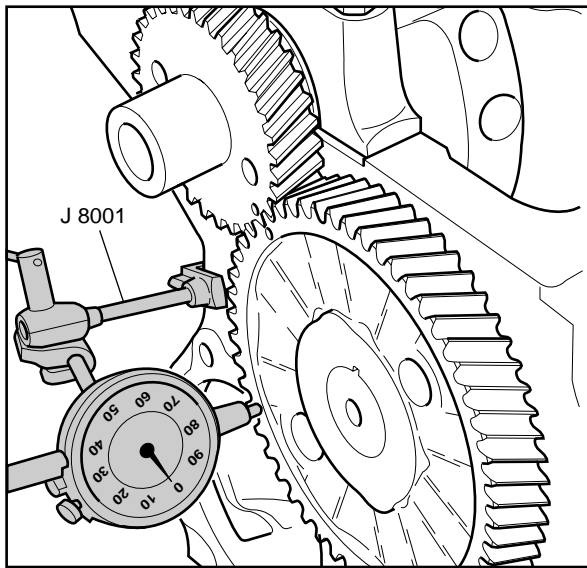


VE030-3L

5. Remove the oil seal from the front cover.
6. Clean the engine front cover in solvent.
7. Inspect the engine front cover for damage to the gasket surface or the oil seal surface.



VE031-3L



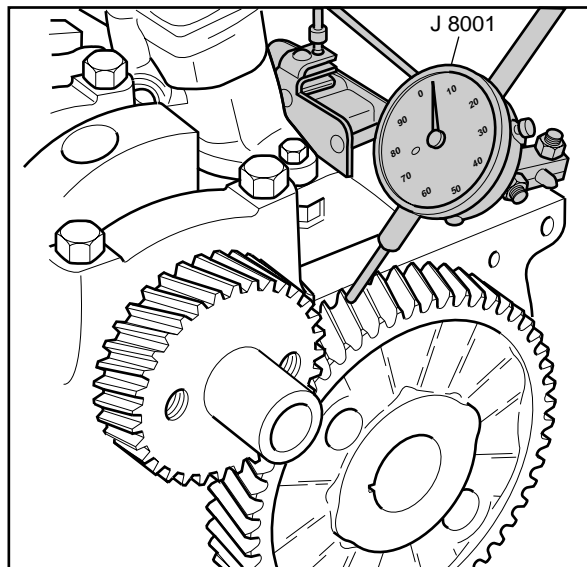
VE032-3L

Measuring Crankshaft and Camshaft Sprocket Runout

Tools Required

- J 8001 Dial Indicator

1. Use the J 8001 in order to measure the crankshaft and camshaft sprocket runout. Refer to *Engine Mechanical Specifications*.
2. If the sprocket runout exceeds specifications, clean and remove any burrs from the shaft or replace the sprocket.



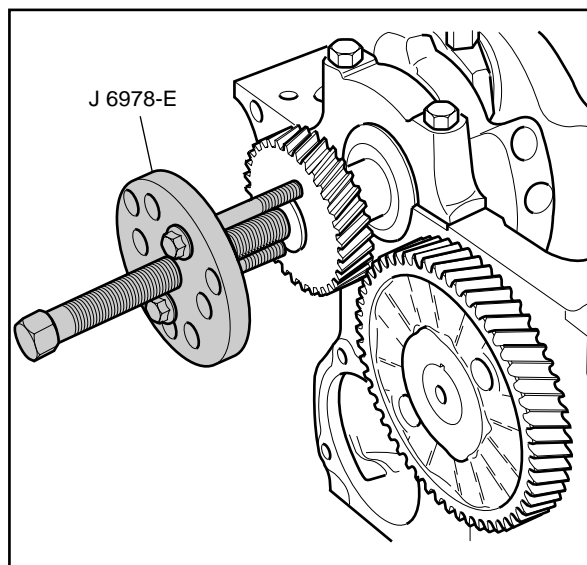
VE033-3L

Measuring Timing Sprocket Teeth Backlash

Tools Required

- J 8001 Dial Indicator

1. Use the J 8001 in order to measure the backlash between the timing sprocket teeth.
2. Refer to *Engine Mechanical Specifications*.



VE034-3L

Crankshaft Sprocket Removal

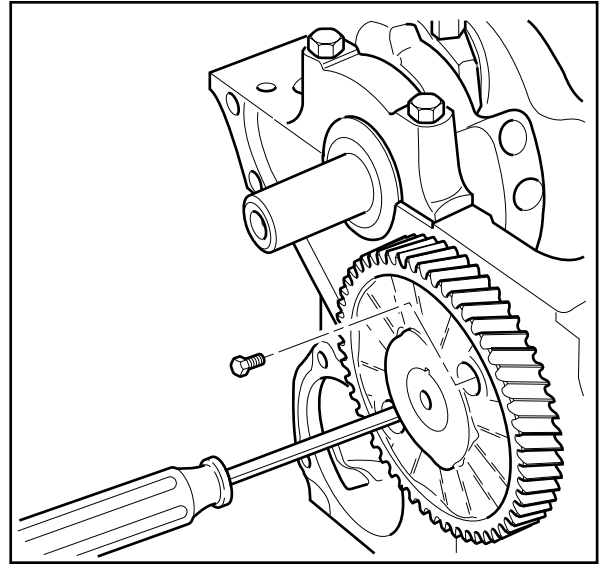
Tools Required

- J 6978-E Crankshaft Sprocket Puller

1. Use the J 6978-E in order to remove the crankshaft sprocket.
2. If necessary, remove the crankshaft keys.

Camshaft Removal

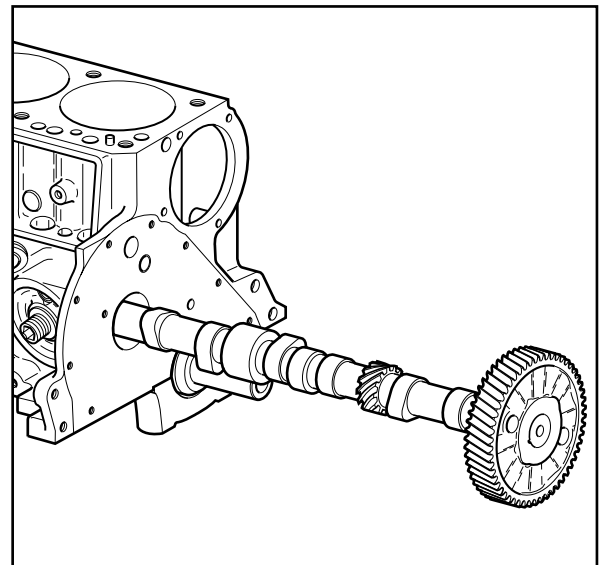
1. Remove the two camshaft retainer bolts, working through the holes in the camshaft sprocket.



VE035-3L

Important: All camshaft journals are the same diameter, so care must be used in removing the camshaft to avoid damage to the bearings.

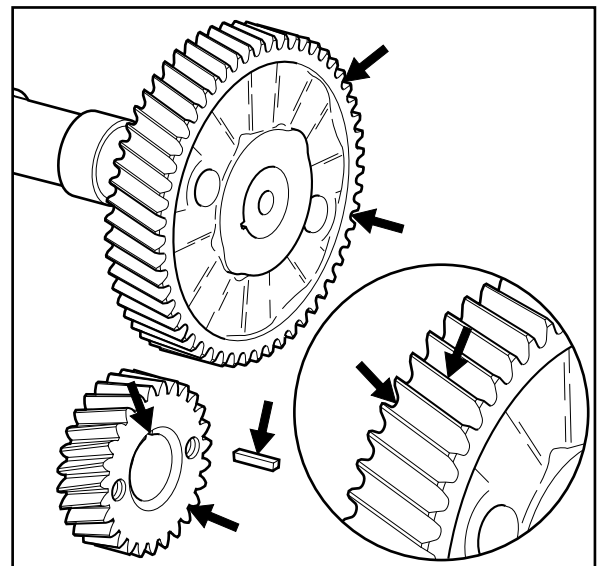
2. Carefully rotate and pull the camshaft out of the bearings.



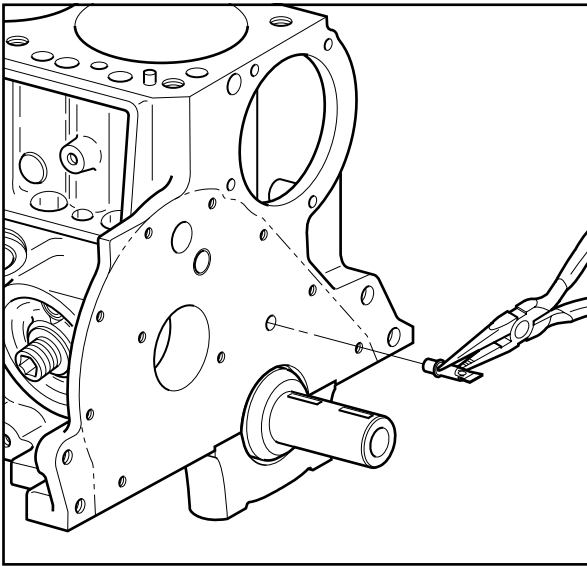
VE125-3L

Crankshaft and Camshaft Sprocket Inspect

- The camshaft and crankshaft sprockets for wear.
- One edge of worn teeth or that are no longer concentric.
- The valley between worn teeth.
- The keys and crankshaft keyways for wear.



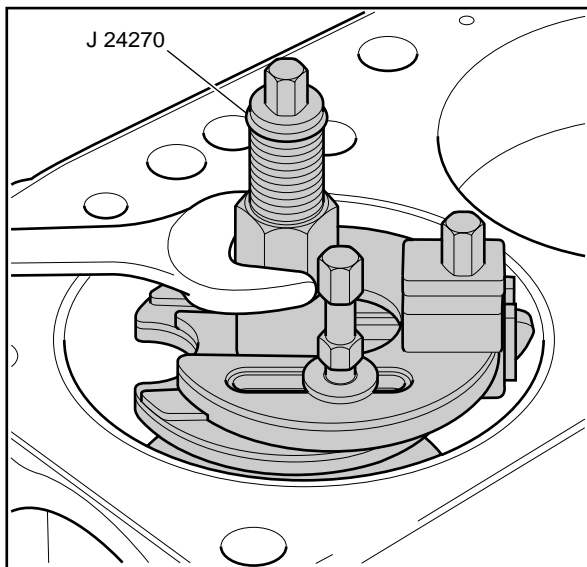
VE126-3L



VE127-3L

Timing Gear Oil Nozzle Removal

1. Remove the oil nozzle with pliers.



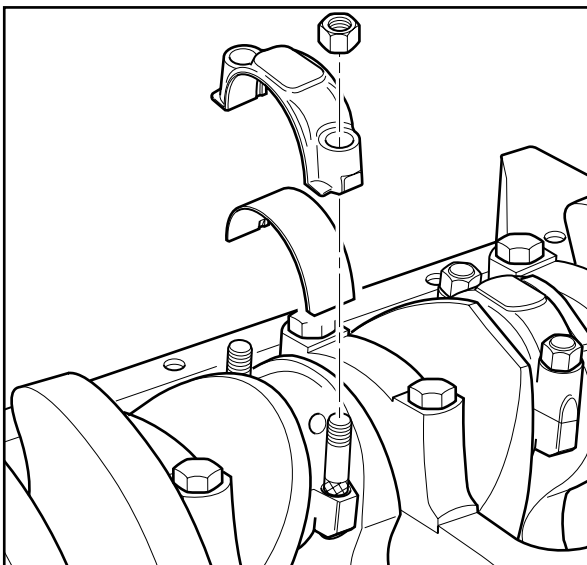
VE036-3L

Piston, Connecting Rod and Bearing Removal

Tools Required

- J 5239 Connecting Rod Guide Tool
- J 24270 Ridge Reamer

1. Remove the ring ridge as following:
 - 1.1. Turn the crankshaft until the piston is at the bottom of the stroke.
 - 1.2. Place a cloth on top of the piston.
 - 1.3. Use the J 24270 to remove the cylinder ring ridge.
 - 1.4. Turn the crankshaft so the piston is at the top of the stroke.
 - 1.5. Remove the cloth.
 - 1.6. Remove the cutting debris.

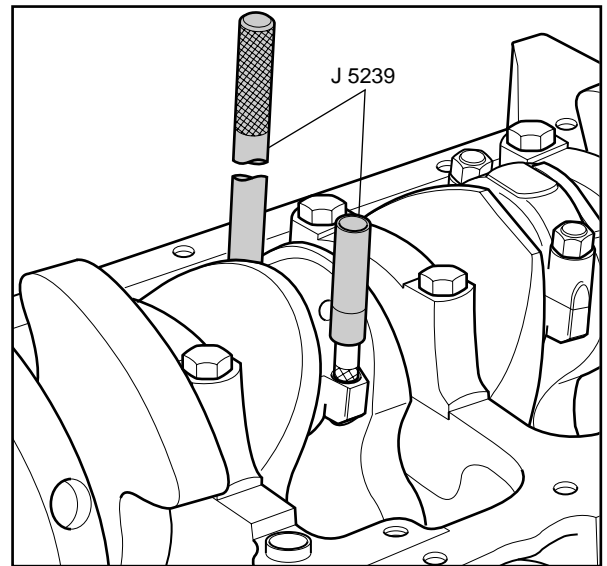


VE037-3L

Important: Place matchmarks or numbers on the connecting rods and the connecting rod caps. Upon removal of the piston and connecting rod assembly, install the connecting rod caps to the matching connecting rods.

2. Remove the connecting rod nuts.
3. Remove the connecting rod cap.
4. Remove the connecting rod bearings.
 - Keep bearings with the original connecting rod and connecting rod cap.
 - Wipe the oil from the bearings.
 - Wipe the oil from the crankpins.

5. Use the J 5239 in order to remove the connecting rod and the piston out of the engine block.
6. Use a hammer and tap lightly on the end of the connecting rod guide tool to remove the piston and connecting rod assembly from the cylinder bore.

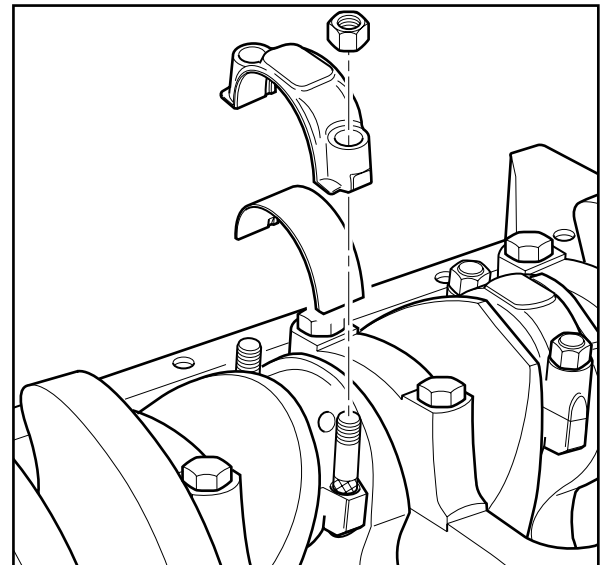


VE038-3L

Crankshaft and Bearings Clean and Inspect (Connecting Rod Bearing Clearance)

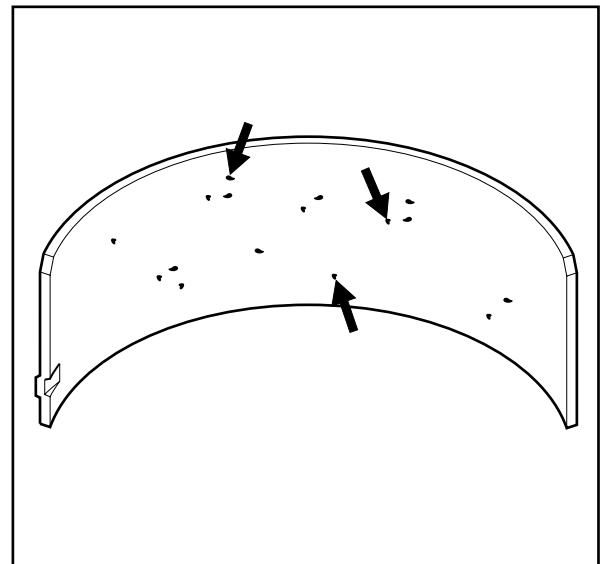
Important: Connecting rod bearings are a precision insert type. Connecting rods are of a powdered metal design and cannot be shimmed or filed for bearing fit. If clearances are found to be excessive, a new bearing and/or connecting rod are required. Do not rotate the crankshaft while gauging plastic is between the crankshaft journal and the bearing surface.

1. Remove the connecting rod nuts.
2. Remove the connecting rod cap and bearing.

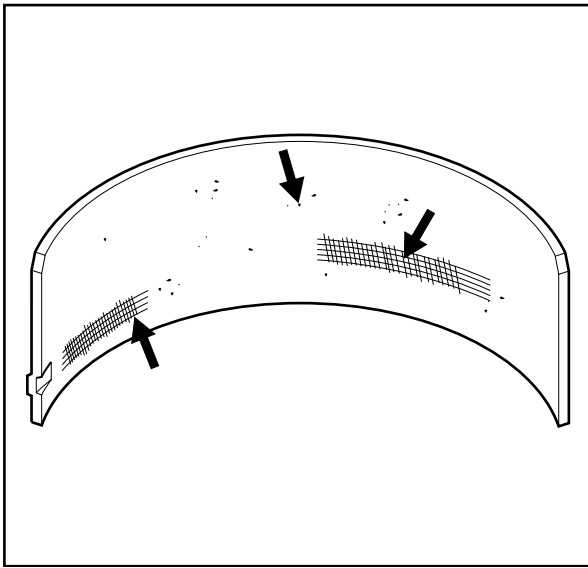


VE037-3L

3. Inspect the crankshaft bearings for craters or pockets. Flattened sections on the bearing halves also indicate fatigue.

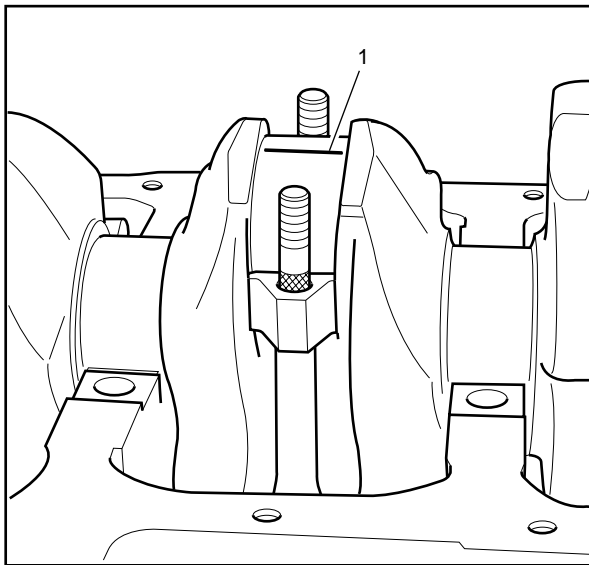


VE039-3L



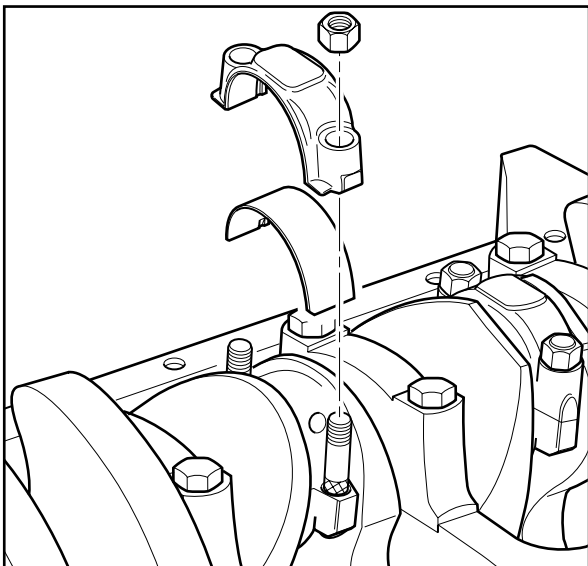
VE040-3L

4. Inspect the crankshaft bearings for excessive scoring or discoloration.
5. Inspect the crankshaft bearings for dirt or debris imbedded into the bearing material.



VE041-3L

6. Install the gauging plastic (1) onto the connecting rod bearing journal. Install the gauging plastic the full width of the journal.



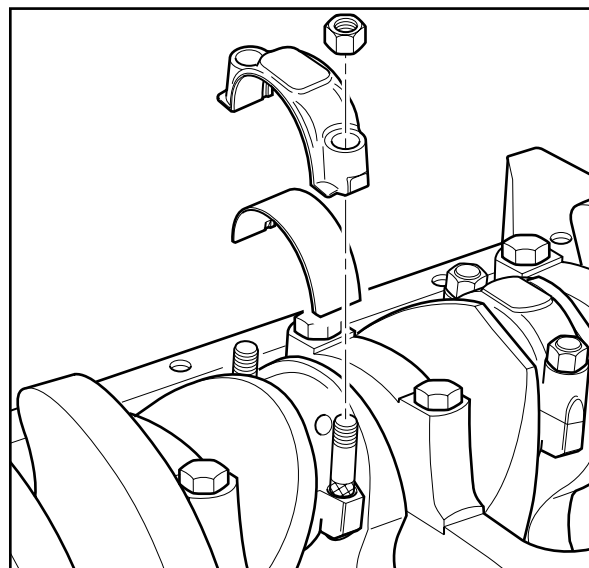
VE037-3L

7. Install the connecting rod cap and bearing.

Tighten

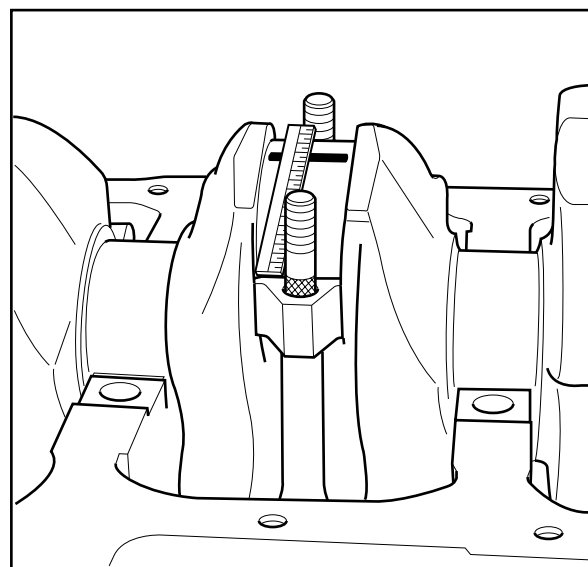
Tighten the nuts evenly to 61 N•m (45 lb ft).

8. Remove the connecting rod nuts.
9. Remove the connecting rod cap and bearing.



VE037-3L

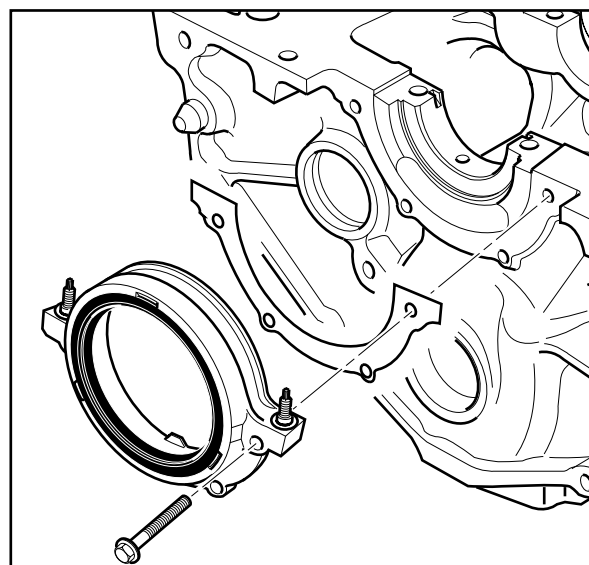
10. Measure the gauging plastic at its widest area using the scale supplied with the plastic gauging kit.
11. Compare the measurements to *Engine Mechanical Specifications*.



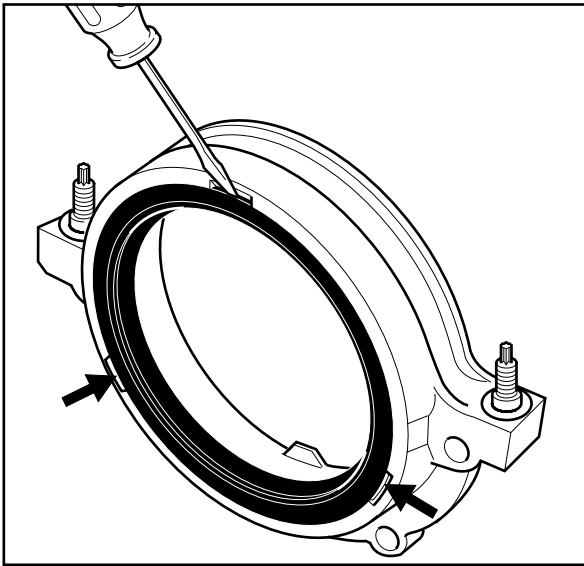
VE042-3L

Crankshaft Rear Oil Seal and Housing Removal

1. Remove the crankshaft rear oil seal housing bolts.
2. Remove the crankshaft rear oil seal housing, seal and gasket.

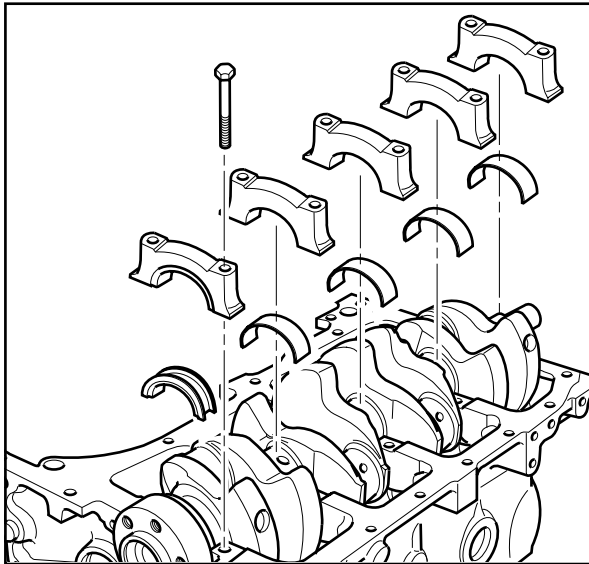


VE043-3L



VE044-3L

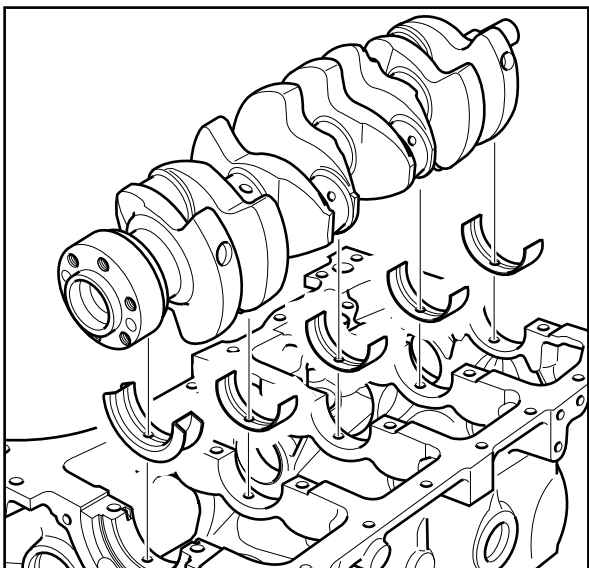
3. Remove the crankshaft rear oil seal from the crankshaft rear oil seal housing.



