

Workshop Manual

Engine

C
2(0)

5.0 GL

5.7 Gi

5.0/5.7 GXi

5.0/5.7 OSi, 5.7 OSXi

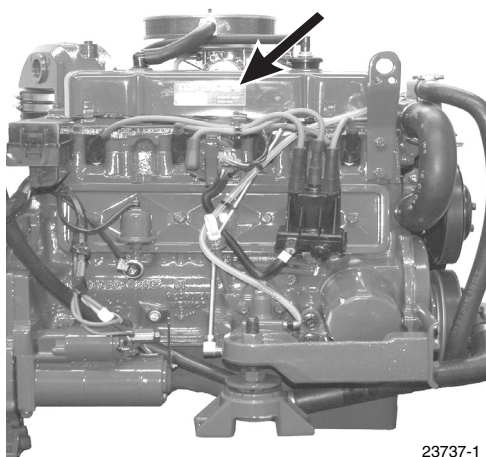
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Model Identification

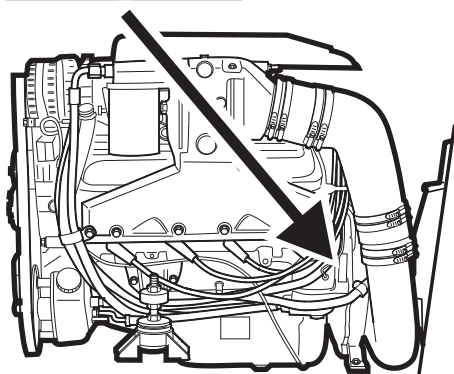
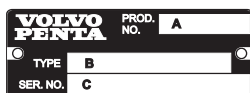
This workshop manual applies to the products listed in Service Bulletin 04-2-67 version 1 dated 08-2007. The unit that you are servicing may be identified from the product model identification plates and/or decals that are placed in various locations to identify Volvo Penta engines, transmissions, transom shields, and drives.

All sterndrive system components must be matched for either single or dual engine installations. Failure to properly match engine, transmission, transom shield, and drive unit will result in poor boat performance, and risk damage to engine and drive because of incorrect drive gear ratio.

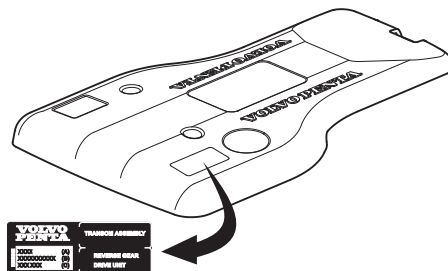


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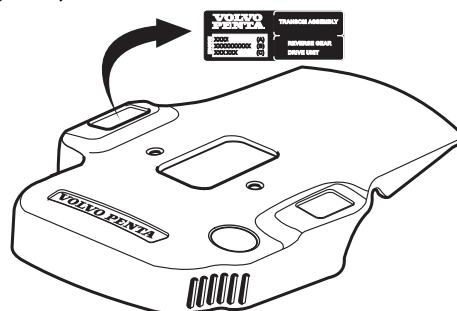
On 3.0L engines, the model identification plate is located on the side of the valve cover.



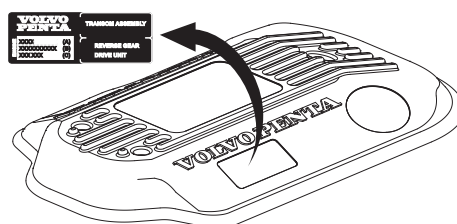
4.3, 5.0, and 5.7 Gi, GXi, OSi, OSXi models



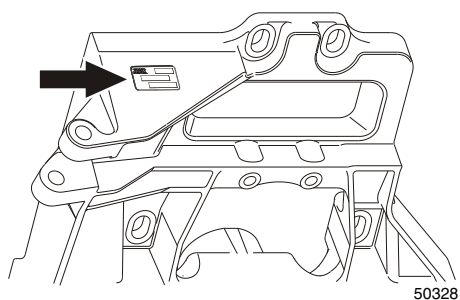
8.1 Gi, GXi, OSi models



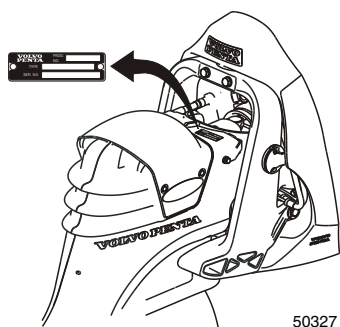
All GL models



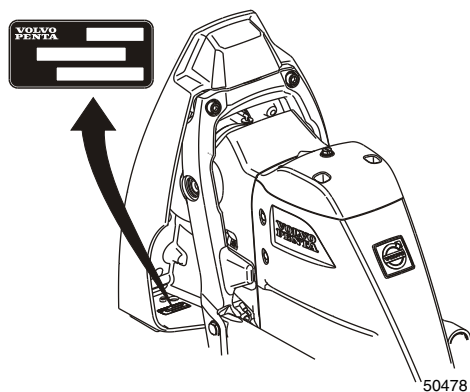
For all other engines, the model identification plate or decal is located either on the port side of the engine cover and/or next to the flywheel housing.



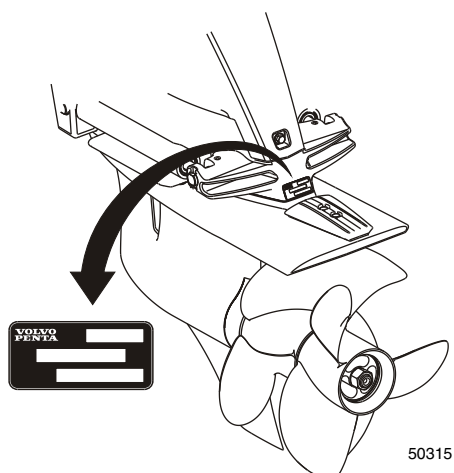
The XP transom shield identification plate is located on the inner transom plate, above the steering ram.



The XDP sterndrive model identification plate is located on top of the drive, in front of the upper gear housing cover.



The SX-A transom identification plate is located on the lower left of the outer transom plate.



The identification plate for the SX-A/DPS-A stern-drives is located on the rear of the upper gear, just above the parting line between the upper and lower gear housing.

General Information

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This service manual is divided into sections concerning various systems and assemblies. Refer to the **Contents** to locate the section covering the system or assembly requiring service. Each section title page has an additional listing that will describe the sections contents in more detail. Be sure to read the **Safety Section** at the end of this manual, and pay special attention to all safety warnings as they appear throughout the text. Since models are subject to change at any time, some photos may not depict actual product.

Good Service Practice

Service required for stern drives is generally one of three kinds:

- **Normal care and maintenance** - which includes putting a new stern drive into operation, storing engines, lubrication, and care under special operating conditions such as salt water and cold weather.
- **Operating malfunctions** - due to improper engine or drive mounting, propeller condition or size, boat condition, or the malfunction of some part of the engine. This includes engine servicing procedures to keep the engine in prime operating condition.
- **Complete disassembly and overhaul** - such as major service or rebuilding a unit.

It is important to determine before disassembly just what the trouble is and how to correct it quickly, with minimum expense to the owner.

When repairing an assembly, the most reliable way to ensure a good job is to do a complete overhaul on that assembly, rather than just to replace the bad part. Wear not readily apparent on other parts could cause malfunction soon after the repair job. Repair kits and seal kits

contain all the parts needed to ensure a complete repair, to eliminate guesswork, and to save time.

Repair time can also be minimized by the use of special tools. Volvo Penta special tools are designed to perform service procedures unique to the product that cannot be completed using tools from other sources. They also speed repair work to help achieve service flat rate times. In some cases, the use of substitute tools can damage the part.

Preparation for Service

Proper preparation is extremely helpful for efficient service work. A clean work area at the start of each job will minimize tools and parts becoming misplaced. Clean an engine that is excessively dirty before work starts. Cleaning will occasionally uncover trouble sources. Obtain tools, instruments and parts needed for the job before work is started. Interrupting a job to locate special tools or repair kits is a needless delay.



CAUTION!

Use proper lifting and handling equipment. Working on engines or stern drives without proper equipment can cause damage and personal injury.

Always use clean fresh fuel when testing engines. Troubles can often be traced to the use of old or dirty fuel.

Service Policy

It is a Volvo Penta policy to provide dealers with service knowledge so they can give professional service demanded by today's consumer. The Volvo Penta Training Centers, frequent mailing of Service Bulletins, Letters and Promotions, Special Tools and this Service Manual represent the latest effort to assist dealers in giving consumers the best and most prompt service possible. If a service question does not appear to be answered in this manual, you are invited to write to the Volvo Penta Service Department for additional help. Always be sure to give complete information, including engine model number and serial number.

Replacement Parts



WARNING!

When replacement parts are required, always use genuine Volvo Penta parts, or parts with equivalent characteristics, including type, strength, and material. Failure to do so may result in product damage and possible injury to the operator and/or passengers.

Parts Catalogs

Parts Catalogs contain exploded views showing the correct assembly of all parts, as well as a complete listing of the parts for replacement. These catalogs are helpful as a reference during disassembly and reassembly, and are available from Volvo Penta Parts.

Special Service Tools

Volvo Penta has specially designed tools to simplify some of the disassembly and assembly operations. These tools are illustrated in this Service Manual, in many cases in actual use. All special tools can be ordered from Volvo Penta Parts. Individual purchasers of Service Manuals must order Special Tools through an authorized dealer.

Product References, Illustrations & Specifications

Volvo Penta reserves the right to make changes at anytime, without notice, in specifications and models and also to discontinue models. The right is also reserved to change any specifications or parts at any time without incurring any obligation to equip same on models manufactured prior to date of such change. All information, illustrations and specifications contained in this manual are based on the latest product information available at the time of printing. The right is reserved to make changes at anytime without notice.

All photographs and illustrations used in this manual may not depict actual models or equipment, but are intended as representative views for reference only. The continuing accuracy of this manual cannot be guaranteed.

The purpose of an engine tune-up is to restore power and performance that has been lost through wear, corrosion or deterioration of one or more parts or components. In the normal operation of an engine, these changes can take place gradually at a number of points, so that it is seldom advisable to attempt an improvement in performance by correction of one or two items only. Time will be saved and more lasting results will be obtained by following a definite and thorough procedure of analysis and correction of all items affecting power and performance.

Economical, trouble-free operation can better be ensured if a complete tune-up is performed once every year, preferably in the spring. Components that affect power and performance can be divided into three groups:

- Components affecting compression
- Components affecting ignition
- Components affecting fuel system

Tuning the Engine

Tune-up procedures should cover these groups in the order given. While the items affecting compression and ignition may be handled according to personal preference, correction of items in the fuel system group should not be attempted until all items affecting compression and ignition have been satisfactorily corrected. Most of the procedures for performing a complete engine tune-up will be covered in greater detail in this manual. This section will deal mainly with the order of procedures involved in tuning the engine.

Engine Compression Testing

During all work done around the engine, while the engine is running or being cranked, use extreme care to avoid getting fingers or clothing caught in any belts, pulleys, or other moving parts.

1. Visually inspect stern drive unit for leaks, missing parts or other obvious defects. **Replace deteriorated parts.**
2. Compression check: Proper compression is essential for good engine performance. An engine with low or uneven compression cannot be properly tuned.
 - Operate engine to normal operating temperature.

NOTICE! Engine must not be started and run without water for cooling.

- Remove any foreign matter from around spark plugs by blowing out with compressed air.
- Remove and inspect all spark plugs. Install thread-type compression gauge in spark plug hole.

To Prevent Sparking



WARNING!

Failure to disable the ignition system during compression testing may cause fire or explosion by igniting gasoline fumes present during cranking and cause personal injury or death.

- Remove (grey) 2-wire connector, with purple and grey wires, at ignition coil.
- With choke and/or throttle plates wide open, crank engine through at least four compression strokes.

Test Conclusion

The indicated compression pressures are considered normal if the lowest reading cylinder is within 75% of the highest.

Example:

If the highest pressure reading was 140 PSI, 75% of 140 is 105. Therefore, any cylinder reading less than 105 PSI indicates an improperly seated valve, worn valve guides, piston, cylinder, or worn or broken piston rings. Any cylinder reading 105 PSI or greater is within specifications, and compression is considered normal.

If one or more cylinders read low, squirt approximately one tablespoon of engine oil on top of the pistons in the low reading cylinders. Repeat compression pressure check on the cylinders.

1. If compression improves considerably, the piston rings are at fault.
2. If compression does not improve, valves are sticking or seating poorly, or valve guides are worn.
3. If two adjacent cylinders indicate low compression pressures and squirting oil on the pistons does not increase the compression, the cause may be a cylinder head gasket leak between the cylinders. This problem could allow engine oil and/or coolant to enter the cylinders. It is recommended the following quick reference chart be used when checking cylinder compression

pressures. The chart has been calculated so that the lowest reading number is 75% of the highest reading.

Compression Pressure Limit in PSI

Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
134	101	154	115	174	131	194	145
136	102	156	117	176	132	196	147
138	104	158	118	178	133	196	148
140	105	160	120	180	135	200	150
142	107	162	121	182	136	202	151
144	108	164	123	184	138	204	153
146	110	166	124	186	140	206	154
148	111	168	126	188	141	208	156
150	113	170	127	190	142	210	157
152	114	172	129	192	144	212	158

After checking cylinder compression, repairs should be made as necessary. Subsequent adjustments to an engine that does not have proper compression will not measurably improve performance or correct operational problems. After verifying compression, check ignition and fuel system components.

Ignition System Components

- Spark Plugs
- Spark Plug Leads
- Distributor Cap
- Rotor
- Ignition Coil
- High Tension Lead
- Ignition Switch
- Circuit Wiring and Connectors

Fuel System Components

- Fuel Tank Pickup and Screen
- Fuel Tank Vent
- Anti-Siphon Valve (if equipped)
- Fuel Octane and Quality
- Boat Fuel Lines and Valves
- External Engine Fuel Filter
- Fuel Pump(s) and Line
- Carburetor Fuel Filter or Screen
- Carburetor Adjustments

- Engine PCV Valve
- Flame Arrestor

All of the above listed components are not necessarily part of an engine tune-up, but must be considered when attempting to correct engine/boat performance problems. Repair or replace components only as required.



WARNING!

Do not substitute automotive parts. Volvo Penta marine components meet U.S. Coast Guard regulations for external ignition proof operation and marine use. Volvo Penta marine components are specially designed not to cause ignition of fuel vapors in the bilge or engine compartment. The use of automotive parts can result in fire and explosion and cause personal injury or death.

Intake Manifold Vacuum Testing

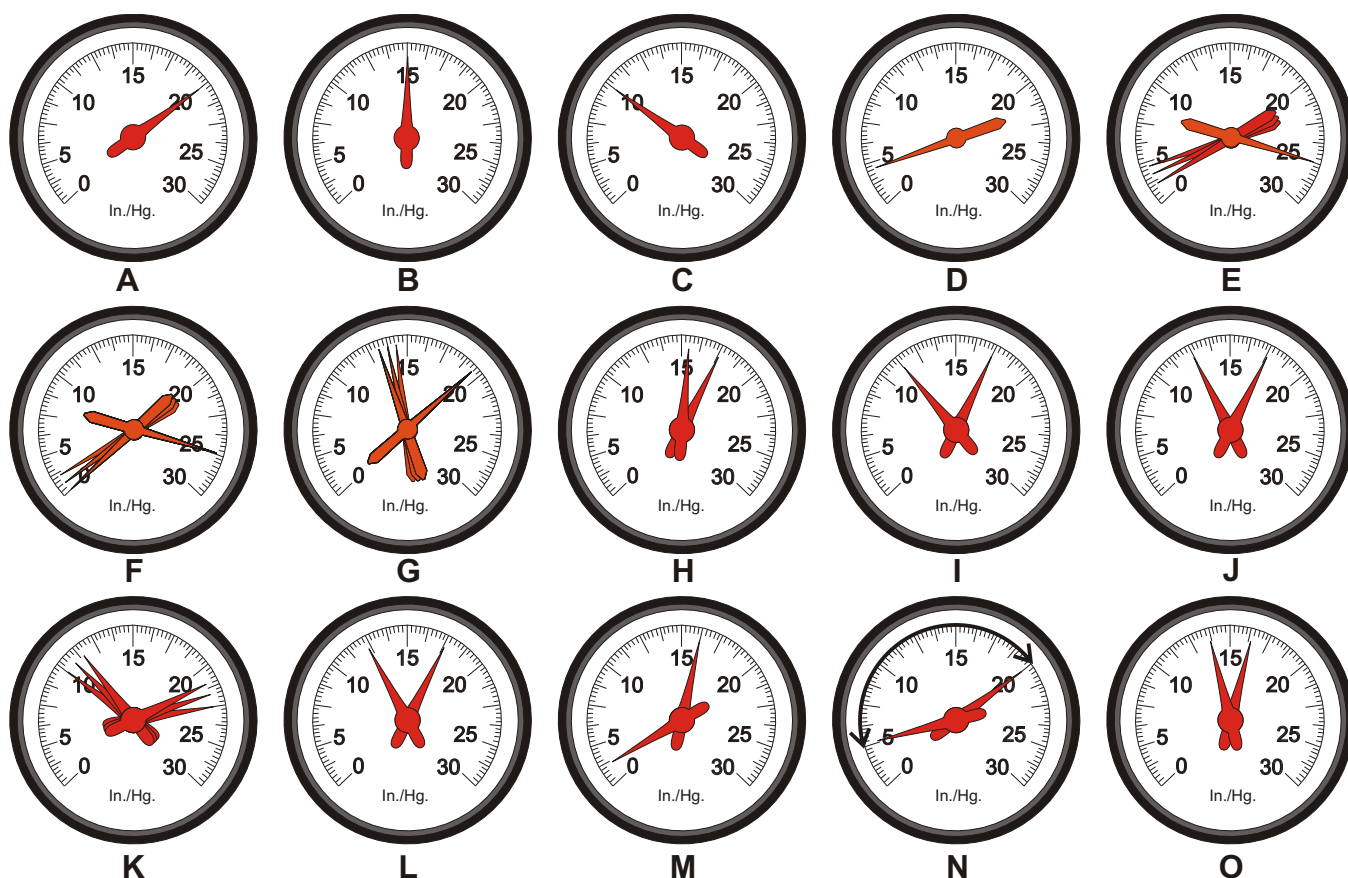
Test Procedures

1. Install a vacuum gauge to a good intake manifold source (usually at the PCV valve port), following the gauge manufacturer's instructions. Start and warm up the engine.
2. Observe the vacuum gauge while operating the engine over a range of engine speeds.

Test Results

1. A steady vacuum reading between 14 and 19 in. Hg. (47-64 kPa) at idle indicates an engine in good mechanical condition.
2. A vacuum reading below 14 in. Hg. (47 kPa) at idle, indicates an engine that is not developing enough vacuum. Further testing for base mechanical problems is needed.
3. Possible causes of low intake manifold vacuum are late ignition timing, low compression, poor engine sealing, leaks at vacuum lines and connections or bad MAP sensor.
4. If the gauge fluctuates at idle, possible causes are sticking or leaking valves, or an ignition miss.
5. If the gauge fluctuates at idle but smooths out as engine RPM increases, check for bad valves or camshaft.
6. If the gauge fluctuates more with increases engine RPM, check for weak or broken valve springs, bad valves, ignition miss, or a leaking head gasket.
7. If the vacuum gauge fluctuates regularly with each engine cycle, check for a bad valve.
8. If the vacuum reading drops steadily as engine RPM increases, check the exhaust system between the engine and vertical drive for restrictions.

9. See table and chart below and on the following page for more information.



Vacuum Gauge Readings

Pos	Condition	Reading
A	Normal at Idle	14-19 in. Hg. (47-64 kPa)
B	Late Ignition Timing	11-17 in. Hg. (37-57 kPa)
C	Late Valve Timing	8-15 in. Hg. (27-50 kPa).
D	Intake Leak	Low but steady reading
E	Normal Acceleration	Drops to 2 then rises to 25 when throttle is rapidly increased and decreased.
F	Worn Rings	Drops to 0, then rises to 22 when throttle is rapidly increased and decreased
G	Sticking Valve(s)	Normally steady, intermittently flicks downward approx. 4 in. Hg. (13 kPa) from highest level.
H	Leaking Valve	Drops 2 in. Hg. (6 kPa) from highest reading.
I	Burned or Warped Valve	Evenly spaced down-scale flicker approximately 5 in. Hg. (17 kPa).
J	Worn Valve	Oscillates Approximately 4 in. Hg. (13 kPa).
K	Weak Valve Springs	Violent oscillations as RPM increases.

Vacuum Gauge Readings

Pos	Condition	Reading
L	Improper Idle Mixture	Floats slowly between 13-17 in. Hg. (44-57 kPa)
M	Restricted Exhaust	Normal when first started. Drops to approx. 0 as RPM increases
N	Head Gasket Leak	Floats between 5-20 in. Hg. (17-68 kPa)
O	Defective Ignition Component	Slight float between 14-16 in. Hg. (47-54 kPa)

Gasoline Requirements

**DANGER!**

Gasoline is extremely flammable and highly explosive under certain conditions. Always stop engine and do not smoke or allow open flames or sparks near the boat when refuelling gas tanks. When filling the gas tank, ground the tank to the source of gasoline by holding the hose nozzle firmly against the side of the deck filler plate, or ground it in some other manner. This action prevents static electricity buildup which could cause sparks and ignite fuel vapors.

USE ONLY UNLEADED FUEL. Use lead-free gasoline with the following minimum or higher octane specification:

Inside the U.S.: $(R+M)/2$ (AKI) = 87

Outside the U.S.: (RON) = 90

If fuels with 89 AKI pump posted (93 RON) octane number or higher are used an increase in power can be expected with EFI models.

Premium fuels contain injector cleaners and other additives that protect the fuel system and provide optimum performance.

NOTICE! Engine damage resulting from the use of gasoline with octane 86 AKI (89 RON) and lower is considered misuse of the engine and will void the engine warranty. *Volvo Penta* suggests the use of 89 AKI or higher fuels. These fuels have additives that are beneficial to maximum engine performance and long life of service components.

To prevent gum formation and corrosion in the fuel system, use a Marine Fuel Stabilizer in the gasoline.

Gasoline Containing Alcohol

Many brands of gasoline being sold today contain alcohol. Two commonly used alcohol additives are Ethanol (ethyl alcohol) and Methanol (methyl alcohol).

See the Owner's Manual for your boat to determine if the boat's fuel system is compatible with alcohol blended fuels. If it is compatible, your engine may be operated using gasoline blended with no more than 10% Ethanol (ethyl alcohol) meeting the minimum octane specifications.

NOTICE! Do not use any gasoline which contains Methanol (methyl alcohol).

See the boat's Operators Manual to determine if the boat's fuel system is compatible with alcohol blended fuels. If it is, your engine may use gasoline blended with no more than 10% Ethanol (ethyl alcohol) meeting the minimum octane specification. **Do not use any gasoline which contains METHANOL (methyl alcohol).**

Continued use of **METHANOL** (methyl alcohol) fuel will cause serious damage to the fuel system.

If you use gasoline containing alcohol, be aware of the following:

- The engine will operate leaner. This may cause engine problems such as vapor lock, low speed stalling, or hard starting.
- Alcohol blended fuels attract and hold moisture. Moisture can cause fuel tank corrosion. Inspect fuel tanks at least annually. Replace corroded or leaking fuel tanks.
- Frequently inspect non-metallic parts of fuel system and replace if excessively stiff, deteriorated or leaking.

Fuel leakage can contribute to a fire and/or explosion.

Crankcase Oil

Initial factory fill is a high quality motor oil for API Service SJ. During the break-in period (20 hours), frequently check the oil level. Somewhat higher oil consumption is normal until piston rings are seated. The oil level should be maintained in the safe range between the Add and Full marks on the dipstick. This range represents approximately 1 litre (1 quart). If it is necessary to add or change the motor oil, use a quality oil with API service category SJ.

NOTICE! Do not fill above full mark. Overfilling results in high operating temperatures, foaming (air in oil), loss of power, low oil pressure and overall reduced engine life.

At the end of the break-in period (20 hours), change the crankcase oil and replace the oil filter. Refer to Lubrication and Inspection Chart for recommended oil change intervals.

NOTICE! The use of multi-viscosity oils, such as 10W-30 or 10W-40, is allowed but not recommended.

Draining and Filling the Engine Crankcase

If using Volvo Penta Premium Synthetic Engine Oil, drain and refill crankcase every 200 hours of operation or once a year, whichever occurs first.

If using oil other than Volvo Penta Premium Synthetic Engine Oil, drain and refill crankcase every 100 hours of operation or once a year, whichever occurs first.



DANGER!

To prevent fire and explosion, always make sure engine compartment is free of gasoline fumes before using any spark-producing tools such as the electric drill motor used with oil withdrawal pump kit.

Check the motor oil level frequently with the dipstick. When oil is to be changed, remove dipstick and withdraw oil from crankcase through withdrawal/dipstick tube. The oil withdrawal tube is provided so oil does not have to be drained into the bilge. Withdraw oil with a suction pump.

Fill the crankcase to the specified capacity with a quality motor oil labelled for service category SJ. When changing motor oil, select from the following chart the SAE viscosity that matches the temperature range in which the boat will be operated. If it is necessary to add motor oil, use motor oil of the same viscosity.

Temperature Viscosity Recommendations

If the lowest Anticipated Temperature is:	The Following SAE Viscosity Oils are Recommended
32° F (0° C) and above	SAE 30
0° F (-18° C) to 32° F (0° C)	SAE 20W-20
Below 0° F (-18° C)	SAE 10

Disregard any reference to multi-viscosity oil printed on engine. Such reference is intended for automotive use only and not for marine applications.

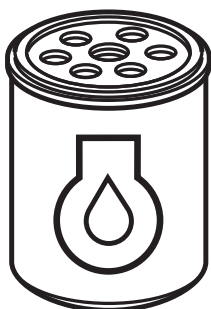
NOTICE! Do not fill above full mark. Overfilling results in high operating temperatures, foaming (air in oil), loss of power, low oil pressure and overall reduced engine life.

Crankcase Capacities

Model	With Filter
3.0GL/GS	4.0 qts. (3.8 liters)
4.3GL/GXi	5.0 qts. (4.7 liters)
5.0GXi	5.5 qts. (5.2 liters)
5.7GL/Gi/GXi/OSi/OSXi	5.5 qts. (5.2 liters)
8.1Gi/GXi/OSi	9.0 qts. (8.5 liters)

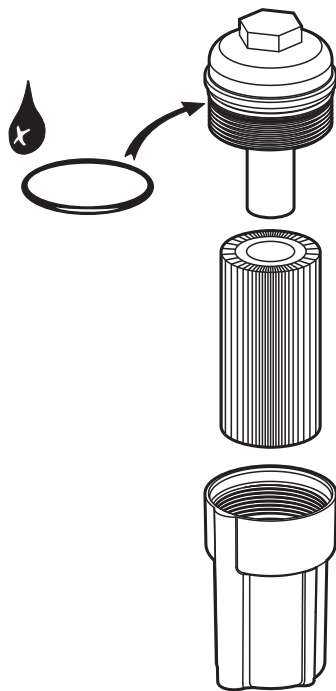
Oil Filter

Canister type



Replace the oil filter whenever the motor oil is changed. This filter is a self-contained, screw-on type. To remove, unscrew filter canister counterclockwise and discard. When attaching a new filter, be sure the gasket is lightly lubricated with motor oil. Hand tighten only, run engine and check for leaks. Do not run engine without supplying cooling water. See *Parts Catalog* for model and filter requirements.

Replaceable Element Type



Replace the oil filter whenever the motor oil is changed. This filter is a replaceable element type that is mounted in a reusable container. To remove the element, unscrew the filter cap counterclockwise and lift the element out.

NOTICE! When replacing the element, always replace the O-ring with a new O-ring.

Slide the element off the filter support and discard according to all local environmental regulations. Replace the O-ring on the filter cap. Slide the new filter element onto the filter support in the filter cap. Install the cap and filter assembly into the canister. Use a 36 mm socket and torque wrench, tighten to 18 ft. lb. (24 Nm)

Power Steering

Maintain the level with Volvo Penta Power Trim/Tilt & Steering Fluid. Approved power steering fluids such as GM power steering fluid or Dexron II automatic transmission fluid can also be used. Do not overfill the pump reservoir.

Steering System Lubrication

Every 60 days, grease the steering ram with Volvo Penta grease.

Power Trim/Tilt Fluid Level

At the beginning of each boating season, check the fluid level in the reservoir as follows:

- Level should be between the “MIN” and “MAX” marks on the reservoir.
- If necessary, add Power Trim/Tilt & Steering Fluid. Replace the cap and tighten securely.

Off-Season Storage

There are nine steps that must be completed for Off-Season Storage Preparation

When gasoline engines are removed from service for long periods (2 months or more), it is important that they are correctly stored or protected (internally). Today's gasoline blends are not as stable as in the past and consideration must be given if the fuel will not be used within a short time or if the engine is being placed in storage. Failure to properly stabilize the fuel can damage fuel system components and is not considered as warrantable a defect that would be covered and repaired under the limited express warranty.

Boat manufacturers should follow the gasoline storage mixture section for testing prior to shipment. Fuel stabilizer can be purchased locally at most marine supply stores.

Limited Use

If the vessels fuel within the tank(s) will not be consumed within a 30-day period from the time of filling, a gasoline fuel stabilizer must be added as per the manufacturer's instructions. This will help prevent the fuel from breaking down and causing reduced engine performance fuel system clogging or damage from uncontrolled combustion.

Storage

If the boat is being placed into storage, a gasoline fuel stabilizer must be added to the tank(s) as per the manufacturers instructions. The amount of stabilizer required is determined by the quantity of fuel and the length of time it will be placed in storage. The maximum period that fuel can be stabilized is six months due to limitations of the stabilizers and fuels.



WARNING!

Any fuel leakage should be corrected immediately to prevent possible fire and/or explosion.

NOTICE! Do not run engine out of fuel or run the electric fuel pumps dry more than 20 seconds. Running the electric fuel pumps dry will cause fuel pump damage.

Step 1. Prepare a storage mixture

In addition to stabilization of the fuel, it is highly desirable to have the valves and cylinders coated with a light film of oil previously accomplished through fogging. Today's fuel injection manifolds are designed with a complex air channel design that will not allow the traditional fogging oils to be injected past the throttle plate while running. The oil will get stuck in the plenum and never reach the cylinders. Together with the stabilizer, two-cycle motor oil can be added to a fuel mixture for stabilization purposes.

- Using an outboard motor six-gallon fuel tank, add two-cycle motor oil at a ratio of 50:1 (one pint to 6 gallons) and stabilizer at one ounce per gallon (unless stated otherwise on the manufacturers label). Mix well.
- Disconnect boat fuel line at engine fuel pump. Attach the storage mixture fuel tank.
- Connect a suitable engine flush device if the boat is not in the water.
- Run the engine on the storage mixture for approximately 5 minutes at 1500 RPM. This will ensure that all fuel system and internal engine components are thoroughly protected. Do not operate the engine above 1500 RPM as the water pump demand may exceed the supply, damaging the pump.
- Reduce the engine speed to idle and stop the engine.
- Reconnect the fuel fitting and check for fuel leaks.