VE045-3L

Crankshaft , Bearings and Bearing Cap Removal

1. Remove the crankshaft bearing cap bolts.
2. Remove the crankshaft bearing caps.



VE046-3L

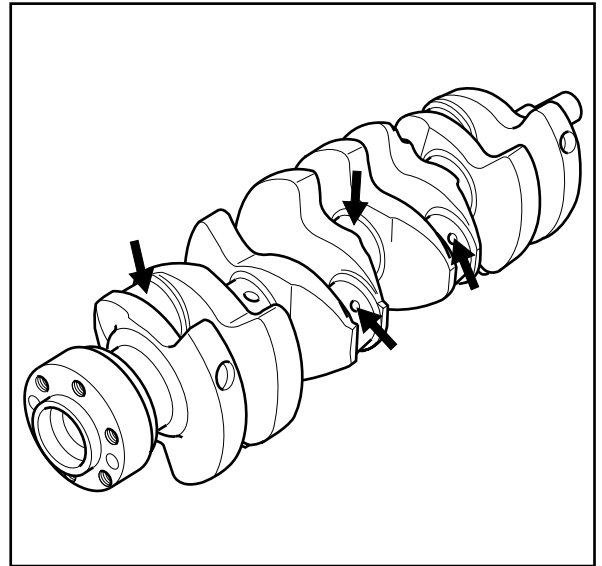
3. Remove the crankshaft.
4. Remove the crankshaft bearings from the bearing caps and from the engine block.

Crankshaft and Bearings Clean and Inspect**Tools Required**

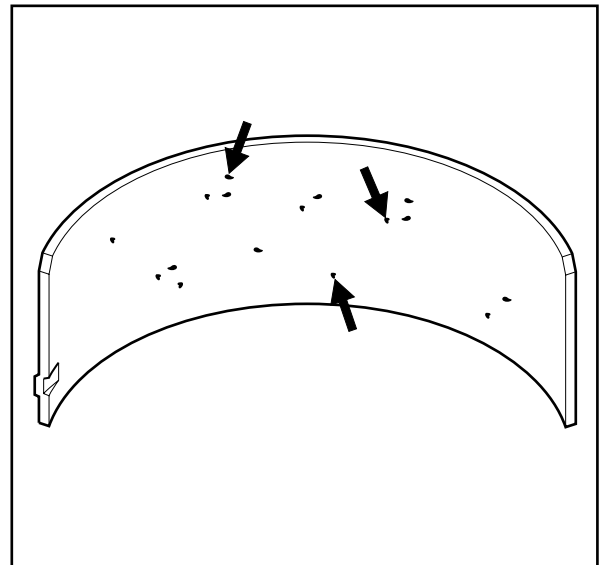
- J 7872 Magnetic Base Indicator Set

Caution: *Wear safety glasses in order to avoid eye damage.*

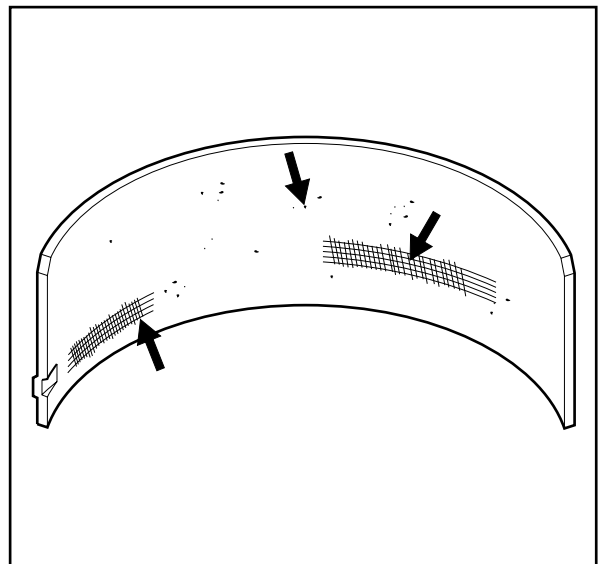
1. Clean the crankshaft in solvent.
 2. Inspect the crankshaft oil passages for restrictions.
 3. Dry the crankshaft with compressed air.
 4. Inspect the crankpins for scoring or wear.
-
5. Inspect the crankshaft bearings for craters or pockets. Flattened sections on the bearing halves also indicate fatigue.
-
6. Inspect the crankshaft bearings for excessive scoring or discoloration.
 7. Inspect the crankshaft bearings for dirt or debris imbedded into the bearing material.



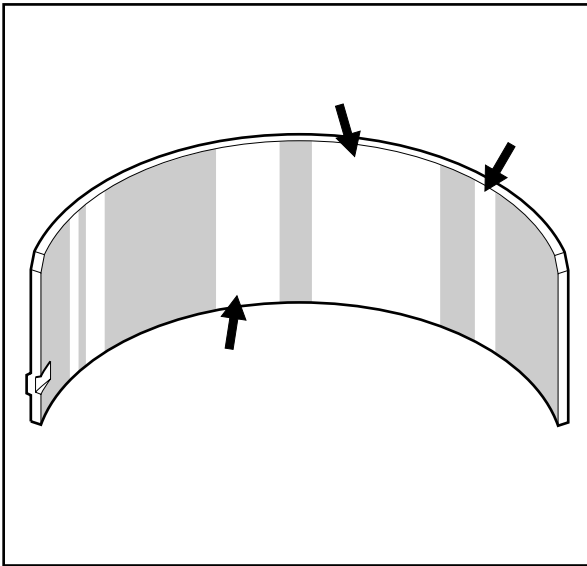
VE047-3L



VE039-3L

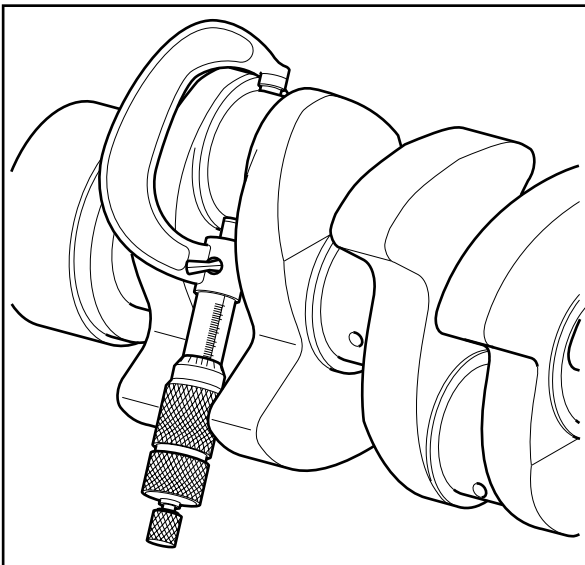


VE040-3L



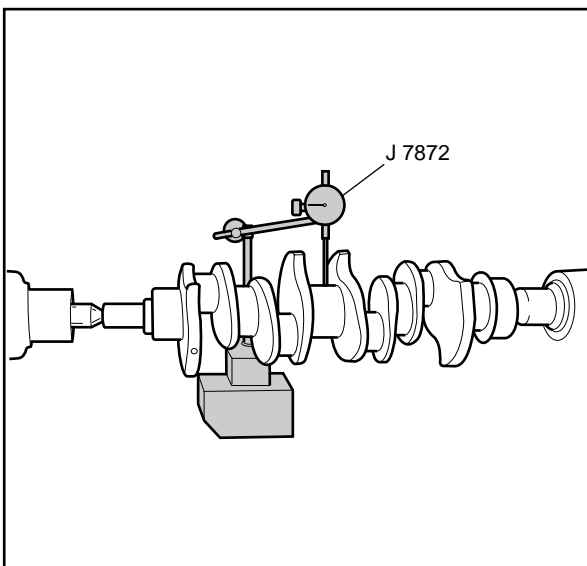
VE048-3L

8. Inspect the crankshaft bearings for improper seating indicated by bright, polished sections of the bearing.
 - If the lower half of the bearing is worn or damaged, both the upper and lower halves must be replaced.



VE049-3L

9. Measure the crankpins for out-of-round, taper or undersize with a micrometer. Refer to *Engine Mechanical Specifications*.



VE050-3L

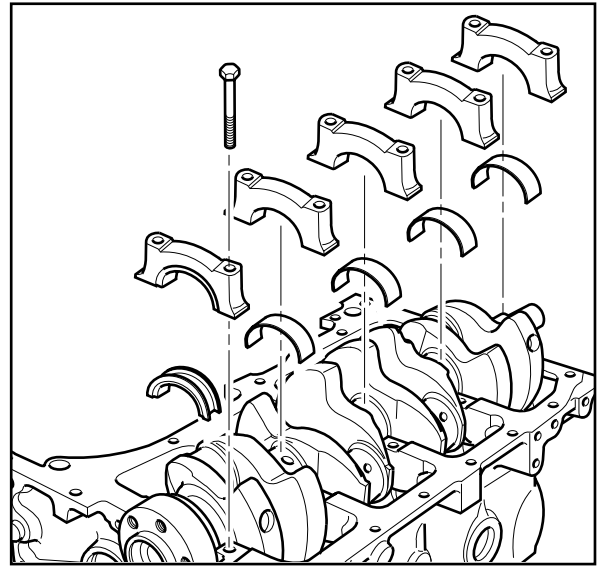
10. Support the crankshaft front and rear journals on V-blocks.
11. Measure the crankshaft run-out at front and rear intermediate journals with J 7872. Refer to *Engine Mechanical Specifications*.
12. Replace or recondition crankshaft if measurements are not within specifications.

Crankshaft and Bearings Clean and Inspect (Main Bearing Clearance)

Important: Crankshaft main bearings are a precision insert type. Main bearing caps are machined with the engine block for proper clearance and cannot be shimmed or filed for bearing fit. Crankshaft bearing clearances are critical. If the clearances are found to be excessive, new bearings and/or engine block and cap repair may be required.

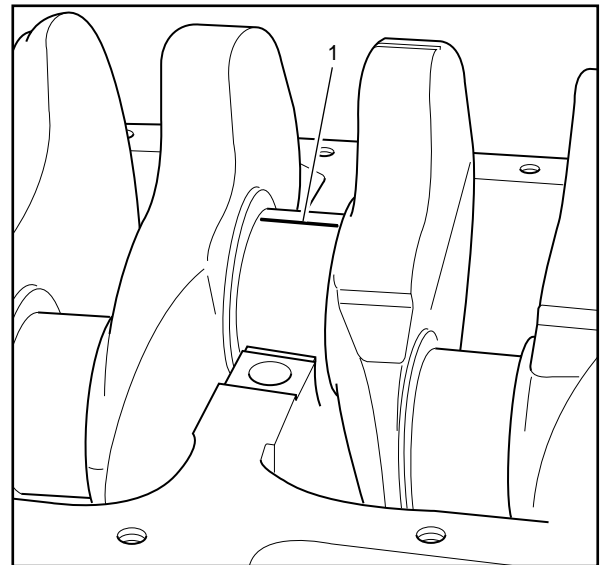
Do not rotate the crankshaft while gauging plastic is between the crankshaft journal and the bearing surface.

1. Remove the crankshaft bearing cap bolts.
2. Remove the crankshaft bearing caps.



VE045-3L

3. Install gauging plastic (1) onto the crankshaft journal. Install the gauging plastic the full width of the crankshaft bearing journal.

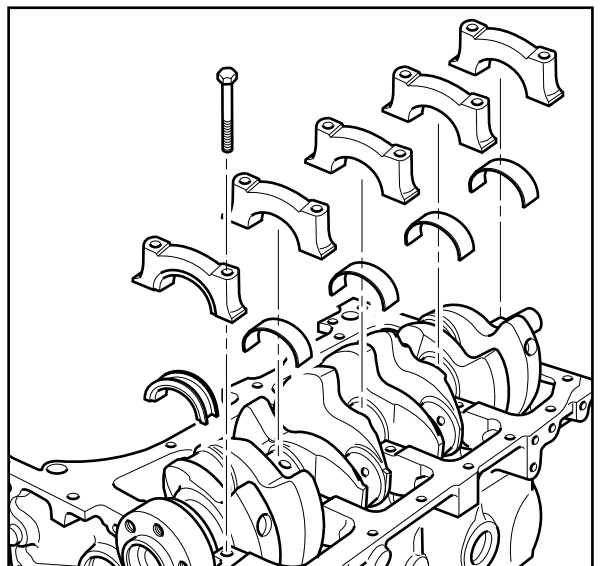


VE051-3L

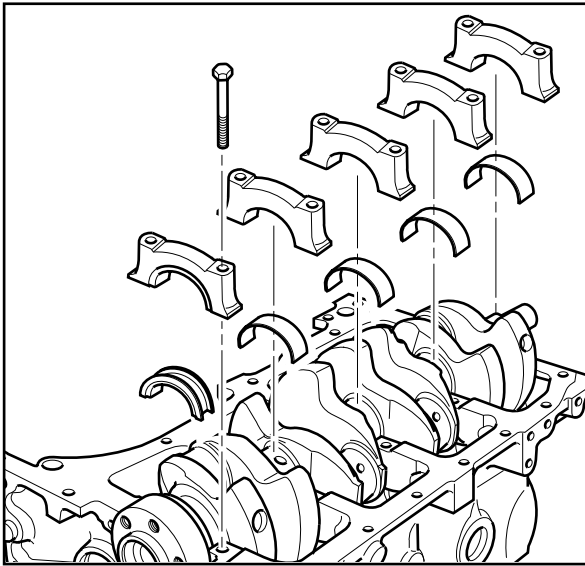
4. Install the bearing, bearing cap and bolts.

Tighten

Tighten the crankshaft bearing cap bolts to 88 N•m (65 lb ft).

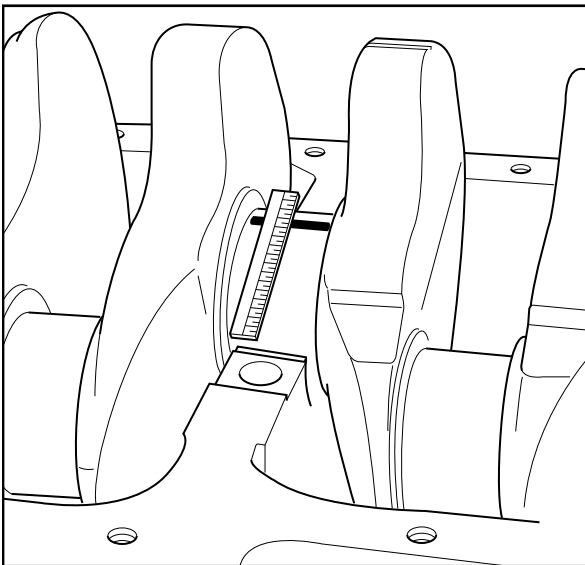


VE045-3L



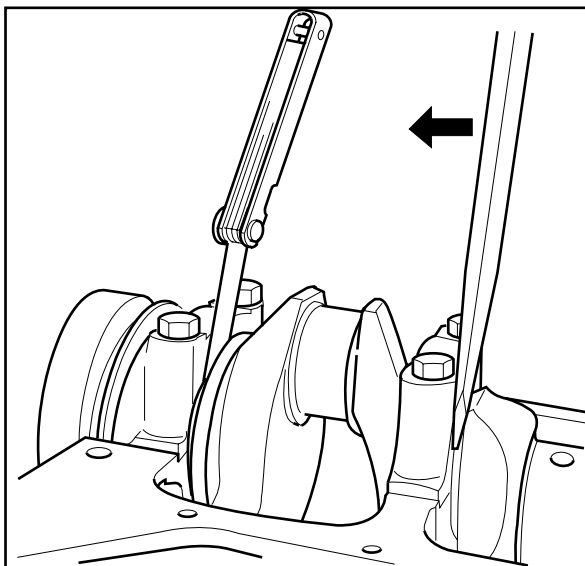
VE045-3L

5. Remove the crankshaft bearing cap bolts.
6. Remove the crankshaft bearing caps.



VE052-3L

7. Measure the gauging plastic at its widest area using the scale supplied with the plastic gauging kit.
8. Compare the measurements to *Engine Mechanical Specifications*.
 - If the gauging plastic shows irregularity in the journal exceeding 0.025 mm (0.001 in), remove the crankshaft and measure the journal with a micrometer.
 - If the clearance is greater than *Engine Mechanical Specifications*, select and install an undersized bearing set. Measure the clearance with gauging plastic.
 - If clearance cannot be brought to specifications, grind the crankshaft for use with the next undersized bearing.



VE053-3L

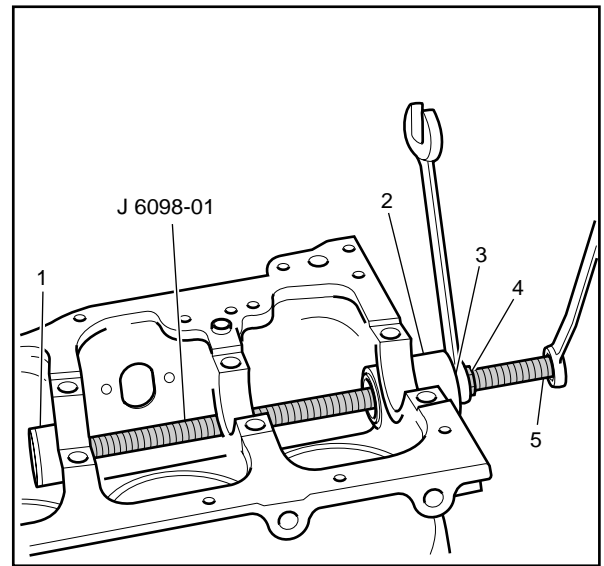
9. Use a dial indicator or feeler gauge in order to measure end play between the front of the rear of the crankshaft bearing cap and the crankshaft thrust surface in order to determine the crankshaft end play.
10. If you use a feeler gauge, measure between the thrust surface of the crankshaft bearing and the crankshaft. Refer to *Engine Mechanical Specifications*.

Camshaft Bearing Removal

Tools Required

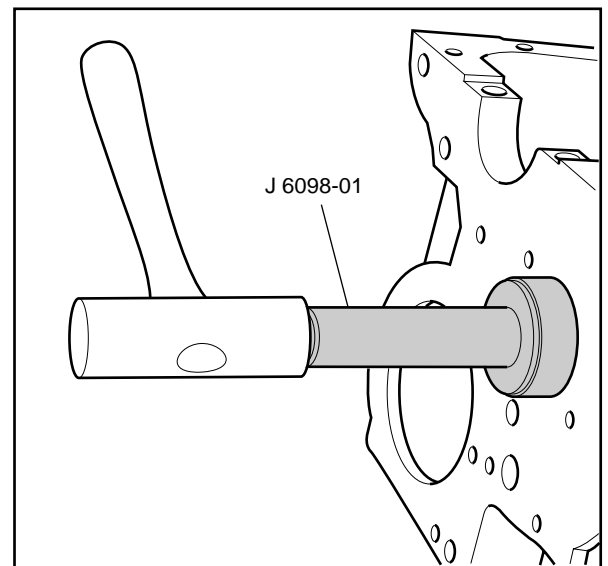
- J 6098-01 Camshaft Bearing Remover/Installer

1. Remove the camshaft rear bearing hole plug.
2. Use the J 6098-01 in order to remove the inner camshaft bearings. Repeat the following procedure for each of the inner camshaft bearings:
 - 2.1. With the nut (4) and the thrust washer (3) installed to the end of the puller screw threads, index the pilot (2) in the camshaft front bearing and install the puller screw through the pilot (2) and the bearing to be removed.
 - 2.2. Install the bearing tool (1) with the shoulder toward the bearing.
 - 2.3. Using two wrenches, hold puller screw (5) while you turn the nut (4) in order to draw the bearing out of the bore.
 - 2.4. When the bearing has been pulled from the bore, remove the bearing tool and the bearing from the puller screw.
 - 2.5. Index the pilot in the rear camshaft bearing in order to remove the rear inner camshaft bearing.

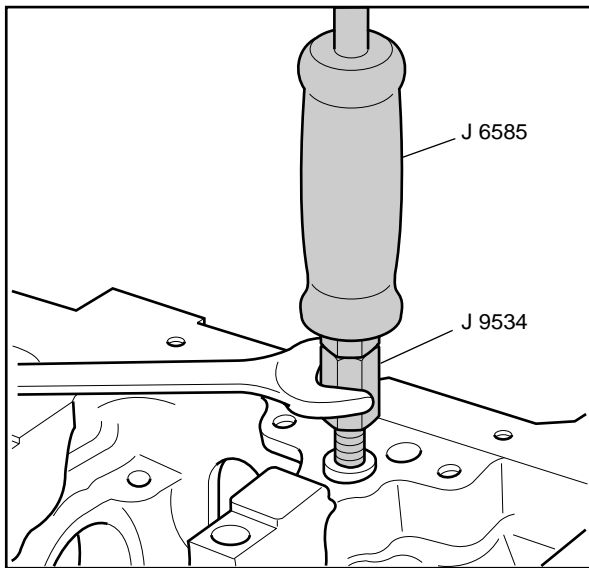


VE054-3L

3. Use the J 6098-01 in order to remove the front and rear camshaft bearings.
 - 3.1. Assemble the bearing tool to the driver.
 - 3.2. Drive the front and rear camshaft bearings out of the block bore. Drive inward toward the center of the engine block.



VE055-3L



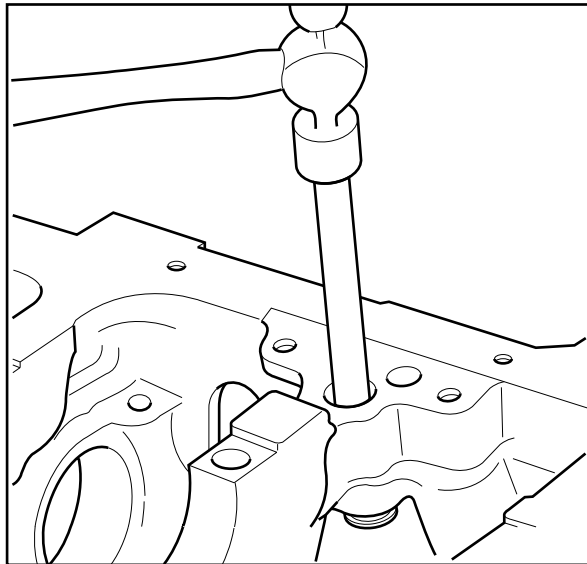
VE056-3L

Distributor Lower Bushing and Thrust Washer Removal

Tools Required

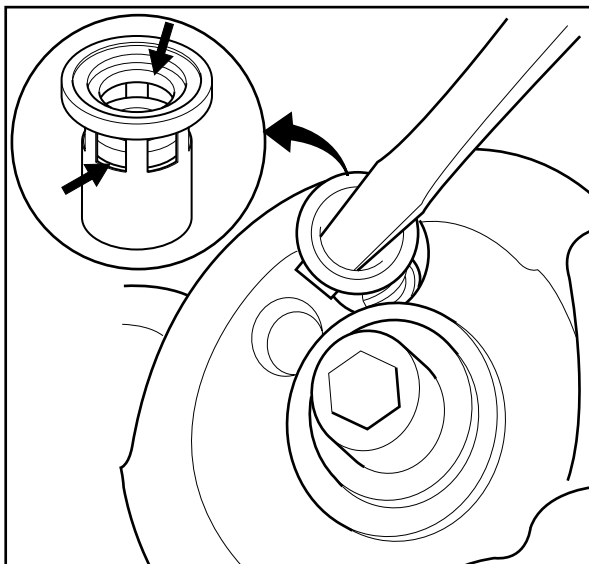
- J 9534 Distributor Lower Bushing Remover
- J 6585 Slide Hammer

1. Install the J 9534 into the distributor lower bushing.
2. Use the J 6585 in order to remove the bushing.



VE057-3L

3. Use a drift punch up through the bushing bore in order to drive the thrust washer (if installed) out of the bore.
4. Clean the bushing bore in the cylinder block and inspect for burrs or damage.



VE058-3L

Oil Filter Bypass Valve Removal and Installation

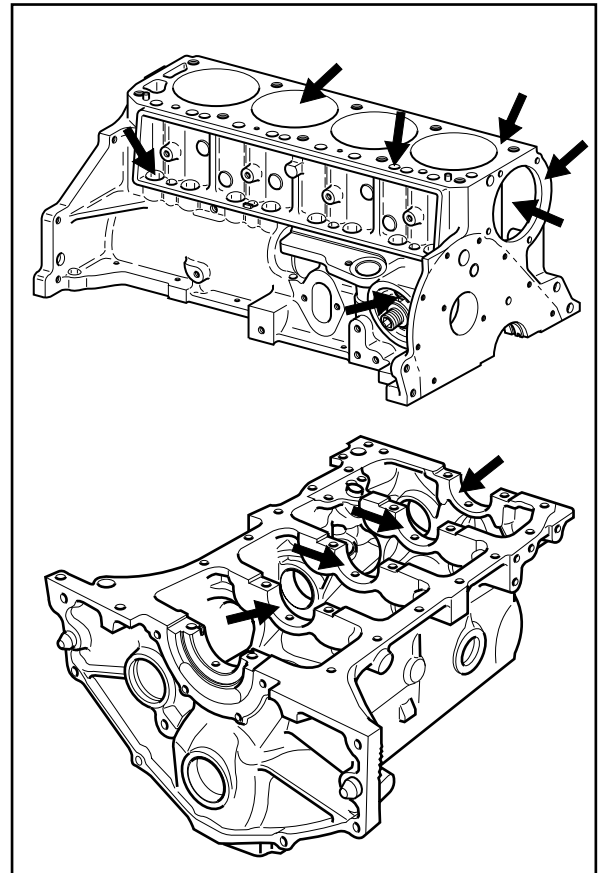
1. Check the spring and fiber valve for operation.
2. Inspect for a cracked or broken valve.
3. Use a screwdriver in order to pry the valve out.
4. Use a 9/16 in thin-wall deep socket in order to tap the new bypass valve in place.