Step 2. Change Motor Oil and Oil Filter:

- Engine should first be operated under load until oil is thoroughly warmed up. If oil is allowed to warm up before draining, a more complete draining will be accomplished. In addition, accumulated impurities will be held in suspension by the oil and be removed during draining operation.
- Remove motor oil by siphoning it out of oil withdrawal tube. Follow the procedure under **Draining and Filling the Engine Crankcase**.
- Install a new oil filter and fill crankcase with recommended oil.

NOTICE! Sterndrive must be submerged in water or an accessory flushing adaptor must be used while operating engine. When using a flushing adaptor, remove propeller before starting engine to prevent accidental contact with rotating propeller.

- With sterndrive in full down position, run engine at a fast idle for a few minutes to distribute clean oil through engine.
- Shut off engine and check oil level. Check oil filter gasket for leaks. Add oil if necessary to bring oil level up to, but not over, the full mark.

Step 3. Change Drive Lubricant:

Drain and refill with fresh GL-5 Synthetic Gear Lubricant or Mobilube 1 SHC Fully Synthetic SAE 75W-90 (meeting or exceeding MIL-L-2105C or D, API GL-4 or 5) gear lubricant. Refer to Vertical Drive Service Manual.

Step 4. Fog Engine:

- Warm up engine to ensure fuel conditioner is throughout fuel system. Use 1/2 pint (0.24 liter) of Fogging Oil 12 oz. (355 ml) spray can to fog engine.
- Remove flame arrester from carburettor. Following instructions on container, bring engine up to a fast idle and slowly pour or spray 2/3 of fogging oil into carburettor. Keep engine running while pouring fogging oil into carburettor throat.

Step 5. Drain Cooling System

When draining the cooling system, raise or lower the bow of the boat to position the engine in a level horizontal plane. This will provide complete drainage of the engine block and manifolds. If the bow is higher or lower than the stern, some water may be trapped in the engine block or manifolds.

Improper or incomplete draining may result in freeze damage to the engine, manifolds, sterndrive, or other components. Freeze damage is not covered under Volvo Penta's Limited Warranty.

Front

1. Disable ignition system See *Engine Compression Testing* on page 5.
2. Remove inlet and outlet hoses from raw water pump and crank the engine with starter 1-2 revolutions.

3. Reconnect ignition system.

Starboard

4. Disconnect and drain large hose at circulation pump

Port

5. Remove exhaust manifold drain plug. Clear hole with a small wire to ensure complete drainage.
6. Remove cap from engine flush hose and lower hose into bilge.

Preparation for Boating After Storage

1. Install all drain plugs. Install cooling hoses and clamps. Check condition of hoses, manifold end caps and clamps. Connect hoses to engine and tighten clamps securely. Install boat drain plug, if removed.
2. Remove the distributor cap and rotor. Wipe the inside of the distributor cap dry with a clean cloth and spray with *Corrosion Spray*. Replace the rotor and cap.
3. Clean the battery terminals. With the ignition switch in the "OFF" position, install the battery and attach the battery cables. Spray terminals with *Corrosion Spray*.
4. **Open the fuel shut-off valve (if so equipped) and check all fuel line connections for leaks.**
5. Check the flame arrestor and clean if necessary. **Reinstall, make sure all parts are in place and tighten nut securely.**
6. Make a thorough check of the boat and engine for loose or missing nuts and screws. Pump the bilge dry and air out the engine compartment.



WARNING!

To prevent a possible explosion, operate the blower as recommended by the boat manufacturer before starting engine. If the boat is not equipped with a bilge blower, open engine cover or hatch prior to starting and leave open until after engine is running.

If operating boat in water, tie boat securely to dock to prevent forward or backward movement.

When using a flushing adaptor, remove the propeller before starting engine to prevent accidental contact with rotating propeller.

7. Test run engine: Launch boat or use a flushing adaptor installed on Sterndrive.

NOTICE! Do not start engine out of water unless using a flushing adaptor. Always turn water on before starting engine. Control water pressure as full water pressure may cause damage to supply pump and engine.

8. With engine compartment open, start the engine. **Monitor the voltmeter, oil pressure and water temperature gauges fre-**

quently to be sure all systems are operating properly.
Check for fuel, oil, and water leaks.

Engine Break-in

All engines have been run for a short period of time as a final test at the factory. You must follow the Engine Break-In procedure during the first 20 hours of operation to ensure maximum performance and longest engine life.

NOTICE! To ensure proper lubrication during the break-in period, do not remove factory break-in oil until after the 20-hour break-in is completed.

First Two Hours

For the first five to ten minutes of operation, operate engine at a fast idle (above 1500 RPM). After engine has reached operating temperature, momentarily reduce engine speed, then increase engine speed, to assist break-in of rings and bearings.

During the remaining first two hours of operation, accelerate to bring boat onto plane quickly and bring throttle back to maintain a planing attitude. During this period, vary the engine speed frequently by accelerating to approximately three-fourths throttle for two to three minutes, then back to minimum planing speed. Maintain planing attitude to avoid excessive engine load.

NOTICE! DO NOT RUN ENGINE AT A CONSTANT RPM FOR PROLONGED PERIODS OF TIME DURING THE BREAK-IN PERIOD.

Next Eight Hours

During next eight hours, continue to operate at approximately three-fourths throttle or less (minimum planing speed). Occasionally reduce throttle to idle speed for a cooling period. During this eight hours of operation it is permissible to operate at full throttle for periods of less than two minutes.

NOTICE! DO NOT RUN ENGINE AT A CONSTANT RPM FOR PROLONGED PERIODS OF TIME DURING THE BREAK-IN PERIOD.

Final Ten Hours

During the final ten hours of break-in, after warming engine to operating temperature, it is permissible to operate at full throttle for five to ten minutes at a time. Momentarily reduce then increase engine speed to assist break-in of rings and bearings. Occasionally reduce engine speed to idle to provide cooling periods.

NOTICE! DO NOT RUN ENGINE AT A CONSTANT RPM FOR PROLONGED PERIODS OF TIME DURING THE BREAK-IN PERIOD.

During break-in period, be particularly observant during initial running of engine, as follows:

1. Check crankcase oil level frequently. Maintain oil level in safe range, between "add" and "full" marks on dipstick.

NOTICE! If you have a problem getting a good oil level reading on dipstick, rotate dipstick 180° in tube.

2. Watch oil pressure gauge. If gauge indication drops below the normal operating oil pressure range (See *Engine Specifications* in the back of this manual.) whenever boat attitude is changed (i.e. turning, climbing on plane, etc.), it may be the oil pickup screen is not covered with oil. Check crankcase dipstick, and add oil to crankcase if required. **DO NOT OVERFILL.** If oil level is correct and condition still exists, check for possible gauge or oil pump malfunction.

NOTICE! Oil pressure will rise as RPM increases, and fall as RPM decreases. In addition, cold oil will generally show higher oil pressure for any specific RPM than hot oil. Both of these conditions reflect normal engine operation.

3. Watch engine temperature indicator to be sure there is proper water circulation.

NOTICE! Failure to follow the break-in procedure will void the engine warranty.

At end of break-in period (20 hours), remove motor oil and replace oil filter. Fill crankcase with recommended 4-cycle motor oil, See *Draining and Filling the Engine Crankcase* on page 11.

Operation After Break-in

After break-in, the engine can be operated at any RPM from idle to full throttle. However, cruising at 3600 RPM or less saves fuel, reduces noise, and prolongs engine life.

When starting a cold engine, always allow engine to warm up gradually. Never run engine at full throttle until engine is thoroughly warmed up. Be sure to check oil level frequently during the first 50 hours of operation, since oil consumption will be high until piston rings are properly seated.

Submerged Engine or Water Ingestion in Cylinders

In the unlikely event that the water level in the boat should get high enough to enter the engine, or water should enter the engine's cylinders through the intake or exhaust system, remove the boat from water as quickly as possible.

1. Remove spark plugs immediately and crank engine to remove water from cylinders. Do not attempt to crank engine with water present in cylinders, internal engine damage will result.



WARNING!

Disable ignition system before cranking engine with spark plugs removed. Failure to disable the ignition may result in fire or explosion and personal injury. See *To Prevent Sparking* on page 6.

2. Drain, flush and refill crankcase with new oil, See *Draining and Filling the Engine Crankcase* on page 11.
3. Change oil filter, See *Oil Filter* on page 12.

It is imperative that all water is removed from the engine and immediately lubricate all internal parts. All electrical devices must also be dried and inspected for water damage. Delay in completing these ac-

tions may allow extensive engine damage. Ensure the fuel system is not contaminated with water before attempting to start engine.

Frequently check engine compartment for gasoline fumes and excessive water accumulation; water depth in bilge should be kept well below flywheel housing.

Water entry through the intake or exhaust system is not considered a defect in the engine and is excluded from coverage under the limited express warranty.

20-Hour Check

1. Change engine oil and oil filter.
2. Check power trim/tilt reservoir for proper fluid level.
3. Clean and inspect the ceramic filter located under the fuel pump.
4. Check flame arrestor for proper mounting.
5. Start engine and check complete fuel system for leaks.
6. Lubricate steering cable ram with Volvo Penta grease P/N 828250. Check power steering pump reservoir for correct fluid level on models equipped with power steering. Failure to properly lubricate the steering system could lead to loss of steering control.
7. Check shift system for proper adjustment and operation. Verify cable attachment clamp on pivot housing is fully seated and secure. Inspect cable anchor and cotter pin at shift linkage on stern drive for proper installation and free movement.
8. Inspect exhaust system. Tighten all hose clamps, and check for leaks. Verify all clamps on exhaust and u-joint bellows are properly located and tightened.
9. Check tension on drive belt.
10. Check all engine mount screws, stern drive mounting nuts and transom shield mounting nuts for tightness.
11. Check for any deficiencies, malfunctions, signs of abuse, etc. Correction of any problems at this time will prevent the worsening of a minor problem and help ensure a trouble-free boating season.
12. Check oil level in Sterndrive and add as necessary with GL-5 Synthetic Gear Lubricant or Mobilube 1 SHC Fully Synthetic SAE 75W-90 (meeting or exceeding MIL-L-2105C or D, API GL-4 or 5) gear lubricant.
13. Make sure engine can achieve maximum rated RPM with normal load.

Positive Closed Ventilation System

A malfunctioning crankcase ventilation system may be indicated by loping or rough engine idle. Do not attempt to compensate for this idle condition by disconnecting the crankcase ventilation system and making adjustments. The removal of the crankcase ventilation system from the engine will adversely affect fuel economy and engine ventilation with resultant shortening of engine life. To determine

whether loping or rough idle condition is caused by a malfunctioning crankcase ventilation system, perform the following tests.

With Engine Idling

1. Remove PCV valve from its mounting, but leave vacuum inlet side connected to hose. If the valve is functioning properly and not plugged, a hissing noise will be heard as air passes through valve. A strong vacuum will be felt when a finger is placed over valve inlet. Check for vacuum leaks in hose line and at all connections.
2. Reinstall PCV valve, then remove crankcase air inlet hose at flame arrestor connection. Loosely hold a small piece of stiff paper (such as a 3 x 5 memo card or parts tag card) over opening at end of inlet hose. After a minute or so, (to allow crankcase pressure to lower) the piece of paper should be sucked against hose opening with a noticeable force.

With Engine Stopped

Remove PCV valve from its mounting and shake it. A metallic clicking noise should be heard, indicating that valve parts are free, and not sticking.

If ventilation system passes these two tests, it can be considered functionally OK, and no further service is required. If it fails either test, replace PCV valve and repeat Engine Idling Test.

If system still does not pass test, clean ventilation system hoses and all passages to induction system in accordance with established procedures.

Servicing PCV Valve

NOTICE! Do not attempt to clean crankcase ventilation regulator valve. It should be replaced.

Clean crankcase ventilation system connection(s) on intake manifold by probing with a flexible wire or bottle brush. Clean hoses, tubes and associated hardware with a low-volatility, petroleum-base solvent and dry with compressed air.

Troubleshooting - System Isolation

The following is to help you isolate a malfunction of one or possibly several systems. After determining which systems are related to the

malfunction, refer to the individual system troubleshooting charts to isolate the specific cause.

System Isolation

Engine Does not Start	Cranking System	Engine should crank at specified RPM. If not, check for 1. Discharged or dead Battery 2. Loose or corroded connections 3. Cranking System Troubleshooting Chart in the Electrical Ignition/ Fuel Service Manual
	Ignition System	Must have good spark at spark plugs. If not, check the: 1. Distributor Cap 2. Coil and spark plug leads 3. Ignition timing 4. Automatic spark advance 5. Appropriate Ignition Troubleshooting Chart in the Electrical/Ignition/Fuel Service Manual. 6. EFI Models: Refer to EFI Diagnostic Manual
	Fuel System	Carburetor accelerator pump should squirt fuel into the Venturi when throttle is advanced. If not, check the: 1. Fuel Tank, valves, and lines 2. Fuel pump and filter 3. Carburetor and Filter 4. Boat Fuel System Troubleshooting Chart 5. Carburetor Troubleshooting Chart 6. Engine Fuel System Troubleshooting Chart
Engine Runs Improperly		Check the following: 1. Compression 2. Ignition system 3. Fuel system and carburetor 4. Lubrication system 5. Cooling System 6. Sterndrive and propeller 7. PCV Valve 8. Engine Troubleshooting Guides

Engine Troubleshooting Guides

EFI Engines Only: Refer to EFI Diagnostic Service Manual.

These guides were written to help you trace the symptoms of the trouble to the source, without having to read through and prove every possibility. Much of the information here will be familiar to well informed mechanics.

Also, many factors will seem insignificant but when you think of it, usually the toughest problem to troubleshoot is caused by the smallest error. The greatest aid to solving a service problem is informa-

tion. Start gathering information from the boat operator and write it on his job card or work ticket. Find out pertinent facts, such as:

- When did this trouble start?
- How was the boat loaded?
- Did the trouble occur suddenly, or start gradually?

Analyze this information and try to match it to similar situations you have experienced in the past. Keep in mind the fundamental rules:

- COMPRESSION - Mixture inducted into cylinder and compressed.
- SPARK - Proper intensity at the proper time.
- FUEL - Proper mixture of air and fuel.

These are very old rules, but necessary for the engine to run. Use these charts and the service information they refer to. Do not try to remember tolerances, settings, measurements, etc., as they are written in the service manual. Leave your mind free to analyze the problem.

Following is a list of the troubleshooting guides which may be found on the pages indicated.

Engine Will Not Crank	22
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Engine Will Not Crank

Starter Circuit - Check:

- Battery condition: weak, dead, sulfated, bad cells
- Battery cables for loose or corroded connections
- Shorted or open ignition switch
- Starter motor and solenoid for shorts, grounds or open circuits
- Starter assist solenoid/starter relay
- Circuit breakers
- Wiring from battery to ignition switch
- See *Electrical/Ignition/Fuel Service Manual*

Engine Cranks, But Will Not Start

Ignition Circuit

Check:

- Primary circuit wiring from ignition switch to ignition coil/ignition module
- Secondary circuit wiring from coil to spark plug
- Spark plugs for proper gap, fouling, burned electrodes, cracked or dirty insulator
- See ***Electrical/Ignition/Fuel Service Manual***
- Low battery voltage

Fuel System

Check:

- Quantity and condition of fuel in boat tank
- Operation and flow capacity of boat anti-siphon valve
- Fuel tank vent is unrestricted
- Fuel tank pick-up screen is clean
- Correct diameter/unrestricted boat fuel lines
- Fuel shutoff and multiple tank valves are open and operating properly
- Fuel pump vent hose for signs of fuel or oil that would indicate a fuel pump failure.
- Fuel pump/relay/circuit breaker operation
- External fuel filter canister and carburetor filter
- Carburetor accelerator pump
- See ***Electrical/Ignition/Fuel System Service Manual***

Cylinder Compression

Check

- Conduct test following procedure in this section, and compare readings to Compression Limit Chart.

Hard Starting - Cold Engine

Ask these questions first:

Has Engine Always Done This?

Check:

1. Carburetor choke operation and adjustment
2. Fuel lines for obstructions
3. For debris inside fuel tank
4. See ***Electrical/Ignition/Fuel System Service Manual***

Was Engine Not Used For A Long Time? (more than two months)

Check:

1. For clean external canister and carburetor fuel filters
2. Empty carburetor float bowl due to evaporation
3. Water in fuel due to condensation
4. Fuel quality deterioration

5. See ***Electrical/Ignition/Fuel System Service Manual***

Is This A New Condition?

Check:

1. Carburetor choke operation and adjustment
2. Carburetor accelerator pump
3. Fuel system for leaks, dirt, or obstructions
4. Engine timing and ignition system
5. See ***Electrical/Ignition/Fuel System Service Manual***

Hard Starting - Hot Engine

Ask these questions first:

Has Engine Always Done This?

Check:

1. Carburetor choke operation and adjustment
2. See ***Electrical/Ignition/Fuel System Service Manual***

Is This A New Condition?

Check:

1. Brand, type or octane of fuel
2. Spark plugs
3. Water in fuel
4. Condition of battery and cables
5. Starter motor for overheat damage

Did Engine Refuse To Start After Being Run?

Check:

1. Ignition system primary circuit
2. Ignition coil(s)/ignition module
3. Engine timing
4. Carburetor choke operation and adjustment
5. See ***Electrical/Ignition/Fuel System Service Manual***

Engine Runs Rough

If Fuel Injected, see ***EFI Diagnostic Workshop Manual***

If At Slow Speed

Check:

1. Idle speed and idle mixture
2. Engine timing and spark plugs
3. Fuel pump pressure
4. Water or contaminants in fuel
5. Carburetor or manifold vacuum leak

6. Internal carburetor fuel leak
7. See ***Electrical/Ignition/Fuel System Service Manual***

If At High Speed

Check:

1. Air leak on suction side of fuel system
2. Too low octane fuel
3. Ignition system secondary circuit
4. Engine timing
5. Wrong model or size carburetor, improper main jets or power valve, defective secondary fuel circuit, secondary vacuum diaphragm failure
6. External canister and carburetor fuel filters
7. Fuel pump pressure
8. Engine compression
9. Water or contaminants in fuel, water in cylinders
10. See General Information section and Electrical/Ignition/ Fuel System Service Manual

Engine Noises and Vibrations

Valves - Hydraulic Lifters

1. Rapping only when starting (oil too heavy for prevailing weather, varnish on lifter, oil needs to be changed)
2. Intermittent rapping (leakage at lifter check ball)
3. Idle noise (excessive leak down rate, faulty check ball seat)
4. Generally noisy (excessive oil in crankcase, stuck lifter plunger)
5. Loud noise at operating temperature (scored lifter plunger, fast leak down rate, oil viscosity too light for prevailing weather or operating temperatures)
6. See appropriate Engine section

Ignition System (Ping or Knock)

1. Improper tuning
2. Incorrect spark plug wire routing
3. Use higher octane fuel
4. See Electrical/Ignition/Fuel Service Manual

Cooling System

1. Supply pump
2. Loose belts, pulleys
3. See ***Cooling System Manual***.

Mountings

1. Loose, broken or worn engine mounts
2. Loose lag screws holding mounts to stringer

Crankshaft Balancer or Flywheel

1. Loose bolt(s)

Alternator

1. Loose pulley, worn bearings
2. Loose mounting bolts

Sterndrive

1. Failed U-joints or gimbal bearing
2. Damaged internal drive components
3. Worn, bent or broken propeller hub or blades
4. Loose, worn or damaged engine coupler

Engine Overheats

Check:

1. Actual engine temperature by verifying with an accurate thermometer at the thermostat housing
2. Gauge operation and wiring circuit
3. Sending unit operation and wiring circuit
4. Supply pump, circulating pump and belt(s)
5. Water intake screens for blockage
6. Thermostat
7. Water supply hoses
8. Engine timing
9. Water leaks on pressure side of supply pump
10. Air leaks on suction side of supply pump including the transom shield and sterndrive.
11. Engine compression

Engine Dies Out

Loss Of, Or Out Of, Fuel

Check:

1. Fuel gauge operation and wiring
2. Fuel level in tank
3. Water or debris in fuel
4. Fuel pickup tube and screen blockage
5. Fuel tank vent blockage
6. Plugged external canister or carburetor fuel filters
7. Air leak on suction side of fuel system
8. Fuel leak on pressure side of fuel system
9. Inoperative, restricted or incorrectly sized anti-siphon valve
10. Boat fuel lines too small in diameter
11. Fuel pump pressure and suction

12. Carburetor cleanliness and operation
13. See *Electrical/Ignition/Fuel System Service Manual*

Loss Of Ignition

Check:

1. Primary and secondary ignition circuits
2. Ignition switch
3. Circuit breakers
4. Wiring between engine and dash
5. Main engine harness wiring
6. See *Electrical/Ignition/Fuel Service Manual*

Engine Stops Or Dies Out Due To Seizure

Check:

1. Vertical drive for internal damage
2. Oil pressure gauge and crankcase oil level
3. Temperature gauge and cooling system operation
4. Internal engine components as required

Engine Won't Reach Operating RPM

Check:

1. Propeller pitch or diameter, damaged blades, slipping hub
2. Crankcase oil volume
3. Marine growth on hull and drive
4. Fuel type or octane
5. Wrong Sterndrive gear ratio
6. Operating at high altitude
7. Restricted carburetor air intake
8. Restricted exhaust outlets in engine, transom bracket or drive
9. Poor cylinder compression
10. Carburetor size and type correct for engine
11. Fuel pump pressure and vacuum
12. Boat overloaded, or load improperly placed
13. Engine overheating
14. Engine timing and ignition system operation
15. Remote control cables and linkage for proper attachment and travel

Defective Engine Lubricating System

Engine Components

Check:

1. Clogged or incorrect oil filter
2. Worn oil pump gears, cover or shaft

3. Worn or collapsed oil pump relief valve spring, or foreign material caught on valve seat
4. Oil pump relief valve plunger loose in cover
5. Damaged filter bypass grommet
6. Clogged oil pickup screen, broken tube or housing
7. Plugged crankshaft or blocked oil galleys
8. Dirty or defective hydraulic lifters, clogged push rod passages
9. Poor quality, incorrect viscosity or quantity of oil
10. Oil level too high - too much oil in the crankcase
11. Incorrect hose routing on remote filter systems
12. Water in crankcase oil from condensation, defective head gasket, oil cooler, or cracked manifold/block water passages

Oil Pressure Warning System

Check:

1. Oil gauge/warning horn operation and wiring
2. Engine temperature
3. Oil pressure gauge and warning horn sender operation and wiring
4. Oil level too high or too low, oil level should be within the "Safe" range on the dipstick

Low Battery Voltage After Short Storage

Engine/Boat Components

Check:

1. All electrical accessories including ignition circuit off
2. Disconnect main battery negative cable from battery
3. Connect ammeter or voltmeter in series between negative battery cable and negative battery post
 - Meter reading of "0" indicates no draw, test battery and charging system
 - Meter movement no matter how slight indicates draw from battery
4. Disconnect main engine harness 10-Pin Connector
 - Meter drops back to "0", problem caused by boat system, continue to isolate each boat electrical accessory until problem is found
 - Meter does not drop back to "0", problem caused by engine electrical system, continue to isolate each engine electrical accessory until problem is found
5. Repair or replace components as necessary

Engine — 5.0 & 5.7 Litre

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General Description

Cylinder Block	The engine block is made of cast iron and has eight cylinders arranged in a “V” shape with four cylinders in each bank. It is a one piece casting with the cylinders encircled by coolant jackets.
Cylinder Head	The cylinder heads are cast iron. The valve guides and valve seats are machined surfaces integral to the head. The spark plugs are located between the intake and exhaust ports.

Camshaft	A steel camshaft is supported by five bearings pressed into the engine block. The camshaft sprocket, mounted to the front of the camshaft is driven by the crankshaft sprocket through a camshaft timing chain. Motion from the camshaft is transmitted to the valves by hydraulic roller valve lifters, valve push rods, and ball-pivot type rocker arms.
Crankshaft	The crankshaft is made of cast nodular iron. It is supported by five crankshaft bearings that are retained by crankshaft bearing caps which are machined with the block for proper alignment and clearances. The 5.0L and 5.7L engines have two bolts per cap. The number five crankshaft bearing at the rear of the engine is the end thrust bearing. Four connecting rod journals (two rods per journal) are spaced 90 degrees apart.
Pistons and Connecting Rods	The pistons are cast aluminum that use two compression rings and one oil control ring assembly. The piston is a low-friction, lightweight design with a flat top and barrel-shaped skirt. The piston pins are chromium steel. They have a floating fit in the piston and are retained by a press fit in the connecting rod assembly. The connecting rods are made out of either forged powdered metal or forged steel. They are machined with the rod cap installed for proper clearances and alignment.
Lubrication	The gear-type oil pump is driven through an extension driveshaft. The extension driveshaft is driven by the distributor which is gear driven by the camshaft. The oil is drawn from the oil pan through a pickup screen and tube. Pressurized oil is delivered through internal passages to lubricate camshaft and crankshaft bearings and to provide valve lash control in the hydraulic valve lifters. Oil is metered from the valve lifters through the valve push rods to lubricate the valve rocker arms and ball pivots. Oil returning to the oil pan from the cylinder heads and the front camshaft bearing, lubricates the camshaft timing chain and crankshaft and camshaft sprockets.

Tools and Shop Equipment

A clean, well-lit, work area should be available. Other necessary equipment includes: a suitable parts cleaning tank, compressed air supply, trays to keep parts and fasteners organized, and an adequate set of hand tools. An approved engine repair stand will help aid with the work and help prevent personal injury or component damage.

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 are necessary for the correct assembly of various parts.

Accessories

The various procedures in this manual assume that the engine accessories have been removed. These accessories include all of the following:

- Power Steering Pump
- Alternator
- Distributor
- Water Supply Pump
- Accessory Brackets and Electrical Wiring
- Starter Motor

Cleaning

Remove the engine accessories before cleaning to provide better access to the engine's exterior surfaces. After removing the distributor, accessory brackets, etc., cover the openings with tape to prevent the entry of contaminants.

Methods used to clean the engine will depend on the means which are available. Steam cleaning, pressure washing, or solvent cleaning are some of the acceptable methods. Allow the engine to dry thoroughly before beginning any work.

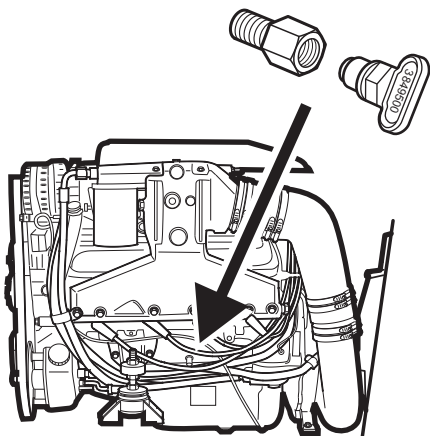
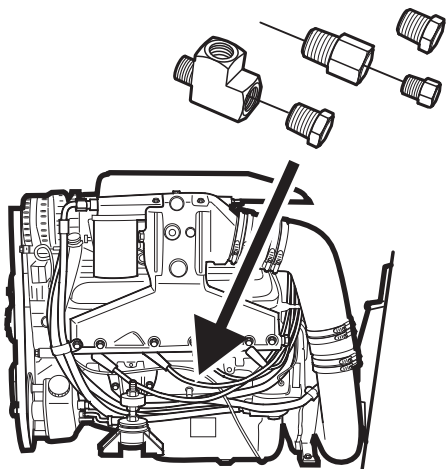
It is important that the engine be as clean as possible to prevent dirt, water, or any other contaminants from entering critical areas during disassembly.

Draining The Engine

Raw Water Cooled Engines

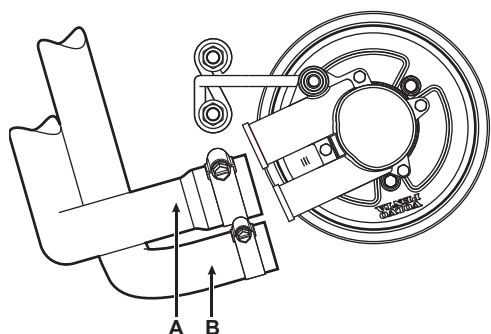
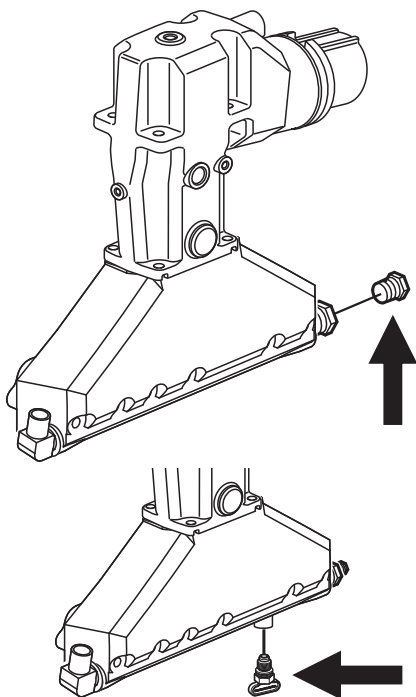
1. With the engine turned off, locate and open the engine drain petcocks located on both sides of the engine block.

NOTICE! Probe the drains with a wire to ensure rust particles have not blocked the drain.

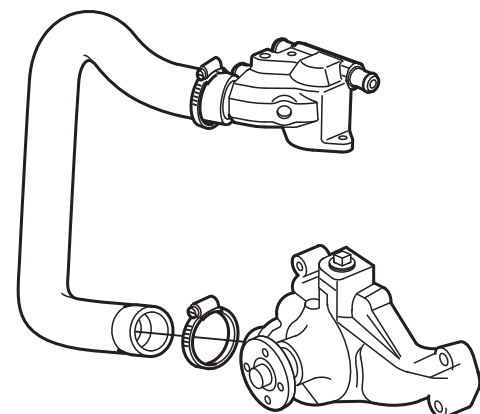


2. Remove drain plugs from exhaust manifolds. After the water has completely drained, reinstall the drain plugs and torque to 29 N•m (22 lb. ft.).

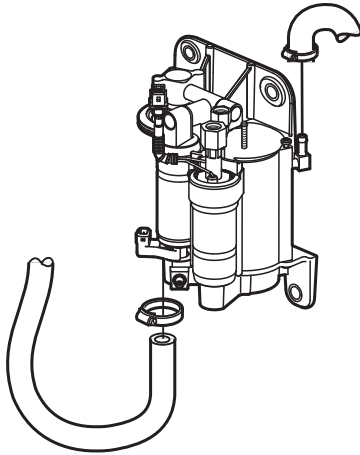
NOTICE! Probe the drains with a wire to ensure rust particles have not blocked the drain.



3. Note the hose orientation on the raw water pump. Loosen the hose clamps and remove the hoses from the raw water pump.
4. Crank the engine briefly, (1 or 2 crankshaft revolutions) but do not start the engine, to clear the water from the pump.

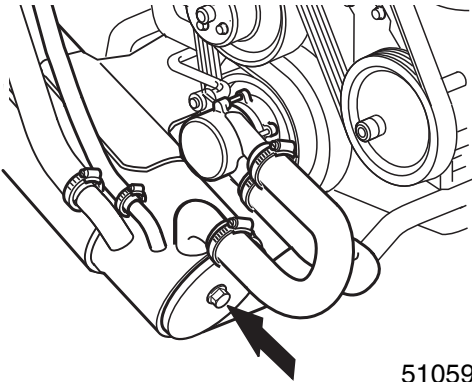


5. Loosen the hose clamp on the large diameter hose and remove it from the circulation pump.

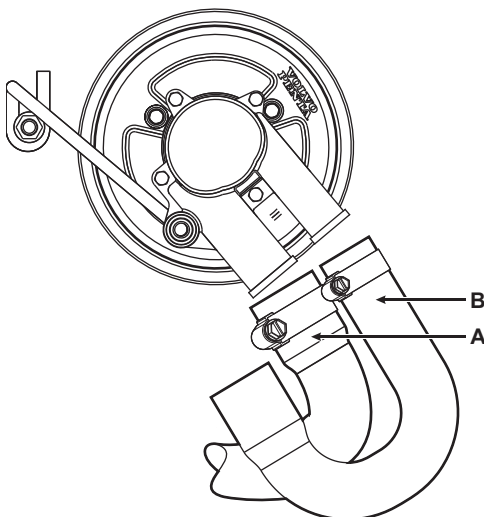


6. Loosen the hose clamp on the lower fuel cell cooling line and remove hose from fuel cell. Allow water to drain from hose.
7. Reinstall all hoses and secure all clamps in the same orientation as removed.

Draining seawater from the Closed Cooling System

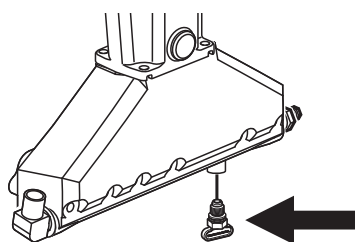
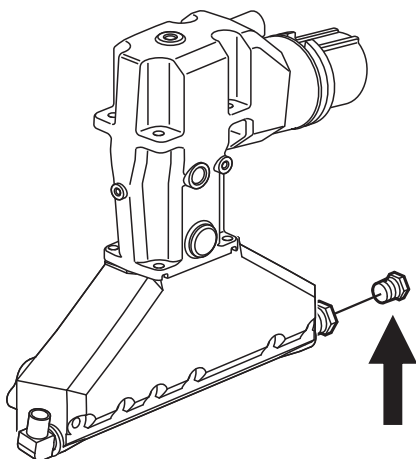


1. With the engine turned off locate and loosen the lower drain cap from the heat exchanger (1). After water has completely drained, retighten the lower drain cap of the heat exchanger to 18-30ft.lb. (25-41 Nm).

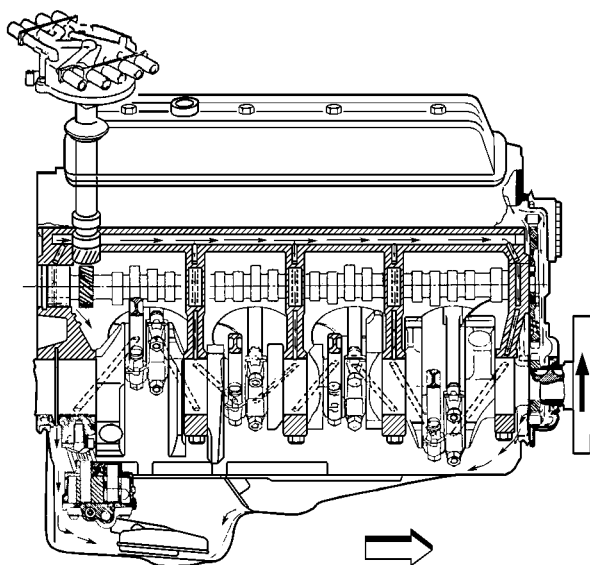


2. Note the hose orientation on the raw water pump. Loosen the hose clamps and remove the hoses from the raw water pump. Crank the engine briefly, (1 or 2 crankshaft revolutions) but do not start the engine, to clear the water from the pump. Reinstall the hoses and secure the clamps in the same orientation as removed.

3. Remove drain plugs from exhaust manifolds. Probe the drains with a wire to ensure rust particles have not blocked the drain. After water is completely drained, reinstall drain plugs and tighten securely.



Engine Lubrication



67757

Full pressure lubrication, through a full-flow oil filter is supplied by a gear-type

4. Oil is drawn up through the oil pump screen and passes through the pump to the oil filter. The oil filter is a full-flow paper

element unit with an anti-drain back valve. An oil filter bypass valve is used to ensure adequate oil supply, in the event the filter becomes plugged or develops excessive pressure drop.

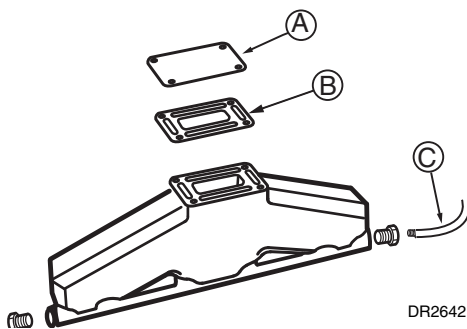
Filtered oil flows into the main gallery and then to the camshaft, balance shaft, rear bearing, and crankshaft bearings. The valve lifter oil gallery supplies oil to the valve lifters. Oil flows from the valve lifters through the hollow valve push rods to the valve rocker arms. Oil drains back to the crankcase through oil drain holes in the cylinder head. The camshaft timing chain is drip fed from the front camshaft bearing. The pistons and piston pins are lubricated by oil splash.

Exhaust Manifold

Removal

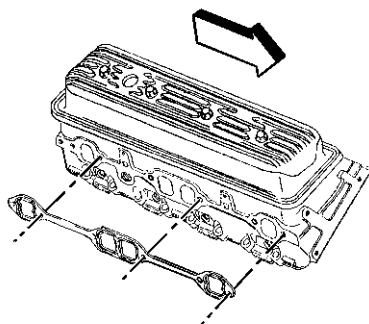
1. Drain water from exhaust manifolds.
2. Disconnect water hose from manifold.
3. Loosen upper exhaust hose clamps, then remove high rise elbow.
4. Remove manifold attaching screws, then remove the manifold.

Inspection

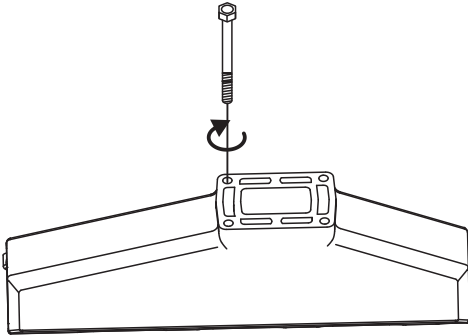


1. Inspect for cracks.
2. To pressure check manifold, use a plate such as pictured, and a new elbow gasket to seal water passage in manifold. Be sure to apply sealer to gasket. Install rubber drain caps to manifold and secure with clamps. Attach a Gearcase Pressure Tester (such as Stevens Company S-34) to the water inlet hose. A bushing can be made to secure pressure tester to hose. With the pressure tester attached to the manifold, submerge manifold in water. Pressurize the manifold to 10-15 PSI (22-25 kPa) and check for leaks. Manifold should not leak around clamps and plate. If so, retighten clamps or reseal plate. No drop in pressure should be realized.

Installation



1. Clean mating surfaces on manifold and head. Install new exhaust gasket, then install manifold and secure with screws. Tighten screws to 20-26 ft. lb. (27-35 N•m).



2. Install a new gasket and high rise elbow to manifold. Tighten bolts to 12-18 ft. lb. (16-24 N•m).

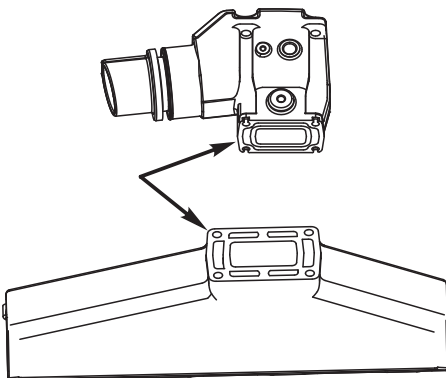
NOTICE! Clean threads in the mounting holes are critical for torquing of the riser bolts and the seal between the riser and manifold.

Check all riser mounting holes in manifolds for debris or excessive coating on threads.

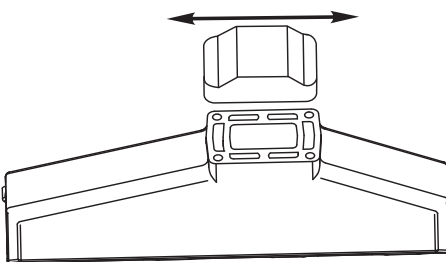
- Bolts should screw completely in to hole by hand, if not, run tap in holes to clear debris and coating.
- Use shop vacuum to remove debris from holes.

NOTICE! The gasket mounting surfaces must be clean and flat to insure the correct seal between the riser and manifold. Carefully follow the steps below to insure a good seal.

NOTICE! Before proceeding place shop towels in the manifold openings to prevent debris from entering the engine. When the cleaning process is done, use a shop vacuum to remove debris from the manifold, riser and engine.

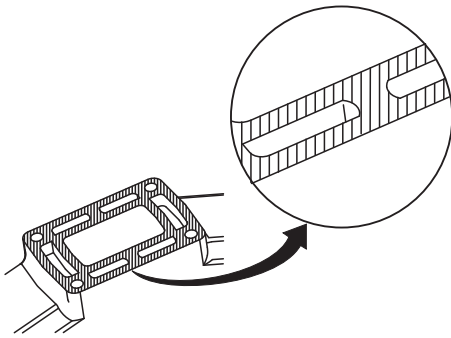


3. Clean the gasket mounting surfaces on both the riser and the manifold.
4. Use spray on gasket remover to remove ALL traces of riser gasket. Heavy scrapping with tools on gasket surfaces may gouge surface, preventing proper seal.
5. Follow pre-cautions on can of gasket remover to prevent damage to paint on manifold, riser or engine.



6. Use 80 grit sandpaper and a sanding block, or equivalent to smooth the gasket mounting surfaces on the riser and manifold.

NOTICE! Do not use rotary power sanding tools, they may leave a circular gouge in the surface.



Each area/section of gasket mounting surface (see example in picture) should be flat and smooth to a tolerance of 0.1mm.

If the surface can not be cleaned or sanded to this tolerance, the part must be machined flat at the gasket mounting surface.

If machined, the following applies;

- The maximum material that can be removed is 0.25mm (0.0098 in.)
- Machine flatness over the gasket surface is 0.075mm (0.0029 in.) maximum overall, with not more than 0.02mm (0.000787 in.) allowable over any 25mm (0.98 in.) span.
- Surface finish should not exceed 0.0032mm (0.0001259 in.) Roughness Average

If the surface can not be machined to these specifications the part must be replaced.

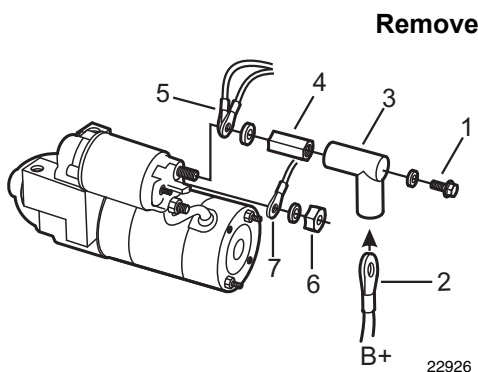
7. Place gasket over mounting surface on manifold.

NOTICE! Be careful not to scratch or cut the black coating on the riser gasket.

NOTICE! Do not use any sealant on the riser gasket.

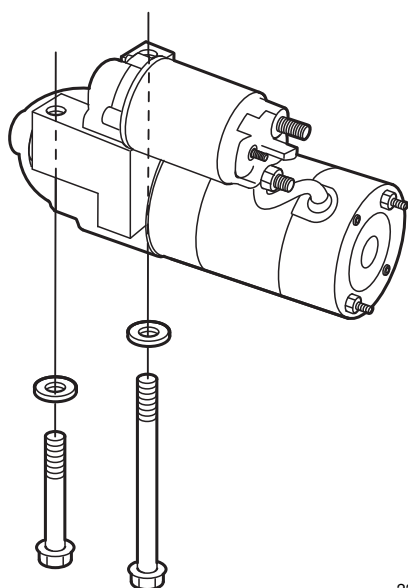
8. Install riser, on to exhaust manifold.
9. Make sure gasket is properly placed.
10. Install bolts and washers to secure riser.
11. Install any parts secured under bolts.
12. Torque riser bolts in a crossing pattern to 40 Nm
13. (30 ft. lb.). Make at least two passes to insure proper torque is reached.
14. Install all other parts mounted to risers.
15. Install exhaust hose and secure with clamps.
16. Connect water hose and secure with clamp.
17. Start engine and check for fuel leaks.

Starter



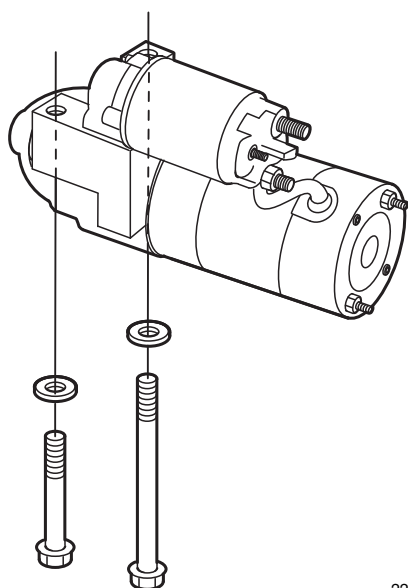
1. Disconnect power from the engine.
2. Remove battery cable (2) from solenoid extension nut
3. Remove solenoid extension nut (4) and cover (3) from solenoid.
4. Remove accessory wires from solenoid (5).
5. Remove start wire nut (6).
6. Remove start wire from solenoid start terminal (7).

NOTICE! GL engines have an additional purple wire attached to the solenoid "R" terminal.

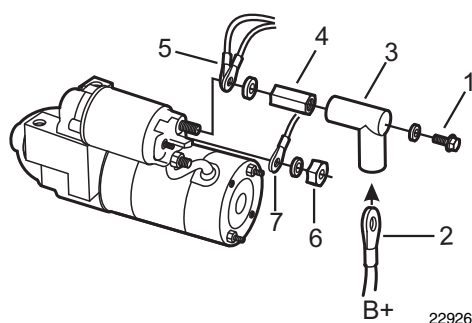


22518

Installation



22518



22926

7. Remove starter mounting bolts.
8. Remove starter.

1. Hold stator against engine mounting pad with mounting holes aligned.
2. Install starter bolts and tighten to 41-49 Nm (30-36 ft.lb).

3. Connect accessory wires (5) to solenoid.
4. Install solenoid extension nut (4) and washer on solenoid terminal. Tighten to 19 - 28 N•m (14 - 20 ft. lb.)
5. Install solenoid extension nut cover (3).
6. Connect battery cable (2) to solenoid extension nut.
7. Install battery cable bolt (1) and washer. Tighten to 19 - 28 N•m (14 - 20 ft. lb.)

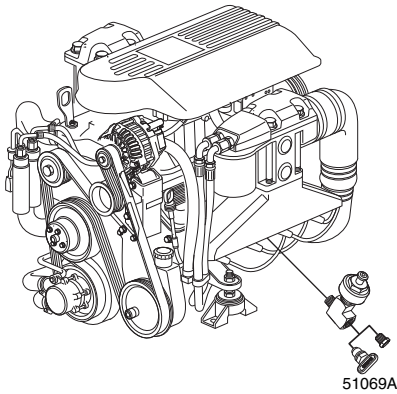
NOTICE! DO NOT overtighten the battery cable bolt. The starter solenoid will be damaged.

8. Install start wire (7) on solenoid stud "S".
9. Install start wire nut (6) and washer. Tighten to 3 - 5 N•m (26 - 44 in. lb.)
10. Connect start wire to solenoid start terminal (1).

11. On GL models, connect the purple wire to the solenoid "R" terminal in the same manner.

Intake Manifold

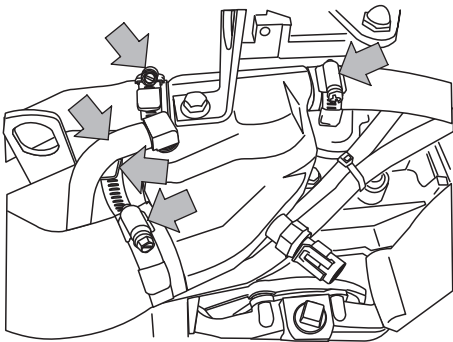
Removal



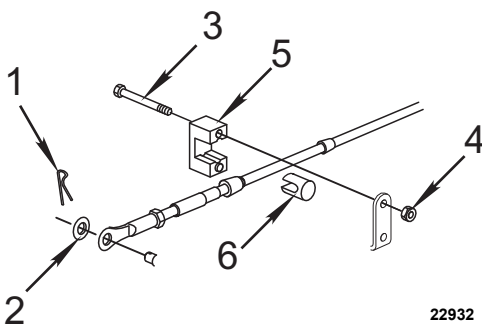
1. Disconnect power from engine.
2. Drain water from engine block. See *Draining The Engine* on page 33.
3. If the engine has closed cooling installed, remove drain plugs from engine block. Catch the coolant from the engine and dispose of properly.

NOTICE! Volvo Penta closed cooling system engines come filled with Ethylene Glycol coolant. Follow all local regulations for the disposal of Ethylene Glycol anti-freeze.

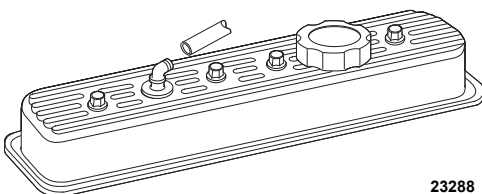
Disconnect:



4. Disconnect hoses from thermostat housing.



5. Disconnect Throttle cable.
 - a. Remove cotter pin (1) and washer (2) and remove throttle cable from throttle lever.
 - b. Loosen and remove anchor block bolt (3) and nut (4).
 - c. Release cable block (5) and trunnion (6).



6. Crankcase ventilation hose from rocker arm covers (both sides if applicable).

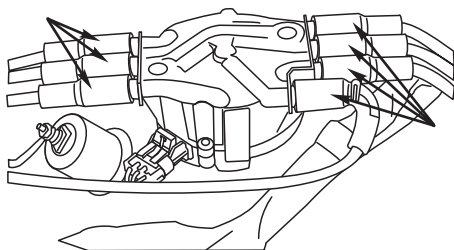
Remove:

1. Disconnect wire at temperature gauge sender unit and engine wiring harness from alternator.

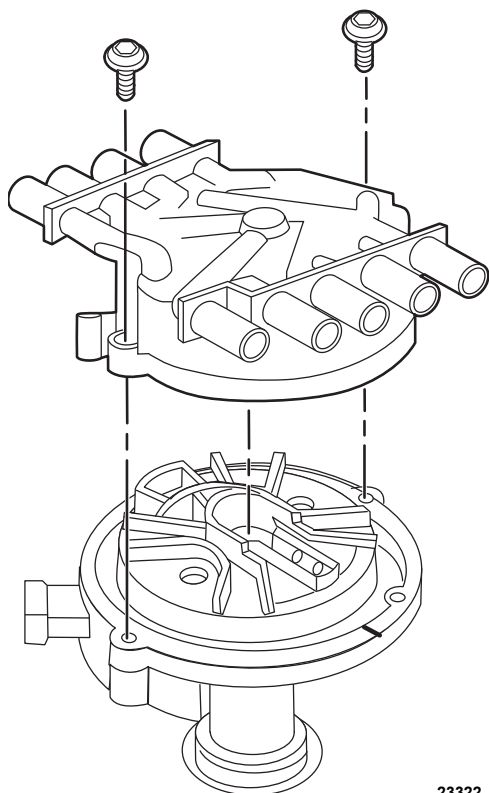
Remove Distributor, Gi and GXi Models

GL Models: See ***Electric, Fuel and Ignition Workshop Manual***.

1. Disconnect distributor high tension leads and ignition primary lead from distributor cap.

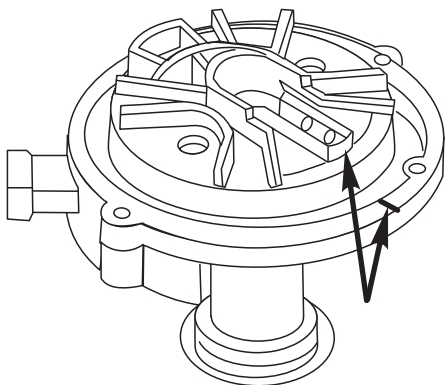


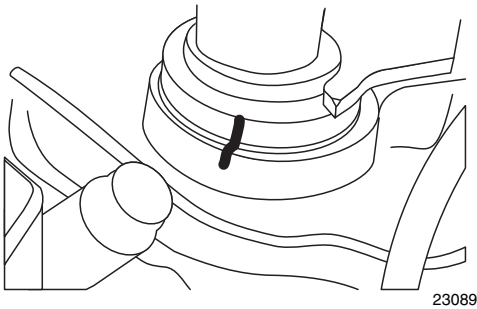
2. Remove the distributor cap bolts and discard.
3. Remove the distributor cap.



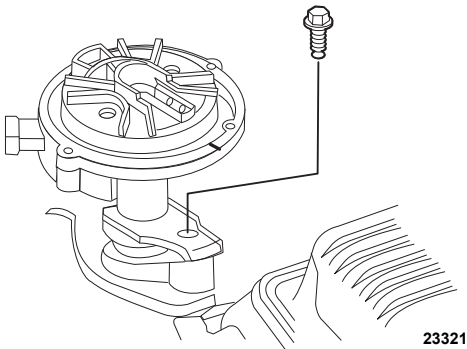
23322

4. Mark the position of the rotor on the housing.

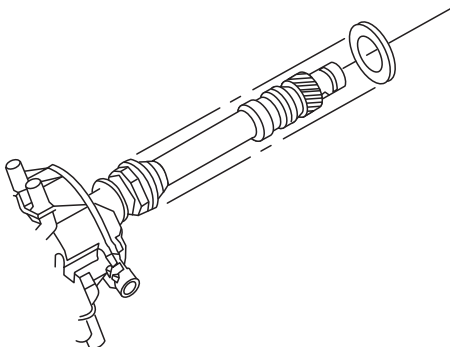




5. Scribe a line on distributor housing and intake manifold for reassembly in the same position.



6. Loosen hold down clamp and remove the distributor.

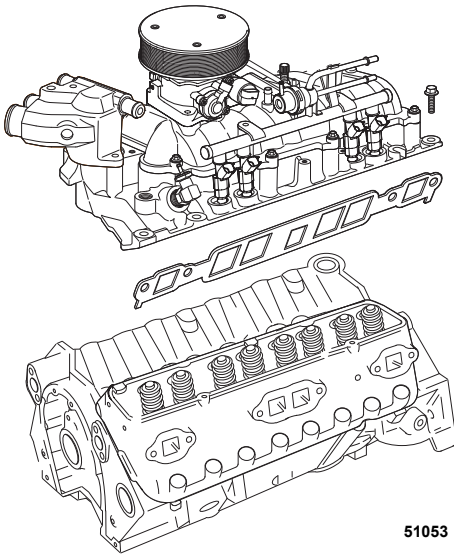


7. Remove Distributor and discard Gasket.
8. Disconnect and remove alternator.
9. Remove Fuse box.
10. Carburetor fuel line from carburetor and fuel pump or fuel lines from fuel rails. To disconnect fuel lines from fuel rail, see **Quick Connect Fitting Service** in *EFI Diagnostic Workshop Manual*.



CAUTION!

Refer to Fuel Pressure Relief Procedures found in *EFI Diagnostic Workshop Manual* before servicing any part of the fuel system. Failure to follow these procedures could result in personal injury.



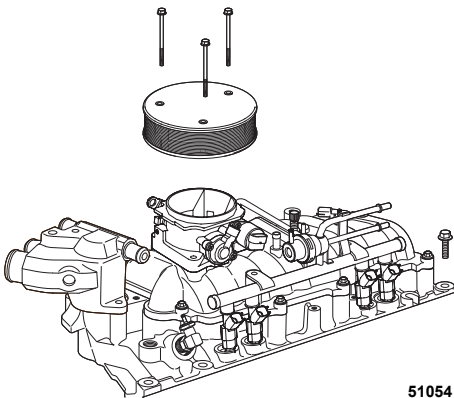
51053

Clean:

11. Remove intake manifold attaching bolts. Lift manifold from engine. Discard front and rear seals and gaskets.
- NOTICE!** If manifold is to be replaced, transfer: carburetor or throttle body, fuel rail assemblies, thermostat and housing (use new gasket), throttle cable anchor block assembly, distributor clamp and temperature sending unit. Transfer additional hardware as required.

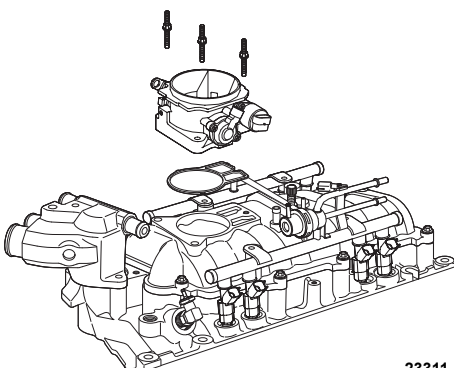
- Old pieces of gasket or RTV from the gasket surfaces.
- Excessive carbon build-up in the intake passages of the intake manifold.
- Scale and deposits from the coolant passages of the intake manifold.

**Disassemble Intake Manifold
(Gi, GXi, OSi, & OSXi)**



51054

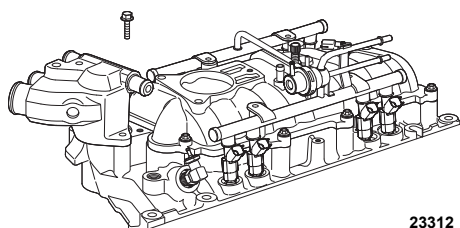
12. Remove Flame arrestor and bracket.



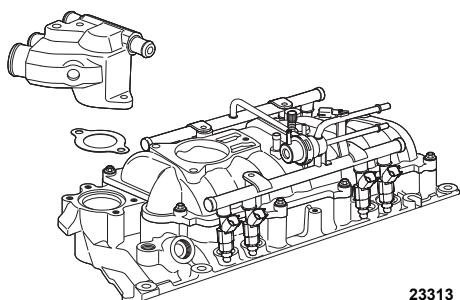
23311

13. Remove throttle body attaching studs.
14. Remove throttle body and gasket. Discard the gasket.

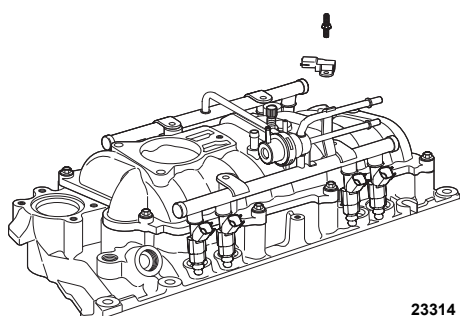
15. Remove Thermostat housing bolts.



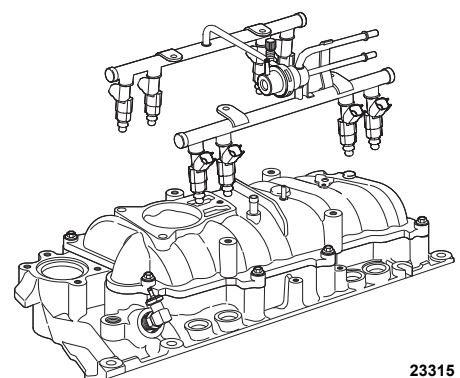
16. Remove Thermostat housing and discard gasket.



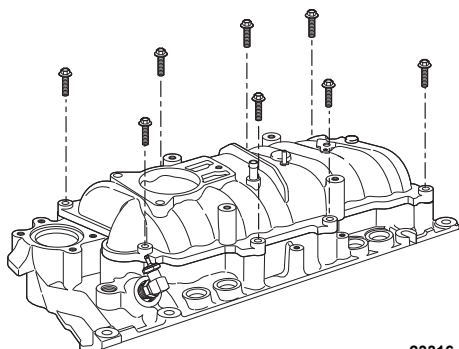
17. Remove MAT/MAP sensor stud and remove sensor from manifold.



18. Remove four retaining studs and remove fuel rail assembly.



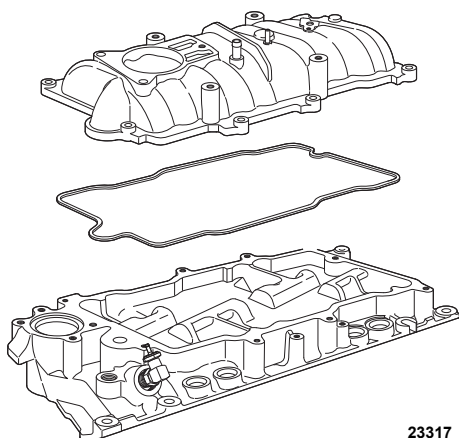
19. Remove upper intake manifold attaching bolts.



23316

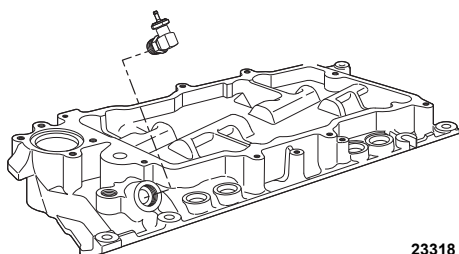
20. Remove upper intake manifold.

21. Remove and discard upper intake manifold to lower intake manifold gasket.



23317

22. Remove impulse limiter.



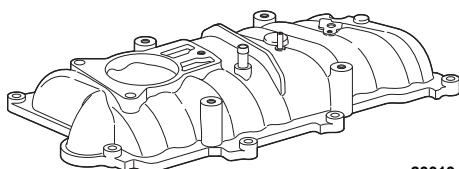
23318

Clean and Inspect

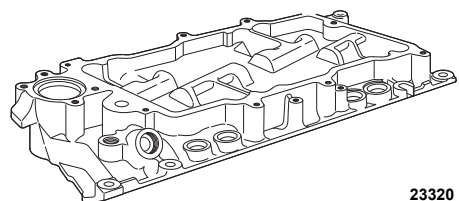


Wear Safety Glasses

1. Clean the upper intake manifold in cleaning solvent.
2. Dry with compressed air.
3. Clean the lower intake manifold in cleaning solvent.
4. Dry with compressed air.

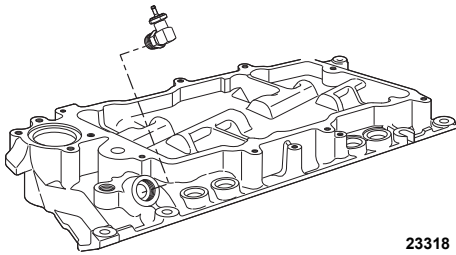


23319



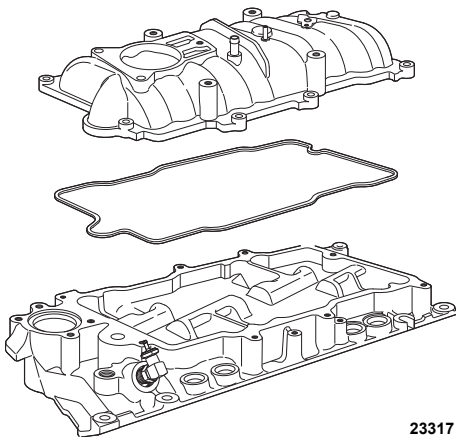
23320

Assemble Intake Manifold



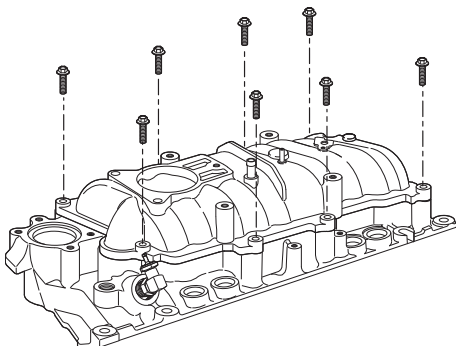
23318

1. If removed, coat the threads of the impulse limiter with sealing compound P/N 1141570.
2. Install impulse limiter into lower intake manifold and tighten to 14-19 N•m (10-14 ft. lb.).