Cylinder Block Clean and Inspect

1. Clean the following areas:
 - The engine block in solvent, removing all sludge, dirt or debris

Caution: *Wear safety glasses in order to avoid eye damage.*

- Dry the block with compressed air.
 - The gasket surfaces.
 - The coolant passages.
 - The oil passages.
 - The main bearing caps.
2. Inspect the following areas:
 - The cylinder walls for excessive scratches, gouging or ring ridge.
 - The coolant jackets for cracks.
 - The valve lifter bores for excessive scoring or wear.
 - The crankshaft bearing webs for cracks.
 - The gasket sealing surfaces for excessive scratches or gouging.
 - The oil passages for restrictions.
 - All threaded bolt holes for thread damage.

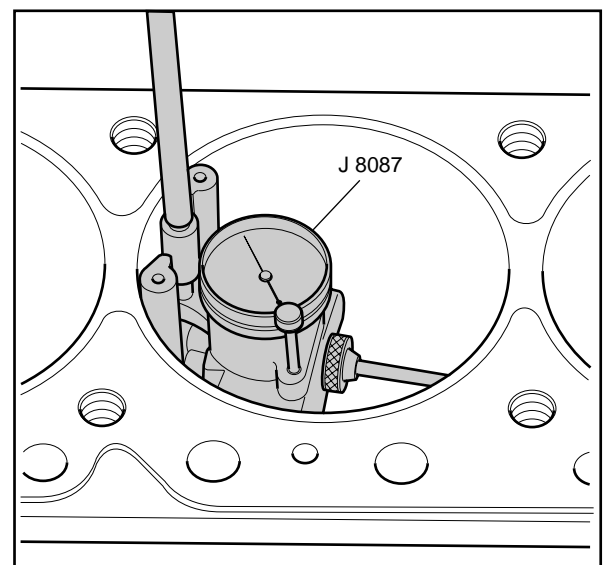


VE059-3L

Cylinder Bore Measurements

Tools Required

- J 8087 Cylinder Bore Gauge
1. Use the J 8087 in order to check cylinder bore taper and out-of-round as follows:
 - 1.1. Set the gauge so that the thrust pin must be forced in about 1/4 in to enter the gauge in the cylinder bore.
 - 1.2. Center the gauge in the cylinder and turn the dial to "0."
 - 1.3. Work the gauge up and down to determine the taper.
 - 1.4. Turn the gauge to different point around the cylinder to determine the out-of-round condition. Refer to *Engine Mechanical Specifications*.



VE060-3L

Cylinder Boring and Honing

Boring Procedure

1. Before you start the honing or reboring process, measure all new pistons with the micrometer, contacting at points exactly 90° from the piston pin centerline. Refer to *Piston Selection*. Select the smallest piston for the piston fitting. Slightly varied pistons in a set may provide correction, in case the first piston is too loosely fitted.
2. Before you use any type of boring bar, file the top of the cylinder block in order to remove any dirt or burrs. If you do not check the cylinder block, the boring bar may be tilted, this could result in the rebored cylinder wall being at incorrect right angles from the crankshaft.
3. Carefully follow the instructions furnished by the manufacturer regarding the use of the equipment.
4. When you rebore cylinders, make sure all crankshaft bearing caps are in place. Tighten the bearing caps to the proper torque in order to avoid distortion of the bores in the final assembly. The crankshaft must be clear of the boring cutter when you bore each cylinder. Cover or tape the crankshaft bearings and other internal parts to protect during the boring or honing process.

Honing Procedure

1. When honing the cylinders, follow the manufacturer's recommendations for use, cleaning and lubrication. Use only clean, sharp stones of the proper grade for the amount of material you remove. Dull, dirty stones cut unevenly and generate excessive heat. When using coarse or medium-grade stones, leave sufficient metal so that all stone marks may be removed with the fine stones you use for finishing in order to provide for proper clearance.
2. During the honing process, thoroughly clean the cylinder bore. Check for a correct fit of the piston you select for the individual cylinder.
3. When honing to eliminate taper in the cylinder, make full strokes of the hone in the cylinder. Repeatedly check the measurement at the top, the middle and the bottom of the bore.

Notice: Handle the pistons with care. Do not force the pistons through the cylinder until you hone the cylinder to the correct size. The piston can be distorted through careless handling.

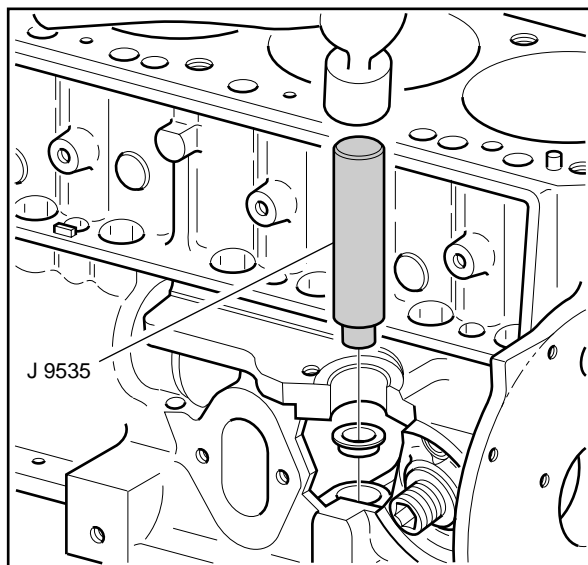
4. When finished honing a cylinder bore to fit a piston, move the hone up and down at a sufficient speed to obtain very fine, uniform surface finish marks in a cross hatch pattern at 45-65 degrees.

5. The finish marks should be clean but not sharp. The finish marks should be free from imbedded particles and torn or folded metal.
6. By measuring the piston to be installed at the sizing point specified and by adding the average of the clearance specification, you can determine the finish hone cylinder measurement. Refer to *Engine Mechanical Specifications*. Measure the block and the piston at normal room temperature.
7. True up the refinished cylinder bores to have less than the specified out-of-round or taper. You must final hone each bore in order to remove all stone or cutter marks and in order to provide a smooth surface.
8. For piston-to-bore tolerance specifications, Refer to *Engine Mechanical Specifications*.
9. After final honing and before the piston is checked for fit, clean the bores with hot water and detergent. Scrub the bores with a stiff bristle brush and rinse the bores thoroughly with hot water. Do not allow any abrasive material to remain in the cylinder bores. This abrasive material will wear the new rings, the cylinder bores and the bearings lubricated by the contaminated oil. After you wash the bore, brush the dry bore clean with a power-driven fiber brush.
10. Permanently mark the piston for the cylinder to which the piston has been fitted.
11. Apply clean engine oil to each bore in order to prevent rusting.

Distributor Lower Bushing and Thrust Washer Installation

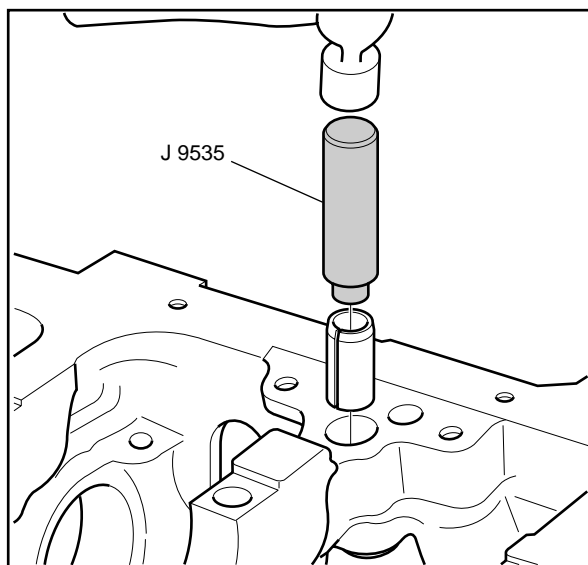
Tools Required

- J 9535 Distributor Lower Bushing Installer
1. Use the J 9535 in order to drive the thrust washer (if removed) into the cylinder block.
 2. Use the J 9535 with the driver-bolt in the driver handle.



VE061-3L

3. Install the driver into the new bushing from the large inside diameter.
4. Drive the new bushing into the cylinder block until the J 9535 bottoms against the cylinder block.

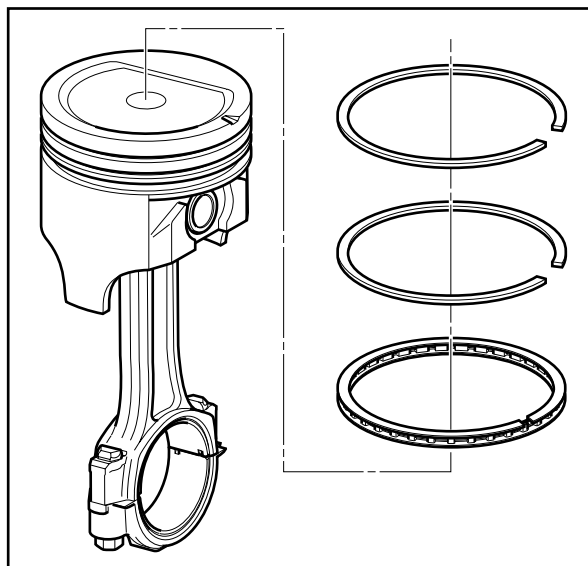


VE062-3L

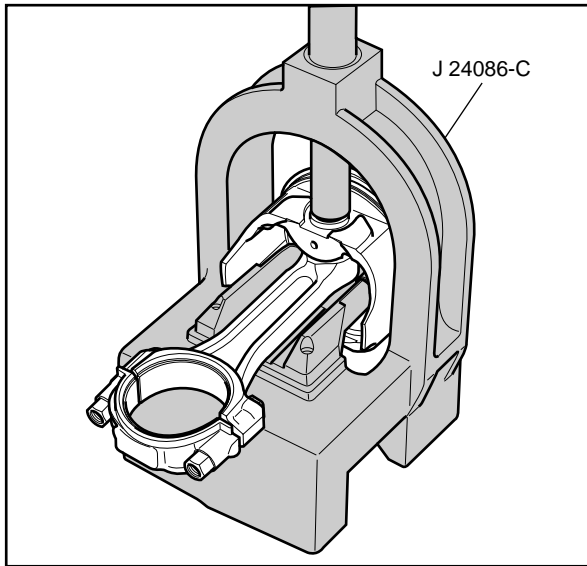
Piston and Connecting Rod Disassemble

Tools Required

- J 24086-C Piston Pin Removal Set
1. Remove the piston rings from the pistons.



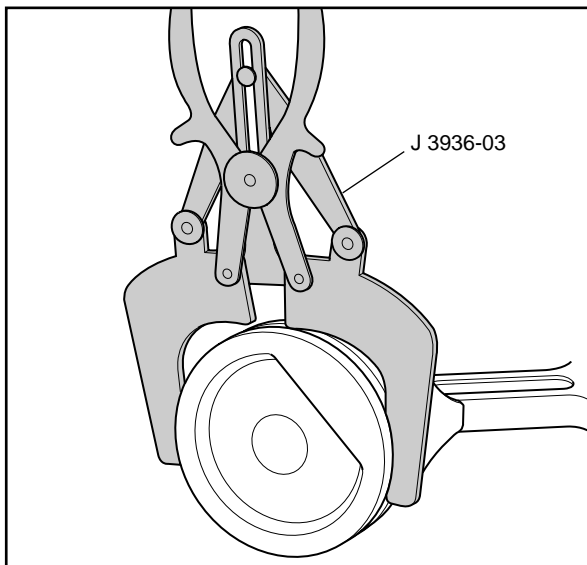
VE063-3L



VE064-3L

2. Remove the pin from the piston.

Notice: After the J 24086-C Installer bottoms on the support assembly, do not exceed 34,475 kPa (5000 psi) or the tool may be damaged.



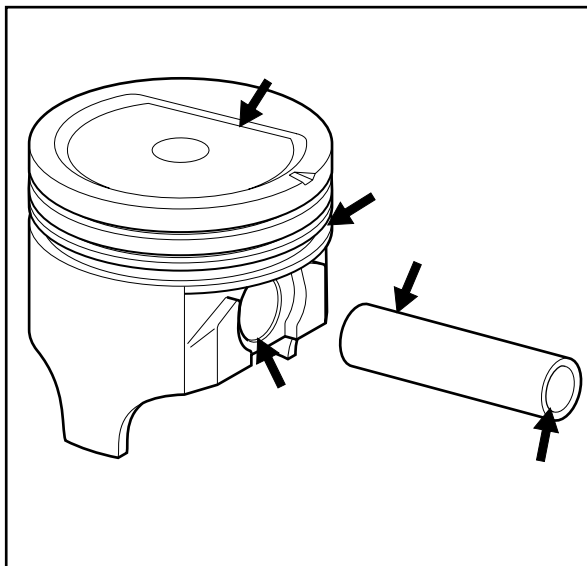
VE065-3L

Piston and Connecting Rod Clean and Inspect

1. Clean the piston ring grooves with a groove cleaner.

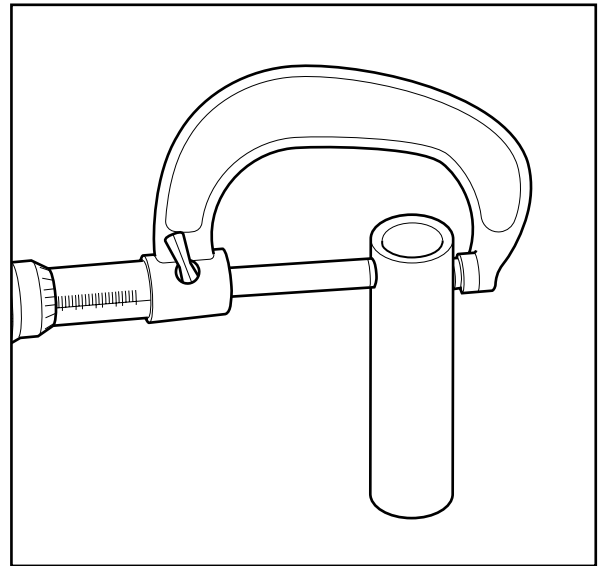
Caution: Wear safety glasses in order to avoid eye damage.

2. Clean the connecting rod in cleaning solvent.
3. Clean the varnish from the piston skirts and the pins with cleaning solvent
4. Dry the components with compressed air.
5. Do not use a wire brush in order to clean any part of the piston.
6. Clean the piston oil ring holes and the slots.
7. Inspect the connecting rod for twisting, nicks and cracks. Replace any damaged connecting rods.
8. Inspect the pistons for the following conditions:
 - Cracked ring lands, skirts or pin bosses.
 - Nicks or spurs in the grooves that may cause binding.
 - Warped or worn ring lands.
 - Scuffed or damaged skirts.
 - Eroded areas at the top of the piston.
 - Worn piston bores and piston pins.
9. Replace pistons that are damaged or show signs of excessive wear.



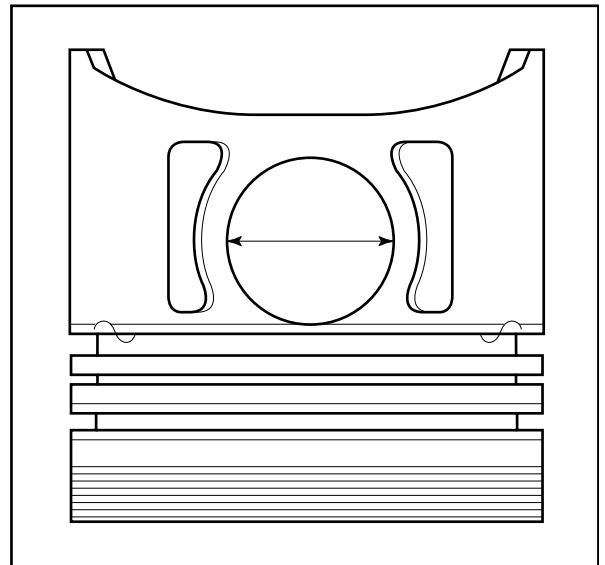
VE066-3L

10. Measure the pin bore-to-piston clearance.
 - 10.1. The piston pin bores and the piston pins must be free of varnish or scuffing when being measured.
 - 10.2. Use a micrometer in order to measure the piston pin.



VE067-3L

- 10.3. Use an inside micrometer in order to measure the piston pin bore. Replace the piston and piston pin if the clearance is in excess of 0.0254 mm (0.001 in).
 - 10.4. Match the piston and piston pin. Do not service separately.

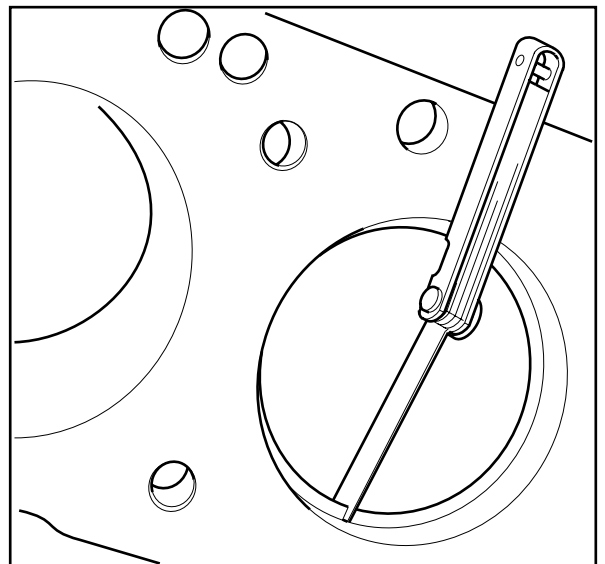


VE068-3L

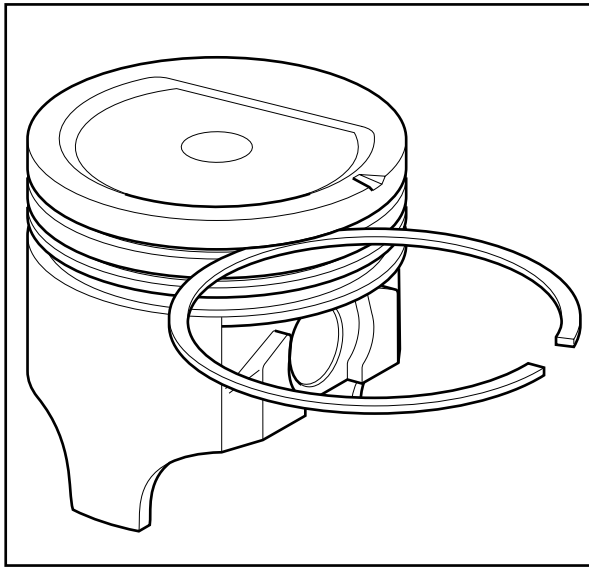
11. Measure the piston compression ring end gap.

Important: Fit each compression ring to the cylinder in which it will be used.

- 11.1. Place the compression ring into the cylinder bore.
 - 11.2. Push the compression ring into the cylinder bore approximately 6.5 mm (0.25 in) above the ring travel. The ring must be square to the cylinder wall.
 - 11.3. Use a feeler gauge in order to measure the end gap.
 - 11.4. Select another size ring set if the end gap exceeds specifications.

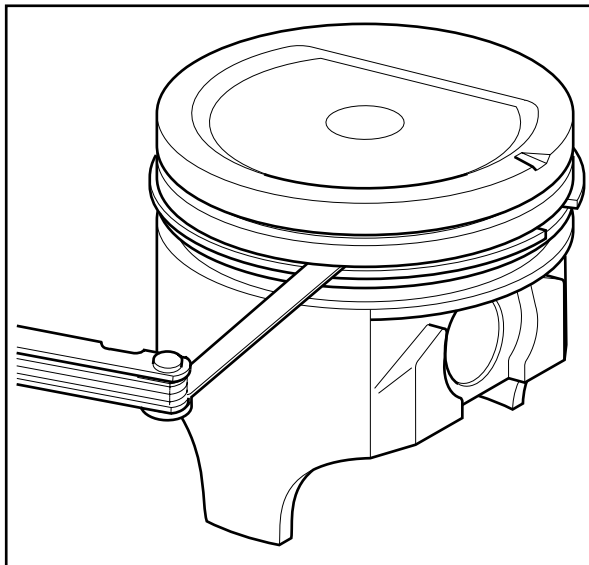


VE069-3L



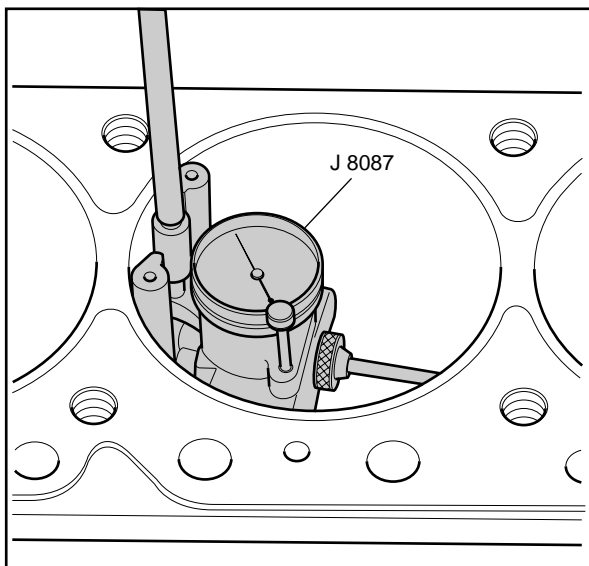
VE070-3L

12. Measure the piston ring side clearance.
 - 12.1. Roll the piston ring entirely around its ring groove on the piston.
 - 12.2. Dress the groove with a fine cut file if the ring groove causes binding.
 - 12.3. Replace the piston ring if a distorted piston ring causes binding.



VE071-3L

- 12.4. Use a feeler gauge in order to measure the side clearance of the piston ring and groove.
- 12.5. Try another piston ring if the side clearance is too small.



VE060-3L

Piston Selection

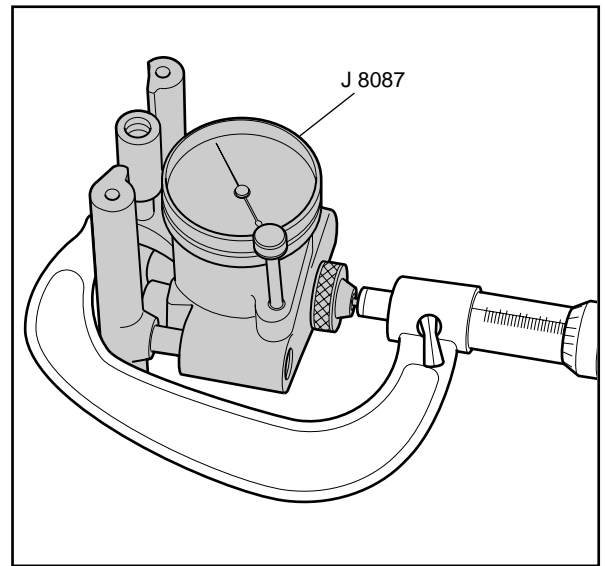
Important: Measurements of all components should be taken with the components at normal room temperature.

For proper piston fit, the engine block cylinder bores must not have excessive wear or taper.

A used piston and pin set may be reinstalled if, after cleaning and inspection, they are within specifications.

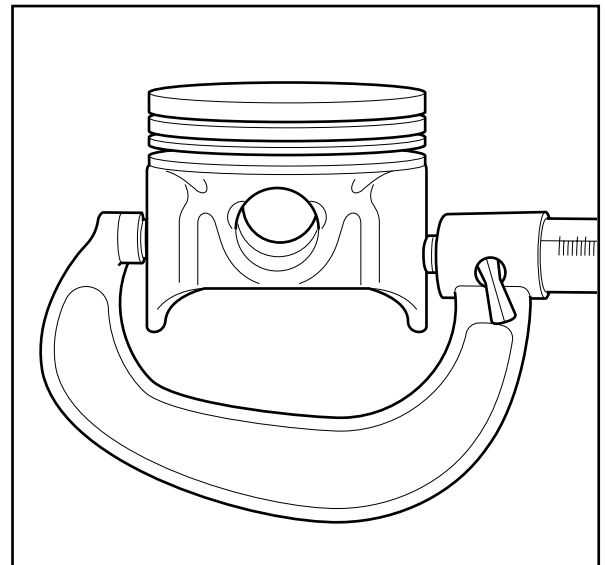
1. Inspect the engine block cylinder bore. Refer to *Cylinder Block Clean and Inspect*.
2. Inspect the piston and piston pin. Refer to *Piston and Connecting Rod Clean and Inspect*.
3. Use a boring gauge in order to measure the cylinder bore diameter at a point of 66 mm (2.5 in) from the top of the cylinder bore.

4. Measure the bore gauge with a micrometer and record the reading.



VE072-3L

5. With a micrometer or caliper at a right angle to the piston, measure the piston 11 mm (0.433 in) from the bottom of the skirt.
6. Subtract the piston diameter from the cylinder bore diameter in order to determine piston-to-bore clearance.
7. For proper piston-to-bore clearance, Refer to *Engine Mechanical Specifications*.
8. If the proper clearance cannot be obtained, select another piston and measure for the clearances. If the proper fit cannot be obtained, the cylinder bore may require boring or honing. Refer to *Cylinder Boring and Honing*.
9. When the piston-to-cylinder bore clearance is within specifications, permanently mark the top of the piston for installation to the proper cylinder.



VE073-3L

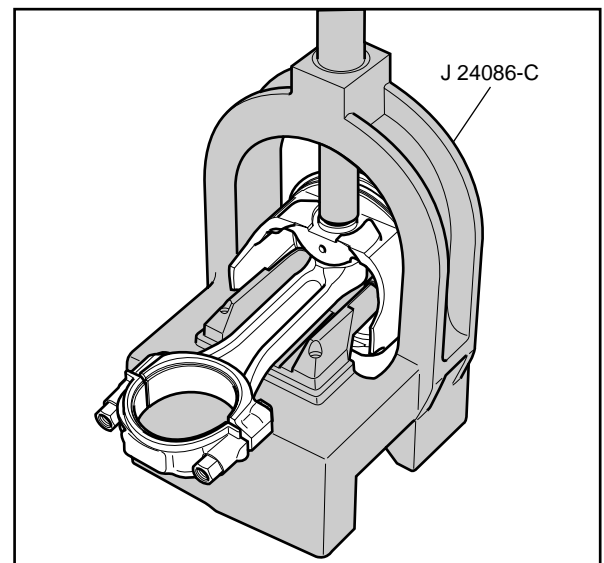
Piston and Connecting Rod Assemble

Tools Required

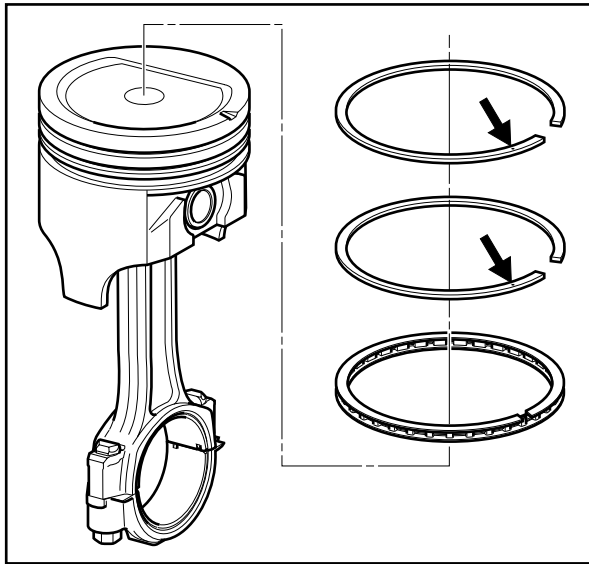
- J 24086-C Piston Pin Removal Set

Important: When assembling the piston and connecting rod, the flange or the heavy side on the connecting rod must face toward the front of the piston (stamped arrow in top of the piston head).

1. Install the piston pin and connecting rod assembly.
 - 1.1. Lubricate the piston pin holes in both the piston and the connecting rod assembly.
 - 1.2. Press the piston pin into the piston and connecting rod assembly using the J 24086-C.
 - 1.3. Inspect for freedom of movement of the piston on the piston pin.

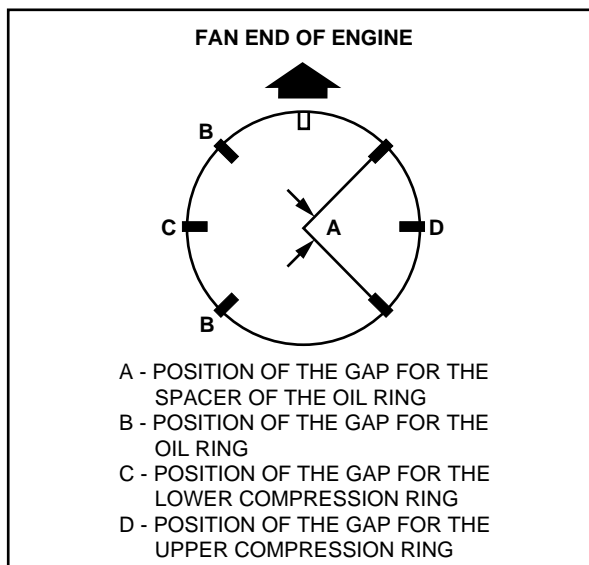


VE064-3L



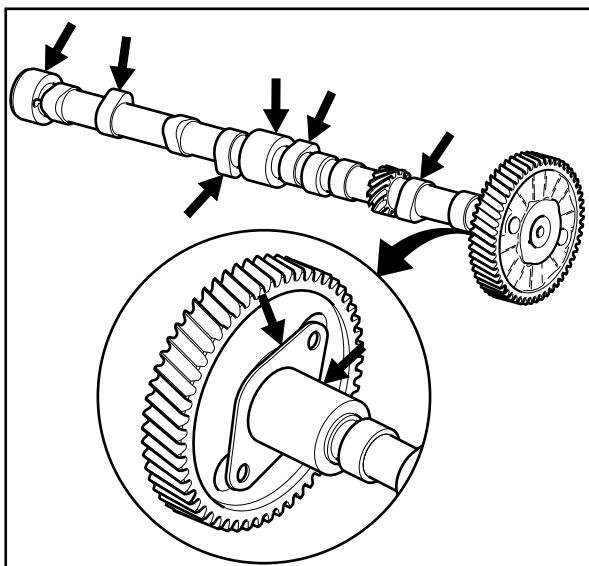
VE123-3L

2. Install the piston rings onto the piston.
The marked side of the piston rings must face toward the top of the piston.



VE074-3L

3. Use the following procedure in order to locate the piston ring gaps:
 - 3.1. Install the oil ring spacer in groove and insert anti-rotation tang in oil hole.
 - 3.2. Hold the spacer ends together and install lower oil ring rail with the gap properly located.
 - 3.3. Install the upper oil ring rail with the gap properly located.
 - 3.4. Flex the oil ring assembly to make sure the rings are free.
 - 3.5. Install the lower compression ring.
 - 3.6. Install the upper compression ring.



VE075-3L

Camshaft and Bearings Clean and Inspect

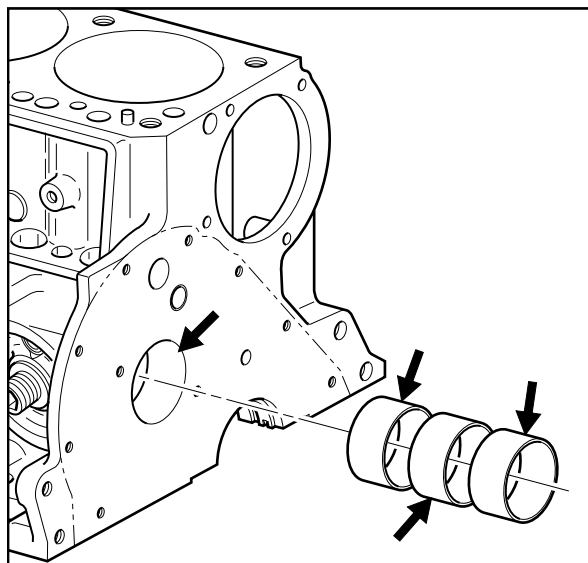
Tools Required

- J 7872 Magnetic Base Indicator Set

Caution: Wear safety glasses in order to avoid eye damage.

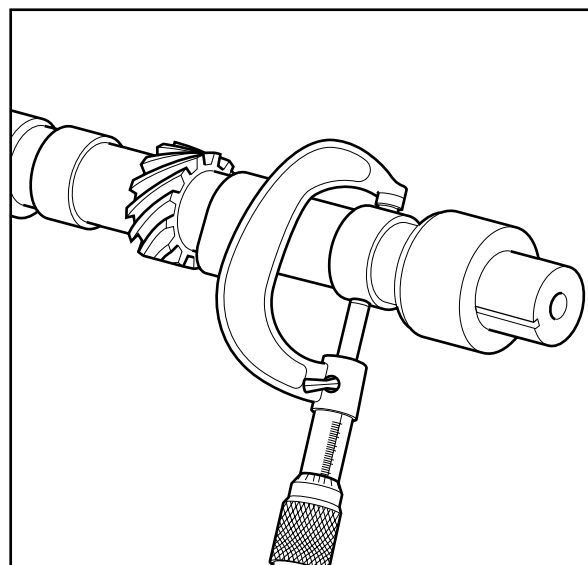
1. Clean the camshaft in solvent.
2. Dry the camshaft with compressed air.
3. Inspect the camshaft bearing journals for scoring or excessive wear.
4. Inspect the camshaft valve lifter lobes for scoring or excessive wear.
5. Inspect the camshaft retainer plate for wear.

6. Inspect the camshaft bearings for proper fit in the engine block. Camshaft bearings have an interference fit to the engine block and should not be loose in their engine block bearing bores.
7. Inspect the camshaft bearings for excessive wear or scoring. Bearings with excessive wear or scoring must be replaced.



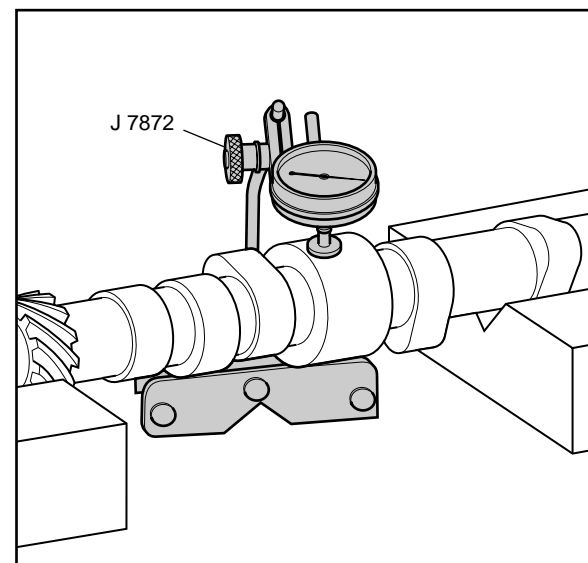
VE076-3L

8. Measure the camshaft for out-of-round, taper or undersize with a micrometer. Refer to *Engine Mechanical Specifications*.

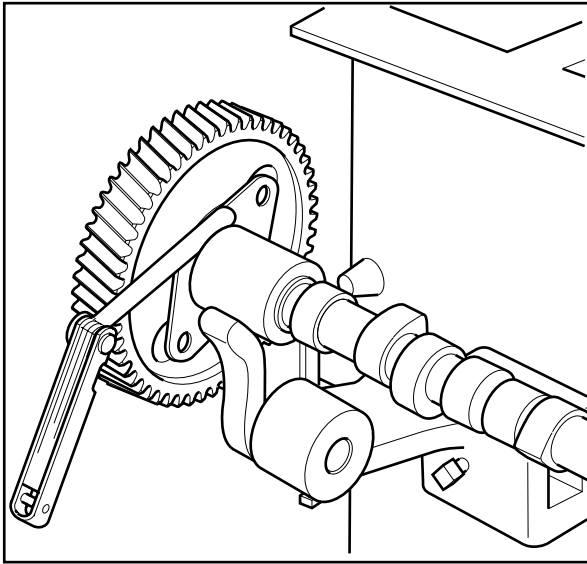


VE077-3L

9. Support the camshaft front and rear journals on V-blocks.
10. Measure the camshaft run-out at the intermediate journal with J 7872. Refer to *Engine Mechanical Specifications*.
11. Replace camshaft if measurements are not within specifications.



VE078-3L



VE079-3L

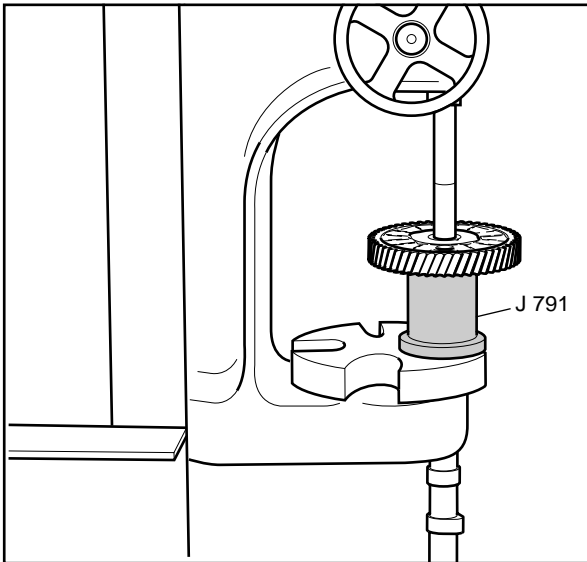
Camshaft Sprocket and Retainer Removal and Installation

Removal

Tools Required

- J 791 Camshaft Sprocket Remover

1. If the inspection indicated that the camshaft, gear and retainer were in good condition, the camshaft end play should be checked. Refer to *Engine Mechanical Specifications*.

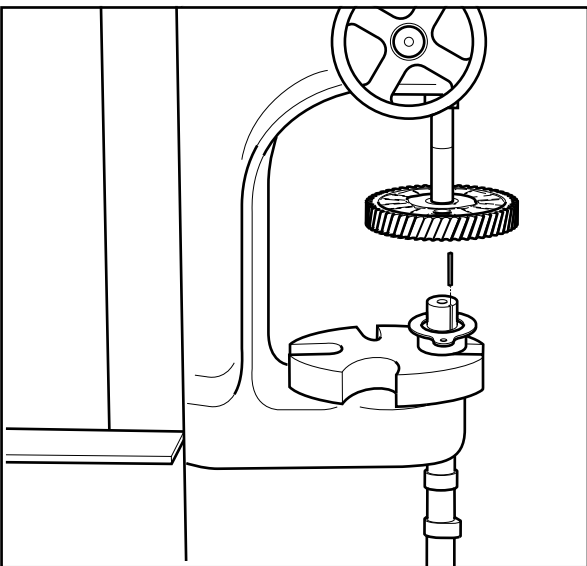


VE080-3L

2. If the inspection indicated that the camshaft, gear or retainer should be replaced, the gear must be removed from the camshaft as follows:
 - 2.1. Place the camshaft through the J 791.
 - 2.2. Place the end of the remover on the table of a press and press the camshaft out of the gear.

Important:

The retainer must be positioned so that the woodruff key in the camshaft does not damage it when the camshaft is pressed out of the gear. Also, support the hub of the gear or the gear will be seriously damaged.



VE081-3L

Installation

1. Install the camshaft sprocket, retainer and gear spacer ring to the camshaft as follows:
 - 1.1. Firmly support the camshaft at the back of the front journal in an arbor press.
 - 1.2. Place the gear spacer ring and retainer over the end of the camshaft and install the woodruff key in the camshaft keyway.
 - 1.3. Align the sprocket keyway with the woodruff key in the camshaft and press it onto the shaft until it bottoms against the gear spacer ring.

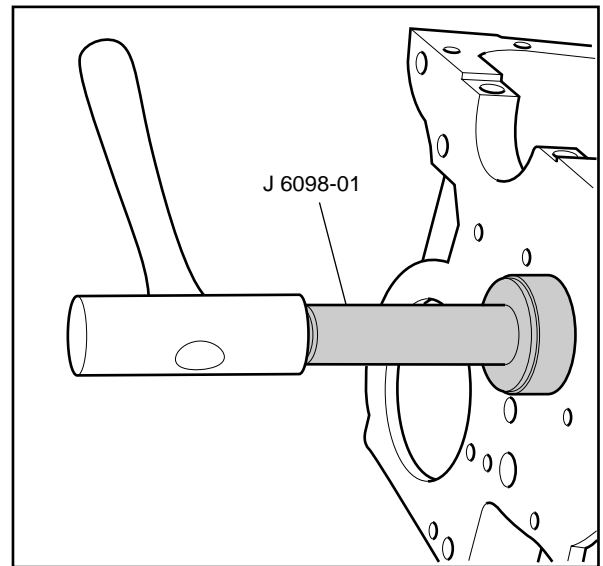
Camshaft Bearing Installation

Tools Required

- J 6098-01 Camshaft Bearing Installer

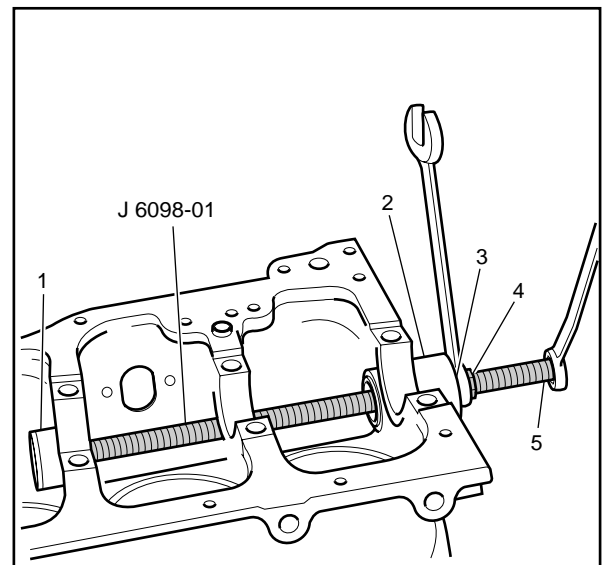
Important:

- A loose camshaft bearing may be caused by an enlarged, out of round or damaged engine block bearing bore.
 - The outer front and rear camshaft bearings must be installed first. These bearings serve as guides for the tool pilot and help center the inner bearings during the installation process.
 - The camshaft bearing oil holes must align with the oil galleys in the engine block. An improperly aligned camshaft bearing oil galley hole will restrict oil flow to the bearing and camshaft journal.
1. Use the J 6098-01 in order to install the front and rear camshaft bearings:
 - 1.1. Assemble the bearing tool to the driver handle.
 - 1.2. Align the oil holes.
 - 1.3. Drive the front and the rear camshaft bearings inward toward the center of the engine block.

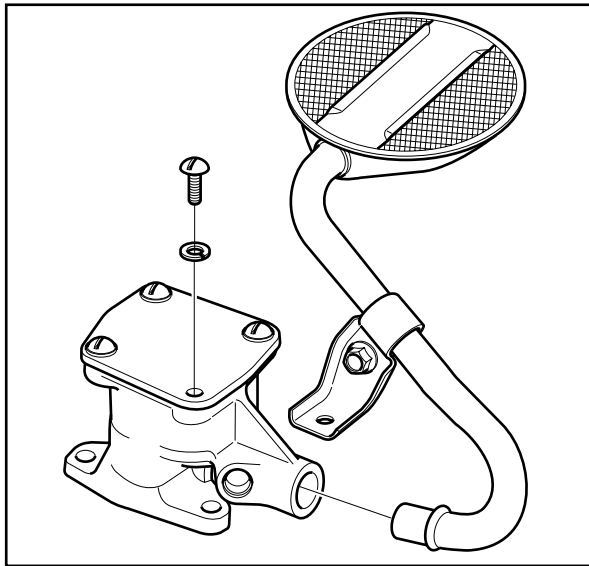


VE055-3L

2. Use the J 6098-01 in order to install the inner camshaft bearings. Repeat the following steps for each of the inner camshaft bearings:
 - 2.1. With the nut (4) and the thrust washer (3) installed to the end of the puller screw threads, index the pilot in the camshaft front bearing and install the puller screw through the pilot (2).
 - 2.2. Index the camshaft bearing in the bore. Make sure you align the oil galley holes.
 - 2.3. Install the puller screw through the bearing bore and bearing to be installed and assemble bearing tool (1) to the puller screw with the shoulder toward the bearing. Make sure that enough threads are engaged.
 - 2.4. Using two wrenches, hold the puller screw (5) while you turn the nut in order to draw the bearing into the bore. When the bearing has been pulled into the bore, remove the bearing tool and the puller screw and check the alignment of the bearing oil hole to the bore oil hole.
3. Install a new camshaft rear bearing hole plug. Coat the plug outside diameter with GM P/N 1052080 sealant, or the equivalent.



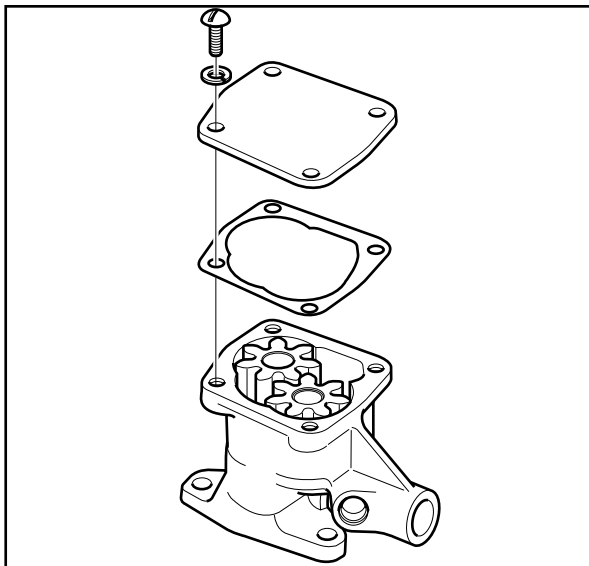
VE054-3L



VE082-3L

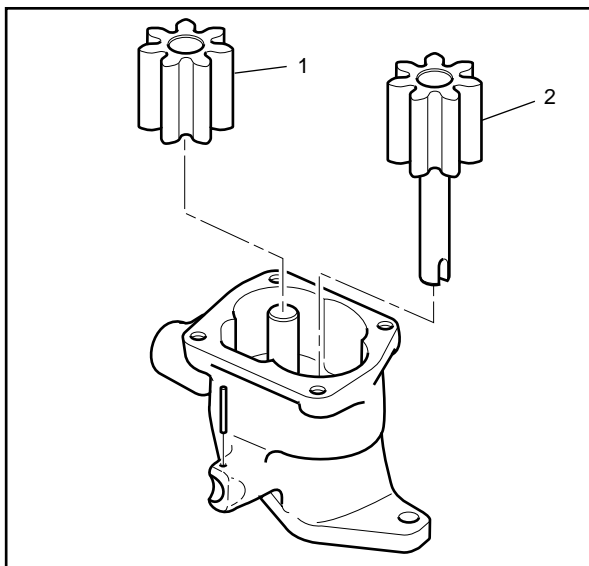
Oil Pump Disassemble

1. If necessary, remove the oil pump screen.
 - The oil pump screen has a press fit in to the pump cover.
 - Do not remove the screen from the pipe. The pipe and screen are serviced as a complete assembly.



VE083-3L

2. Remove the cover bolts.
3. Remove the pump cover.

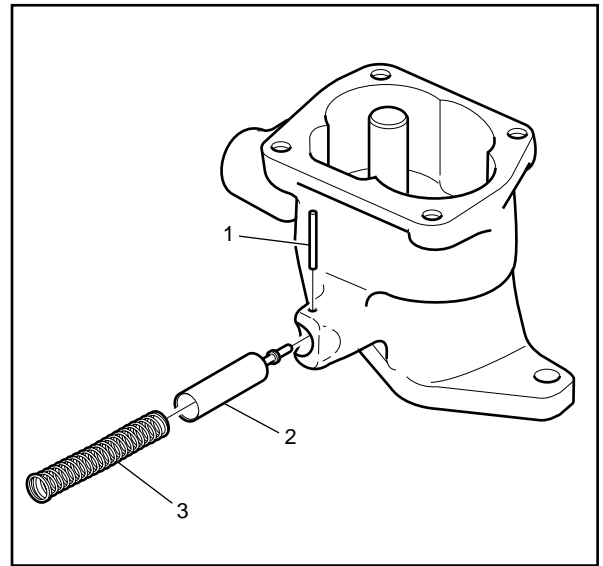


VE084-3L

4. Remove the drive gear (2) and the driven gear (1). Matchmark the gear teeth for assembly.

5. Remove the following items:

- The retaining pin (1).
- The pressure relief valve spring (3).
- The pressure relief valve (2).



VE085-3L

Oil Pump Clean and Inspect

Important: The internal parts of the oil pump are not serviced separately. If the oil pump components are worn or damaged, replace the oil pump as an assembly.

The oil pump pipe and screen are to be serviced as an assembly. Do not attempt to repair the wire mesh portion of the pipe and screen assembly.

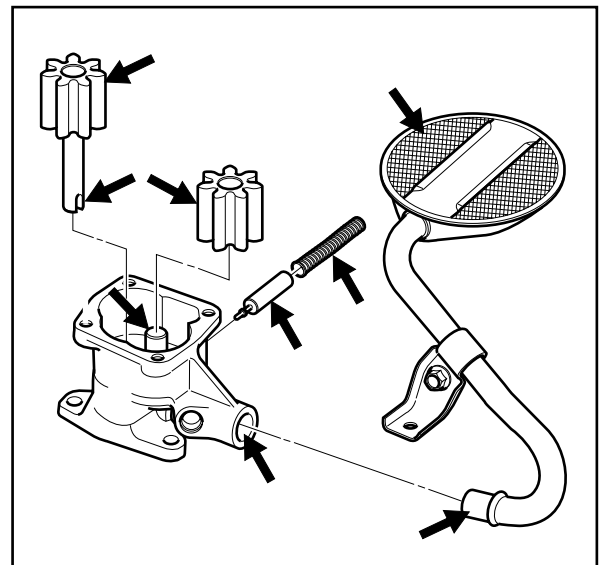
1. Clean all of the parts in cleaning solvent.

Caution: *Wear safety glasses in order to avoid eye damage.*

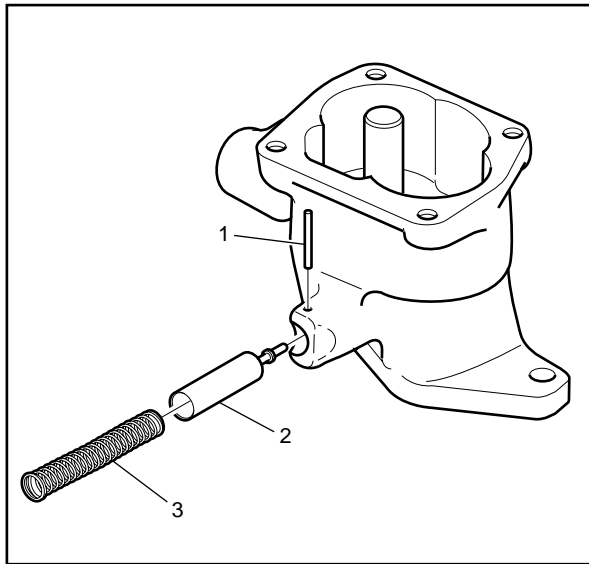
2. Dry the parts with compressed air.
3. Inspect the following areas:
 - The oil pump housing and cover for cracks, scoring, casting imperfections and damaged threads.
 - The drive gear shaft (If the shaft is loose in the oil pump housing, replace the oil pump).
 - The pressure relief valve for scoring and sticking (Burs may be removed with a fine oil stone).
 - The pressure relief valve spring for loss of tension.
 - The oil pump screen for broken wire mesh or looseness (If the pipe is loose or has been removed from the screen, the oil pump screen must be replaced).
 - The gears for chipping, galling and wear.

Important: If the drive gear and driveshaft are worn, replace the entire oil pump.

- The drive gear and driveshaft for looseness and wear.



VE086-3L



VE085-3L

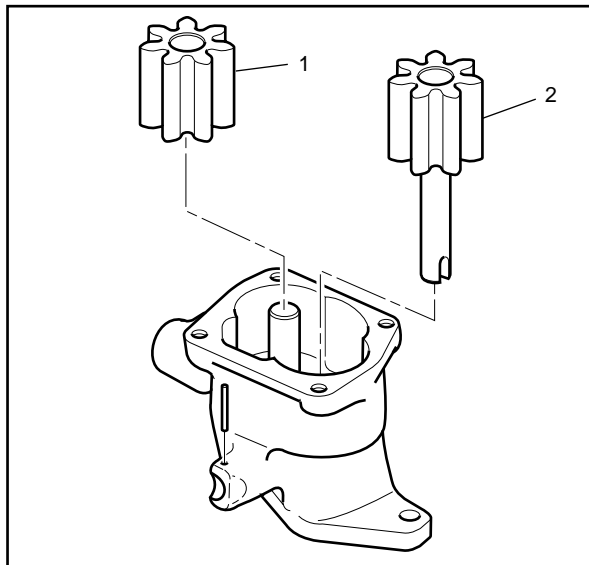
Oil Pump Assemble

Tools Required

- J 21882 Oil Suction Pipe Installer

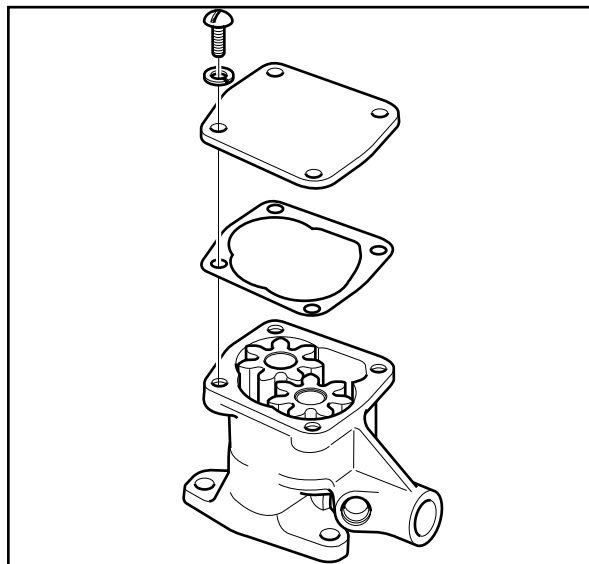
Important: Replace the pressure relief valve spring when you reuse the oil pump.