23317

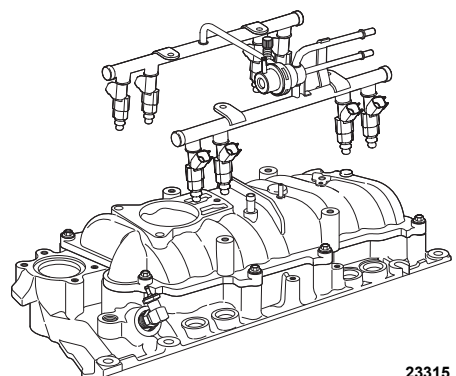
3. Place a NEW upper intake manifold gasket into the upper intake manifold gasket groove.
4. Place the upper intake onto the lower intake manifold.



23316

NOTICE! If reusing the fasteners, apply threadlock Volvo Penta P/N 1161053 or equivalent to the threads of the fuel meter body bracket bolt.

5. Install upper intake manifold bolts.
6. Tighten the upper intake manifold bolts in two stages.
 - First pass 5 N•m (44 in. lb.).
 - Final pass 9 N•m (80 in. lb.).



23315

7. Inspect O-rings on fuel injectors. Replace any damaged, cut, or missing O-rings.
8. Install the fuel injectors into the lower intake manifold.
9. Install the fuel rail retaining studs and tighten to

Intake Manifold Installation

NOTICE! Do NOT reuse intake manifold gaskets.

Install or Connect:

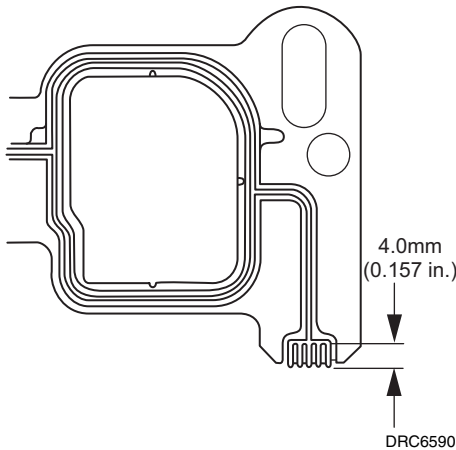
Sealant to the intake manifold gasket, cylinder head side.

NOTICE! Care must be used to apply the correct amount of sealant onto the gaskets. Applying excessive amounts of sealant may prohibit the intake gaskets from sealing properly.

1. Apply a 4.0 mm (0.157 in) patch of adhesive Volvo Penta P/N 1161277 or equivalent to the cylinder head side of the lower intake manifold gasket at each end.

NOTICE! The lower intake manifold gasket must be installed while the adhesive is still wet to the touch.

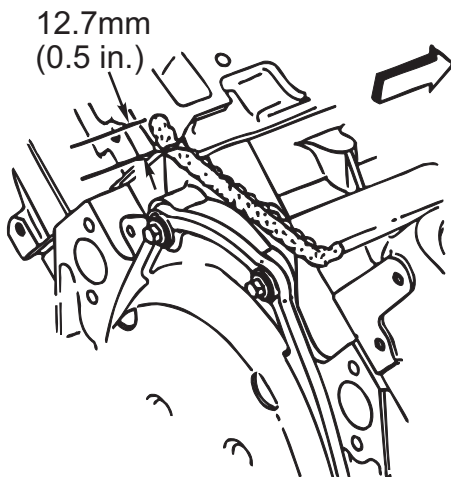
2. Install the lower intake manifold gasket onto the cylinder head. Use the gasket locator pins in order to properly seat the lower intake manifold gasket on the cylinder head.



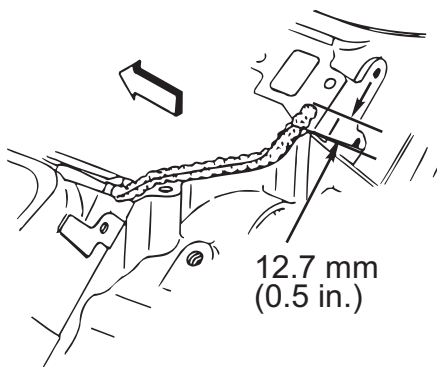
NOTICE! Care must be used to apply the correct amount of sealant onto the gaskets. Applying excessive amounts of sealant may prohibit the intake manifold gaskets from sealing properly.

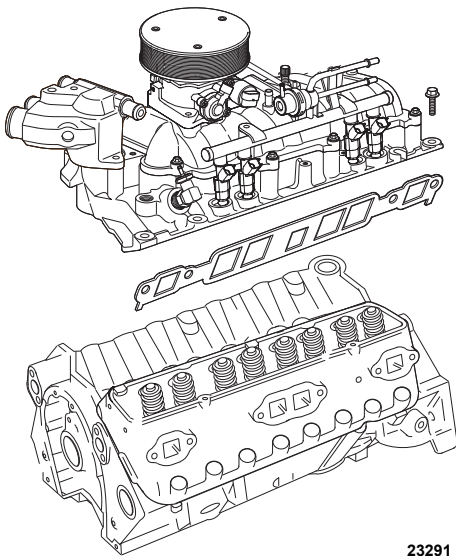
NOTICE! The lower intake manifold must be installed and the fasteners tightened while the adhesive is still wet to the touch.

3. Apply a 5.0 mm (0.197 in) bead of adhesive Volvo Penta P/N 1161277 or equivalent to the front top of the engine block.

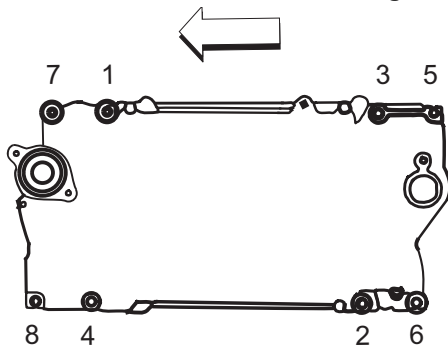


4. Apply a 5.0 mm (0.197 in) bead of adhesive Volvo Penta P/N 1161277 or equivalent to the rear top of the engine block. Extend the adhesive bead 13 mm (0.50 in) onto each lower intake manifold gasket.





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Tighten:

5. Install the intake manifold assembly onto the engine block.
6. If reusing the fasteners, apply threadlock Volvo Penta P/N 1161053 or equivalent to the threads of the manifold bolts.
7. Install the manifold bolts.

NOTICE! Proper lower intake manifold fastener tightening sequence and torque is critical. Always follow the tightening sequence, and torque the intake manifold bolts using the 3 step method. Failing to do so may distort the crankshaft bearing bore alignment and cause damage to the crankshaft bearings.

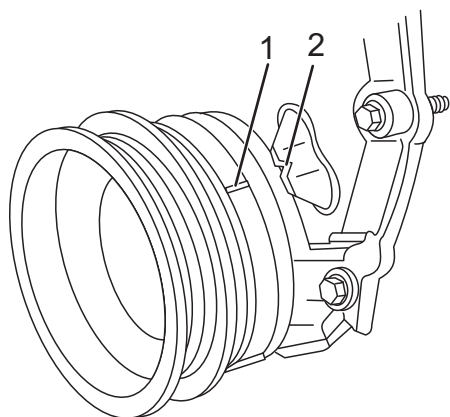
8. Tighten the intake manifold bolts.
 - a. Tighten the bolts in sequence (1-8) on the first pass to 3 N•m (27 lb. in).
 - b. Tighten the bolts in sequence (1-8) on the first pass to 12 N•m (106 lb. in).
 - c. Tighten the bolts in sequence (1-8) on the first pass to 15 N•m (11 lb. ft.).
9. Connect fuel lines to fuel rail. See Quick Connect Fitting Service on page 346 of *EFI Diagnostic Workshop Manual* 7742218.

Distributor Installation

Install distributor with rotor and aligned exactly as marked during removal.

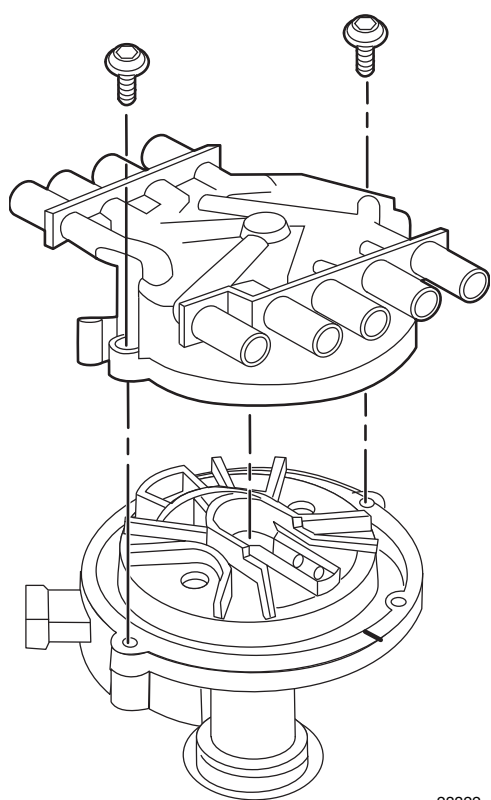
NOTICE! If the crankshaft was moved while distributor was out, complete ignition timing procedure must be followed. See below.

Gi and GXi models



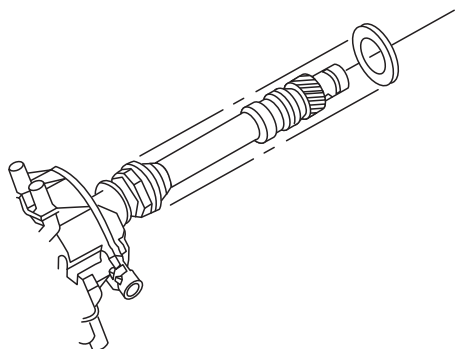
GL models: See ***Electric, Fuel and Ignition Workshop Manual***.

1. Rotate the crankshaft balancer clockwise until the alignment marks on the crankshaft balancer (1) are aligned with the tabs on the engine front cover (2) and the number 1 piston is at top dead center of the compression stroke.



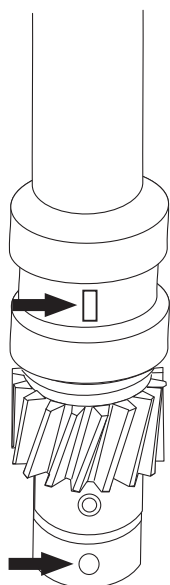
23322

2. If not already removed, remove and discard the distributor cap screws.
3. Remove the distributor cap

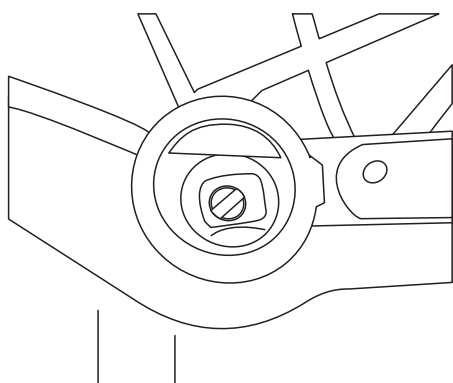


4. Install NEW distributor gasket onto the distributor.

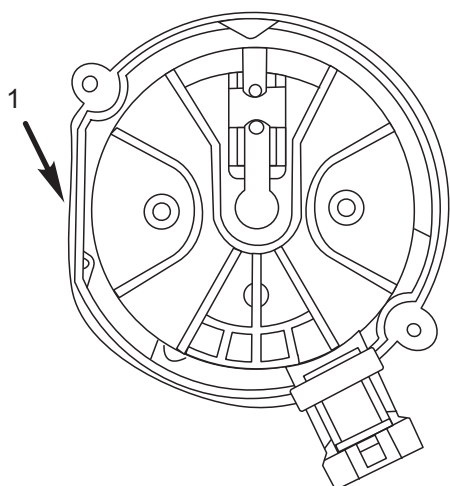
5. Align the indent hole on the distributor gear with the paint mark on the distributor housing.



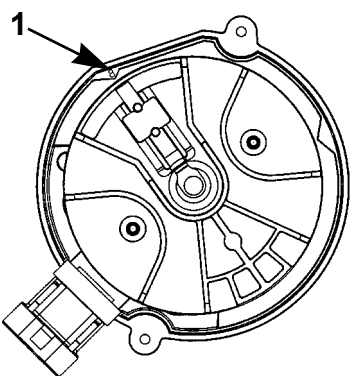
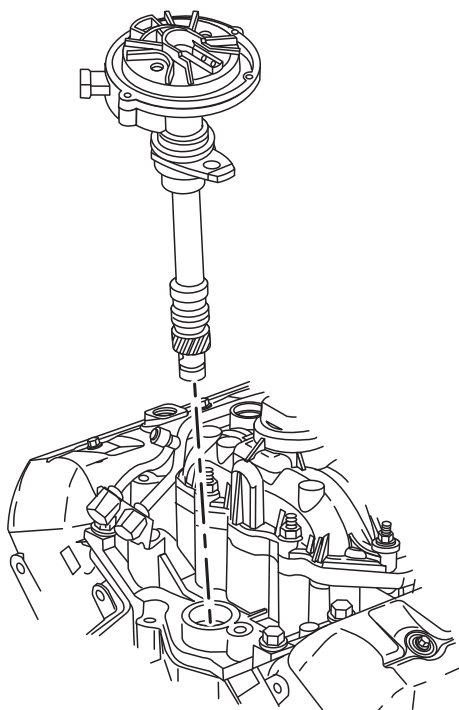
6. Align the slotted tang in the oil pump driveshaft with the distributor driveshaft. Rotate the oil pump driveshaft with a screwdriver if necessary.



7. Align the flat (1) in the distributor housing toward the front of the engine.



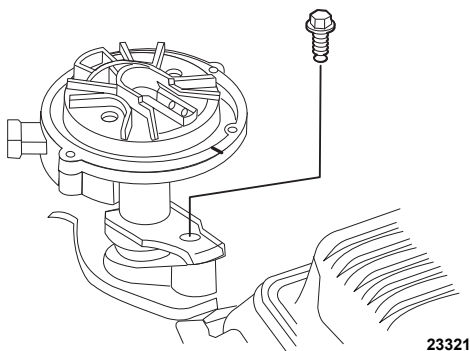
8. Install the distributor and distributor clamp. The flat in the distributor housing must be pointing toward the front of the engine.



9. Once the distributor is fully seated, align the distributor rotor segment with the number 8 pointer (1) that is cast into the distributor base.

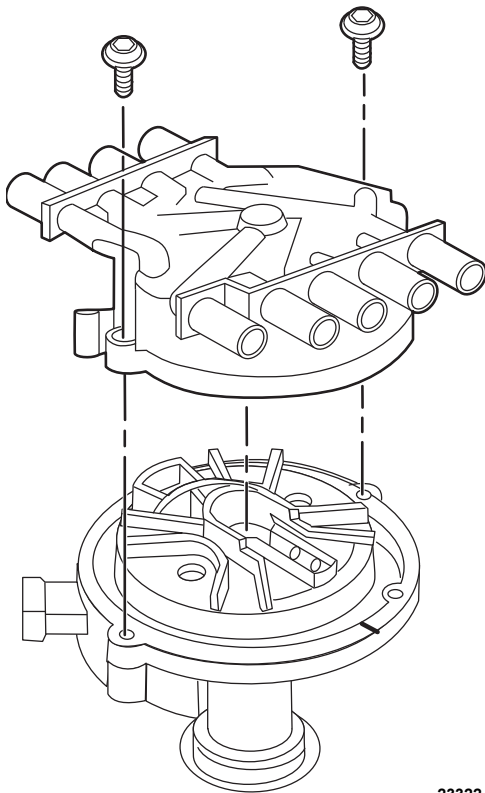
NOTICE! If the distributor rotor segment does not come within a few degrees of the number 8 pointer, the gear mesh between the distributor and camshaft may be off a tooth or more. Repeat the procedure again in order to achieve proper alignment.

68505



23321

10. Install the distributor clamp bolt. and Tighten the bolt to 25 N.m (18 lb. ft.).

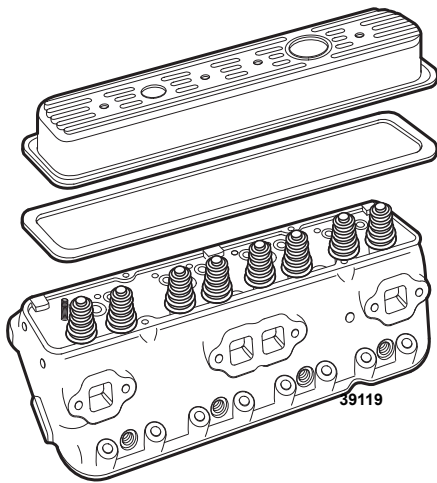


23322

Alternator with mounting bracket.**Connect:**

11. Install the distributor cap and NEW distributor cap bolts. Tighten the screws to 2.4 N.m (21 lb. in).
12. Set timing, GL Models see *Electrical Fuel and Ignition Workshop Manual*. Gi and GXi Models see *EFI Diagnostic Workshop Manual, On Board Repair*.
13. Install distributor cap and high tension leads. See the General Information section in Electrical/Ignition/Fuel Service Manual for correct firing order and spark plug wire routing.
14. Install oil pressure sending unit.
15. All electrical connections. Apply black neoprene dip, or equivalent, on all exposed connections.
16. Fuel lines to carburetor and fuel pump or throttle body and fuel pump/vapor separator.
17. Throttle cable.
18. All water hoses, and close all drain petcocks.
19. Both crankcase ventilation hoses.
20. Battery cables.
21. Start engine. Check ignition timing, carburetor idle speed and mixture. Check for leaks.

Rocker Arm Cover



- Remove:**
1. Valve rocker arm cover bolts.
 2. Valve rocker arm cover.
 3. Gasket.

- Clean:**
- a. Parts in solvent. Remove all sludge and varnish.
 - b. Old gaskets from the gasket surfaces.

- Inspect:**
- a. Gasket flanges for bending or damage.
 - b. Rubber grommets and parts for deterioration.

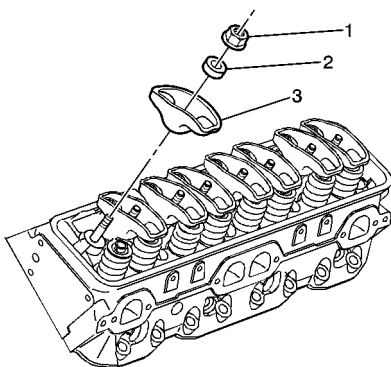
- Installation**
1. New gasket.
 2. Valve rocker arm cover.
 3. Valve rocker arm cover bolts.

- Tighten:**
1. Valve rocker arm cover bolts to 106 in. lb. (12 N•m).

Valve Train

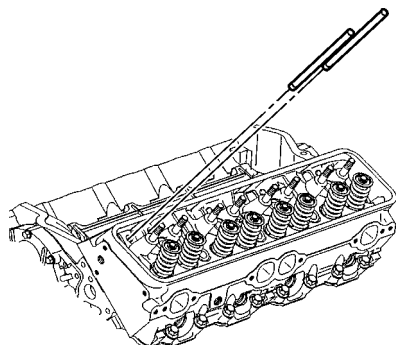
- Removal**
- NOTICE!** Store all reusable components in an exact order, so they can be reassembled in the same wear pattern location from which they were removed. Mark the front end of the retainer.

1. Remove rocker arms.



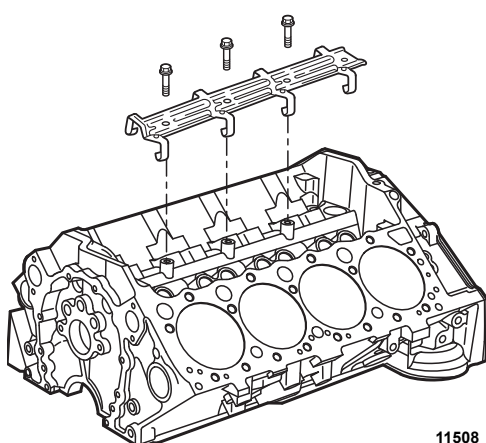
182835

2. Remove pushrods and keep in order with the valve lifters and rocker arms.



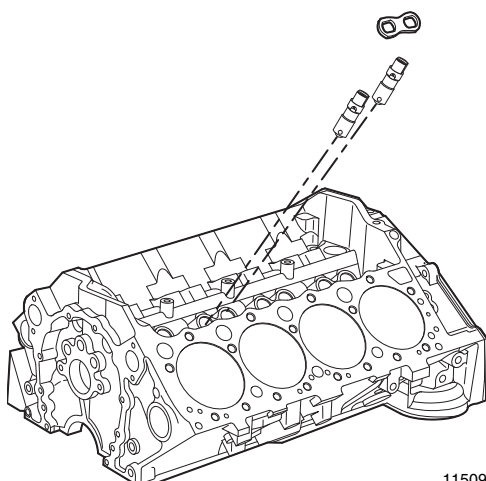
51055

3. Remove valve lifter retainer bolts and valve guide retainer.

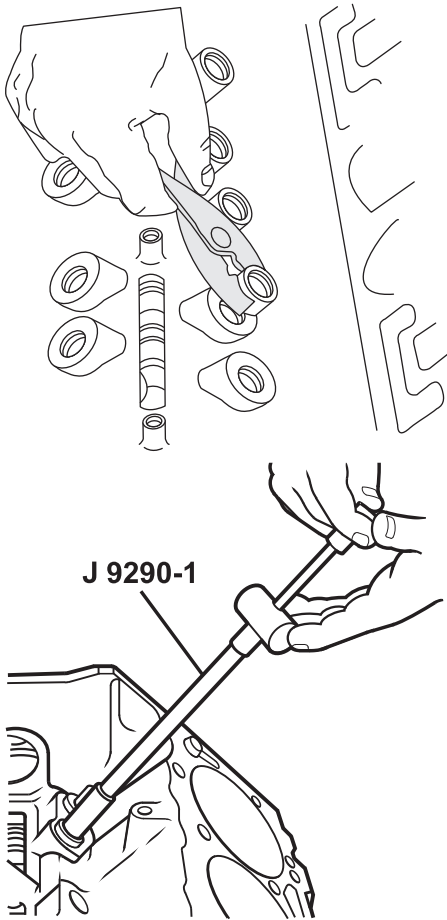


11508

4. Remove the valve guides and valve lifters.



11509



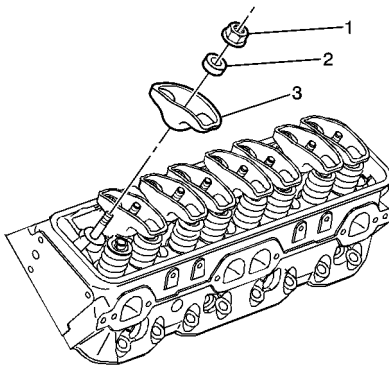
5. Remove the lifters one at a time using J 9290-01/J 3049 or equivalent and place them in an organizer rack.
6. Store all reusable components in an exact order, so they may be reassembled in the same wear pattern location from which they were removed.

Clean:

1. Mark, sort and organize the components for assembly.
2. Clean the components with cleaning solvent.
3. Dry the components with compressed air.

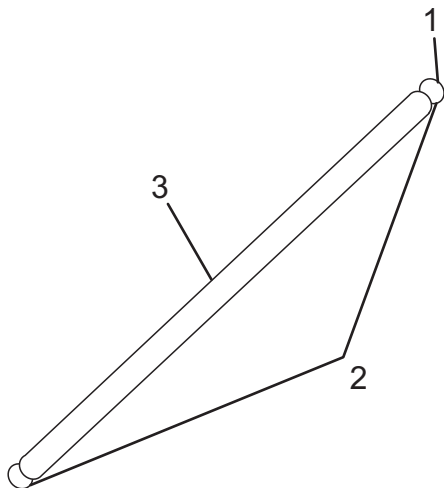
Inspect:

NOTICE! Parts that are to be reused must be marked, sorted and organized for assembly.



182835

4. Inspect the valve rocker arm components for the following:
 - Wear or scoring of the valve rocker arm (3) ball area.
 - Valve rocker arm (3) pushrod sockets and valve stem contact surface. The contact surfaces should be smooth with no scoring or excessive wear.
 - Valve rocker arm ball (2) for wear or scoring. The contact surfaces should be smooth with no scoring or excessive wear



5. Inspect the valve push rods for the following:

- Restriction of the oil passage (1)
- Wear or scoring of the end contact surfaces (2). The end contact surfaces must be smooth with no scoring or excessive wear.
- Shaft for bends (3). Roll the valve pushrod on a flat surface to determine if the valve pushrod is bent.

Valve Lifters and Guides Clean and Inspect

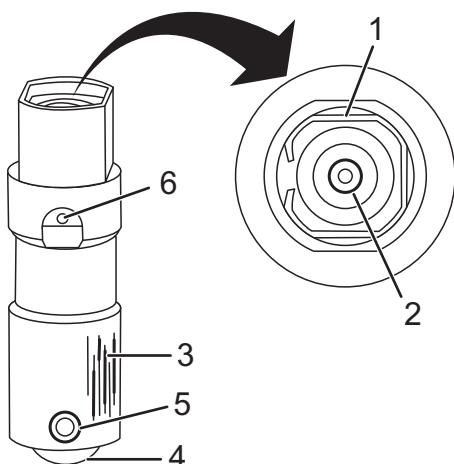
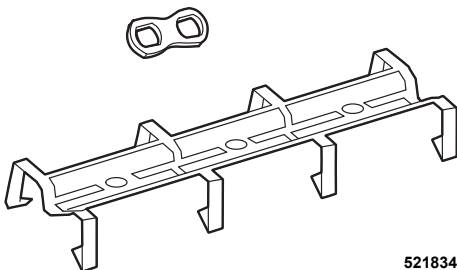
NOTICE! Parts that are to be reused must be marked, sorted and organized for assembly.

1. Mark, sort and organize the components for assembly.
2. Clean the components with cleaning solvent.



CAUTION! Always wear safety glasses when using compressed air.

3. Dry the components with compressed air.
4. Inspect the valve lifter pushrod guides (1) for excessive wear, cracks or damage.
5. Inspect the valve lifter guide retainer for wear, damage or stress cracking in the leg areas (2) and wear or damage in the bolt holes (3).



6. Inspect the valve lifter for the following:

- Broken or damaged clip (1)
- Worn pushrod socket (2)
- Scuffed or worn lifter body (3)

If the valve lifter shows scuffing or wear, inspect the engine block valve lifter bores for wear.

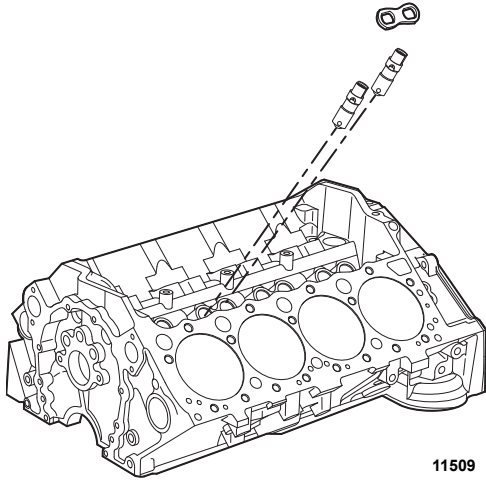
- Worn roller (4)
- Loose or damaged pin (5)
- Plugged oil hole (6)

Installation

If replacing valve lifters, change the engine oil and filter, and add GM Engine Oil Supplement, P/N 1052367, or equivalent to the engine oil whenever a new camshaft is installed.

NOTICE! Lubricate the valve lifter bodies and roller with GM Engine Oil Supplement, P/N 1052367, or equivalent.

Valve Lifter Installation

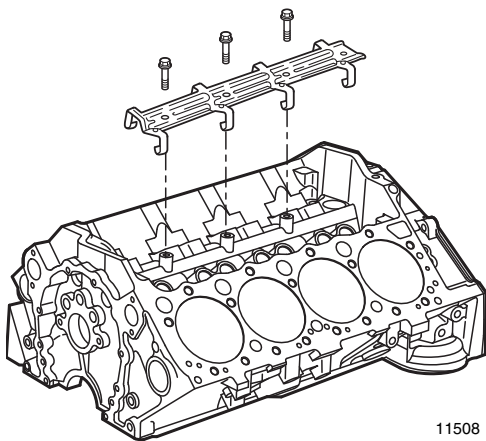


1. Apply lubricant GM P/N 12345501 or equivalent to the valve lifter rollers.

NOTICE! If reusing the valve lifters, install the valve lifters in the original positions.

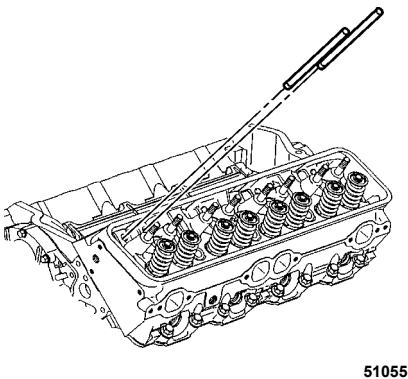
2. Install the valve lifters.

Valve Lifter Pushrod Guides



3. Install the valve lifter pushrod guides.
4. Tighten the valve lifter pushrod guide bolts to 25 N•m (18 lb. ft.).

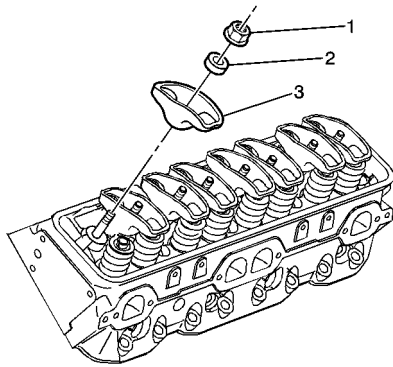
Valve Push Rod



NOTICE! Be sure to keep parts in order. Parts must be reinstalled into the original location and position.