1. Install the following items:
 - The pressure relief valve (2).
 - The pressure relief valve spring (3).
 - The retaining pin (1).



VE084-3L

2. Coat the drive gear, the driven gear and the housing gear surfaces with clean engine oil.
3. Install the drive gear (2) and the driven gear (1) into the pump body. Align the matchmarks on the gears. Install the smooth side of the gear toward the pump cover.



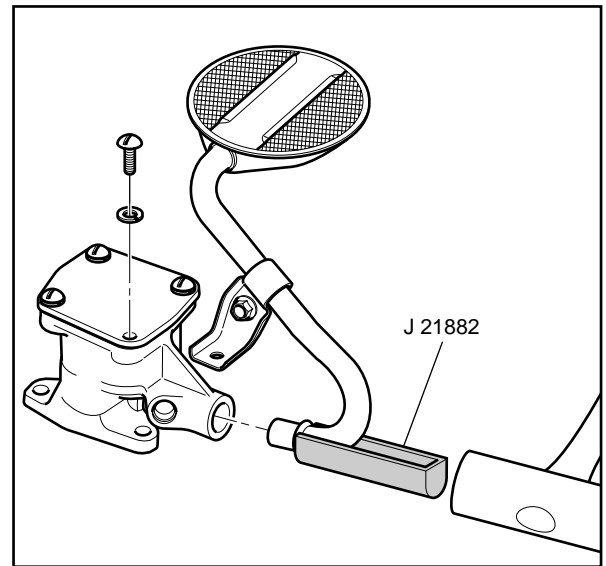
VE083-3L

4. Install the pump cover.
5. Install the cover bolts.

Tighten

Tighten the bolts to 8 N•m (72 lb in).

6. Inspect the pump for smoothness of operation by turning the oil pump driveshaft by hand.
7. Install the oil pump screen.
 - 7.1. If removed, replace the oil pump screen. The oil pump screen must have a good press fit into the oil pump body.
 - 7.2. Mount the oil pump in a soft jawed vise.
 - 7.3. Apply sealer to the end of the pipe.
 - 7.4. Use the J 21882 and a soft-faced hammer in order to tap the oil pump screen into the pump body. The screen must align parallel with the bottom of the oil pan when it is installed.



VE087-3L

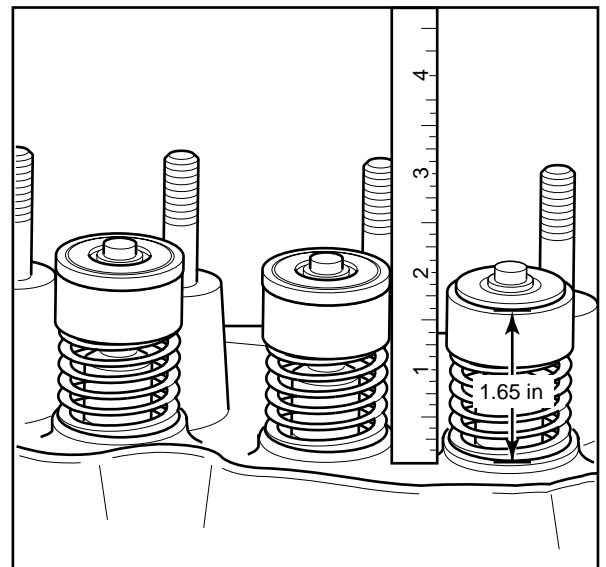
Cylinder Head Disassemble

Tools Required

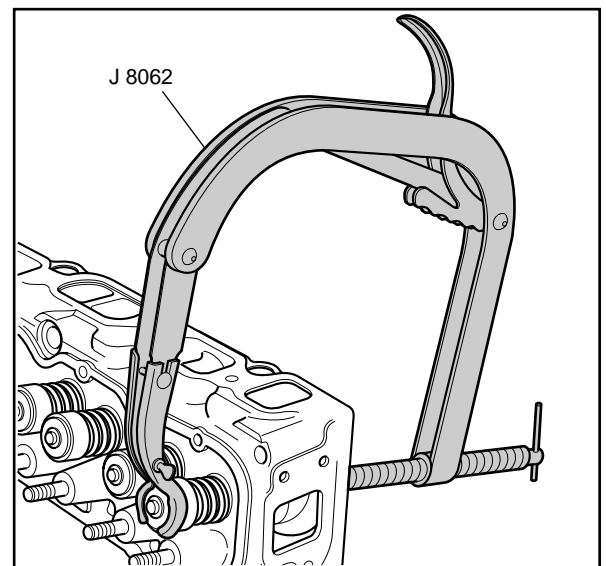
- J 8062 Valve Spring Compressor

Important: Mark, organize or sort the cylinder head components for assembly. Return the components to their original location during assembly.

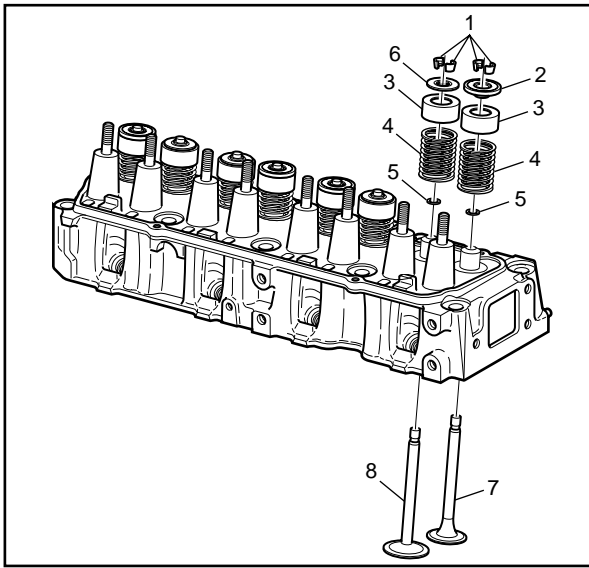
1. Measure the valve spring installed height using a ruler. Measure from the machined surface of the cylinder head to the top of the valve spring cap. Refer to *Engine Mechanical Specifications*
2. Use the J 8062 in order to compress the valve springs.



VE088-3L



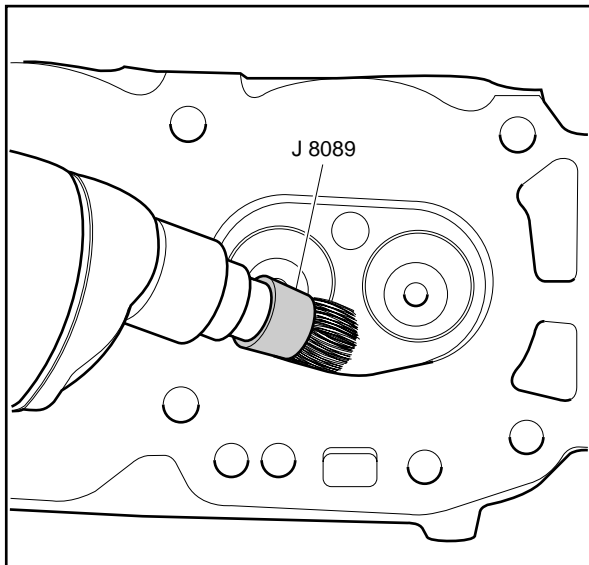
VE089-3L



VE090-3L

3. Remove the valve stem keys (1).
4. Remove the cap from the valve spring (2&6).
5. Remove the valve stem oil shield (3).
6. Remove the valve spring (4).
7. Remove the valve stem oil seal (5).
8. Remove the valve (7&8).

Important: Place the valves in a rack in the proper sequence so that you can install them in the same order.



VE091-3L

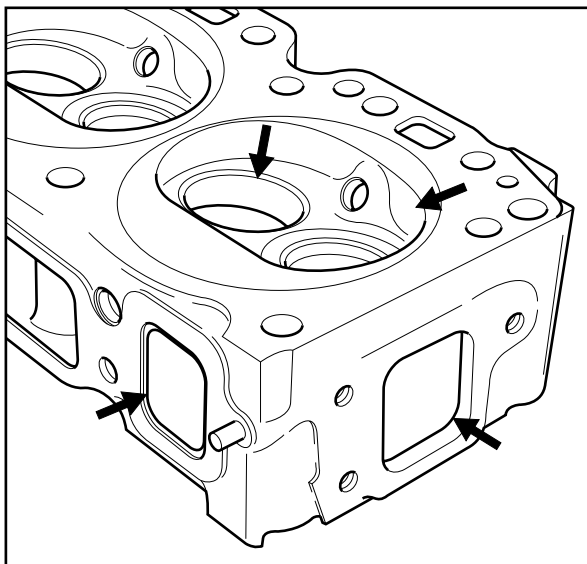
Cylinder Head Clean and Inspect

Tools Required

- J 8089 Carbon Remover Brush
- J 9666 Valve Spring Tester
- J 8001 Dial Indicator

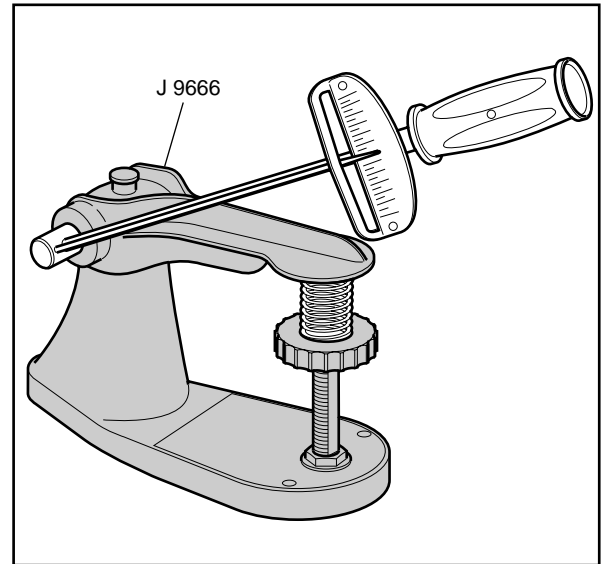
Caution: Wear safety glasses in order to avoid eye damage.

1. Use the J 8089 in order to clean the carbon from the combustion chambers and the valve ports. Be careful not to scuff the chamber.
2. Clean the following areas:
 - 2.1. The carbon and the sludge from the valve pushrods and the valve rocker arms.
 - 2.2. The valve stems and heads on a buffing wheel.
 - 2.3. The cylinder head and engine block gasket surfaces.
 - 2.4. The bolt holes and threads in the cylinder head and the engine block.
3. Inspect the following areas:
 - 3.1. The cylinder head for cracks in the exhaust ports and the combustion chambers.
 - 3.2. The cylinder head for external cracks in the water chamber.
 - 3.3. The valves for burned heads, cracked faces or damaged stems.



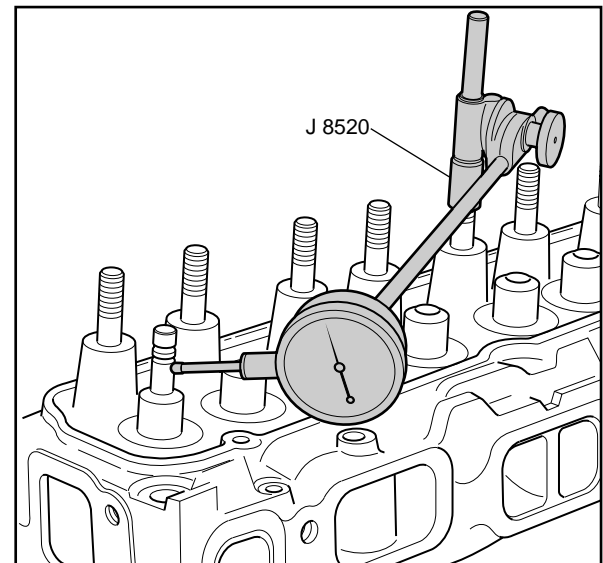
VE092-3L

4. Use the J 9666 and a flex bar torque wrench in order to measure the valve spring pressure.
 - Replace the valve spring if the spring pressure is less than 444 N (100 lb.) at 40.9 mm (1.61 in). Refer to *Engine Mechanical Specifications*.

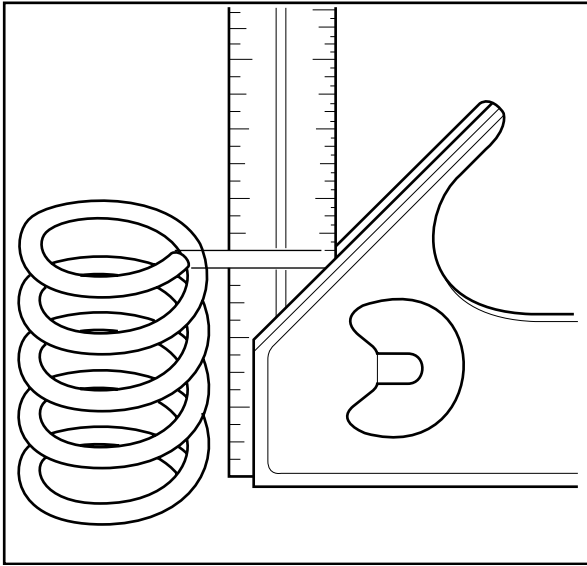


VE093-3L

5. Excessive valve stem-to-bore clearance will cause excessive oil consumption and may cause a valve to break. Insufficient clearance will result in noisy and sticky functioning of the valve and will disturb the engine assembly smoothness.
 - 5.1. Install the valve into the guide.
 - 5.2. Install the J 8520 onto the cylinder head.
 - 5.3. Locate the indicator so that the movement of the valve stem from side to side (crosswise to the cylinder head) will cause a direct movement of the indicator stem.
 - 5.4. The indicator stem must contact the side of the valve stem just above the valve guide.
 - 5.5. Drop the valve head about 1.6 mm (0.0064 in) off the valve seat.
 - 5.6. Use light pressure and move the valve stem from side to side in order to obtain a clearance reading.
 - 5.7. If the valve stem to guide clearance is excessive, the valve must be replaced and/or the guide must be repaired to obtain the proper clearances. Refer to *Engine Mechanical Specifications*.

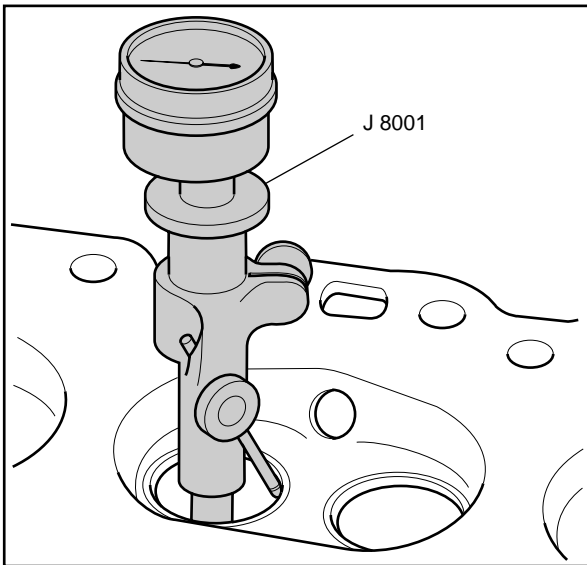


VE094-3L



VE095-3L

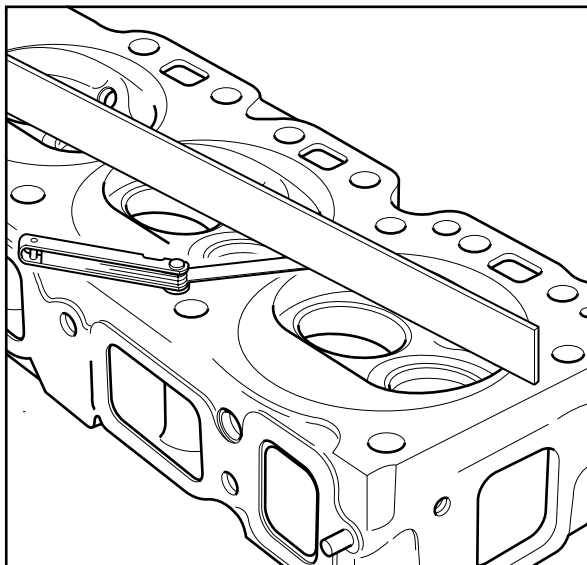
6. Inspect the valve springs for squareness.



VE096-3L

7. Measure the valve seat runout.

- Use the J 8001 in order to check the valve seat runout.
- The valve seats should be concentric to within 0.0508 mm (0.002 in).

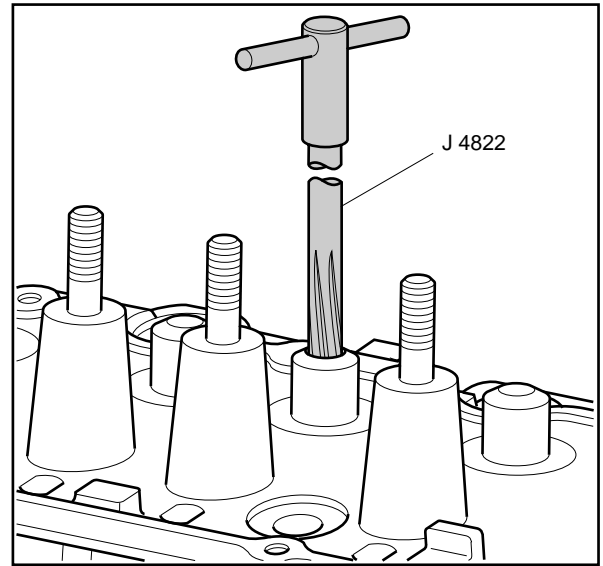


VE097-3L

8. Measure the cylinder head for warpage with a straight edge and a feeler gauge. A cylinder head with excessive warpage must be repaired or replaced. Refer to *Engine Mechanical Specifications*.

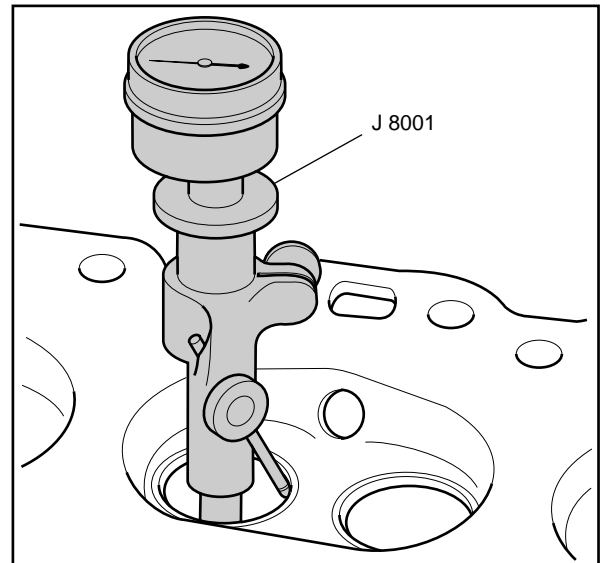
Valve Guide Reaming/Valve and Seat Grinding

1. Ream the valve guides for oversize valves if the clearance exceeds the specifications.
2. Service valves are available in the standard and 0.038 mm (0.015 in).
3. Ream the valve guide bores for the service valves as necessary.



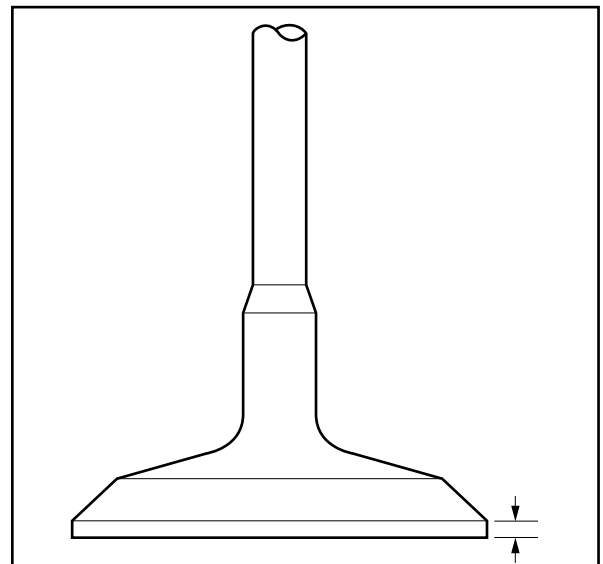
VE098-3L

4. Reconditioning the valve seats is very important.
5. Recondition the valve seat after reaming the valve guide bores or installing the new valve guides.
 - The valves must seat perfectly for the engine to deliver optimum power and performance.
 - Cooling the valve heads is another important factor. Good contact between each valve and its seat in the cylinder head is necessary to ensure that the heat in the valve head is properly carried away.
 - Regardless of what type of equipment is used, it is essential that the valve guide bores are free from carbon or dirt to ensure the proper centering of the pilot in the guide.
 - The valve seats should be concentric to within 0.0508 mm (0.002 in) total indicator reading.

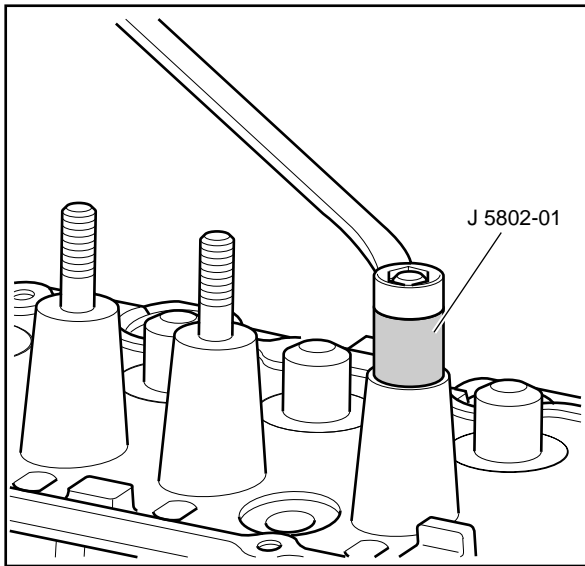


VE096-3L

6. Reface pitted valves on a valve refacing machine in order to ensure the correct relationship between the head and the stem.
 - Replace the valves that show excessive wear or are warped.
 - Replace the valve if the edge of the head is less than 0.8 mm (0.031 in) thick after grinding.
 - Several different types of equipment are available for reconditioning valves and valve seats. Use the manufacturers recommendations of equipment to obtain the proper results.



VE099-3L



VE100-3L

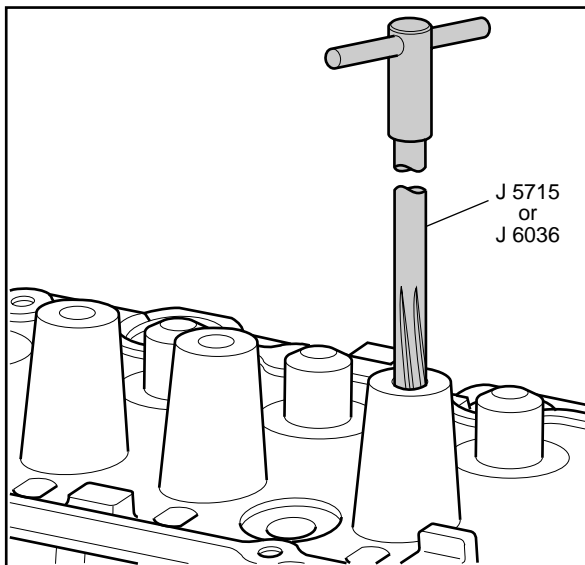
Rocker Arm Stud Removal and Installation

Tools Required

- J 5802-01 Rocker Arm Stud Remover
- J 6880 Rocker Arm Stud Installer

Rocker arm studs with damaged threads or with loose fit in cylinder head should be replaced with new, oversize studs.

1. Remove the old stud by placing J 5802-01 over the stud, installing nut and flat washer and removing the stud by turning out.

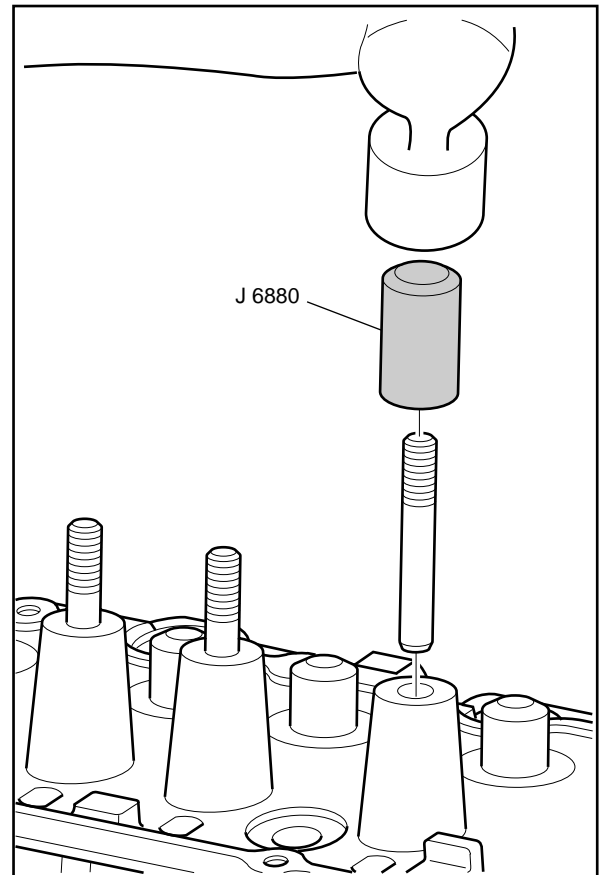


VE101-3L

2. Ream the hole for the oversize stud.

Important: Do not attempt to install an oversize stud without reaming the stud hole.

3. Coat the press-fit area of the stud with Perfect Seal.
4. Install the new stud, using J 6880 as a guide.

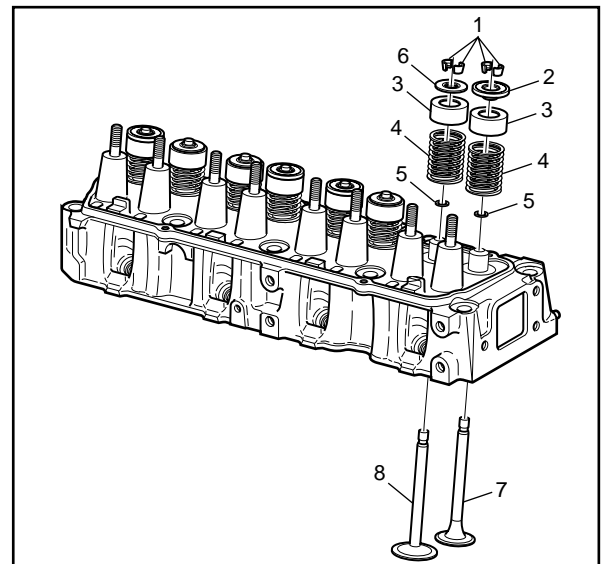


VE102-3L

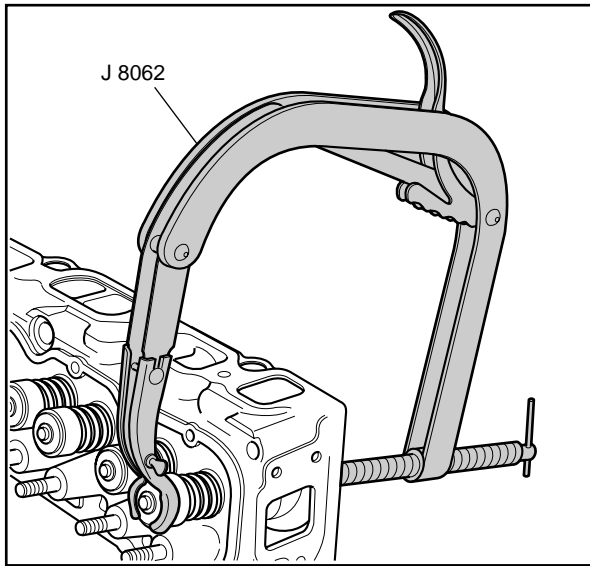
Cylinder Head Assemble

Tools Required

- J 8062 Valve Spring Compressor
1. Install the valve (7&8) into the proper port.
 2. Lubricate oil seal (5) with clean engine oil.
 3. Install the oil seal onto the valve stem.
 4. Install the valve spring (4).
 5. Install the valve stem oil shield (3).
 6. Install the cap on the valve spring (2&6).



VE090-3L



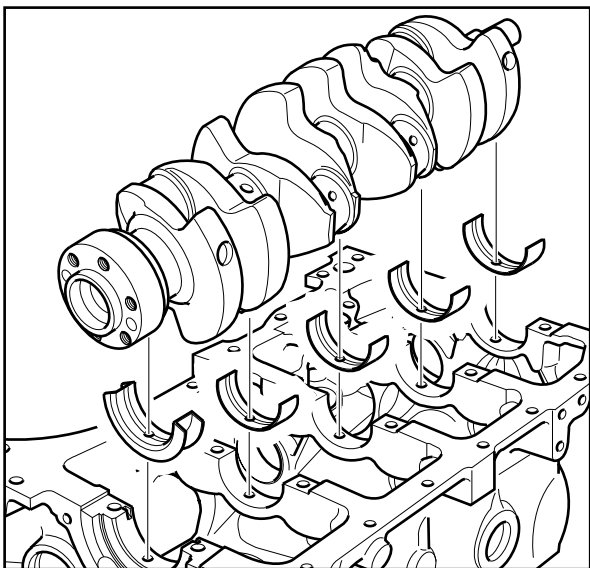
VE089-3L

Caution: Wear safety glasses in order to avoid eye damage.

7. Use the J 8062 in order to compress the valve spring.
8. Install the valve stem keys.
 - 8.1. Use grease to hold the keys in place while disconnecting the J 8062.
 - 8.2. Make sure that the keys seat properly in the upper groove of the valve stem.
 - 8.3. Tap the end of the valve stem with a plastic-faced hammer in order to seat the keys if necessary.

Service Prior to Assembly

- Dirt or debris will cause premature wear of the rebuilt engine. Clean all components. Refer to *Cleanliness and Care*.
- Use the proper tools to measure components when checking for excessive wear. Components that are not within the manufacturers specifications must be repaired or replaced.
- When components are reinstalled into an engine, return the components to their original location, position and direction. Refer to *Separating Parts*.
- During assembly, lubricate all moving parts with clean engine oil or engine assembly lubricant (unless otherwise specified). This will provide initial lubrication when the engine is first started. Refer to *Sealers, Adhesives and Lubricants*.



VE046-3L

Crankshaft, Bearings and Bearing Cap Installation

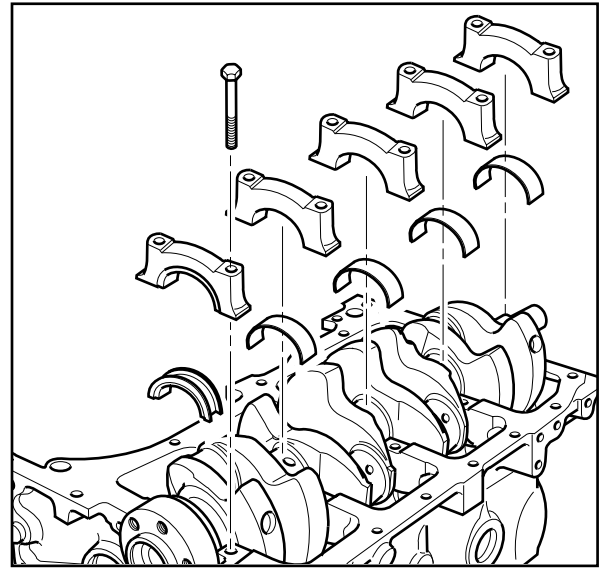
Important

- Crankshaft bearing caps must be installed to the proper location and direction.
 - When installing the crankshaft bearings, align the locating tabs on the bearings with the locating notches in the engine block journal bore and the bearing cap.
 - Always install crankshaft bearings with their machined partner. Do not file bearings or mix bearing halves.
1. Install the crankshaft bearings into the engine block and the crankshaft bearing caps.
 2. Coat the crankshaft bearings with clean engine oil.
 3. Install the crankshaft.

4. Install the crankshaft bearing caps with the crankshaft bearings.
5. Be sure that the cap directional arrows point toward the front of the engine block and the cap is in its original position.
6. Install the crankshaft bearing cap bolts.
7. Thrust the crankshaft rearward in order to set and align the thrust bearings and the bearing caps.
8. Thrust the crankshaft forward in order to align the rear faces of the rear crankshaft bearings.

Tighten

Tighten all of the bolts to 88 N•m (65 lb ft).



VE045-3L

Crankshaft Rear Oil Seal and Housing Installation

Tools Required

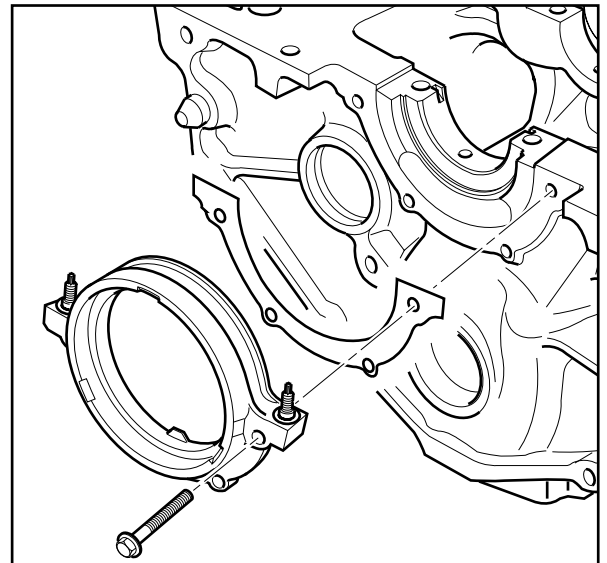
- J 35621 Crankshaft Rear Oil Seal Installer

Important: Always use a new crankshaft rear oil seal and new crankshaft rear oil seal housing gasket when you install the crankshaft rear oil seal housing.

1. Install the new gasket and the crankshaft rear oil seal housing on to the studs.
2. Install the rear oil seal housing nuts and bolts.

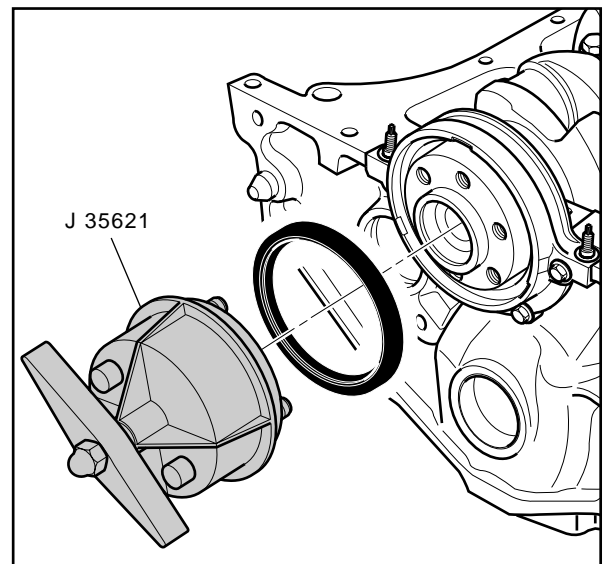
Tighten

Tighten the crankshaft rear oil seal housing nuts and bolts to 15 N•m (135 lb in).

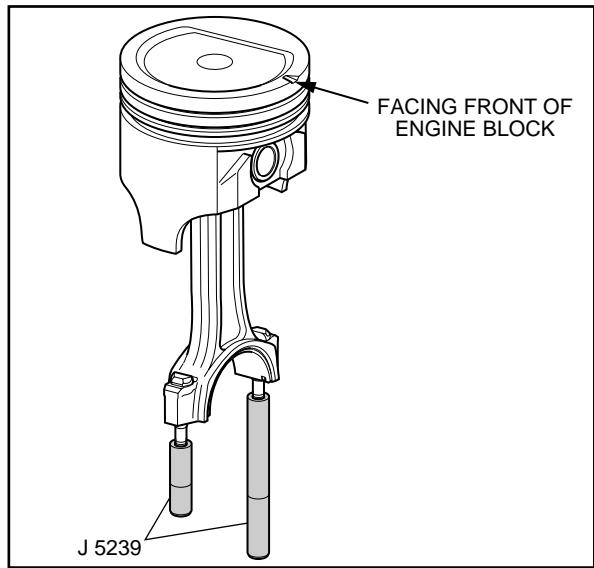


VE103-3L

3. Coat the new oil seal entirely with clean engine oil.
4. Install the seal onto the J 35621.
5. Install the J 35621 onto the rear of the crankshaft. Tighten the screws snugly in order to ensure that the seal will be installed squarely over the crankshaft.
6. Install the crankshaft rear oil seal onto the crankshaft and into the crankshaft rear oil seal housing. Tighten the wing nut on the J 35621 until the oil seal bottoms.
7. Remove the J 35621 from the crankshaft rear oil seal housing.



VE104-3L



VE124-3L

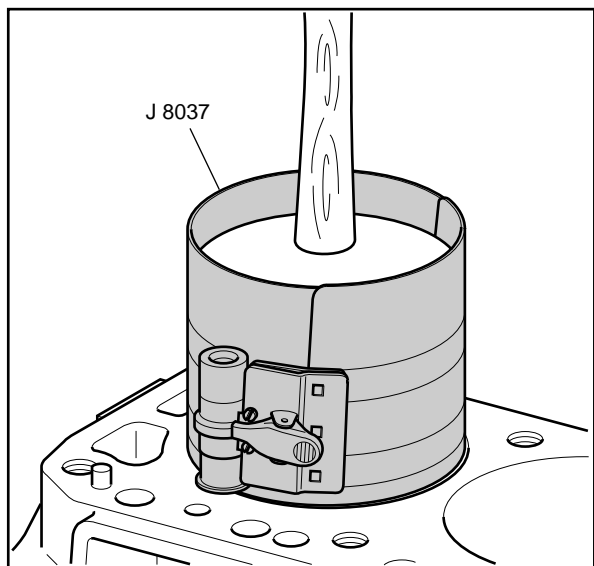
Piston, Connecting Rod and Bearing Installation

Tools Required

- J 5239 Guide Set
- J 8037 Piston Ring Compressor

Important

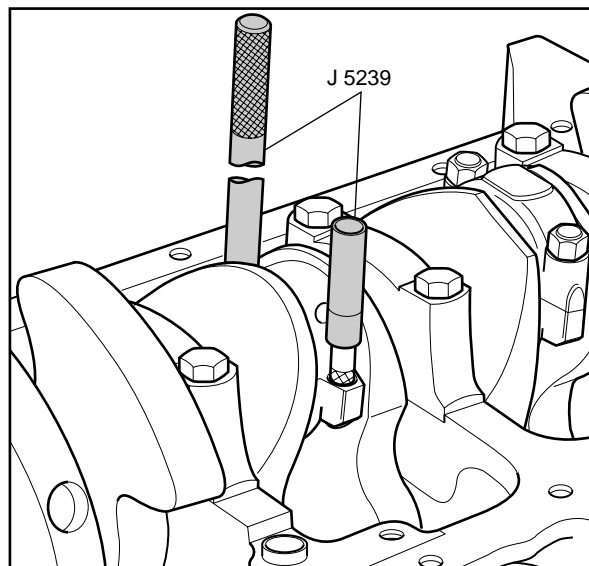
- The piston and cylinder bore have been measured and the bore has been sized for the proper clearance. Install the piston and connecting rod assembly into the proper cylinder bore.
 - The piston alignment mark **MUST** face the front of the engine block.
1. Lubricate the following components with clean engine oil:
 - The piston.
 - The piston rings.
 - The cylinder bore.
 - The bearing surfaces.
 2. Install the connecting rod bearing into the connecting rod and bearing cap.
 3. Install the J 5239 onto the connecting rod.
 4. Install the J 8037 or equivalent onto the piston and compress the piston rings.



VE105-3L

5. Install the piston assembly into its matched bore with the stamped arrow facing forward.
6. Use the J 8037 and the J 5239 and lightly tap the top of the piston with a wooden hammer handle.
 - Hold the J 8037 firmly against the engine block until all of the piston rings enter the cylinder bore.
 - Use the J 5239 in order to guide the connecting rod onto the crankshaft journal.

7. Remove the J 5239.

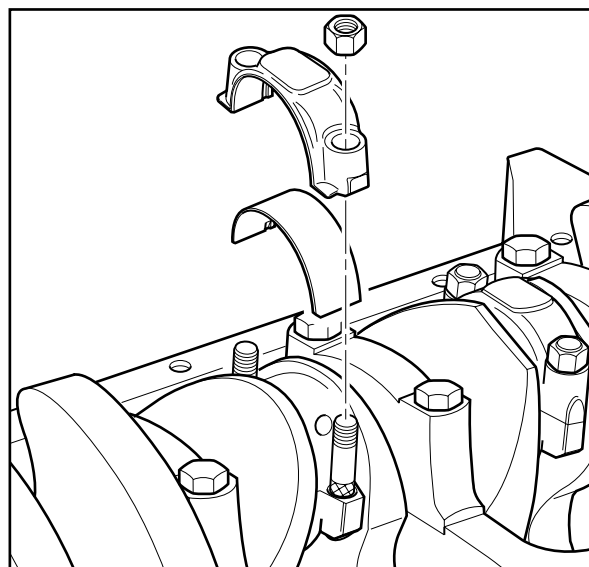


VE038-3L

8. Install the connecting rod cap and nuts.

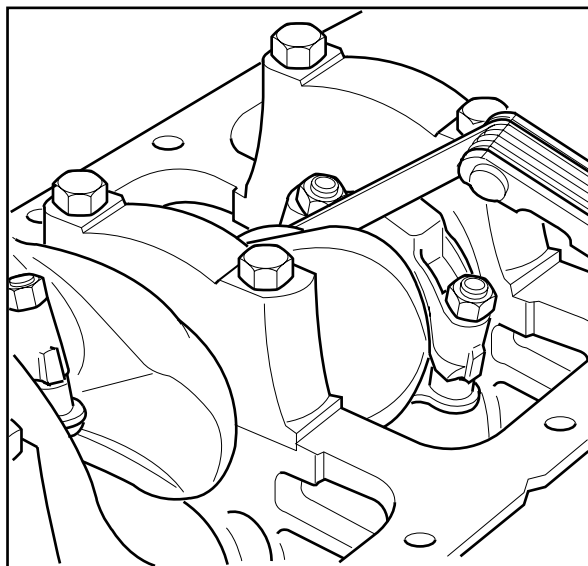
Tighten

Tighten the nuts evenly to 61 N•m (45 lb ft).

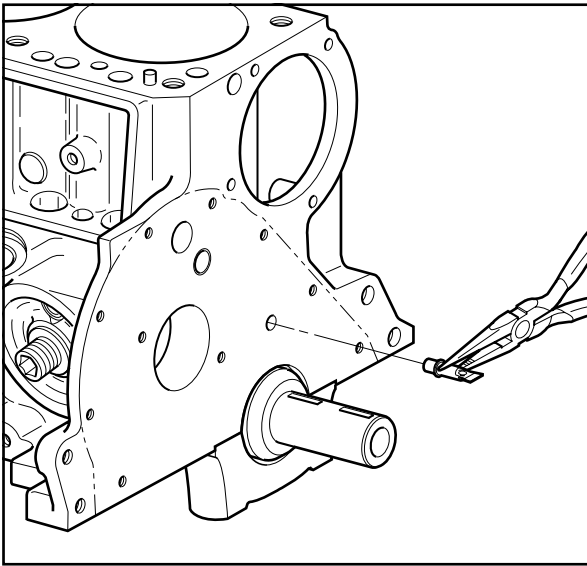


VE037-3L

8. When all of the connecting rod bearings are installed, tap each connecting rod assembly lightly parallel to the crankpin in order to make sure that they have clearance.
9. Use a feeler gauge or a dial indicator in order to measure the side clearance between the connecting rod caps. Refer to *Engine Mechanical Specifications*.



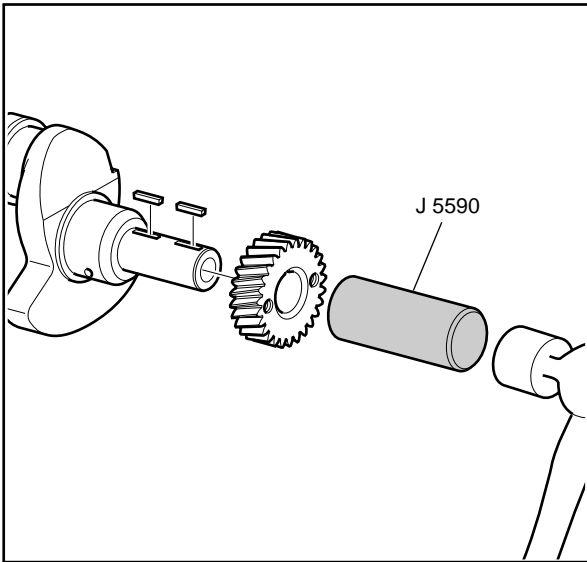
VE106-3L



VE127-3L

Timing Gear Oil Nozzle Installation

1. Drive the new nozzle in place (oil hole facing up) with a suitable light plastic or rubber hammer.

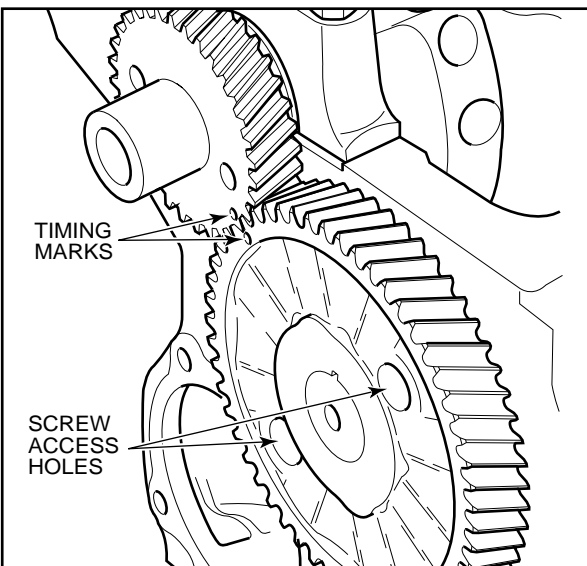


VE107-3L

Crankshaft Sprocket Installation

Tools Required

- J 5590 Crankshaft Sprocket Installer
1. Install the keys into the crankshaft keyways.
 2. Use the J 5590 in order to install the crankshaft sprocket.



VE108-3L

Camshaft Installation

Important: If camshaft replacement is required, the valve lifters must also be replaced.

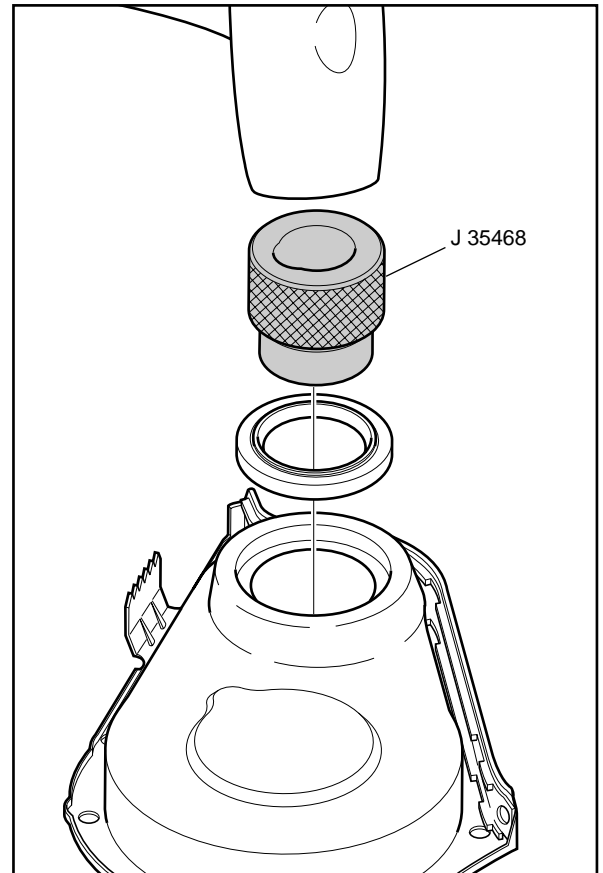
1. Carefully rotate and install the camshaft into the engine.
2. Install the two camshaft retainer bolts working through the holes in the camshaft sprocket. Be sure to align the camshaft and the crankshaft sprocket alignment marks.

Tighten

Tighten the camshaft retainer bolts to 9 N•m (80 lb in).

Engine Front Cover and Oil Seal Installation**Tools Required**

- J 35468 Engine Front Cover Aligner and Oil Seal Installer
1. Use the J 35468 in order to install the engine front cover oil seal.

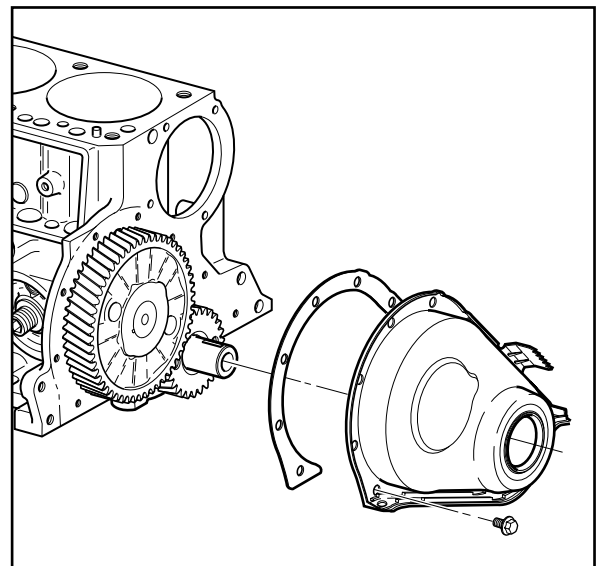


VE109-3L

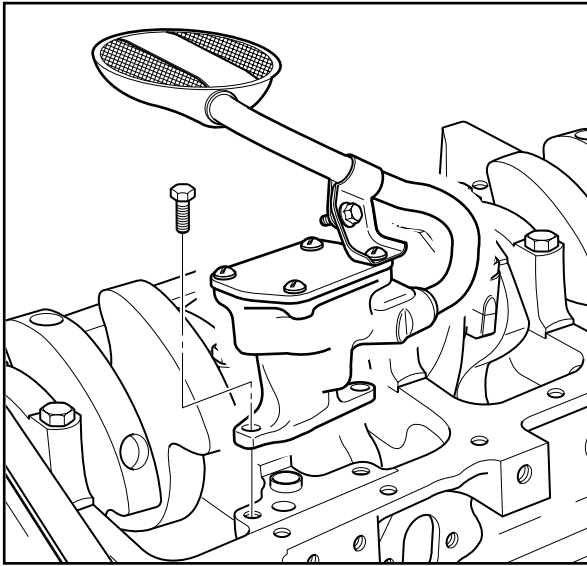
2. Install the engine front cover gasket.
3. Install the engine front cover and bolts.

Tighten

Tighten engine front cover bolts to 3.4 N•m (30 lb in).



VE030-3L



VE110-3L

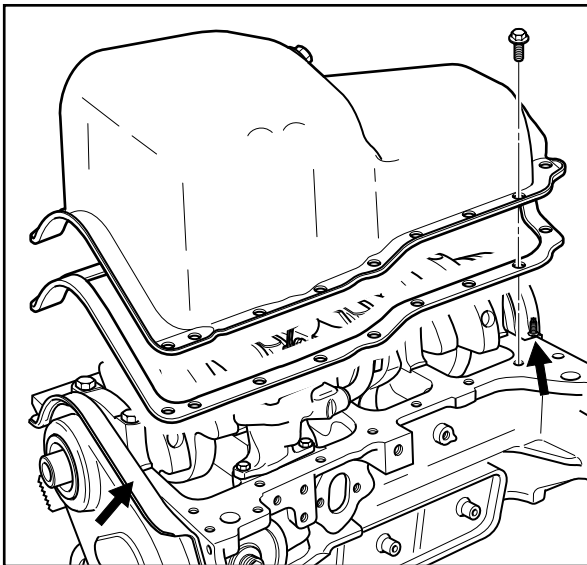
Oil Pump Installation

Important: Inspect the oil pump and engine block oil galley passages. These surfaces must be clear and free of debris or restrictions.

1. Install the oil pump.
2. Install the bolts that attach the oil pump to the engine block.

Tighten

Tighten the oil pump bolts to 14 N•m (120 lb in).



VE111-3L

Oil Pan Installation

Important: Apply the sealer 25 mm (1.0 in) in either direction of the radius cavity of the junctions.

1. Apply a small amount of sealer, GM P/N 1052914 or equivalent, 10 mm (0.393 in) wide and 20 mm (0.787 in) long at the engine front cover to engine block junction.
2. Apply a small amount of sealer, GM P/N 1052914 or equivalent, 25 mm (1.0 in) long at the crankshaft rear oil seal housing to engine block junction.
3. Install the new oil pan gasket.
4. Install the oil pan.
5. Install the nuts and bolts to the oil pan.