1. Install the valve pushrods.
 - Seat the valve push rods into the socket of the valve lifters.

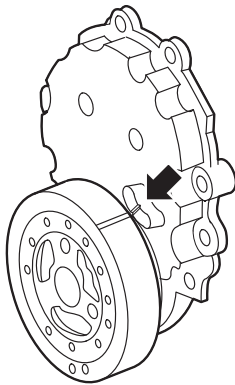
Install Rocker Arm Assemblies



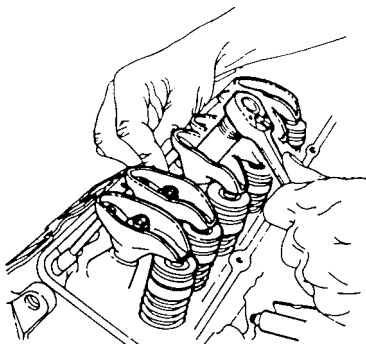
182835

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

Valve Lash Adjustment

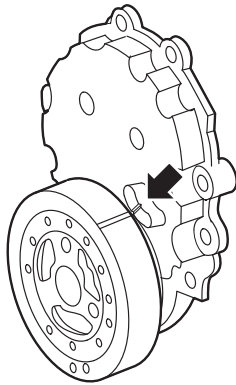


195336

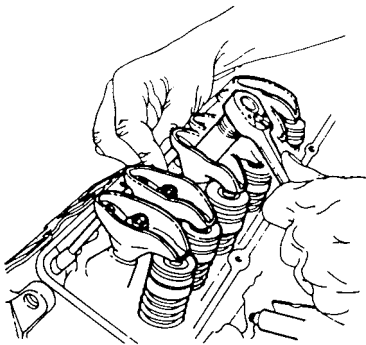


22759

1. Turn the valve rocker arm nuts clockwise until all of the valve lash is removed.
2. Turn the crankshaft clockwise until the alignment mark on the crankshaft balancer is aligned with the notch in the engine front cover tab.
3. Look at the number 1 cylinder valves as the crankshaft balancer alignment mark approaches the notch in the engine front cover tab. If a valve moves as the alignment mark moves into position, the engine is in the number 6 firing position. If this happens, turn the crankshaft clockwise one revolution in order to reach the number 1 firing position.
4. With the engine in the number 1 cylinder firing position, adjust the exhaust valves for cylinder numbers 1, 3, 4, and 8 and the intake valves for cylinder numbers 1, 2, 5, and 7 using the following process:
 - Turn the valve rocker arm nut counterclockwise until the valve lash is felt in the valve pushrod.
 - Turn the valve rocker arm nut clockwise until all the valve lash is removed (zero valve lash). Zero valve lash can be felt by moving the pushrod up and down between you thumb and forefinger until there is no more up and down movement of the pushrod.
 - When all the valve lash is removed, then turn the valve rocker arm nut clockwise 1 additional turn (360°)



195336



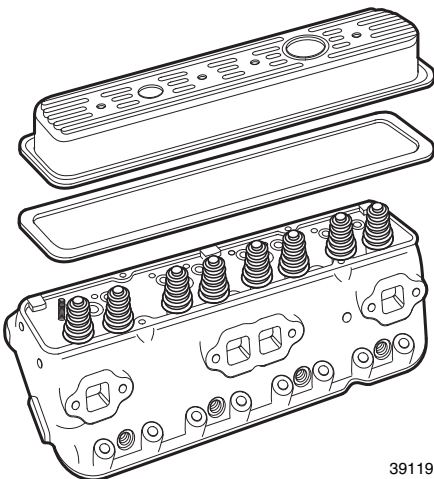
22759

5. Turn the crankshaft clockwise 1 revolution until the alignment mark on the crankshaft balancer is aligned with the notch in the engine front cover tab.

6. With the engine in the number 6 cylinder firing position, adjust the exhaust valves for cylinder numbers 2, 5, 6 and 7 and the intake valve for cylinder numbers 3, 4, 6 and 8 using the following process:

- Turn the valve rocker arm nut counterclockwise until the valve lash is felt in the valve pushrod.
- Turn the valve rocker arm nut clockwise until all the valve lash is removed (zero valve lash). Zero valve lash can be felt by moving the pushrod up and down between you thumb and forefinger until there is no more up and down movement of the pushrod.
- When all the valve lash is removed, then turn the valve rocker arm nut clockwise 1 additional turn (360°)

Valve Rocker Arm Cover Installation



39119

1. Install the NEW valve rocker arm cover gasket into the groove of the valve rocker arm cover.

NOTICE! Do not reuse the valve rocker arm cover gasket or the valve rocker arm cover grommets.

2. Install the NEW valve rocker arm cover bolt grommets into the valve rocker arm cover.
3. Install the valve rocker arm cover onto the cylinder head.
4. Install the valve rocker arm cover bolts.
5. Tighten the valve rocker arm cover bolts to 12 N.m (106 lb. in).

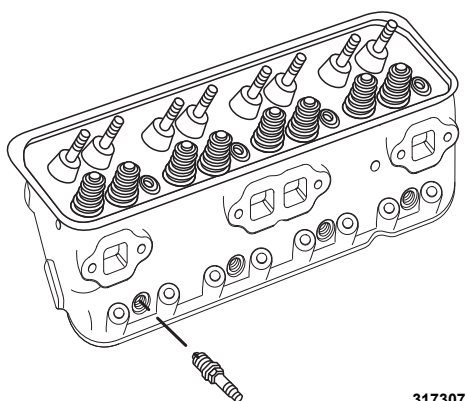
Cylinder Head

Removal

Intake manifold See *Intake Manifold* on page 41.

Remove rocker arm covers See *Rocker Arm Cover* on page 54.

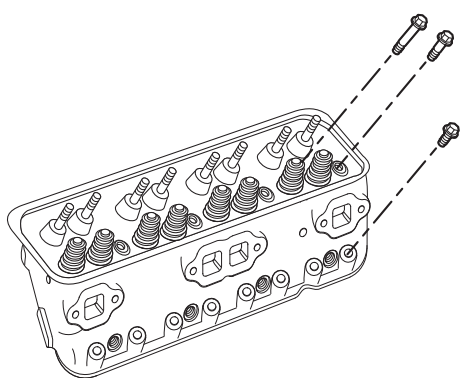
1. Remove spark plugs.



317307

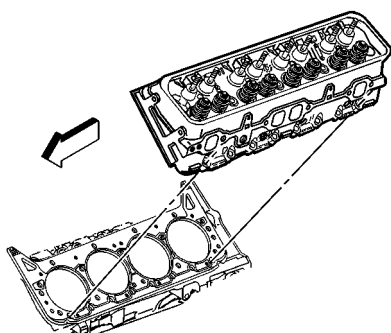
2. Remove cylinder head bolts.

NOTICE! Place cylinder head on two wooden blocks to prevent damage.



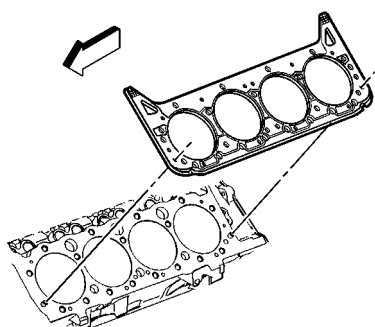
317217

3. Remove cylinder heads.



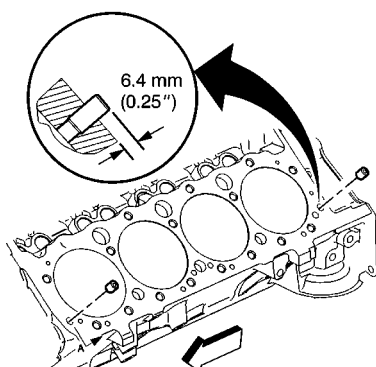
317227

4. Remove and discard head gaskets.



317233

5. If required, remove the dowel pin (cylinder head locator).

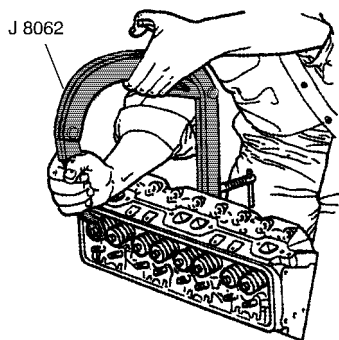


182846

Cylinder Head Disassemble and Recondition

Tool Required: J 8062 Valve Spring Compressor

Disassemble:



34468

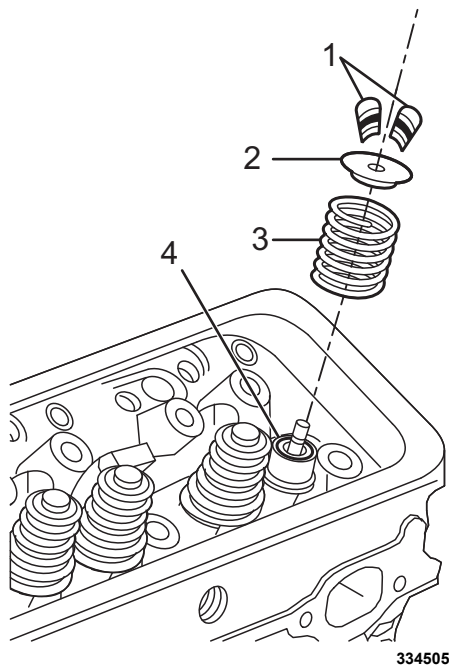
1. Compress the springs with J 8062.



CAUTION!

Wear safety glasses. Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

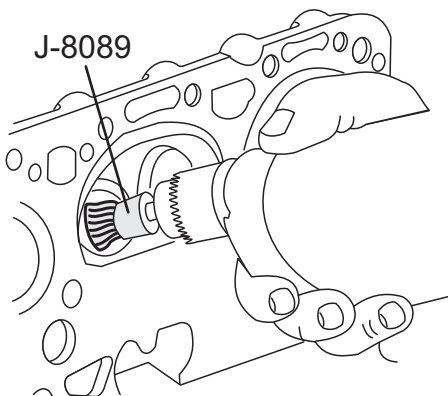
NOTICE! Mark, sort and organize the components so that the components can be reinstalled in their original location and position.



2. Remove the valve stem keys (1).
3. Remove the J 8062 from the cylinder head.
4. Remove the valve spring cap (2).
5. Remove the valve spring (3).
6. Remove the valve stem oil seal (4).
7. Discard the valve stem oil seal.
8. Remove the valve.

Cylinder Head Clean and Inspect

Clean:



Tools Required

J 8001 Dial Indicator Set

J 8089 Carbon Removing Brush

J 9666 Valve Spring Tester

1. Clean the valve stems and cylinder heads on a buffing wheel.
2. Clean the following components in cleaning solvent:
 - Valve stem keys (1)
 - Valve spring cap (2)
 - Valve spring (3)
 - Cylinder head
3. Dry the components with compressed air.



CAUTION! Always wear safety glasses when using compressed air.

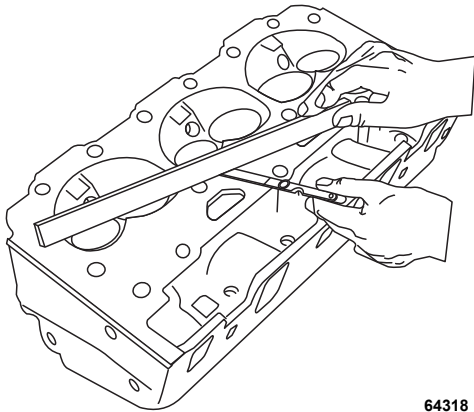
4. Use the J 8089 to clean the carbon from the cylinder head combustion chambers.

NOTICE! Be careful not to scuff the combustion chambers.

5. Inspect the cylinder head for the following:
 - Damage to the gasket surfaces
 - Damage to the threaded bolt holes
 - Burnt or eroded areas in the combustion chambers
 - Cracks in the exhaust ports and combustion chambers

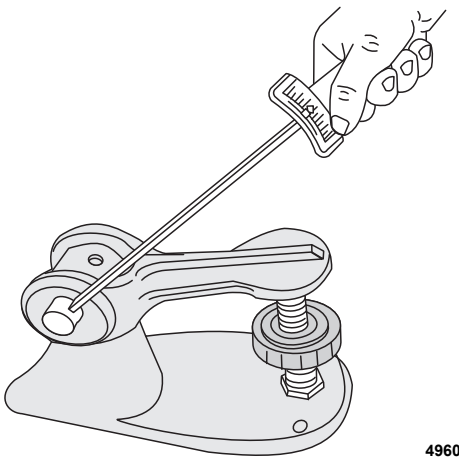
- External cracks in the water chambers
- Restrictions in the intake or exhaust passages
- Restrictions in the cooling system passages
- Rusted, damaged or leaking core plugs

Inspect:



6. Measure the cylinder head for warping with a straight edge and feeler gauge
 - A cylinder head block deck with warping in excess of 0.10 mm (0.004 in) within a 152.4 mm (6.0 in) area must be repaired or replaced.
 - A cylinder head exhaust manifold deck with warping in excess of 0.05 mm (0.002 in) within a 152.4 mm (6.0 in) area must be repaired or replaced.
 - A cylinder head intake manifold deck with warping in excess of 0.10 mm (0.004 in) within a 152.4 mm (6.0 in) area must be repaired or replaced.

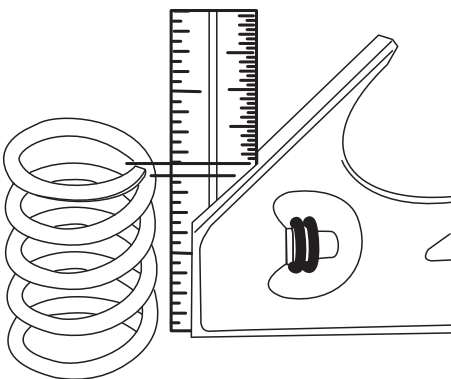
Valve Spring Tension



1. Use the J 9666 in order to measure the valve spring.

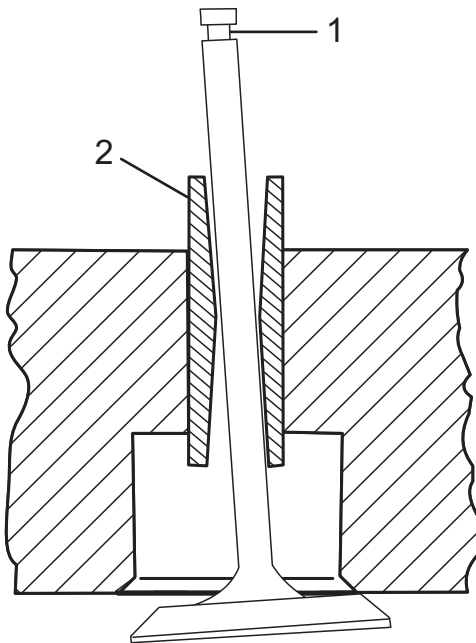
Replace the valve spring if the valve spring tension is less than 338 N (76 lb.) at 43.2 mm (1.70 in).

Valve Spring Straightness

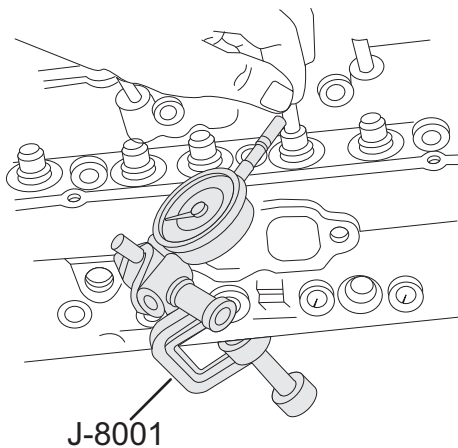


2. Inspect the valve springs for Straightness.

Valve Stems



3. Valve stems (1) with excessive valve guide (2) clearance must be repaired or the cylinder head replaced.



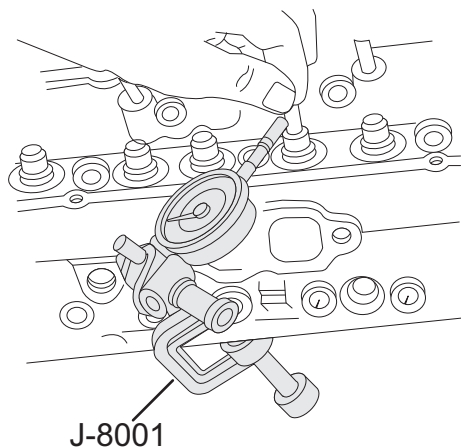
4. Measure the valve stem-to-guide clearance.

Excessive valve stem-to-guide clearance may cause an excessive oil consumption and may also cause a valve to break. Insufficient clearance will result in noisy and sticky functioning of the valve and will disturb the engine assembly smoothness.

- a. Clamp the J 8001 on the exhaust port side of the cylinder head.
- b. Position the dial 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 dial indicator stem. The dial indicator stem must contact the side of the valve stem just above the valve guide.
- c. Drop the valve head about 1.6 mm (0.063 in) off the valve seat.
- d. Use light pressure and move the valve stem from side to side in order to obtain a valve stem-to-guide clearance reading.

Valve Guide Reaming and Seat Grinding

Measuring:



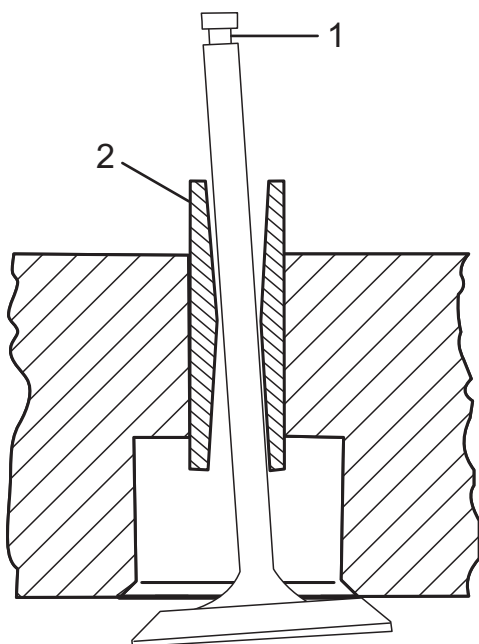
Tools Required:

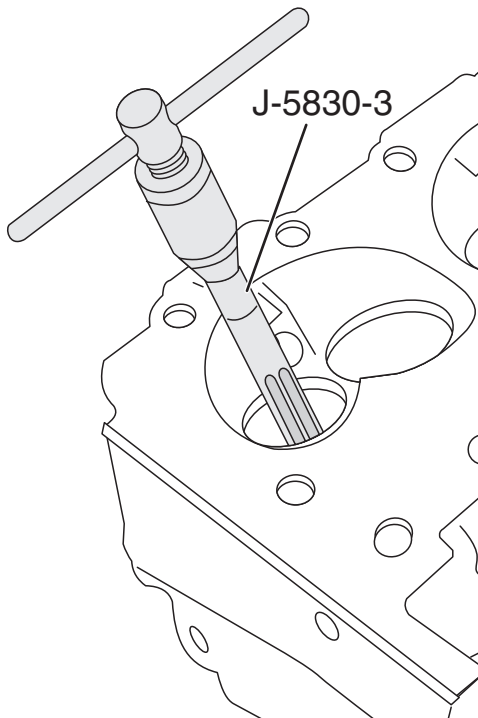
J 5830-02 Valve Guide Reamer Set

J 8001 Dial Indicator Set

1. Measure the valve stem-to-guide clearance. See *Cylinder Head Clean and Inspect* on page 63..

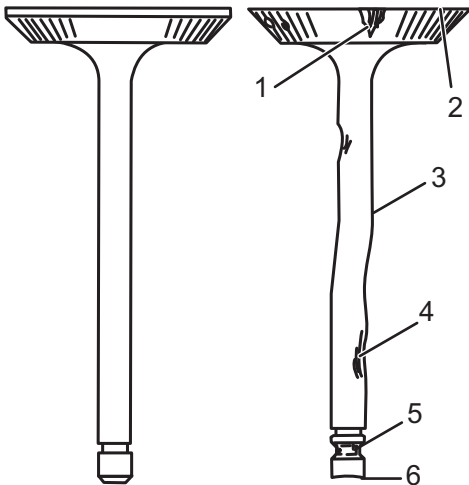
2. Improper valve stem (1) to valve guide (2) clearance may cause excessive oil consumption.



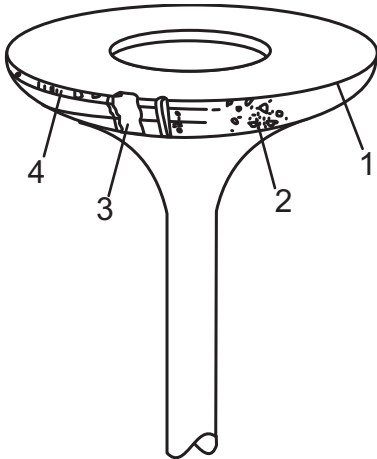
Reaming:**CAUTION! Wear Safety Glasses.**

NOTICE! Exhaust valves with excessive valve stem-to-guide clearance must be replaced with the available service valve that has an 0.0774 mm (0.0305 in) oversize valve stem. The intake valves are NOT available with oversize valve stems. Replace the cylinder head if after using a NEW intake valve in order to measure the valve stem-to-guide clearance, the valve stem-to-guide clearance is not within specifications.

3. Use the J 5830-3 in order to ream the exhaust valve guide in order to achieve the correct valve stem-to-guide clearance.
4. Always recondition the exhaust valve seat after reaming the exhaust valve guide bores and installing new exhaust valves.

Inspect

5. Inspect the valves for the following:
 - Burnt or damaged areas (1)
 - Undersize margin (2)
 - Bent stem (3)
 - Scoring or other damage to the stem (4)
 - Worn key groove (5)
 - Worn stem tip (6)



6. Inspect the valve contact surface for the following:

- Undersized margin (1)
- Pitted surfaces (2)
- Burnt or eroded areas (3)
- Acceptable edge (margin) (4)

Valves with excessive damage must be replaced.

Minor imperfections of the valve or valve seat may be repaired.

7. Reconditioning of the valves and valve seats:

- 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 valve seat in the cylinder head is necessary to insure 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 in order to ensure the proper centering of the pilot in the valve guide.

The valve seats should be concentric to within 0.05 mm (0.002 in) total indicator reading.

- Reface pitted valves on a valve refacing machine in order to ensure the correct relationship between the valve head and the valve stem.
- Replace the valve if the valve stem is excessively worn or warped.
- Replace the valve if the edge margin (4) of the valve head is less than 0.79 mm (0.031 in) thick after grinding.

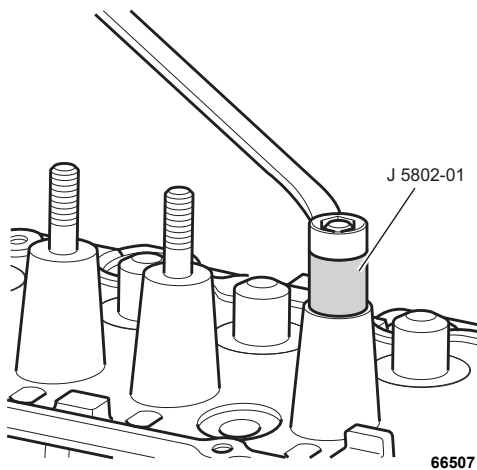
Several different types of equipment are available for reconditioning valves and valve seats. Follow the equipment manufacturer's recommendations for equipment use to attain the proper results.

Valve Rocker Arm Stud Removal

Tools Required

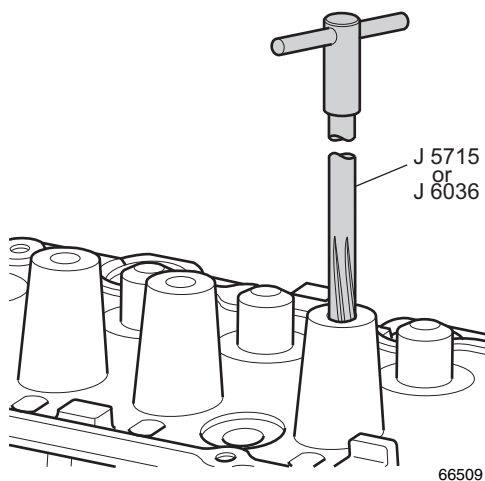
J5802 Rocker Arm Stud Remover

NOTICE! Valve rocker arm ball studs that have damaged threads or are loose in the cylinder heads should be replaced.



1. Place the J 5802-01 over the valve rocker arm ball stud to be removed.
2. Install a nut and a flat washer.
3. Rotate the clockwise to remove the valve rocker arm ball stud.

Valve Rocker Arm Stud Installation



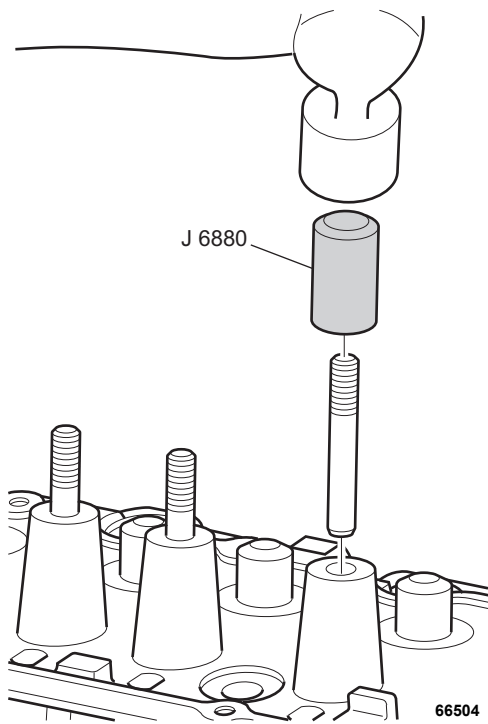
Tools Required

J5715 Reamer (0.0762 mm (0.003 in))

J 6036 Reamer (0.0332 mm (0.013 in))

J 6880 Rocker Arm Stud Installer

1. Ream the hole to the proper size for the replacement oversize valve rocker arm ball stud. Use J 5715 for 0.0762 mm (0.003 in) oversize valve rocker arm ball studs or J 6036 for 0.03302 mm (0.013 in) oversize valve rocker arm ball studs.
2. Apply lubricant GM P/N 1052271 or equivalent to the lower end (press-fit end) of the valve rocker arm ball stud.



3. Use J 6880 and a hammer to install the valve rocker arm ball stud into place. The valve rocker arm ball stud is installed to proper depth when the J 6880 bottoms onto the cylinder head.

Cylinder Head Assemble

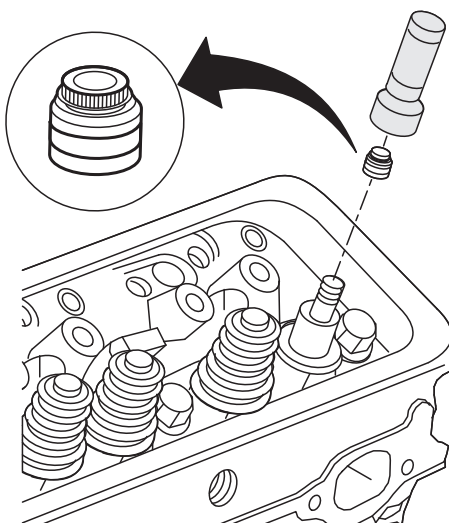
Tools Required

J 8062 Valve Spring Compressor

J 42073 Valve Stem Seal Installer

NOTICE! The exhaust valve oil stem seal has the letters EX (1) molded into the top of the seal. The exhaust valve oil stem seal material is brown in color (2) with a white stripe (3) painted onto the outside diameter of the seal, or the material may be red in color (2) with no paint stripe. The intake valve oil seal is black in color.

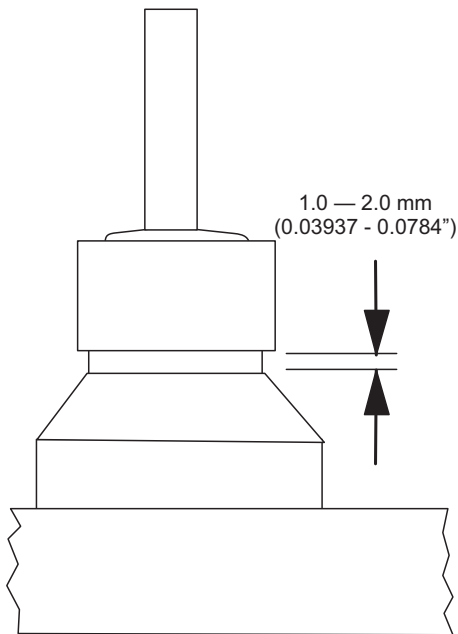
Install Oil Seal



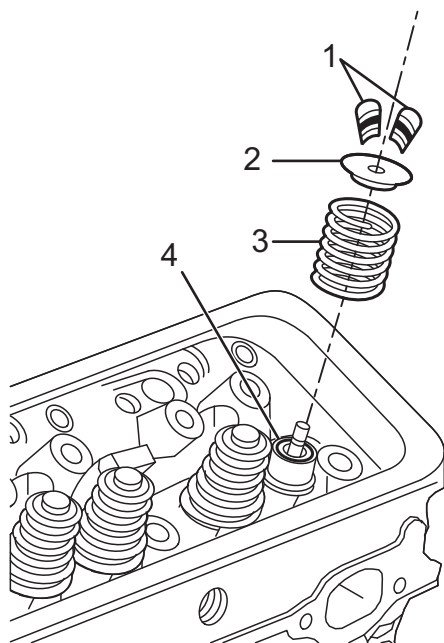
1. Assemble the valve into the proper valve guide.
2. Select the proper valve stem oil seal for the specific valve guide.
3. Lubricate the valve stem oil seal and the outside diameter of the valve guide with clean engine oil.
4. Assemble the valve stem oil seal onto the valve stem.



CAUTION! Wear safety glasses.



Install Valve Spring



5. Install the valve stem oil seal onto the valve guide using the J-42073. Tap the valve stem oil seal onto the valve guide until the J-42073 bottoms against the valve spring seat.
6. Inspect the valve stem oil seal. The valve stem oil seal should not be bottomed against the valve guide.

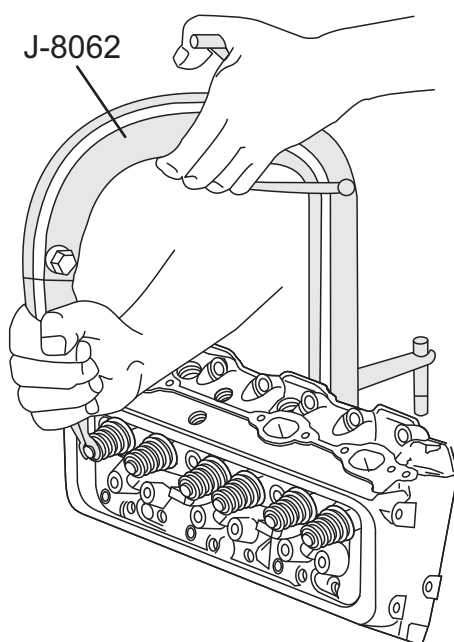
There should be a 1-2 mm (0.03937-0.07874 in) gap between the bottom edge of the valve stem oil seal and the valve guide.

7. Install the valve spring (3).
8. Install the valve spring cap (2) onto the valve spring (3) and over the valve stem.



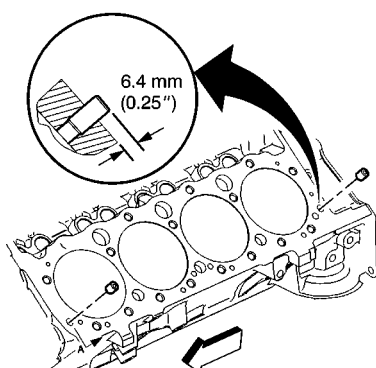
CAUTION!

Wear Safety Glasses. Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.



9. Use the J 8062 in order to compress the valve springs.
10. Install the valve stem keys.
 - a. Use grease in order to hold the valve stem keys in place while disconnecting the J 8062.
 - b. Look to ensure that the valve stem keys seat properly in the upper groove of the valve stem.
 - c. Tap the end of the valve stem with a plastic-faced in order to seat the valve stem keys, if necessary.