Tighten

Tighten the rear oil pan nuts to 18.6 N•m (165 lb in).

Tighten the oil pan bolts to the crankcase to 9 N•m (80 lb in).

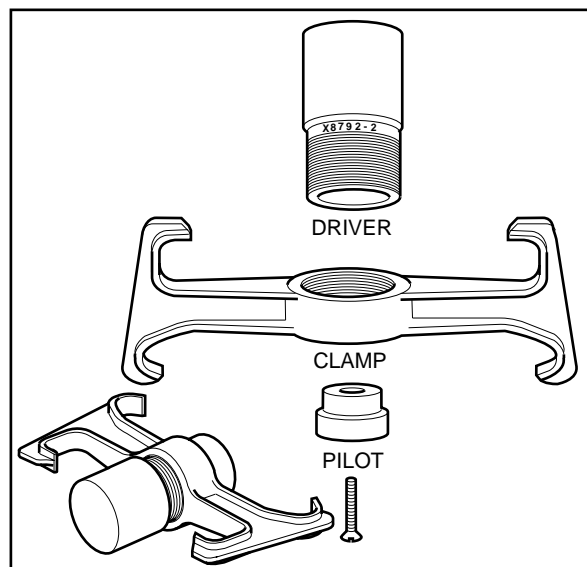
Tighten the oil pan bolts to the front cover to 5 N•m (45 lb in).

Tighten the oil pan studs to the oil seal retainer to 1.7 N•m (15 lb in).

Crankshaft Pulley Installation

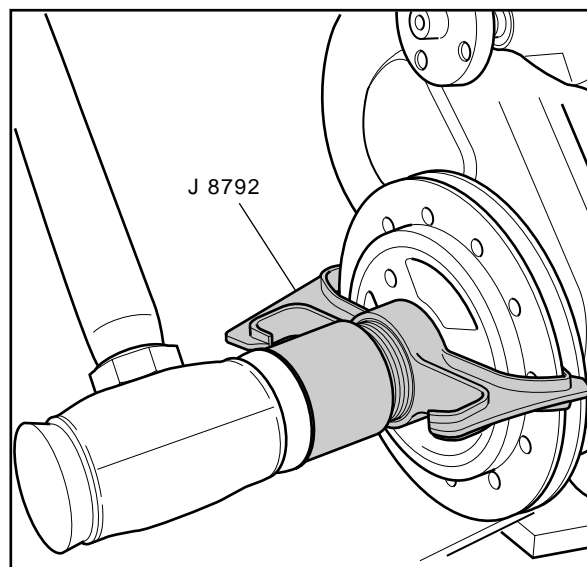
Tools Required

- J 8792 Crankshaft Pulley Installer
1. Coat the front cover oil seal contact area of the crankshaft pulley with clean engine oil.
 2. Assemble the J 8792 as shown.



VE112-3L

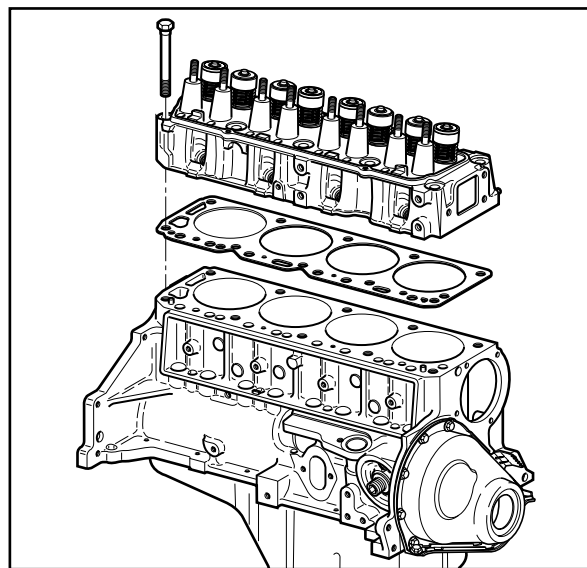
3. Install the J 8792 onto the crankshaft pulley.
4. Position the pulley on the crankshaft and drive into position until it bottoms against the crankshaft sprocket.



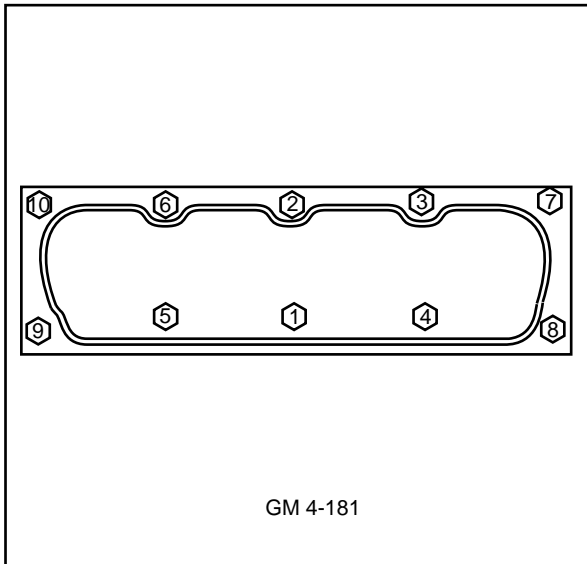
VE113-3L

Cylinder Head Installation

1. Install the new cylinder head gasket over the locating pins.
2. Install the cylinder head over the locating pins and the gasket.



VE114-3L

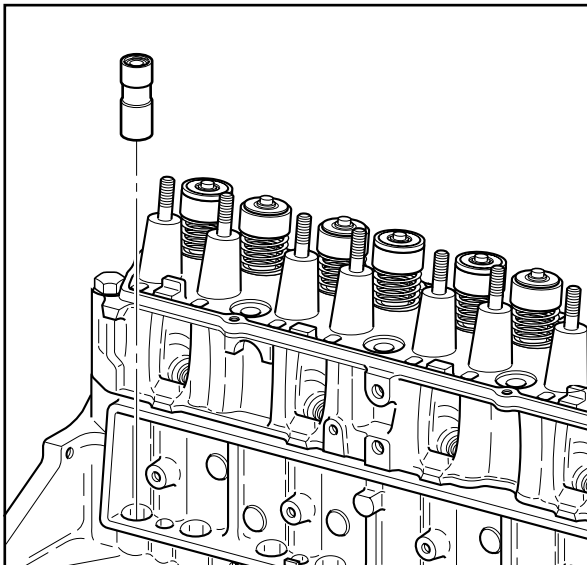


VE115-3L

3. Install the cylinder head bolts finger tight.

Tighten

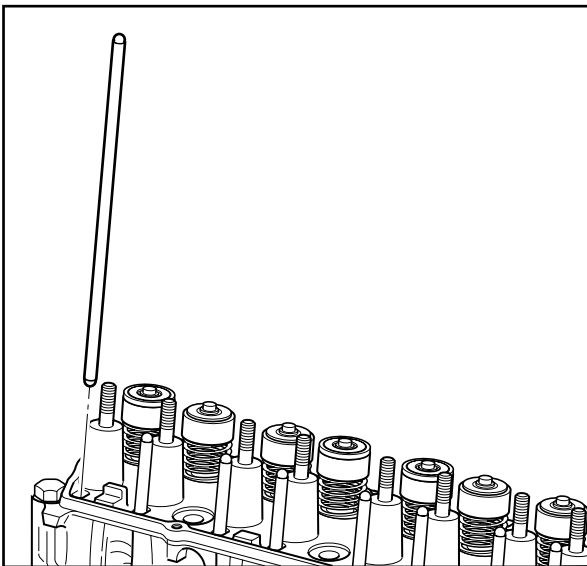
Tighten the cylinder head bolts in sequence to 122 N•m (90 lb ft).



VE116-3L

Valve Lifter Installation

1. Coat the bottom of the valve lifters with prelube, GM P/N 1052365 or equivalent.
2. If reusing the valve lifters, install in their original location.
3. Install the valve lifters.



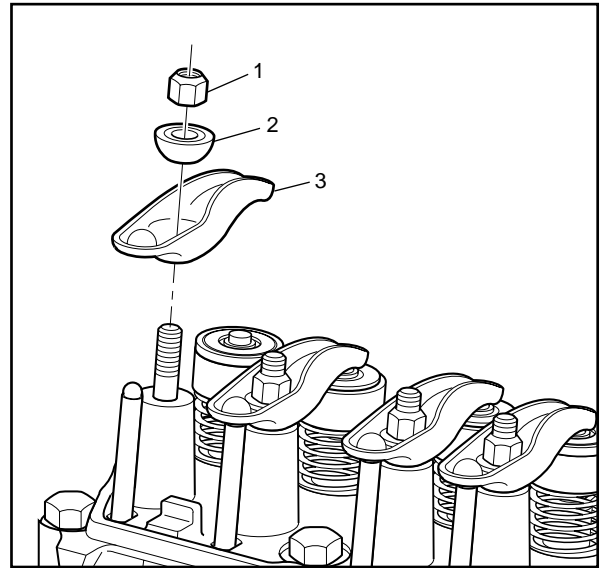
VE023-3L

Valve Rocker Arm and Pushrod Installation

Important: Be sure to keep parts in order. Parts must be installed from where they were removed.

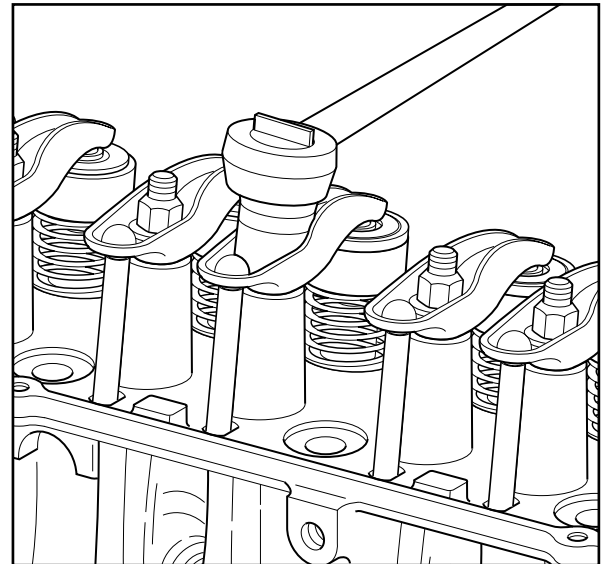
1. Install the valve pushrods. Be sure that the valve pushrods seat in the valve lifter sockets.

2. Install the following components:
 - 2.1. The valve rocker arms (3).
 - 2.2. The valve rocker arm balls (2).
 - 2.3. The valve rocker arm nuts (1).

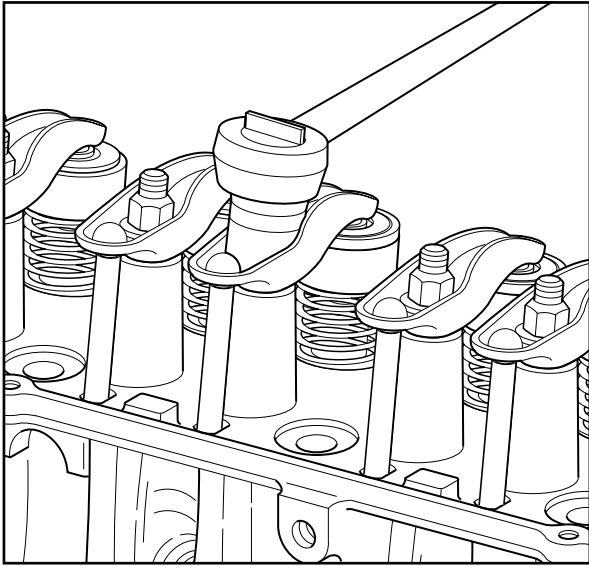


VE021-3L

3. Adjust the valve rocker arm nuts as follows:
 - 3.1. Turn the crankshaft until the mark on the crankshaft pulley lines up with "0" on the timing tab and number 1 cylinder is at top dead center.
 - 3.2. Place fingers on the number 1 valves as the mark approaches "0." If the valves move as the mark approaches "0," the engine is on number 4 top dead center and should be rotated one more revolution in order to reach number 1 top dead center.
 - 3.3. With the engine at number 1 top dead center, adjust the following valves:
 - The exhaust valves 1,3
 - The intake valves 1,2,4
 - 3.4. Adjust the correct valves as follows:
 - 3.4.1. Back off the valve rocker arm nut until the lash is felt in the valve pushrod.
 - 3.4.2. Tighten the valve rocker arm nut until all the lash is removed.
 - 3.4.3. Zero lash can be felt by moving the valve pushrod up and down between your thumb and forefinger until there is no more movement.
 - 3.4.4. When all the free play is gone, tighten the valve rocker arm nut 1 additional turn (360 degrees).

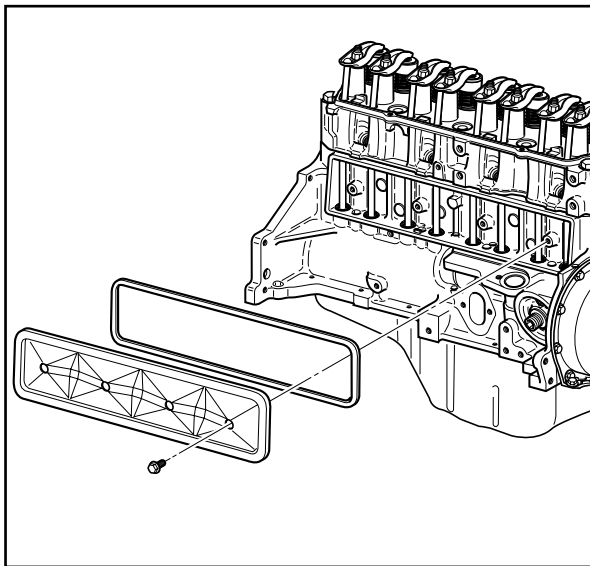


VE117-3L



VE117-3L

- 3.5. Turn the crankshaft 1 revolution until the mark on the crankshaft pulley lines up with "0" on the timing tab. This is number 4 top dead center.
- 3.6. With the engine at number 4 top dead center, adjust the following valves:
 - The exhaust valves 2,4
 - The intake valves 3
- 3.6.1. Back off the valve rocker arm nut until the lash is felt in the valve pushrod.
- 3.6.2. Tighten the valve rocker arm nut until all the lash is removed.
- 3.6.3. Zero lash can be felt by moving the valve pushrod up and down between your thumb and forefinger until there is no more movement.
- 3.6.4. When all the free play is gone, tighten the valve rocker arm nut 1 additional turn (360 degrees).



VE118-3L

Pushrod Cover Installation

1. Install the pushrod cover gasket.
2. Install the pushrod cover.
3. Install the pushrod cover bolts.

Tighten

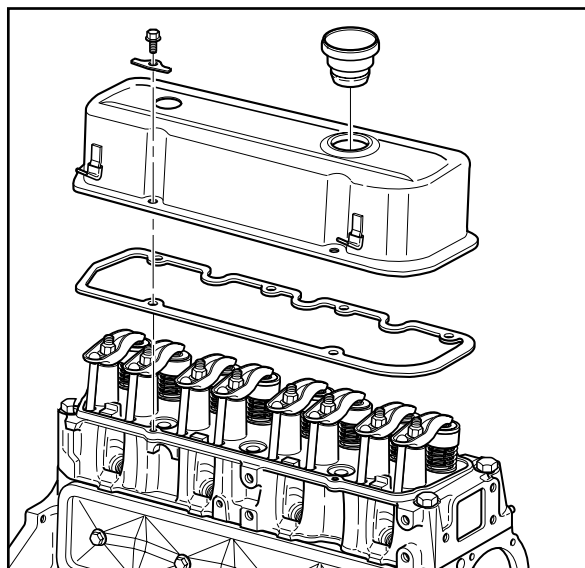
Tighten the pushrod bolts to 4.5 N•m (40 lb in).

Valve Rocker Arm Cover Installation

1. Install the valve rocker arm cover gasket.
2. Install the valve rocker arm cover.
3. Install the valve rocker arm bolts.

Tighten

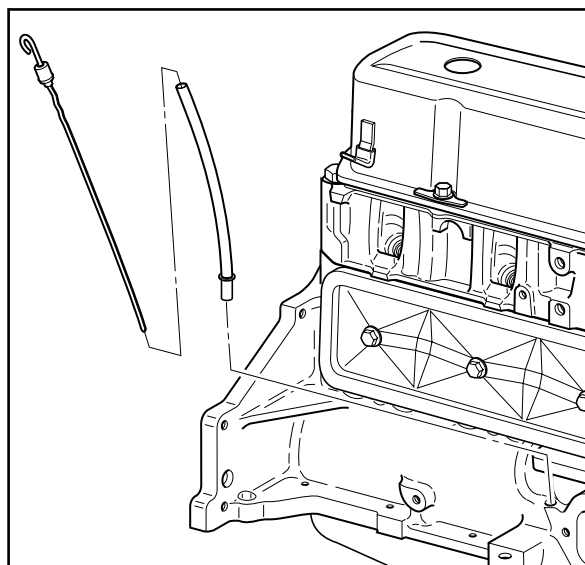
Tighten the valve rocker arm cover bolts to 4.5 N•m (40 lb in).



VE119-3L

Oil Level Indicator and Tube Installation

1. Install the oil level indicator tube into the engine block.
2. Use a light plastic or rubber hammer in order to tap the tube until it seats in the engine block.
3. Install the oil level indicator into the tube.



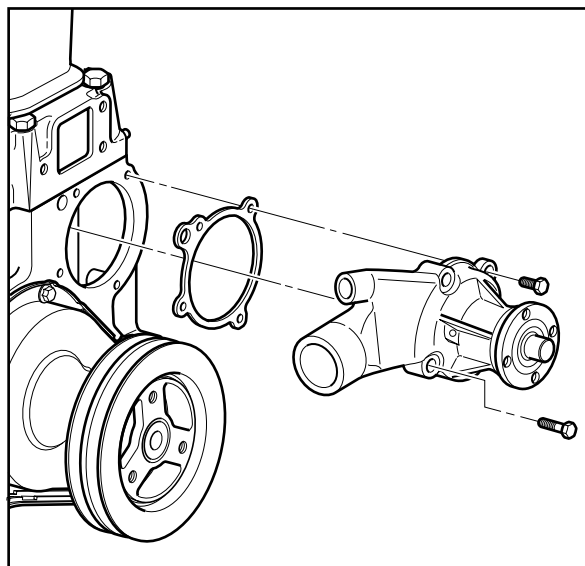
VE120-3L

Water Pump Installation

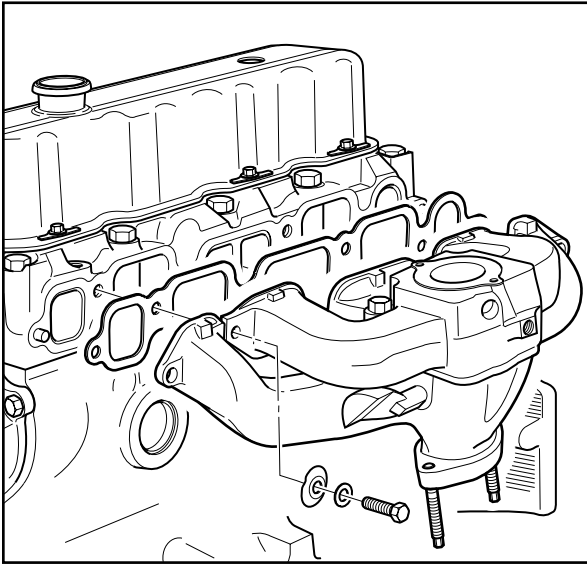
1. Position the water pump and gasket to the engine block.
2. Install the water pump bolts.

Tighten

Tighten the water pump bolts to 20 N•m (15 lb ft).



VE017-3L



VE014-3L

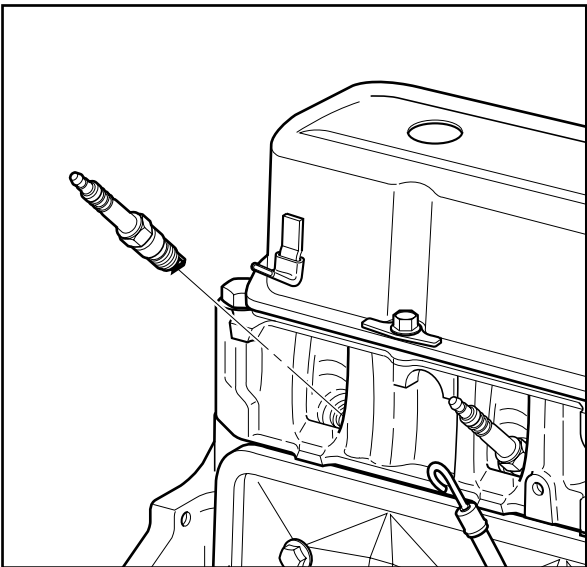
Intake/Exhaust Manifold Installation

1. Install the intake/exhaust manifold gasket over the locating pins on the cylinder head.
2. Install the bolts and clamps while holding the manifold in place.

Tighten

Tighten the two center bolts to 27-34 N•m (20-25 lb ft).

Tighten the end bolts to 20-27 N•m (15-20 lb ft).



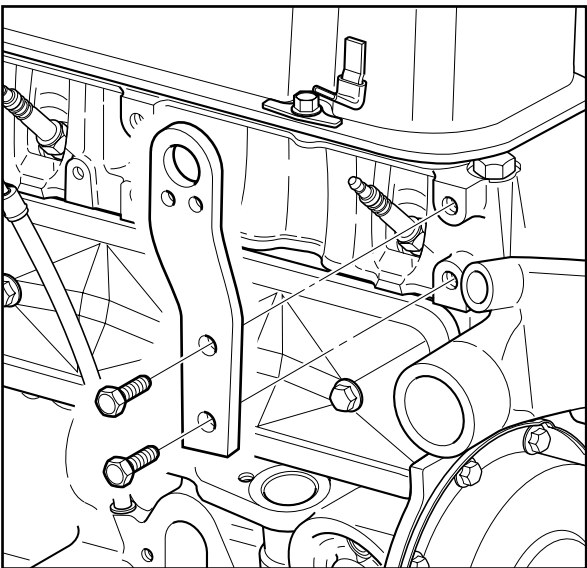
VE013-3L

Spark Plug Installation

1. Install the spark plugs.

Tighten

Tighten the spark plugs to 30 N•m (22 lb ft).



VE012-3L

Lift Bracket Installation

1. Install the lift bracket.
2. Install the lift bracket bolts.

Tighten

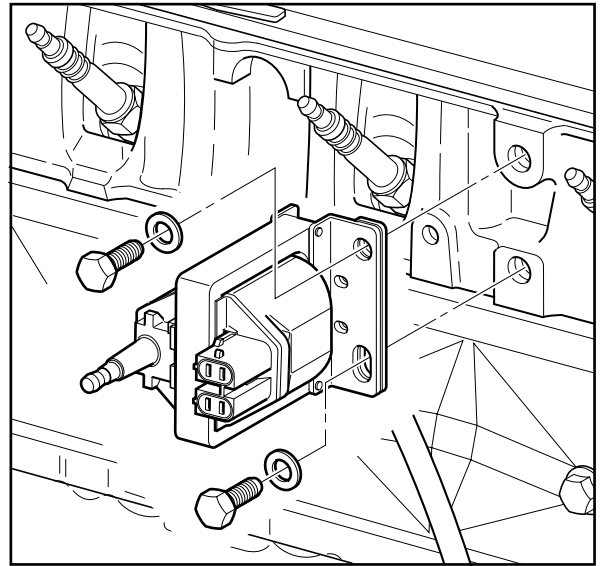
Tighten the lift bracket bolts to 54 N•m (40 lb ft).

Ignition Coil Installation

1. Install the ignition coil.
2. Install the ignition coil bracket attaching bolts.

Tighten

Tighten the attaching bolts to 22 N•m (16 lb ft).



VE011-3L

Distributor Installation

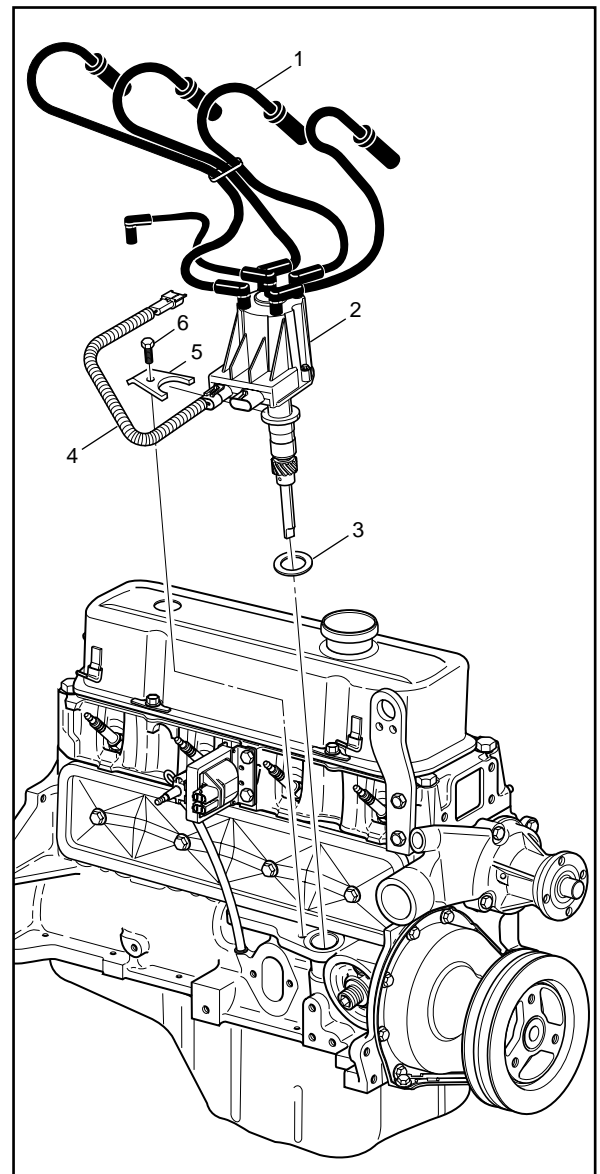
Important: To ensure correct ignition timing, the distributor must be installed in the correct position. Position the engine at top dead center on number one cylinder. The distributor cap must be removed in order to position the rotor when installing the distributor.

1. Install the distributor (2) and new gasket (3), making sure the distributor rotor is pointing to number one tower on the distributor cap.
2. Install the distributor hold down (5) and bolt (6).