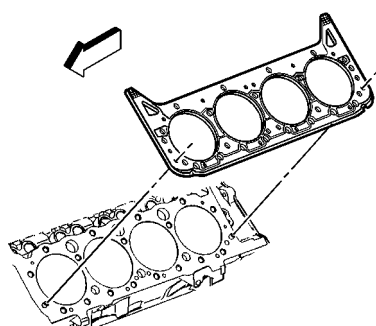
Installation



182846

1. Clean the cylinder head gasket surfaces on the engine block.
2. Inspect the dowel pins (cylinder head locators) for proper installation.
3. Clean the cylinder head gasket surfaces on the cylinder heads.

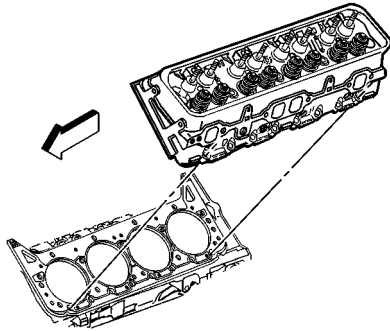
NOTICE! Do not use any sealer on the cylinder head gaskets.



317233

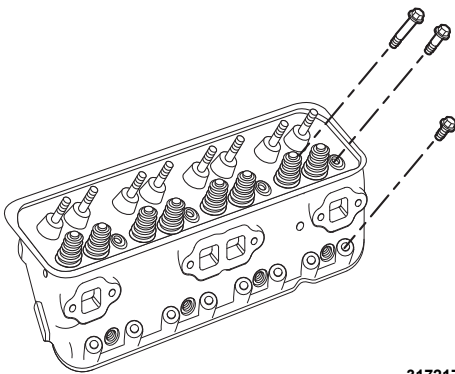
4. Install NEW cylinder head gaskets in position over the locator pins.

5. Install the cylinder head onto the cylinder block. Guide the cylinder head carefully into position over the locator pins and the cylinder head gasket.



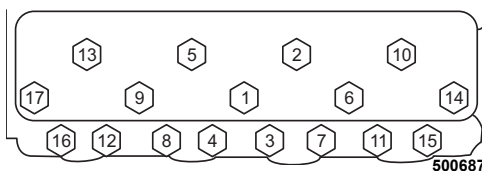
317227

6. Apply sealant 1141570 or equivalent to the threads of the cylinder head bolts.
7. Install the cylinder head bolts finger tight.



317217

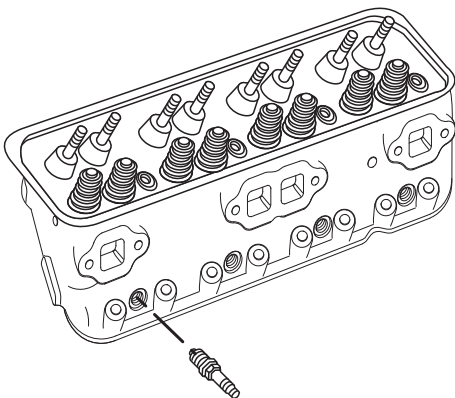
Tighten:



500687

Tighten the cylinder head bolts in sequence in two steps.

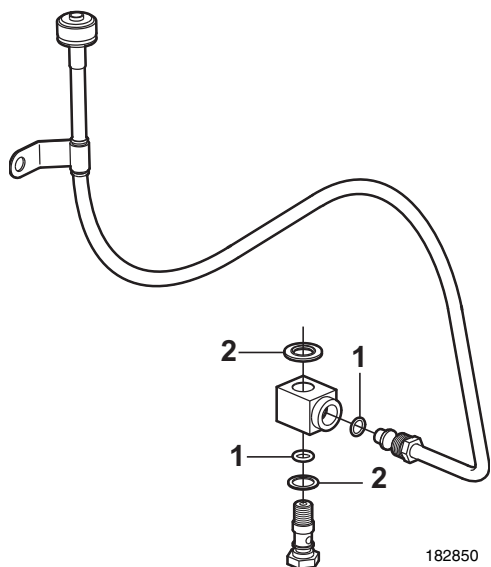
1. First step, 30 N•m (22 ft. lb.)
2. Final step use special tool J 36660 and tighten as follows;
 - a. Tighten the long bolts (1, 2, 5, 6, 9, 10 and 13) on the final step sequence to 75 degrees.
 - b. Tighten the middle length bolts (14 and 17) on the final step sequence to 65 degrees.
 - c. Tighten the short length bolts (3, 4, 7, 8, 11, 12, 15 and 16) on the final step sequence to 55 degrees.
3. Install New spark plugs adjusted to the proper gap.
4. Install Rocker Arm Cover. See *Rocker Arm Cover* on page 54.



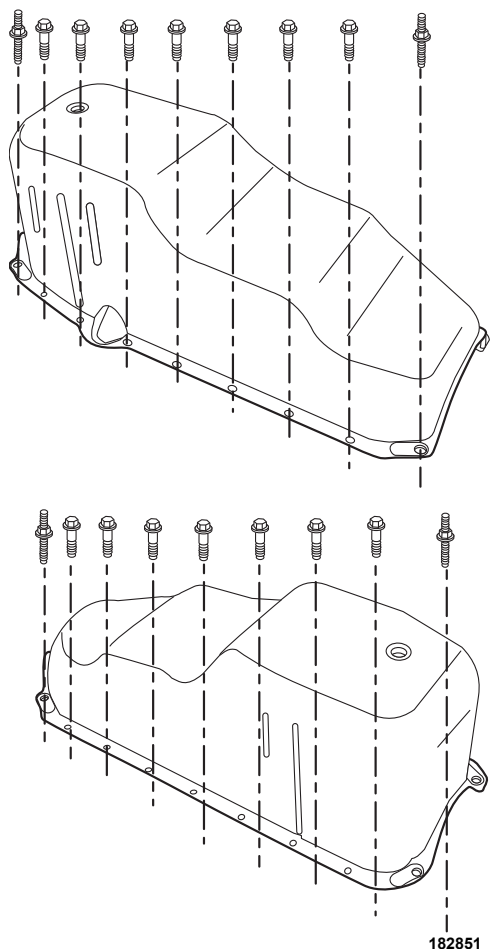
Oil Pan and Oil Pump

1. Drain oil from engine. See *Draining The Engine* on page 33.
2. Remove engine from boat. See *Removal and Installation Workshop Manual*.
3. Disconnect and remove the dipstick tube. Discard the O-rings (1) and seals (2).

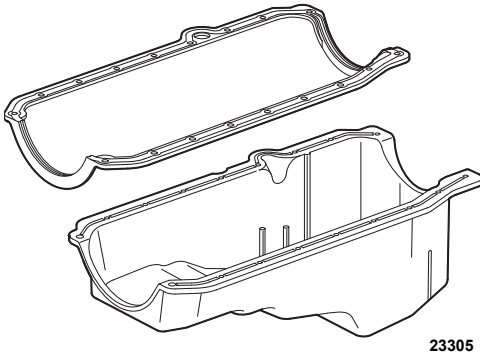
Removal



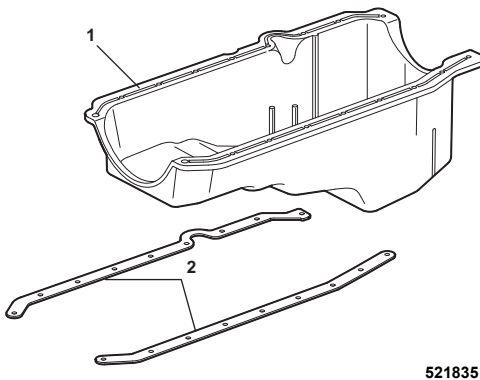
4. Remove the oil pan bolts and nuts.
5. Remove the oil pan.



6. Remove and discard the oil pan gasket.



Oil Pan Clean and Inspect

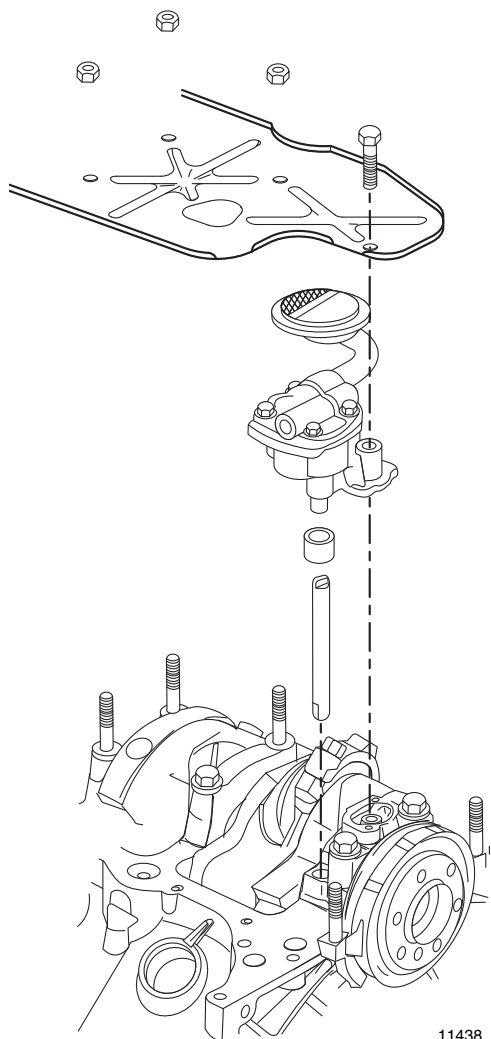


CAUTION! Wear safety glasses.

1. Clean the oil pan baffle in cleaning solvent.
2. Dry the oil pan and the oil pan baffle with compressed air.
3. Inspect the oil
 - Gouges or damage to the oil pan sealing surfaces (1)
 - The oil pan drain plug hole for damaged threads
 - Damaged oil pan drain plug threads
 - Damage to the oil pan reinforcements (2)
 - Damage to the oil pan baffle
 - Dents or damage to the exterior of the oil pan

An oil pan that is dented may interfere with the proper position of the oil pump screen, or may not distribute oil properly in the oil pan sump area.

Oil Pump Removal

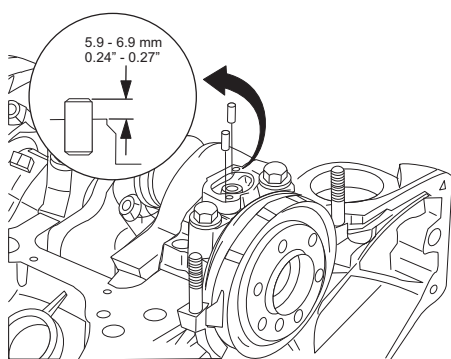


11438

1. Remove the nuts (6) and the crankshaft oil deflector (2).
2. Remove the oil pump bolt (1).
3. Remove the oil pump (3), the oil pump driveshaft (5) and the oil pump driveshaft retainer (4).
4. Separate the oil pump (3), the oil pump driveshaft (5) and the oil pump driveshaft retainer (4).

NOTICE! Always install a NEW oil pump driveshaft retainer during assembly.

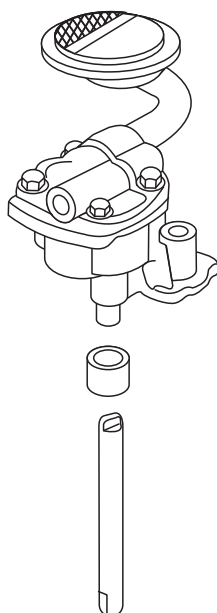
5. Discard the oil pump driveshaft retainer.



6. Inspect the pins (oil pump locator) for damage, and replace if required.

Oil Pump Disassemble

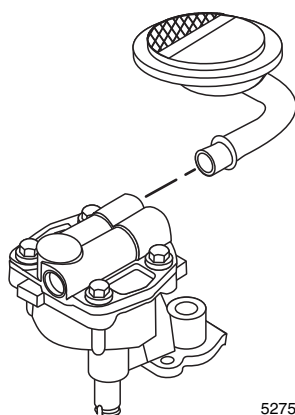
1. Remove the oil pump driveshaft and retainer.



5274

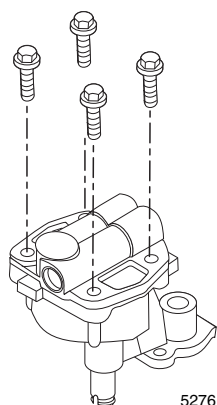
2. Remove oil pump screen (if necessary)

- The oil pump screen has a press fit into the oil pump cover.
- DO NOT remove the oil pump screen from the pipe. The pipe and oil pump screen are serviced as a unit.



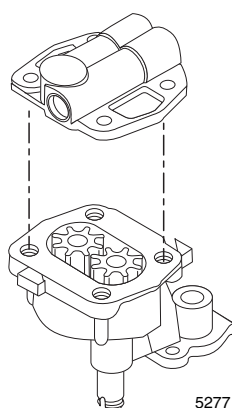
5275

3. Remove the oil pump cover bolts

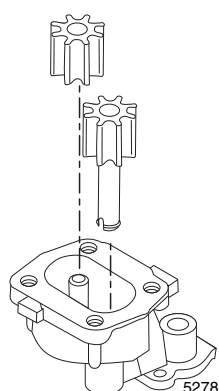


5276

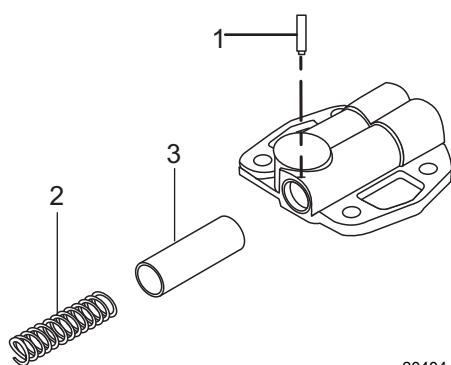
4. Remove the oil pump cover



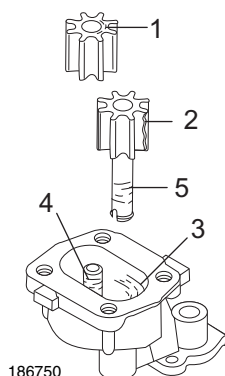
5. Remove the oil pump drive gear and the oil pump driven gear.
6. Match mark the gears for reassembly.



7. Remove the oil pressure relief valve retaining pin (1)
8. Remove the oil pressure relief spring (2).
9. Remove the oil pump pressure relief valve (3).



Oil Pump Clean and Inspect



1. Clean the oil pump components in cleaning solvent.
2. Dry the components with compressed air.

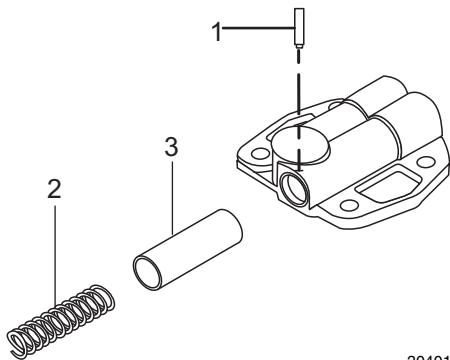


CAUTION! Always wear safety glasses when using compressed air.

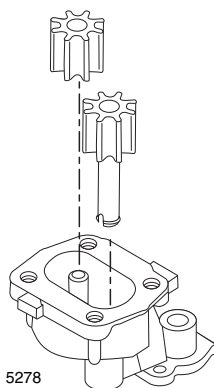
3. Inspect the oil pump for the following conditions:
 - Scoring on the top of the gears (1)
 - Damaged gears (2) for the following:
 - Chipping
 - Galling

— Wear

- Scoring, damage or casting imperfections to the body (3)
 - Damaged or scored gear shaft (4)
 - Damaged or scored gear shaft (5)
 - Damaged bolt hole threads
 - Worn oil pump driveshaft bore
 - Damaged or sticking oil pump pressure relief valve (minor imperfections may be removed with a fine oil stone)
 - Collapsed or broken oil pump pressure relief valve spring
4. If the oil pump is to be reused, install a NEW oil pump pressure relief valve spring.
 5. During oil pump installation, install a NEW oil pump driveshaft retainer.

Oil Pump Assemble

30401



5278

Tools Required

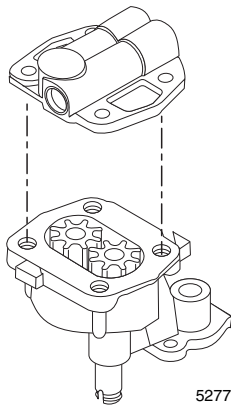
J 21882 Oil Suction Pipe Installer

1. Apply clean engine oil GM P/N 12345610 or equivalent to the oil pump pressure relief valve, oil pump pressure relief valve spring and oil pump body.

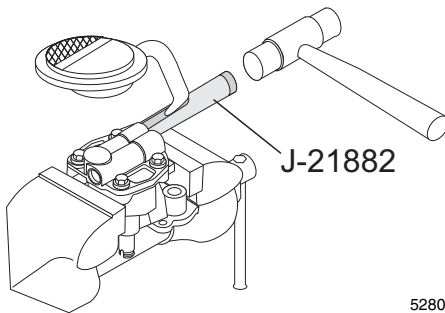
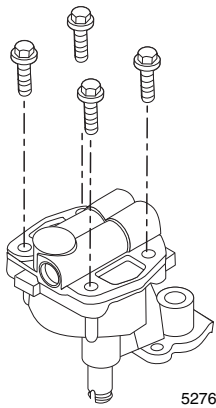
**CAUTION! Wear safety glasses.****NOTICE! Replace the oil pump pressure relief valve spring when you reuse the oil pump.**

2. Install the following items:
 - a. The oil pump pressure relief valve
 - b. The oil pump pressure relief valve spring
 - c. The oil pump pressure relief valve spring straight pin
3. Apply clean engine oil GM P/N 12345610 or equivalent to the oil pump drive gear, the oil pump driven gear and the oil pump body internal surfaces.
4. Install the oil pump drive gear and the oil pump driven gear into the oil pump body.
 - a. Align the match marks on the oil pump drive and driven gears.
 - b. Install the smooth side of the oil pump drive and driven gears toward the oil pump cover.

5. Install the pump cover.



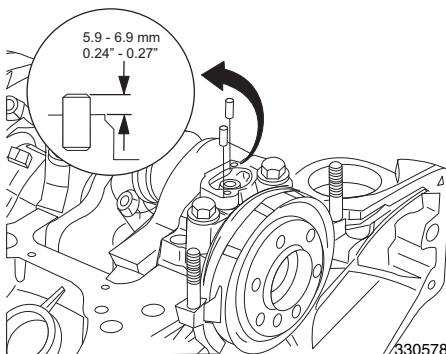
6. Install the oil pump cover bolts. Tighten the bolts to 12 N•m (106 lb. in).
7. Inspect the oil pump for smoothness of operation by turning the oil pump driveshaft by hand.

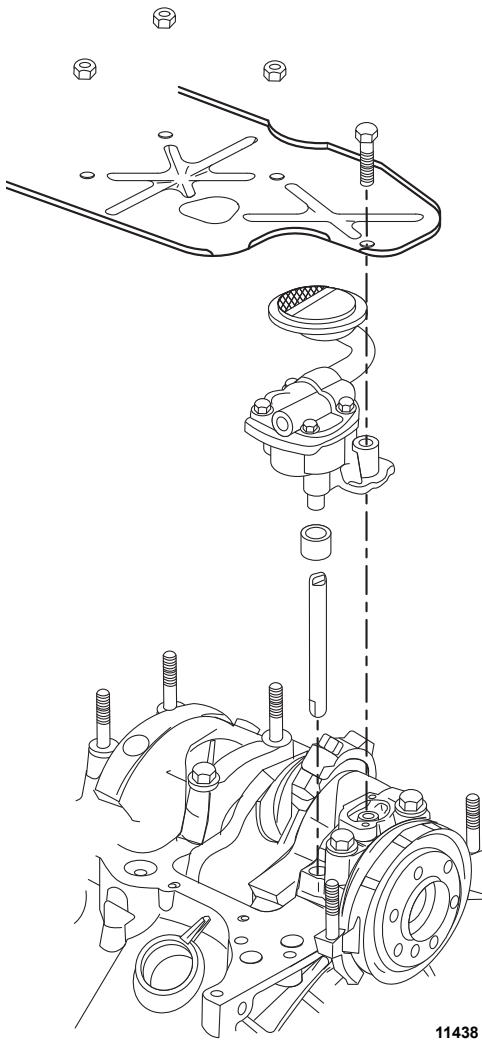


8. Install the oil pump screen.
 - a. If removed, replace the oil pump screen.
 - b. The oil pump screen must have a good press fit into the oil pump body.
 - c. Mount the oil pump in a soft jawed vise.
 - d. Apply sealant 1141570 or equivalent to the end of the oil pump screen pipe.
 - e. Use the J 21882 and a soft-faced hammer in order to tap the oil pump screen into the pump body.
9. The oil pump screen must align parallel with the bottom of the oil pan when the oil pan is installed.

Oil Pump, Pump Screen and Deflector Installation

1. Inspect for properly installed pins (oil pump locator).





NOTICE! DO not reuse the oil pump driveshaft retainer (4).

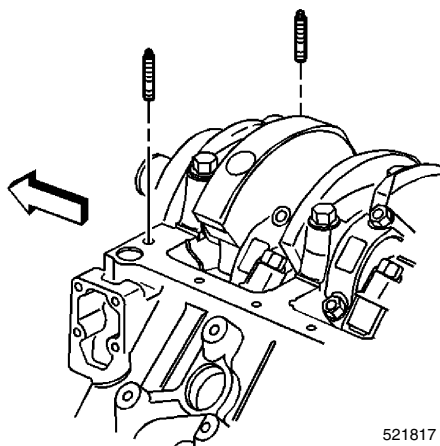
During assembly, install a **NEW** oil pump driveshaft retainer.

2. Assemble the oil pump (3), the oil pump driveshaft (5) and a **NEW** oil pump driveshaft retainer (4).
3. Install the oil pump (3). Position the oil pump onto the pins.
4. Install the crankshaft oil deflector (2) and the nuts (6).
5. Install the bolt (1) attaching the oil pump to the rear crankshaft bearing cap.

Tighten

- Tighten the oil pump bolt on the first pass to 20 N.m (15 lb. ft.).
- Tighten the oil pump bolt on the final pass to 65 degrees using the J 36660.
- Tighten the crankshaft oil deflector nuts to 40 N.m (30 lb. ft.).

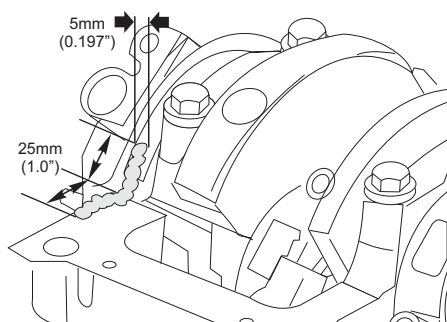
Oil Pan Installation



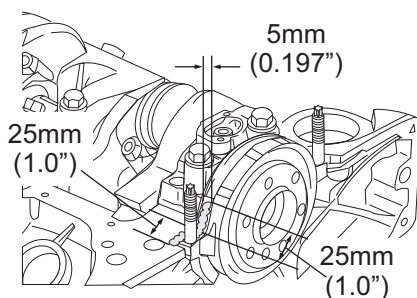
1. Install the oil pan studs into the engine block if removed.

Tighten

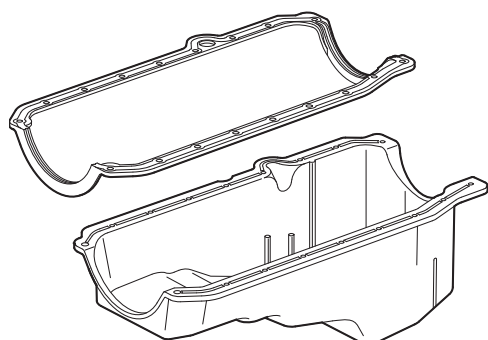
2. Tighten the oil pan studs to 6 N.m (53 lb. in).



3. Apply a 5 mm (0.197 in) wide and 25 mm (1.0 in) long bead of adhesive Volvo Penta P/N 1161277 or equivalent to both the right and left sides of the engine front cover to engine block junction at the oil pan sealing surfaces.



4. Apply a 5 mm (0.197 in) wide and 25 mm (1.0 in) long bead of adhesive Volvo Penta P/N 1161277 or equivalent to both the right and left sides of the crankshaft rear oil seal housing to engine block junction at the oil pan sealing surfaces.



23305

NOTICE! Always install a NEW oil pan gasket.

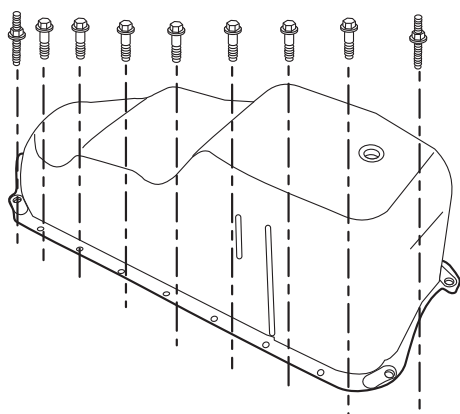
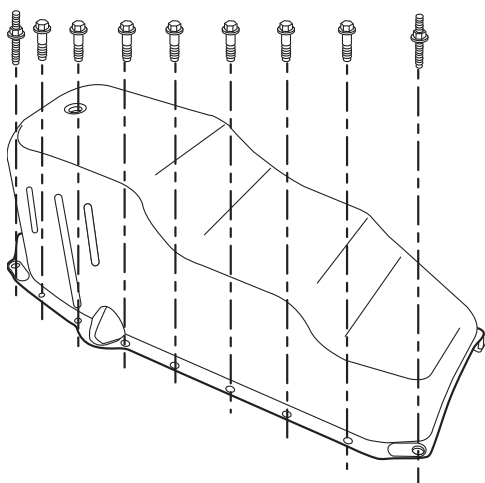
The oil pan gasket and oil pan must be installed and the fasteners tightened while the adhesive is still wet to the touch.

5. Install the NEW oil pan gasket into the groove in the oil pan.

6. Install the oil pan onto the engine block.

Press the oil pan gasket into the grooves of the engine front cover and crankshaft rear oil seal housing.

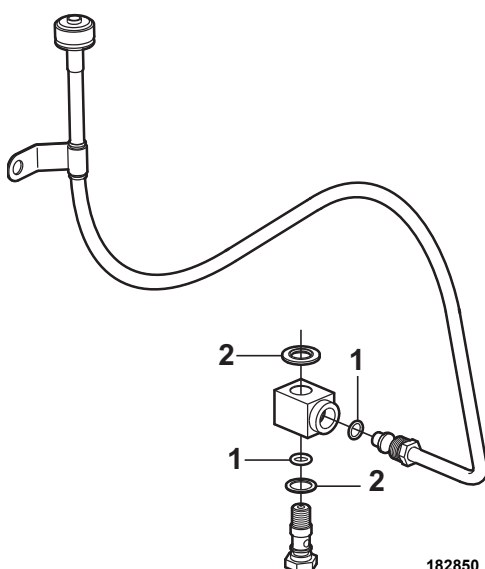
7. Slide the oil pan back against a suitable straight edge.



182851

8. Using new seals and O-rings, install the dipstick tube. Tighten bolt to 25 N•m (18 ft. lb.)

NOTICE! Always use new seals and O-rings when the dipstick is removed.

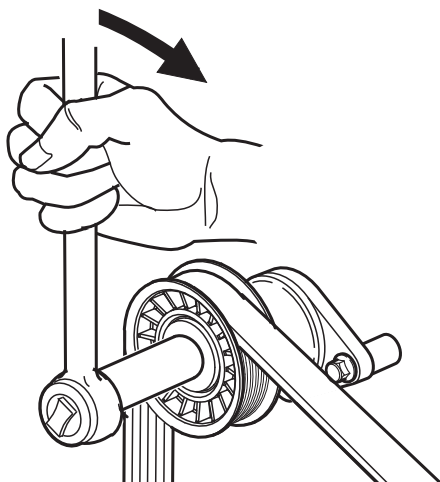


182850

Water Pump

GXi

Removal

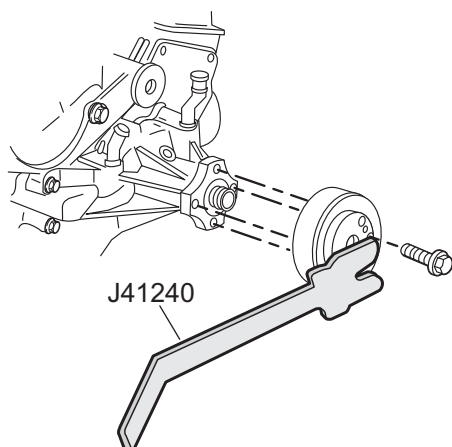


Tools Required

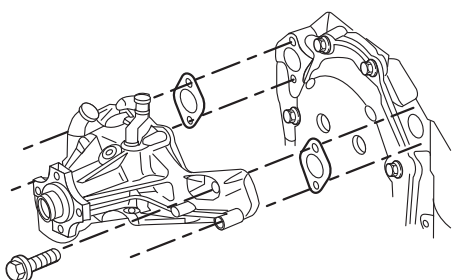
J41240 Fan Clutch Remover and Installer

1. Release tension on the bent tensioner and remove the serpentine belt from the water pump pulley.

NOTICE! It is not necessary to remove the belt from the rest of the other pulleys unless the belt is worn or deteriorated.



2. Remove the bolts and the water pump pulley using the J41240 or suitable substitute.

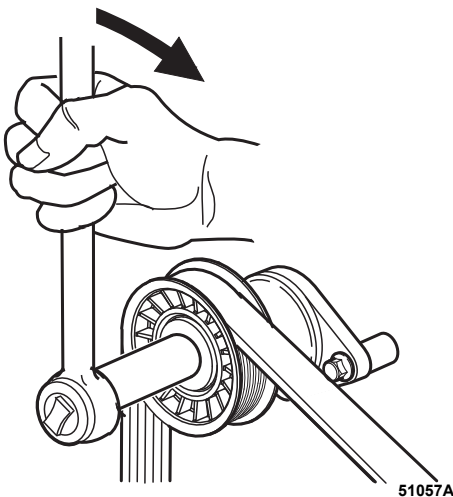
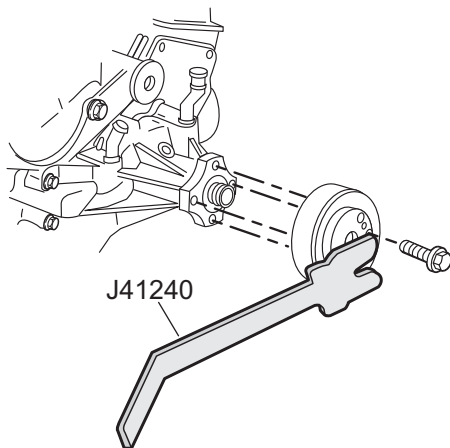
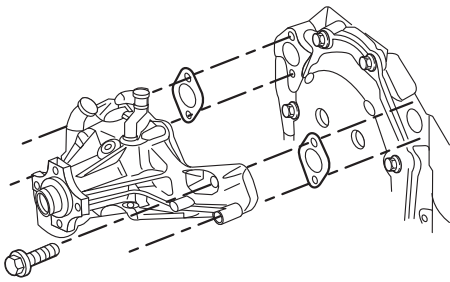


3. Remove the water pump bolts.
4. Remove the water pump.
5. Remove and discard the water pump gaskets.

Inspection

The circulation pump is not a serviceable unit. Replace the circulation pump if necessary.

Installation



Tools Required

J41240 Fan Clutch Remover and Installer

1. If reusing the fasteners, apply sealant 1141570 or equivalent to the threads of the water pump bolts.
2. Clean any residual gasket material from cooling ports on the engine. If reusing the circulation pump, clean any residual gasket material from the face of the mounting ports.
3. Install the water pump and the NEW water pump gaskets.
4. Install the water pump bolts and tighten to 45 N.m (33 lb. ft.).
5. Install the fan and water pump pulley and bolts using the J41240 or suitable substitute.
6. Tighten the fan and water pump pulley bolts to 25 N.m (18 lb. ft.).

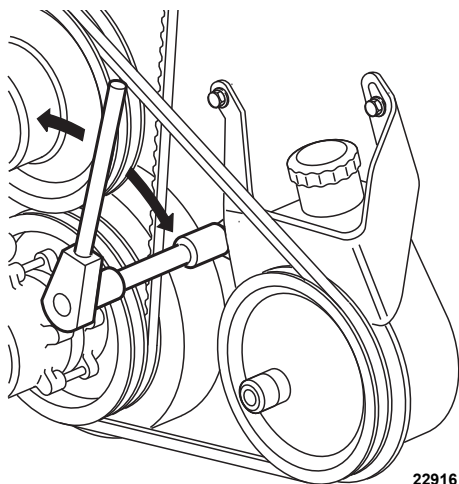
7. Release the belt tensioner and reinstall the serpentine belt.

NOTICE! Be sure the belt is aligned on the grooved pulleys before operating the engine. The belt life will be significantly shortened if the belt is misaligned on the grooved pulleys

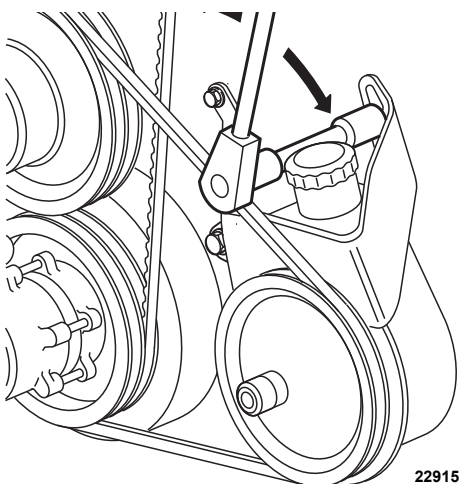
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Remove

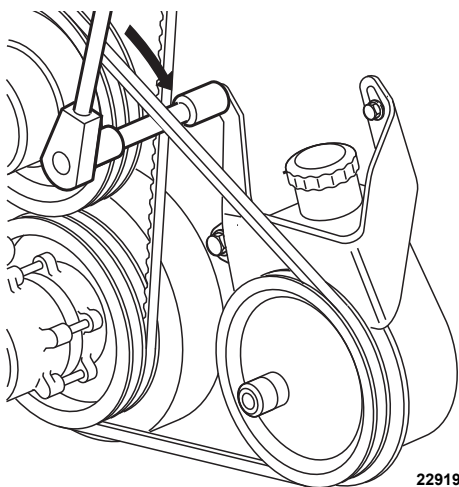
1. Loosen power steering pump nut.



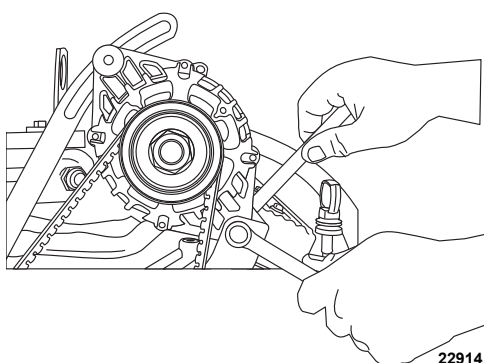
2. Loosen power steering pump bolt.



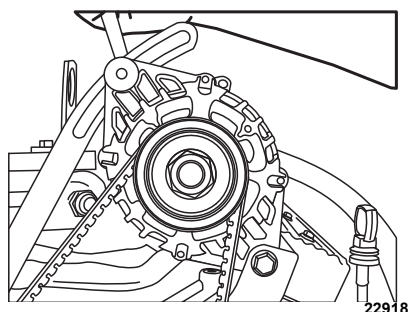
3. Loosen power steering pump pivot nut.
4. Pull up on power steering pump belt to loosen belt tension and remove the belt.



5. Loosen alternator pivot bolt.



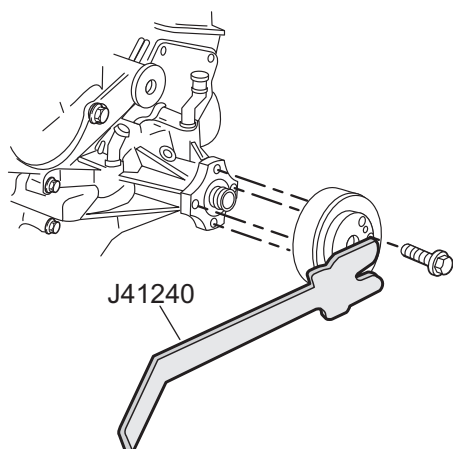
6. Loosen alternator belt tension bolt.
7. Pull on alternator belt to loosen the alternator and remove the belt.



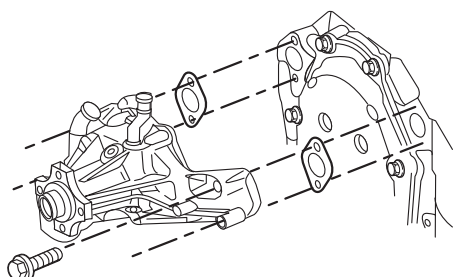
Tools Required

J 41240 Fan Clutch Remover and Installer

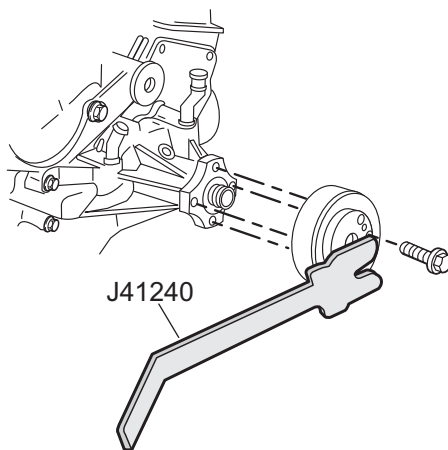
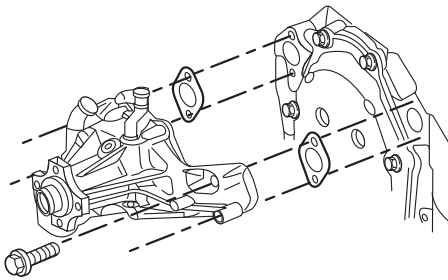
8. Remove the bolts and the fan and water pump pulley using the J41240.



9. Remove the water pump bolts.
10. Remove the water pump
11. Remove the water pump gaskets.
12. Discard the water pump gaskets.



Water Pump Installation



Tools Required

J 41240 Fan Clutch Remover and Installer

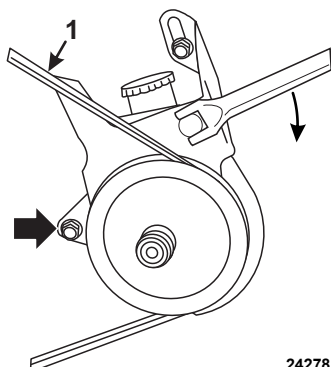
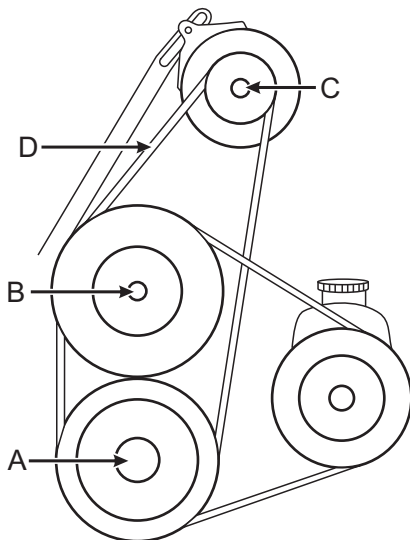
1. If reusing the fasteners, apply sealant 1141570 or equivalent to the threads of the water pump bolts.
2. Install the water pump and the NEW water pump gaskets.
3. Install the water pump bolts. Tighten the water pump bolts to 45 N.m (33 lb. ft.).
4. Install the fan and water pump pulley and bolts using the J41240. Tighten the fan and water pump pulley bolts to 25 N.m (18 lb. ft.).

Tools Required

5. Install Alternator belt.

NOTICE! Do not substitute automotive belts. Belts used for the alternator, circulating pump, and power steering pump are heavy duty.

6. Tighten alternator belt to $33,6 \pm 2,7$ N (75 $\pm$ 10 lb.) or 6,4 mm ($\frac{1}{4}$ in.) deflection with light pressure on belt. Check belt tension midway between the water pump pulley and the alternator pulley (2).
7. Install power steering pump belt.



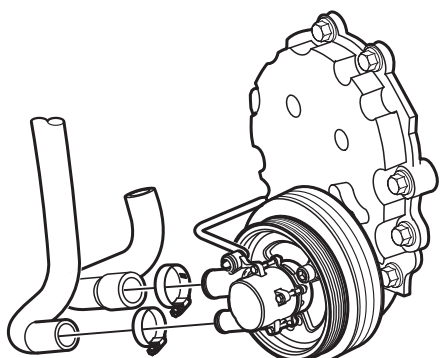
24278

8. Tighten power steering belt to $33,6 \pm 2,7$ N (75 $\pm$ 10 lb.) or 6,4 mm ($\frac{1}{4}$ in.) deflection with light pressure on belt. Check belt tension midway between the water pump pulley and the power steering pump pulley (1).

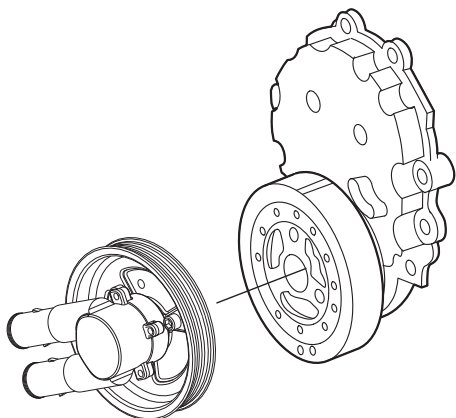
Crankshaft Balancer

Removal

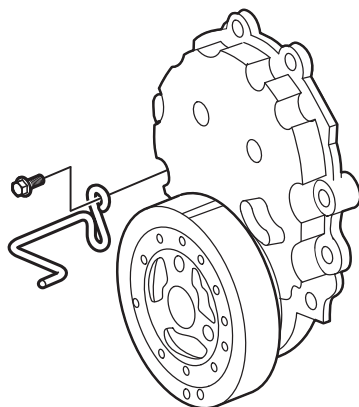
1. Disconnect hoses from raw water pump.



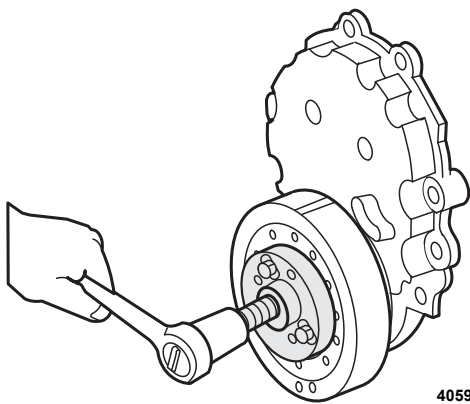
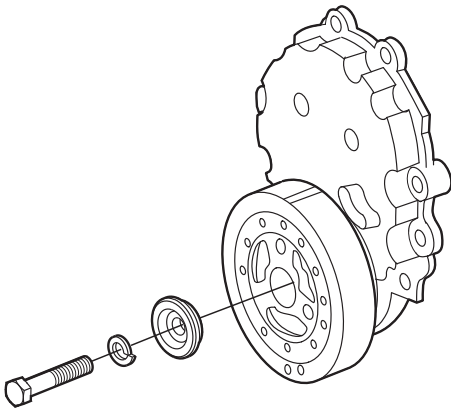
2. Remove raw water pump retaining bolts and remove the pump.



3. Remove water pump stay bracket.



4. Remove the crankshaft balancer bolt and washer.



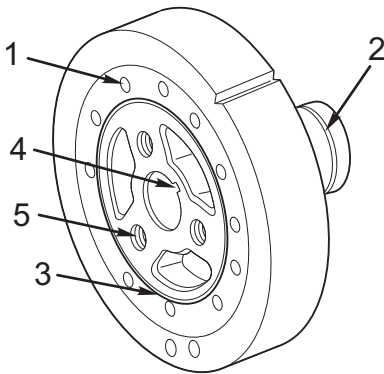
4059

Tools Required

J23523-F Balancer Remover and Installer.

5. Use the J23523-F in order to remove the crankshaft balancer.
 - a. Install the J 23523-F plate and bolts onto the crankshaft balancer. Tighten the bolts to 25 N•m (18 lb. ft.).
 - b. Install the J 23523-F forcing screw into the plate.
 - c. Rotate the J 23523-F forcing screw clockwise in order to remove the crankshaft balancer.
6. Remove the J23523-F from the crankshaft balancer.

Crankshaft Balancer Inspect



1. Clean the crankshaft balancer in cleaning solvent.
2. Dry the crankshaft balancer with compressed air.
3. Inspect the crankshaft balancer for the following:
 - Loose or improperly installed front groove pin (1)(crankshaft balancer). A properly installed front groove pin should be installed until flush or below flush with the face of the crankshaft balancer.

Important: A crankshaft front oil sealing surface with excessive scoring, grooves, rust or other damage must be replaced.

- Worn, grooved or damaged crankshaft front oil sealing surface (2). Minor imperfections on the crankshaft balancer crankshaft front oil seal surface may be removed with a polishing compound or fine grade emery cloth.
- Worn, chunking or deteriorated rubber (3) between the hub and the outer ring
- Worn or damaged keyway (4)
- Worn or damaged bolt hole threads (5)

Crankshaft Balancer Installation

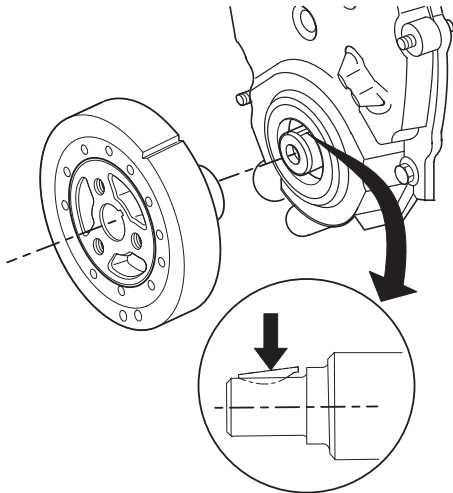
Tools Required

J 23523-F Balancer Remover and Installer

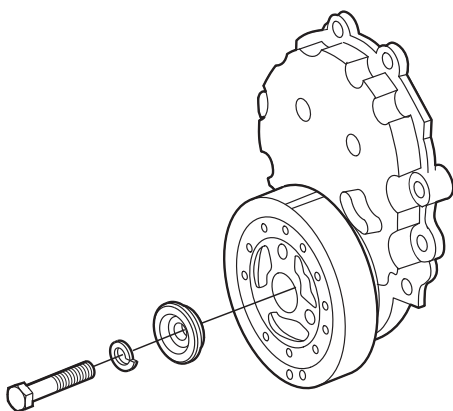
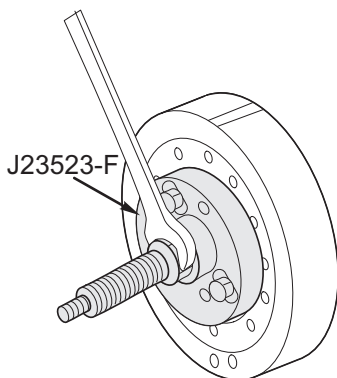
NOTICE! The inertial weight section of the crankshaft balancer is assembled to the hub with a rubber type material.

The correct installation procedures (with the proper tool) must be followed or movement of the inertial weight section of the hub will destroy the tuning of the crankshaft balancer.

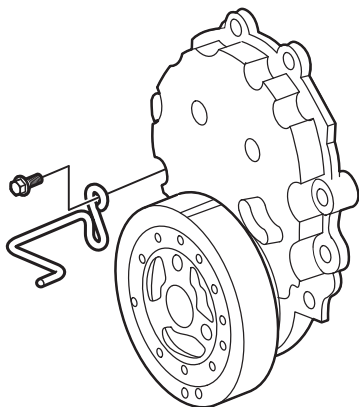
1. Apply a small amount of adhesive Volvo Penta P/N 1161277 or equivalent onto the crankshaft balancer keyway in order to seal the crankshaft balancer keyway and crankshaft joint.
2. Align the keyway of the crankshaft balancer with the crankshaft balancer key.
3. Install the crankshaft balancer onto the end of the crankshaft.



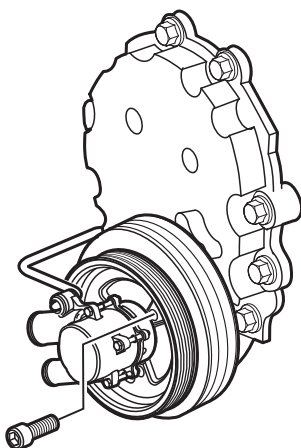
4. Use the J 23523-F in order to press the crankshaft balancer onto the crankshaft.
 - a. Install the J 23523-F plate and bolts onto the front of the crankshaft balancer. Tighten the J23523-F plate bolts to 25 N•m (18 lb. ft.).
 - b. Install the J 23523-F screw into the end for the crankshaft.
 - c. Install the J 23523-F bearing, the washer and the nut onto the J 23523-F screw.
 - d. Rotate the J 23523-F nut clockwise until the crankshaft balancer hub is completely seated against the crankshaft position sensor reluctor ring.
5. Remove the J23523-F.
6. Install the balancer bolt, lock washer, and centering washer. Tighten the balancer bolt to 58 N•m (43 lb. ft.)



7. Install the water pump stay bracket.

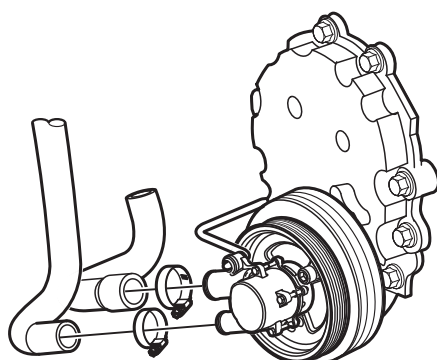


8. Install raw water pump and pulley. Tighten bolts to 33-39 N•m (25-29 ft. lb.)
9. Install water pump retaining bracket



10. Install water hoses in the correct orientation and tighten clamps

NOTICE! Crossing the raw water hoses will damage the water pump impeller and engine.



Engine Front Cover

Remove engine. See *Removal and Installation Workshop Manual*.

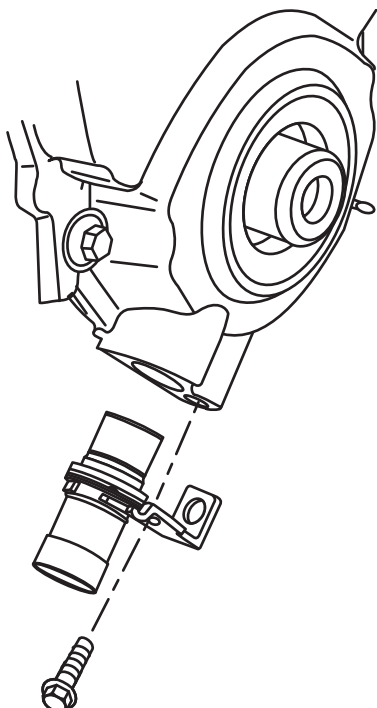
Remove engine circulation pump. See *Water Pump* on page 84..

Remove crankshaft balancer and engine raw water pump. See *Crankshaft Balancer* on page 89.

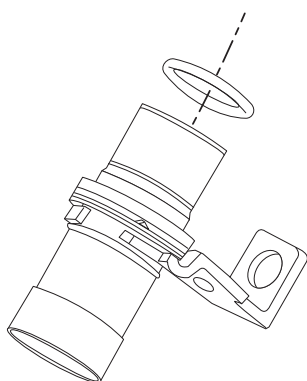
Remove oil pan. See *Oil Pan and Oil Pump* on page 74.

Removal

1. Remove the crankshaft position sensor bolt.
2. Remove the crankshaft position sensor.

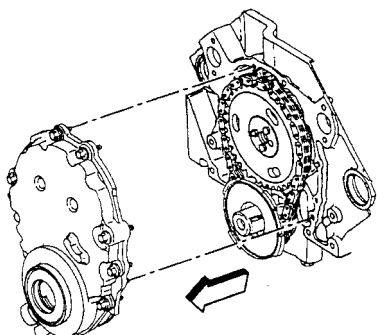


3. Remove and discard the crankshaft position sensor seal (O-ring).



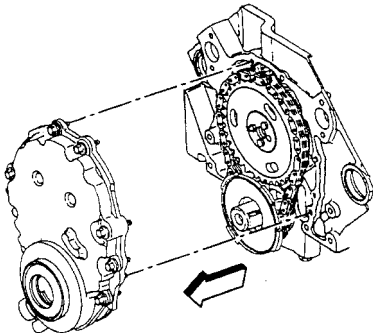
4. Remove engine front cover bolts and front cover.

NOTICE! The engine front cover is made of composite material and has an intergral gasket. Once the front cover is removed, it must be discarded and a new front cover must be used.

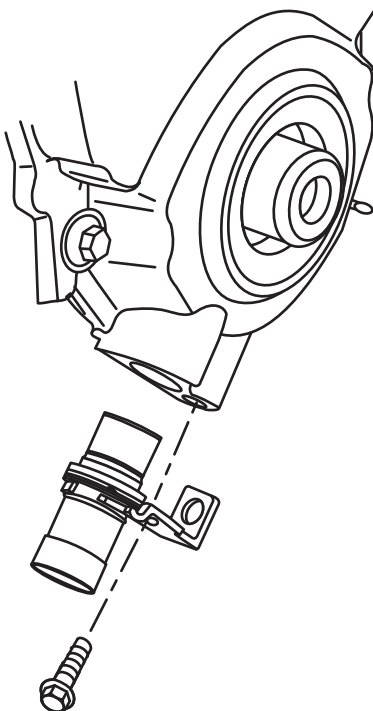
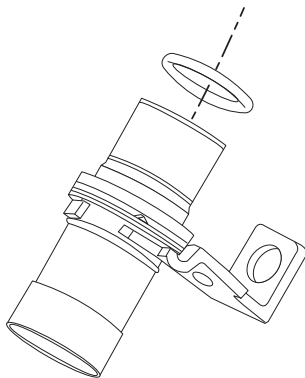


69010

Engine Front Cover Installation



69010



NOTICE! The engine front cover is made of composite material and has an intergral gasket. Once the front cover is removed, it must be discarded and a new front cover must be used.

1. Install the NEW engine front cover.
2. Install the engine front cover bolts and tighten to 12 N•m (106 lb. in).

NOTICE! DONOT reuse the original crankshaft position sensor seal (o-ring). When installing the crankshaft position sensor, be sure the crankshaft position sensor is fully seated and held stationary in the engine front cover crankshaft position sensor bore. A crankshaft position sensor that is not completely seated will cock in the engine front cover and may result in erratic engine operation.

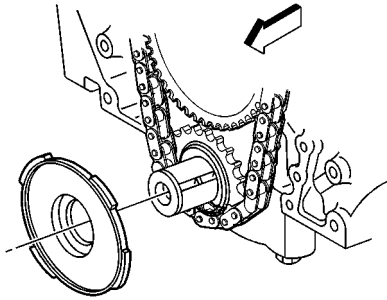
3. Lubricate the NEW crankshaft position sensor seal (O-ring) with clean engine oil.
4. Install the NEW crankshaft position sensor seal (O-ring) onto the crankshaft position sensor.
5. Install the crankshaft position sensor until fully seated into the engine front cover.
6. Install the crankshaft position sensor bolt and tighten to 9 N•m (80 lb. in).
7. Install oil pan, *Oil Pan and Oil Pump* on page 74 .
8. Install crankshaft balancer, *Crankshaft Balancer* on page 89 .
9. Install engine circulation pump, *Water Pump* on page 84 .
10. Install engine in boat, see *Engine Removal and Installation Workshop Manual*.

Timing Chain and Sprocket

Removal **Tools Required**

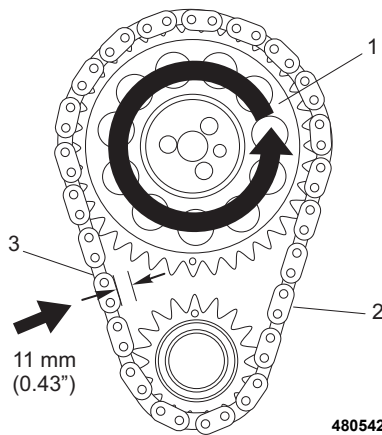
J 5825-A Crankshaft Gear Remover

1. Remove engine front cover. See *Engine Front Cover* on page 92.
2. Remove the crankshaft position sensor reluctor ring.



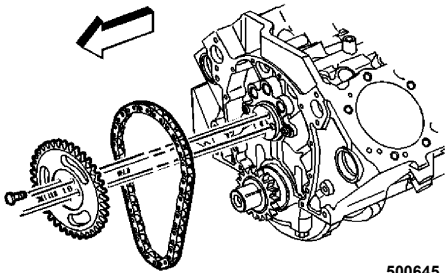
69450

3. Check the camshaft timing chain free play.
 - a. Rotate the camshaft sprocket (1) counterclockwise until all slack is removed from the camshaft timing chain (2).
 - b. Measure the free play on the slack side (3) of the camshaft timing chain. If the camshaft timing chain can be moved side to side in excess of 11 mm (0.43 in), replacement of the camshaft timing chain and the sprockets is recommended during assembly.



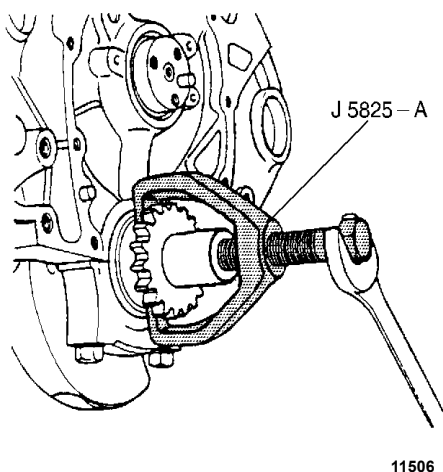
480542

4. Remove the camshaft sprocket bolts.
5. Remove the camshaft sprocket and the camshaft timing chain.

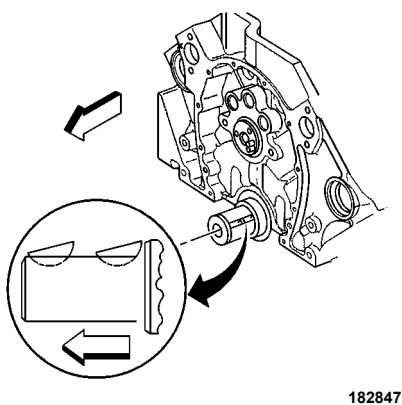


500645

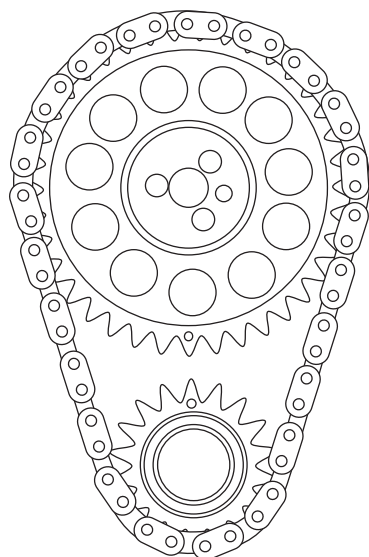
6. Remove the crankshaft sprocket using the J 5825-A.



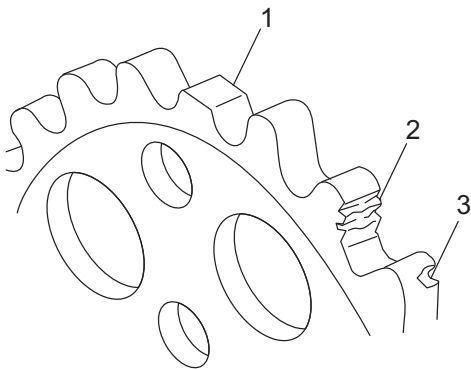
7. Remove the crankshaft balancer key.



Inspection

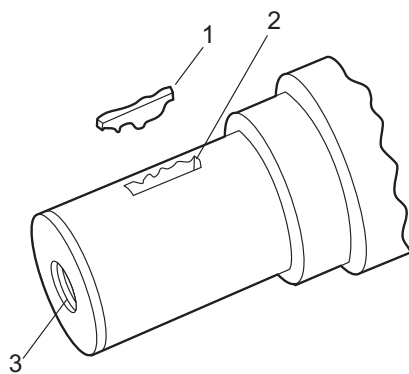


1. Clean the components with cleaning solvent.
 2. Dry the components with compressed air.
- ⚠ CAUTION! Always wear safety glasses when using compressed air.**
3. Inspect the camshaft timing chain for binding or wear.



4. Inspect the camshaft sprocket and the crankshaft sprocket for the following:

- Broken teeth (1)
- Damaged teeth (2)
- Chipped teeth (3)
- Worn teeth
- Uneven wear on the edge of the teeth
- Worn valleys between the sprocket teeth



5. Inspect the crankshaft balancer key (1), the keyway (2) and the threaded hole (3) for damage.

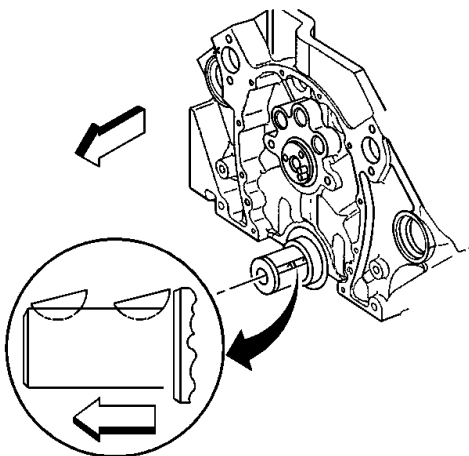
6. Repair or replace the crankshaft as necessary.