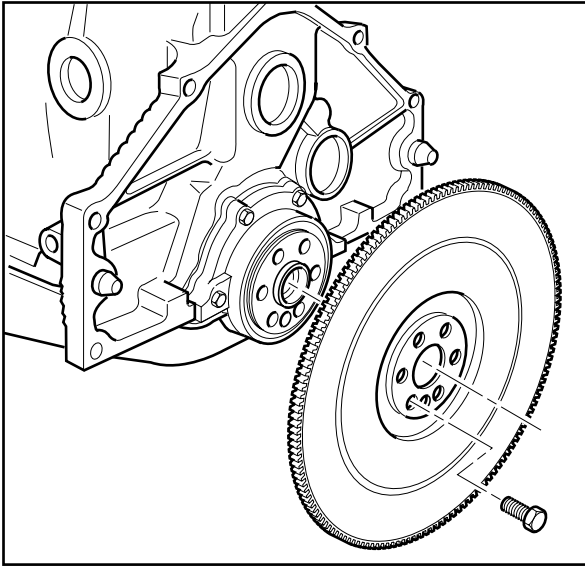
Tighten

Tighten the hold down bolt to 27 N•m (20 lb ft).

3. Connect the primary ignition harness (4) to the ignition coil.
4. Connect the secondary ignition wires (1) to the spark plugs and the ignition coil.



VE010-3L



VE009-3L

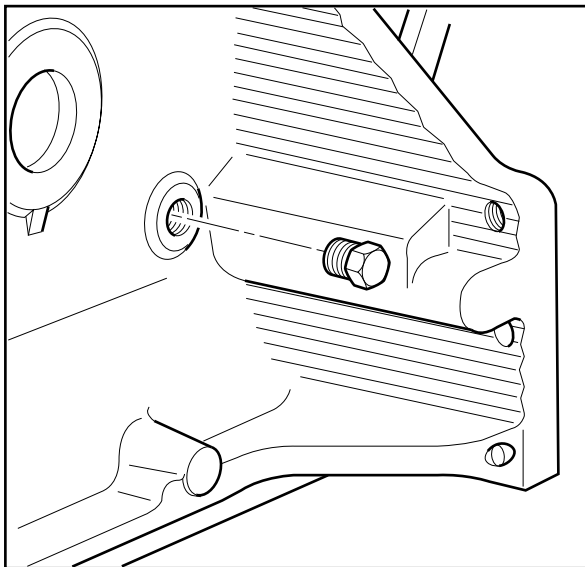
Engine Flywheel Installation

Important: Note the position and direction of the engine flywheel before removal. The flywheel center alignment hole is a tapered fit to the crankshaft. The engine flywheel must be reinstalled to the original position and direction. The engine flywheel will not initially seat against the crankshaft flange, but will be pulled onto the crankshaft by the engine flywheel bolts.

1. Install the engine flywheel.
2. Install the engine flywheel bolts.

Tighten

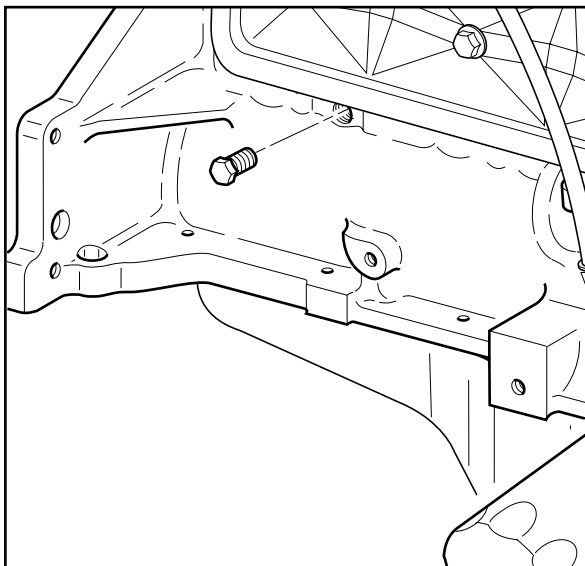
Tighten the flywheel bolts to 88 N•m (65 lb ft).



VE008-3L

Engine Block Coolant Plug/Oil Filter Installation

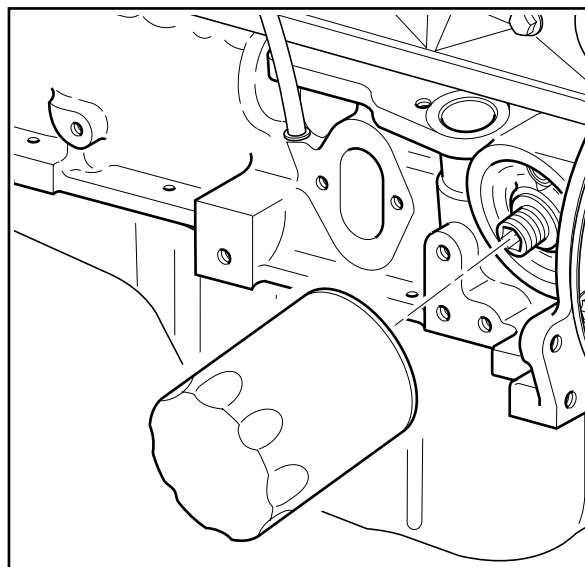
1. Install the left rear engine block coolant plug.



VE007-3L

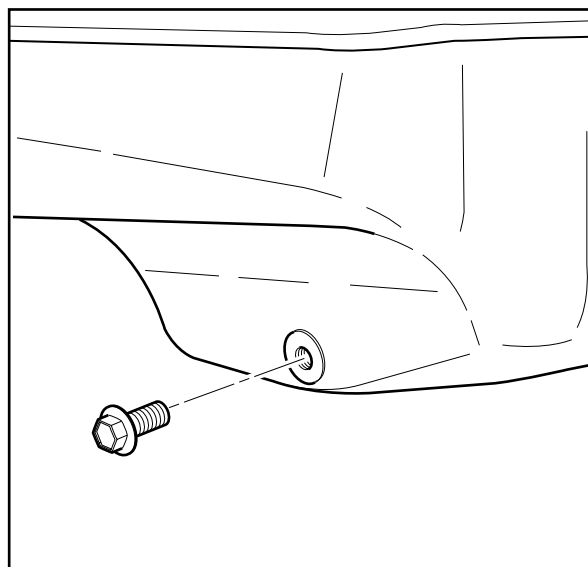
2. Install the right rear engine block coolant plug.

3. Install the oil filter.



VE006-3L

4. Install the oil pan drain plug.



VE005-3L

Description and Operation

Engine Component Description

Engine Block

The engine block has four cylinders arranged in an "in-line" construction. Starting at the front of the engine, the cylinders are numbered 1-2-3-4. The firing order of the cylinders is 1-3-4-2. The cylinders are encircled by coolant jackets.

Cylinder Head

The cylinder head has one intake and one exhaust valve per cylinder. A spark plug is located between the valves in the side of the cylinder head. The valve guides are integral and the valve rocker arms are retained on individual threaded studs.

Crankshaft

The crankshaft is cast nodular iron and is supported by five crankshaft bearings. The bearings are retained by crankshaft bearing caps that are machined with the engine block for proper alignment and clearances.

Camshaft

A billet steel one piece camshaft is supported by four full round, sleeve-type bearings. These bearings are a press fit into the engine block. The camshaft timing sprocket is mounted to the front of the camshaft and is driven the crankshaft sprocket.

Pistons and Connecting Rods

The pistons are made of cast-aluminum alloy using two compression rings and one oil control ring assembly. The piston pins are a press fit in the connecting rods and a floating fit in the pistons.

Valve Train

The valve train is a ball-pivot type. Motion is transmitted from the crankshaft through the valve lifter and valve pushrod to the valve rocker arm. The valve rocker arm pivots on its ball and transmits the camshaft motion to the valve. The valve lifters keep all parts of the valve train in constant contact. Each lifter acts as an automatic adjuster and maintains zero lash in the valve train. This eliminates the need for periodic valve adjustment.

Lubrication

The oil pump is gear driven from the camshaft. Oil is drawn from the oil pan through a pickup screen and tube. The gear type oil pump has a pressure regulator valve which controls the lubrication system pressure by bypassing excess oil back to the oil pan sump.

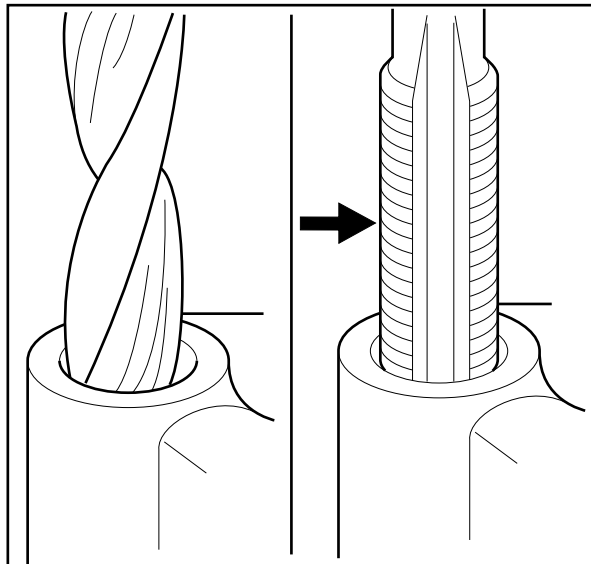
Pressurized oil from the oil pump flows to the full flow filter. A bypass valve allows oil to bypass the filter if it becomes clogged or restricted. Oil then flows into an oil passage that runs along the right side of the block and intersects the lifter bosses. Oil from this passage is routed to the crankshaft main bearings and camshaft bearings through smaller drilled passages. Oil is supplied to the connecting rod bearings by holes drilled in the crankshaft. Oil is supplied to the rocker arms through holes in the hydraulic lifters which feed oil up the pushrods to the rocker arms. The oil is metered by discs under the pushrod seat.

Many internal engine parts have no direct oil feed and are supplied by either gravity or splash from other direct feed components. Timing gears are lubricated by oil supplied through a passage from the front of the camshaft to a calibrated nozzle above the crankshaft gear.

Thread Repair

Tools Required

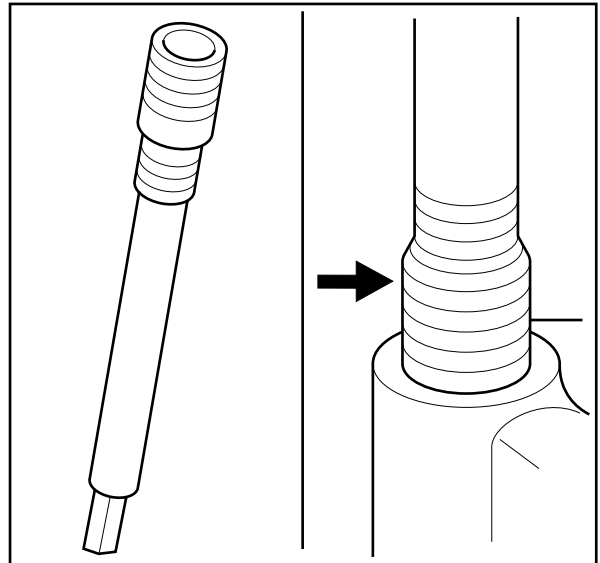
General purpose thread repair kits. These kits are available commercially



VE121-3L

Caution: Wear safety glasses in order to avoid eye damage.

1. Determine the size, pitch and depth of the damaged thread. If necessary, adjust the stop collars on the cutting tool and tap to the required depth.
2. Drill out the damaged thread. Clean out any chips.
3. Avoid any buildup of chips. Back out the tap every few turns and remove the chips.
4. Tap the hole. Lubricate the tap with light engine oil. Clean the thread.



VE122-3L

5. Thread the insert onto the mandrel of the installer. Engage the tang of the insert onto the end of the mandrel.

Important: The insert should be flush to one turn below the surface.

6. Lubricate the insert with light engine oil (except when installing in aluminum) and install the insert.
7. If the tang of the insert does not break off when backing out the installer, break the tang off with a drift.

Cleanliness and Care

- Throughout this section, it should be understood that proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure. This is considered standard shop practice even if not specifically stated.
- When any internal engine parts are serviced, care and cleanliness is important.
- When components are removed for service, they should be marked, organized or retained in a specific order for reassembly. Refer to *Separating Parts*.
- At the time of installation, components should be installed in the same location and with the same mating surface as when removed.
- An engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in millimeters or thousandths of an inch. These surfaces should be covered or protected to avoid component damage.
- A liberal coating of clean engine oil should be applied to friction areas during assembly.
- Proper lubrication will protect and lubricate friction surfaces during initial operation.

Replacing Engine Gaskets

1. Gasket reuse and applying sealants:
 - Do not reuse any gasket unless specified.
 - Gaskets that can be reused will be identified in the service procedure.
 - Do not apply sealant to any gasket or sealing surface unless specified in the service procedure.
2. Separating components:
 - Use a rubber mallet to separate components.
 - Bump the part sideways to loosen the components.
 - Bumping should be done at bends or reinforced areas to prevent distortion of the parts.
3. Cleaning gasket surfaces:
 - Remove all gasket and sealing material from the part using a plastic or wood scraper (if required).
 - Care must be taken to avoid gouging or scraping the aluminum sealing surfaces.
 - Do not use any other method or technique to remove sealant or gasket material from a part.
 - Do not use abrasive pads, sand paper or power tools to clean gasket surfaces.
 - These methods of cleaning can cause damage to the component sealing surfaces.

- Abrasive pads also produce a fine grit that the oil filter cannot remove from the oil.
- This grit is abrasive and has been known to cause internal engine damage.

4. Assembling components:

- When assembling components, use only the sealant specified or equivalent in the service procedure.
- Sealing surfaces should be clean and free of debris or oil.
- Specific components such as crankshaft oil seals or valve stem oil seals may require lubrication during assembly.
- Components requiring lubrication will be identified in the service procedure.
- When applying sealant to a component, apply the amount specified in the service procedure.
- Do not allow the sealant to enter into any blind threaded holes, as it may prevent the bolt from clamping properly or cause component damage when tightened.
- Tighten bolts to specifications. Do not overtighten.

Use of RTV and Anaerobic Sealer

Important: Three types of sealer are commonly used in engines. These are RTV sealer, anaerobic gasket eliminator sealer and pipe joint compound. The correct sealer and amount must be used in the proper location to prevent oil leaks. DO NOT interchange the three types of sealers. Use only the specific sealer or the equivalent as recommended in the service procedure.

Pipe Joint Compound

- Pipe joint compound is a pliable sealer that does not completely harden. This type sealer is used where two nonrigid parts (such as the oil pan and the engine block) are assembled together.
- Do not use pipe joint compound in areas where extreme temperatures are expected. These areas include: exhaust manifolds, head gasket or other surfaces where gasket eliminator is specified.
- Follow all safety recommendations and directions that are on the container.
- To remove the sealant or the gasket material, Refer to *Replacing Engine Gaskets*.
- Apply a continuous bead of pipe joint compound to one sealing surface. Sealing surfaces to be resealed must be clean and dry.
- Tighten the bolts to specifications. Do not overtighten.

RTV Sealer

- Room Temperature Vulcanizing (RTV) sealant hardens when exposed to air. This type sealer is used where two nonrigid parts (such as the oil pan and the engine block) are assembled together.
- Do not use RTV sealant in areas where extreme temperatures are expected. These areas include: exhaust manifolds, head gasket or other surfaces where gasket eliminator is specified.
- Follow all safety recommendations and directions that are on the container.
- To remove the sealant or the gasket material, Refer to *Replacing Engine Gaskets*.
- Apply RTV to a clean surface. Use a bead size as specified in the service procedure. Run the bead to the inside of any bolt holes. Do not allow the sealer to enter any blind threaded holes, as it may prevent the bolt from clamping properly or cause damage when the bolt is tightened.
- Assemble components while RTV is still wet (within three minutes). Do not wait for RTV to skin over.
- Tighten the bolts to specifications. Do not overtighten.

Anaerobic Sealer

- Anaerobic gasket eliminator hardens in the absence of air. This type sealer is used where two rigid parts (such as castings) are assembled and no sealer or gasket is readily noticeable, the parts were probably assembled using a gasket eliminator.
- Follow all safety recommendations and directions that are on the container.
- To remove the sealant or the gasket material, Refer to *Replacing Engine Gaskets*.
- Apply a continuous bead of gasket eliminator to one flange. Surfaces to be resealed must be clean and dry.
- Spread the sealer evenly with your finger to get a uniform coating on the sealing surface. Do not allow the sealer to enter any blind threaded holes, as it may prevent the bolt from clamping properly or cause damage when the bolt is tightened.
- Tighten the bolts to specifications. Do not overtighten.
- After properly tightening the fasteners, remove the excess sealer from the outside of the joint.

Separating Parts

Important: Many internal engine components will develop specific wear patterns on their friction surfaces.

When assembling the engine, internal components **MUST** be separated, marked or organized in a way to ensure reinstallation to original location and position.

Mark or identify the following components:

- Piston and the piston pin.
- Piston assembly to the specific cylinder bore.
- Piston rings to the specific piston assembly and cylinder bore.
- Connecting rod to the crankshaft journal.
- Connecting rod to bearing cap.
- Crankshaft main and connecting rod bearings.
- Camshaft and valve lifters.
- Valve lifters, guides, pushrods, pivot supports and rocker arms.
- Valve to the valve guide.
- Valve spring and shim .
- Engine block main bearing cap location and direction.
- Oil pump drive and driven gears.

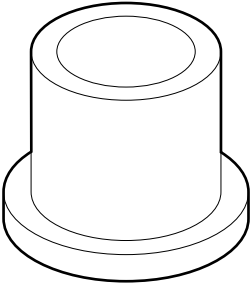
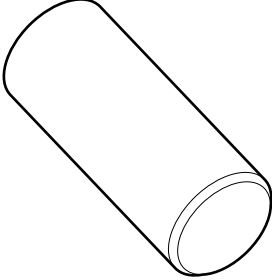
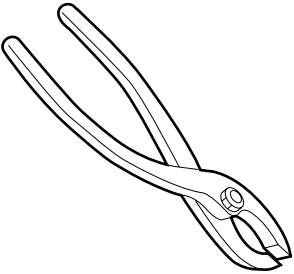
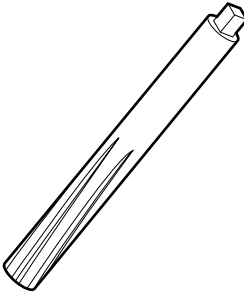
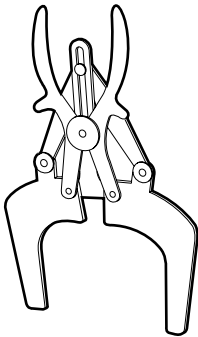
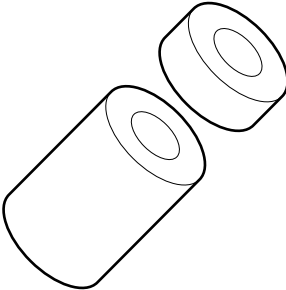
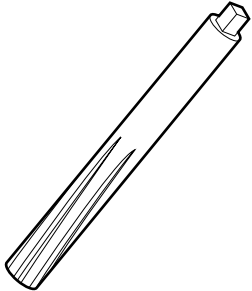
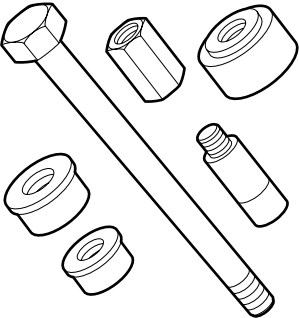
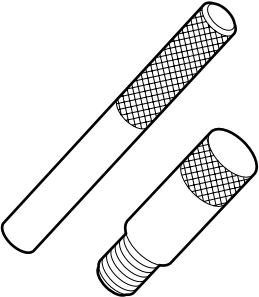
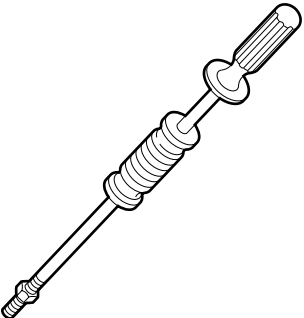
Tools and Equipment

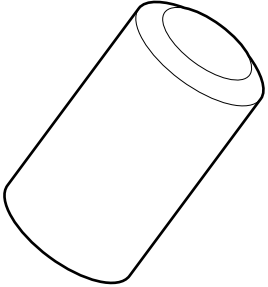
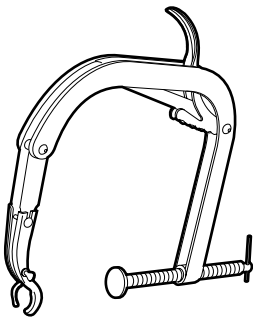
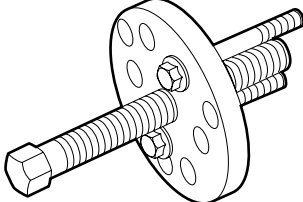
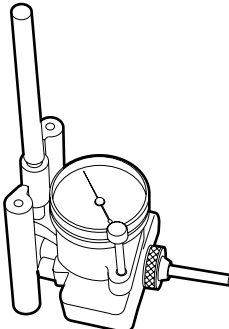
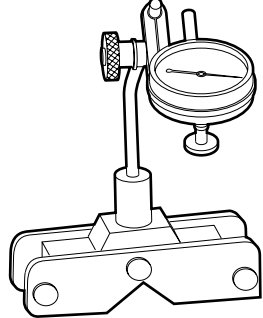

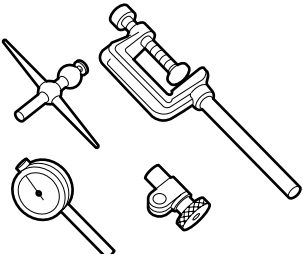
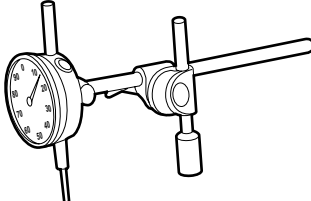
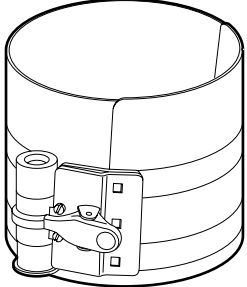
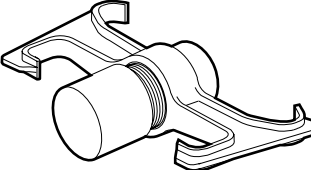
Special tools are listed and illustrated throughout this section with a complete listing at the end of the section. These tools (or their equivalents) are specially designed to quickly and safely accomplish the operations for which they are intended. The use of these special tools will also minimize possible damage to engine components. Some precision measuring tools are required for inspection of certain critical components. Torque wrenches and a torque angle meter are necessary for the proper tightening of various fasteners.

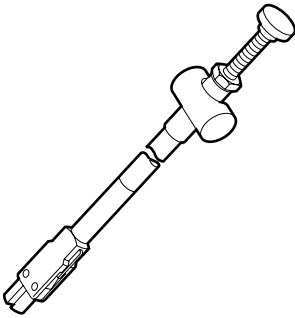
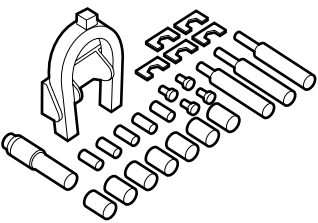
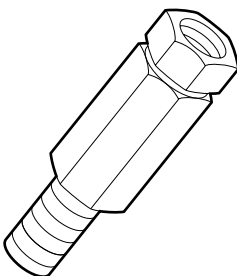
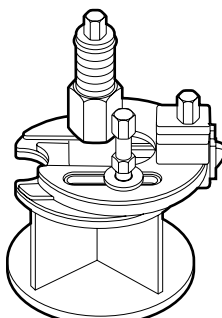
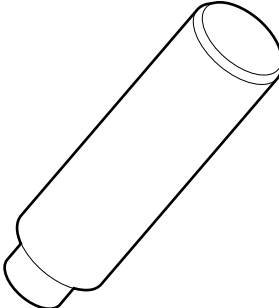
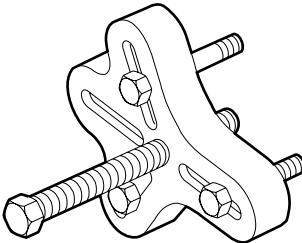
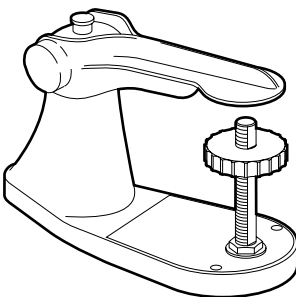
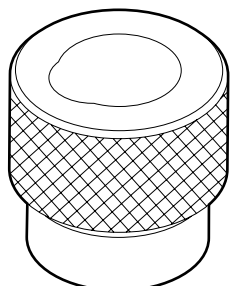
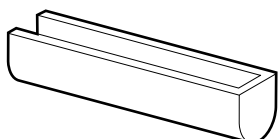
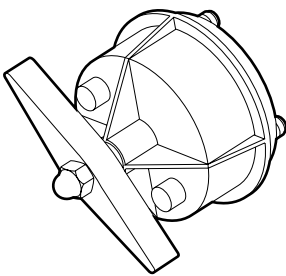
To properly service the engine assembly, the following items should be readily available:

- Approved eye protection and safety gloves.
- A clean, well-lit work area.
- A suitable parts cleaning tank.
- A compressed air supply.
- Trays or storage containers to keep parts and fasteners organized.
- An adequate set of hand tools.
- Approved engine repair stand.
- An approved engine lifting device that will adequately support the weight of the components.

Special Tools and Equipment

	J 791 Camshaft Sprocket Remover		J 5590 Crankshaft Sprocket Installer
	J 3049-A Valve Lifter Remover		J 5715 or J 6036 Rocker Stud Hole Reamer
	J 3936-03 Piston Ring Groove Cleaner		J 5802-01 Rocker Arm Stud Remover
	J 4822 Valve Guide Reamer		J 6098-01 Camshaft Bearing Remover/Installer
	J 5239 Connecting Rod Bolt Guide Set		J 6585 Slide Hammer

	J 6880 Rocker Arm Stud Remover		J 8062 Valve Spring Compressor
	J 6978-E Crankshaft Sprocket Puller		J 8087 Cylinder Bore Gauge
	J 7872 Magnetic Base Dial Indicator		J 8089 Carbon Remover Brush
	J 8001 Dial Indicator		J 8520 Camshaft Lobe Lift Indicator
	J 8037 Piston Ring Compressor		J 8792 Crankshaft Pulley Installer

	J 9290-01 Valve Lifter Remover (Slide Hammer Type)		J 24086-C Piston Pin Remover/Installer Set
	J 9534 Distributor Lower Bushing Remover		J 24270 Ridge Reamer
	J 9535 Distributor Lower Bushing Installer		J 24420-C Universal Crankshaft Pulley Remover
	J 9666 Valve Spring Tester		J 35468 Engine Front Cover Aligner and Oil Seal Installer
	J 21882 Oil Suction Pipe Installer		J 35621 Crankshaft Rear Oil Seal Installer