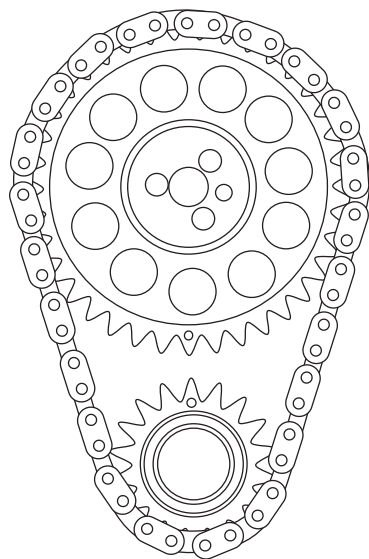
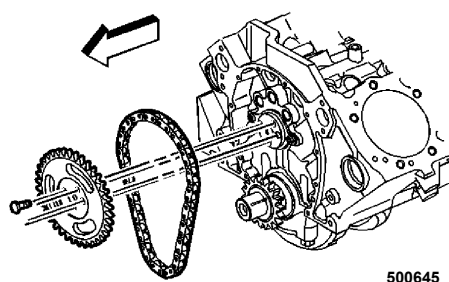
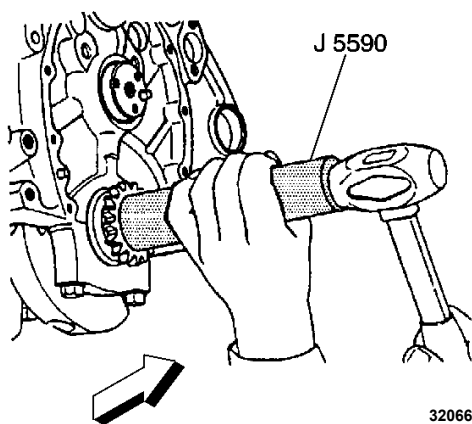
Installation

Tools Required

J 5590 Installer

1. Install the crankshaft balancer key into the crankshaft keyway.
 - The crankshaft balancer key should be parallel to the crankshaft or with a slight incline.





2. Align the keyway of the crankshaft sprocket with the crankshaft balancer key.



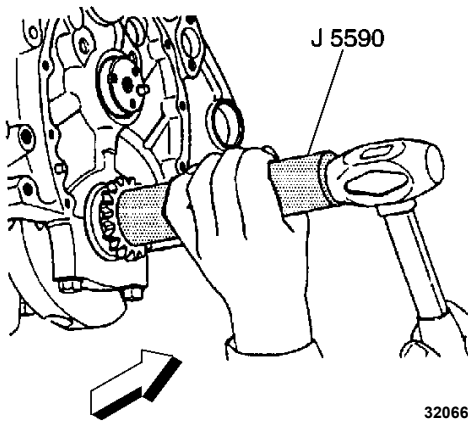
CAUTION! Wear safety glasses.

3. Use the J 5590 to install the crankshaft sprocket.

4. Rotate the crankshaft until the crankshaft sprocket is at the 12 o'clock position.
5. Install the camshaft sprocket and the camshaft timing chain.
6. Install the camshaft sprocket bolts and tighten to 25 N•m (18 lb. ft.).

NOTICE! Do not use a hammer to install the camshaft sprocket onto the camshaft. To do so may dislodge the expansion cup plug (camshaft rear bearing hole).

7. Install the camshaft sprocket with the alignment mark at the 6 o'clock position.

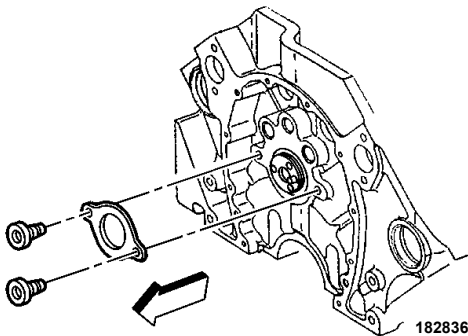


8. Install the crankshaft position sensor reluctor ring.
 - a. Align the keyway on the crankshaft position sensor reluctor ring with the crankshaft balancer key in the crankshaft.
 - b. Use the J 5590 in order to push the crankshaft position sensor reluctor ring onto the crankshaft until completely seated against the crankshaft sprocket.
9. Install front cover. See *Engine Front Cover* on page 92..

Camshaft

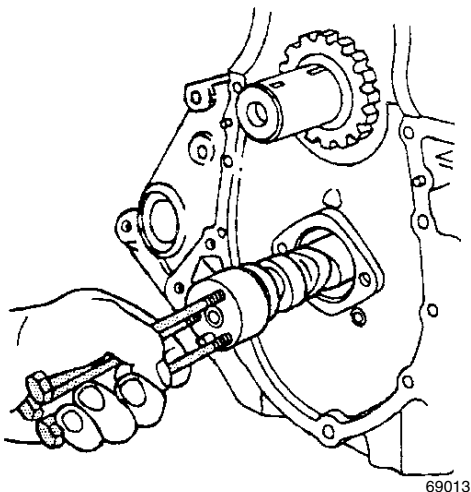
Remove

1. Remove timing chain and sprockets, *Timing Chain and Sprocket* on page 94 .
2. Remove intake manifold, *Intake Manifold* on page 41
3. Remove valve lifters, *Valve Train* on page 54
4. Remove the camshaft retainer bolts and retainer.



NOTICE! All camshaft journals are the same diameter, so care must be used in removing or installing the camshaft to avoid damage to the camshaft bearings.

5. Remove the engine camshaft.
 - a. Install the three 5/16-18 x 4.0 inch bolts into the engine camshaft front bolt holes.
 - b. Using the bolts as a handle, carefully rotate and pull the engine camshaft out of the camshaft bearings.
 - c. Remove the bolts from the front of the engine camshaft.



Inspect

Tools Required

J 7872 Magnetic Base Dial Indicator

1. Clean the engine camshaft in cleaning solvent.

2. Dry the engine camshaft with compressed air.

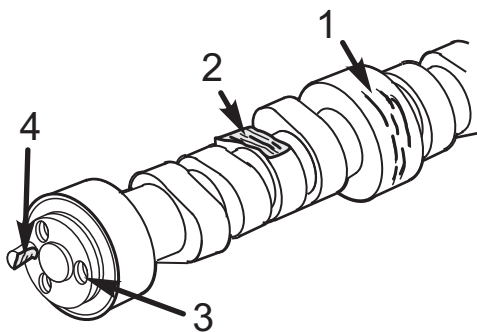


CAUTION! Always wear safety glasses when using compressed air.

3. Inspect the camshaft retainer plate for damage.
If the camshaft retainer plate is damaged, replace as necessary.
4. Inspect the camshaft bearings for correct fit into the engine block camshaft bearing bores.

NOTICE! The camshaft bearings have an interference fit to the engine block camshaft bearing bores and must not be loose in the engine block camshaft bearing bores.

NOTICE! If any camshaft bearing is excessively worn or scored, replace all the camshaft bearings.

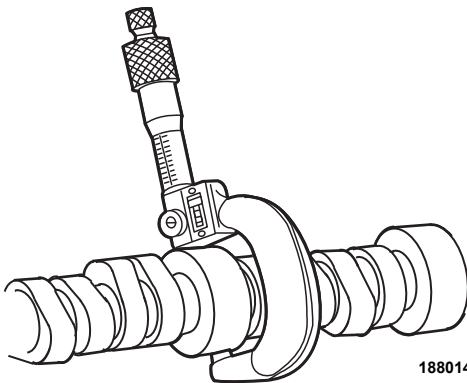


188095

5. Inspect the camshaft bearings for excessive wear or scoring.
6. Inspect the engine camshaft for the following:
 - Worn, scored or damaged bearing journals (1)
 - Worn engine camshaft lobes (2)
 - Damaged bolt hole threads (3)
 - Damaged camshaft sprocket locator pin (4)

7. Measure the engine camshaft journals with a micrometer.

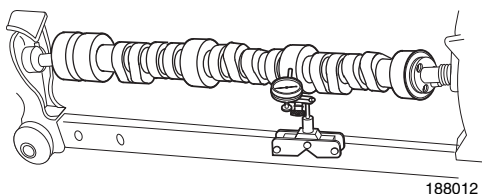
If the camshaft journals are more than 0.025 mm (0.0010 in) out-of-round, then replace the engine camshaft.



188014

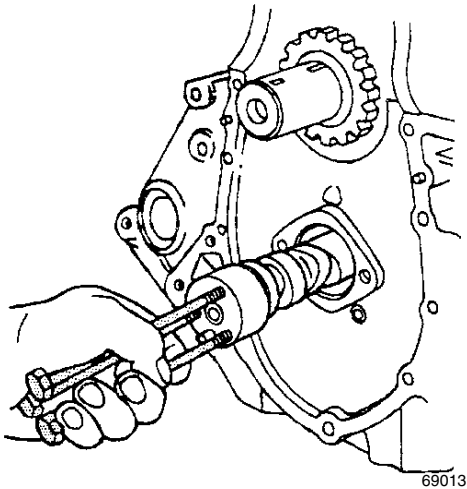
8. Measure for a bent engine camshaft or excessive engine camshaft run-out using the J 7872.

- a. Mount the engine camshaft in a suitable stand between centers.
- b. Use the J 7872 in order to check the intermediate engine camshaft journals.



188012

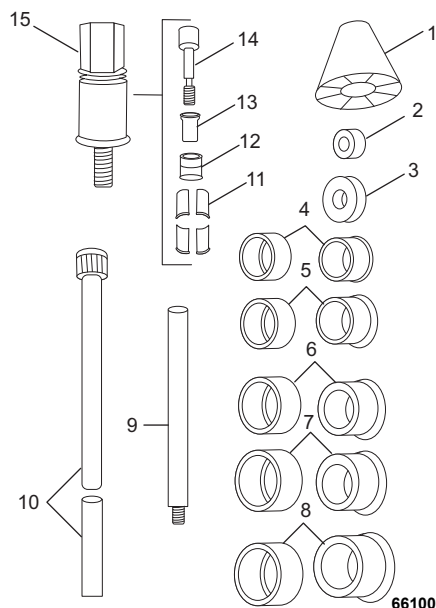
9. Measure the engine camshaft lobe lift using the J 7872.
 - a. Place the engine camshaft on the V-blocks.
 - b. Use the J 7872 in order to measure the engine camshaft lobe lift.
10. Replace the engine camshaft if the engine camshaft lobe lift is not within specifications. Refer to Engine Mechanical Specifications.

Installation

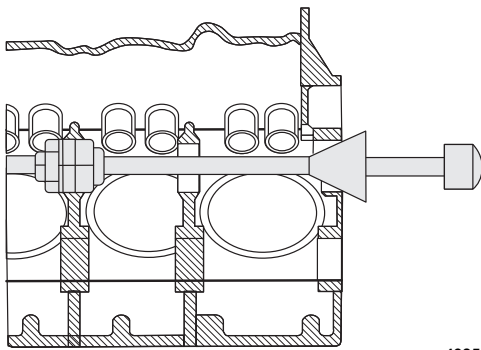
1. Apply clean engine oil GM P/N 12345610 or equivalent, or engine oil supplement GM P/N 1052367 or equivalent to the following components:
 - The engine camshaft lobes
 - The camshaft bearing journals
 - The camshaft bearings
2. Install three 5/16-18 x 4.0 in. bolts into the engine camshaft front bolt holes.

NOTICE! All camshaft journals are the same diameter, so care must be used in removing or installing the camshaft to avoid damage to the camshaft bearings.

3. Use the bolts as a handle in order to install the engine camshaft.
4. Remove the 3 bolts from the front of the engine camshaft.
5. Install the timing chain and sprockets, See *Timing Chain and Sprocket* on page 94..
6. Install the valve lifters, *Valve Train* on page 54 .
7. Install the intake manifold, See *Intake Manifold* on page 41..

Camshaft Bearings**Remove****Tools Required****J 33049 Camshaft Bearing Service Kit**

1. Remove camshaft, See *Camshaft* on page 99.
2. Select the cone (1), the handle (10), the expanding driver (4-8), the washer (2 or 3) and the expander assembly (15) from the J 33049.
3. Assemble the J 33049.



4985

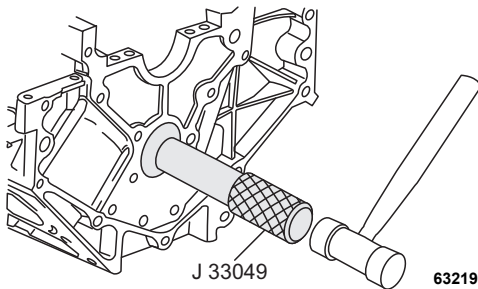
NOTICE! A loose camshaft bearing may be caused by an enlarged, out-of-round or damaged engine block camshaft-bearing bore.

NOTICE! Always remove the camshaft inner bearings #2 and #3 first. The camshaft outer bearings #1 and #4 serve as a guide for the J 33049.



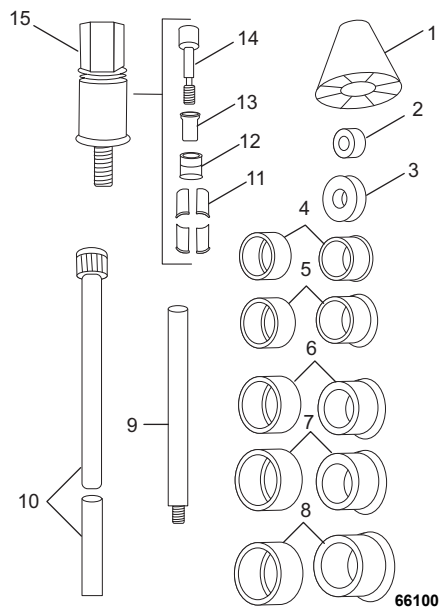
CAUTION! Wear safety glasses.

4. Remove the camshaft inner bearings #2, #3 and #4.
 - a. Insert the J 33049 through the front of the engine block and into the camshaft inner bearing #2.
 - b. Tighten the J 33049 expander assembly nut until snug.
 - c. Push the J 33049 guide cone into the camshaft front bearing in order to align the J 33049.
 - d. Drive the camshaft inner bearing #2 from the camshaft inner bearing bore #2.
 - e. Loosen the J 33049 expander assembly nut.
 - f. Remove the camshaft inner bearing #2 from the J 33049 expander assembly.
 - g. Insert the J 33049 expander assembly into the camshaft inner bearing #3.
 - h. Tighten the J 33049 expander assembly nut until snug.
 - i. Push the J 33049 guide cone into the camshaft front bearing in order to align the J 33049.
 - j. Drive the camshaft inner bearing #3 from the camshaft inner bearing bore #3.
 - k. Loosen the J 33049 expander assembly nut.
 - l. Remove the camshaft inner bearing #3 from the J 33049 expander assembly.
 - m. Insert the J 33049 expander assembly into the camshaft inner bearing #4.
 - n. Tighten the J 33049 expander assembly nut until snug.
 - o. Push the J 33049 guide cone into the camshaft front bearing in order to align the J 33049.
 - p. Drive the camshaft inner bearing #4 from the camshaft inner bearing bore #4.
 - q. Loosen the J 33049 expander assembly nut.
 - r. Remove the camshaft inner bearing #4 from the J 33049 expander assembly.
5. Remove the J 33049 from the engine block.



6. Remove the camshaft outer bearings #1 and #5.
 - a. Insert the J 33049 into the camshaft outer bearing #1.
 - b. Tighten the J 33049 expander assembly nut until snug.
 - c. Drive the camshaft outer bearing #1 from the camshaft outer bearing bore #1.
 - d. Loosen the J 33049 expander assembly nut.
 - e. Remove the camshaft outer bearing #1 from the J 33049 expander assembly.
 - f. Remove the J 33049 from the engine block.
 - g. Insert the J 33049 expander assembly into the camshaft outer bearing #5.
 - h. Tighten the J 33049 expander assembly nut until snug.
 - i. Drive the camshaft outer bearing #5 from the camshaft outer bearing bore #5.
 - j. Loosen the J 33049 expander assembly nut.
 - k. Remove the camshaft outer bearing #5 from the J 33049 expander assembly.
7. Remove the J 33049 from the engine block.
8. Discard the camshaft bearings.

Installation



Tools Required

J 33049 Camshaft Bearing Service Kit

NOTICE! Always install the camshaft outer bearings #1 and #5 first. The camshaft outer bearings serve as a guide for the J 33049 and help center the camshaft inner bearings during the installation process.

NOTICE! Ensure that the camshaft bearing lubrication hole or holes align with the oil gallery hole or holes in the engine block. On some engines, the oil gallery holes may be difficult to see.

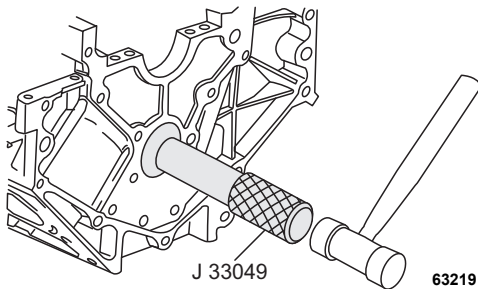
1. Select the handle (10), the expanding driver (4-8), the washer (2 or 3) and the expander assembly (15) from the J 33049.
2. Assemble the J 33049



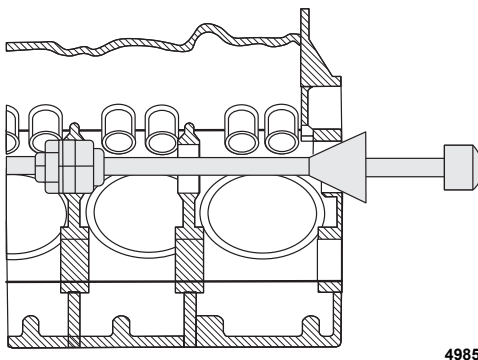
CAUTION! Wear safety glasses.

NOTICE! The camshaft bearings vary in size. When ordering the new camshaft bearings, be sure to order the correct camshaft bearings for the application to be serviced.

NOTICE! Always install the camshaft outer bearings #1 and #4 first. The camshaft outer bearings serve as a guide for the J 33049 and help center the camshaft inner bearings during the installation process.



3. Install the NEW camshaft outer bearings #5 and #1.
 - a. Install the NEW camshaft outer bearing #4 onto the J33049 expander assembly.
 - b. Tighten the J 33049 expander assembly nut until snug.
 - c. Align the camshaft outer bearing #5 lubrication hole with the oil gallery hole in the camshaft outer bearing bore #5 at the rear of the engine block.
 - d. Drive the camshaft outer bearing #5 into the camshaft outer bearing bore #5 at the rear of the engine block.
 - e. Loosen the J 33049 expander assembly nut.
 - f. Remove the camshaft outer bearing #5 from the J33049 expander assembly.
 - g. Install the NEW camshaft outer bearing #1 onto the J33049 expander assembly.
 - h. Tighten the J 33049 expander assembly nut until snug.
 - i. Align the camshaft outer bearing #1 lubrication hole with the oil gallery hole in the camshaft outer bearing bore #1 at the front of the engine block
 - j. Drive the camshaft outer bearing #1 into the camshaft outer bearing bore #1 at the front of the engine block.
 - k. Loosen the J 33049 expander assembly nut.
 - l. Carefully slide the J 33049 into the engine block until the J 33049 expander assembly is positioned between the camshaft inner bearing bore #3 and the camshaft inner bearing bore #4.



4. Install the NEW camshaft inner bearings #4, #3 and #2.
 - a. Install the NEW camshaft inner bearing #4 onto the J33049 expander assembly.
 - b. Tighten the J 33049 expander assembly nut until snug.
 - c. Align the camshaft inner bearing #4 lubrication hole with the oil gallery hole in the camshaft inner bearing bore #4 of the engine block.
 - d. Push the J 33049 guide cone into the camshaft front bearing bore #1 in order to align the J 33049.
 - e. Drive the camshaft inner bearing #4 into the camshaft inner bearing bore #4.
 - f. Loosen the J 33049 expander assembly nut.

- g. Carefully slide the J 33049 until the J 33049 expander assembly is positioned between the camshaft inner bearing bore #3 and the camshaft inner bearing bore #2.
 - h. Install the NEW camshaft inner bearing #3 onto the J33049 expander assembly.
 - i. Tighten the J 33049 expander assembly nut until snug.
 - j. Align the camshaft inner bearing #3 lubrication hole with the oil gallery hole in the camshaft inner bearing bore #3 of the engine block.
 - k. Push the J 33049 guide cone into the camshaft front bearing bore #1 in order to align the J 33049.
 - l. Drive the camshaft inner bearing #3 into the camshaft inner bearing bore #3.
 - m. Loosen the J 33049 expander assembly nut.
 - n. Carefully slide the J 33049 until the J 33049 expander assembly is positioned between the camshaft inner bearing bore #2 and the camshaft outer bearing bore #1.
 - o. Install the NEW camshaft inner bearing #2 onto the J33049 expander assembly.
 - p. Tighten the J 33049 expander assembly nut until snug.
 - q. Align the camshaft inner bearing #2 lubrication hole with the oil gallery hole in the camshaft inner bearing bore #2 of the engine block.
 - r. Push the J 33049 guide cone into the camshaft front bearing bore #1 in order to align the J 33049.
 - s. Drive the camshaft inner bearing #2 into the camshaft inner bearing bore #2.
 - t. Loosen the J 33049 expander assembly nut.
5. Install camshaft, See *Camshaft* on page 99.

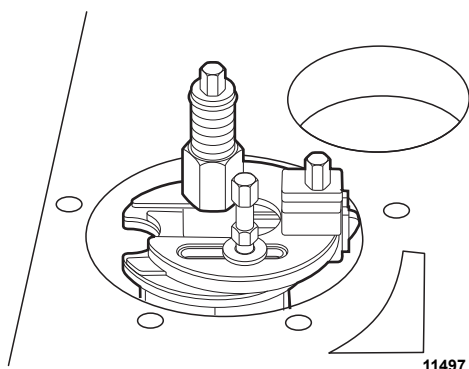
Piston, Connecting Rod, and Bearings

- 1. Remove engine from boat. See *Removal and Installation Workshop Manual*.
- 2. Remove cylinder heads. See *Cylinder Head* on page 60.
- 3. Remove oil pan. See *Oil Pan and Oil Pump* on page 74..

Tools Required

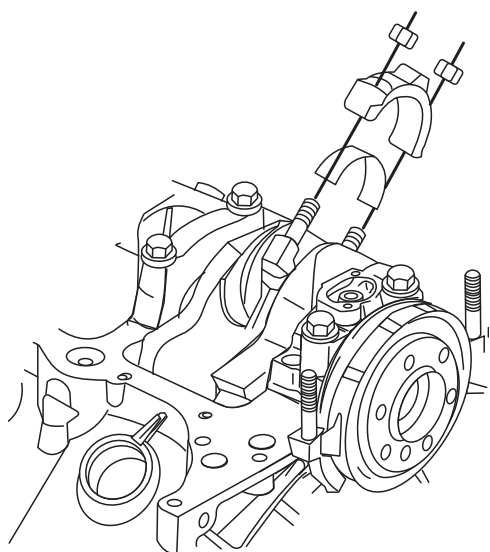
J 5239 Connecting Rod Bolt Guide Set

J 24270 Cylinder Bore Ridge Reamer

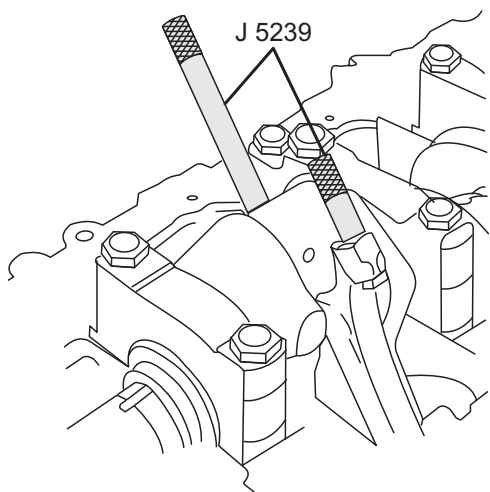


4. Use the J 24270 in order to remove the cylinder ring ridge.
 - a. Turn the crankshaft until the piston is at the bottom of the stroke.
 - b. Place a cloth on top of the piston.
 - c. Use the J 24270 to remove all of the cylinder ring ridge.
 - d. Turn the crankshaft so the piston is at the top of the stroke.
 - e. Remove the cloth.
 - f. Remove the cutting debris.

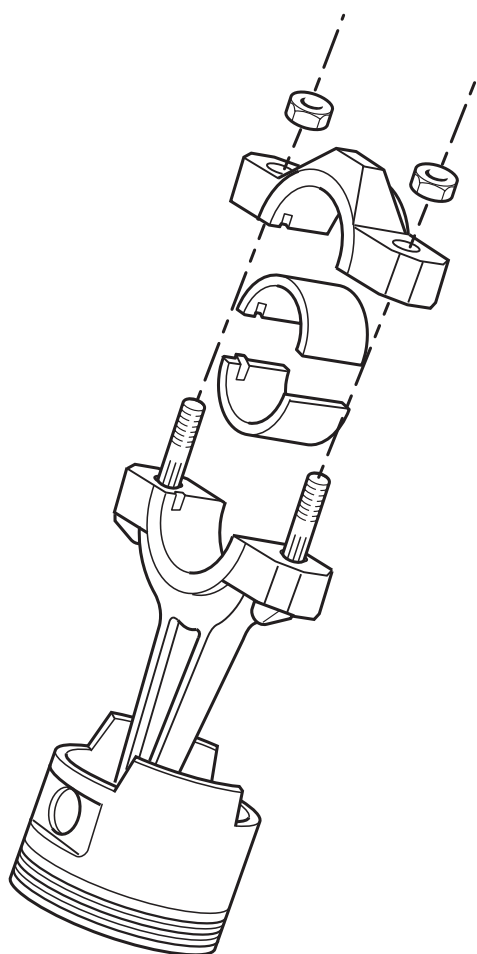
NOTICE! Place match marks or numbers on the connecting rods and the connecting rod caps.



5. Remove the connecting rod nuts.
6. Remove the connecting rod cap.



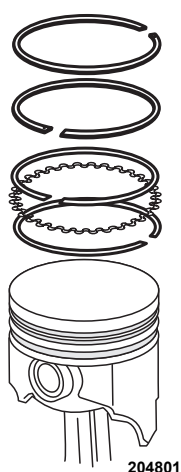
7. Use the J 5239 in order to protect the crankshaft journals and remove the connecting rod and the piston out of the top of the engine block.



NOTICE! Always assemble the connecting rod caps to the matching connecting rods.

8. Remove the connecting rod bearings.
 - a. Keep the connecting rod bearings with the original connecting rod and connecting rod cap.
 - b. Wipe the oil from the connecting rod bearings.
 - c. Wipe the oil from the crankpin.

Piston and Connecting Rod Disassemble



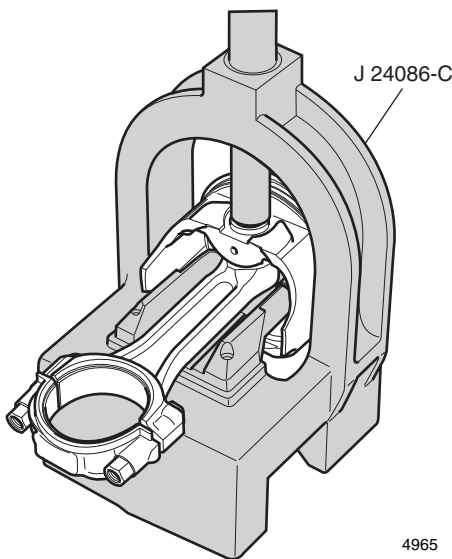
Tools Required

J 24086-C Piston Pin Remover/Installer

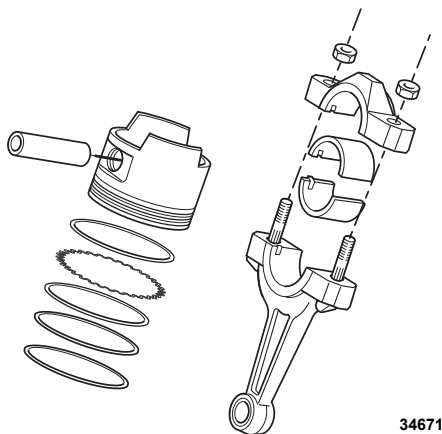


CAUTION! Wear safety glasses.

1. Remove the piston rings from the pistons.

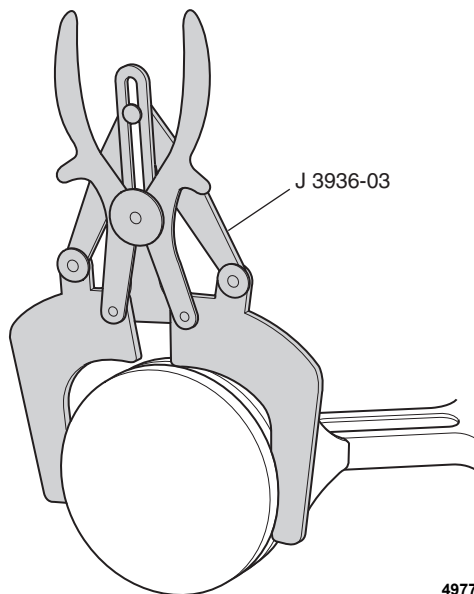


2. Press the piston pin from the connecting rod using the J 24086-C.
3. The piston pin has an interference fit into the connecting rod, and is full floating in the piston.



4. Mark separate, and organize the parts for assembly.

Clean and Inspect



NOTICE! Measurement of all components should be taken with the components at room temperature.

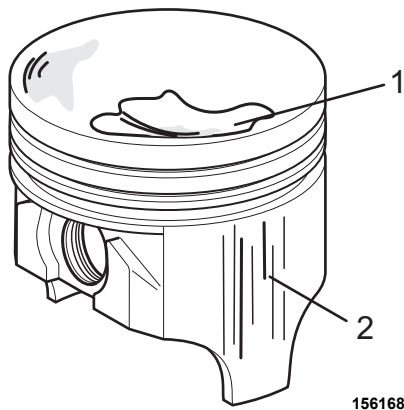
NOTICE! Do not use a wire brush in order to clean any part of the piston. Particles from the wire will become embedded in the piston and damage the cylinder and piston.

Blasting techniques can be employed to remove hard carbon deposits if suitable equipment is available. Suitable types of grit for dry blasting are plastic pellets and processed natural materials such as wheat grains and crushed fruit pits or shells. Air pressure must be adjusted to the lowest setting that will produce the desired cleaning action. Small holes and machine finished surfaces must be protected from the blast by seals and covers.

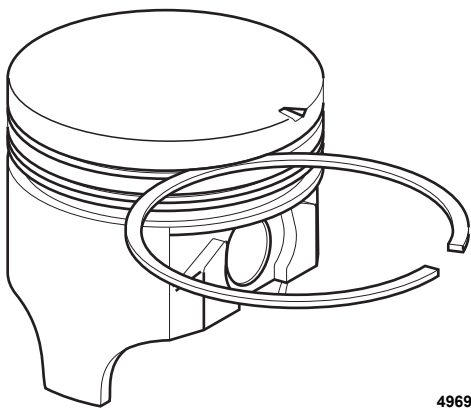


CAUTION! Wear safety glasses.

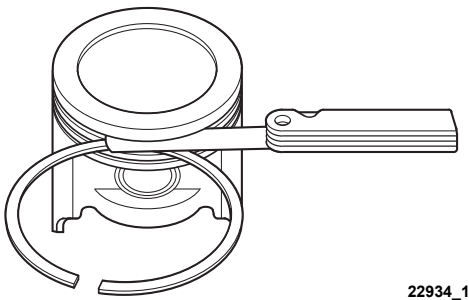
1. Clean the piston and connecting rod in solvent.
2. Dry the components with compressed air.



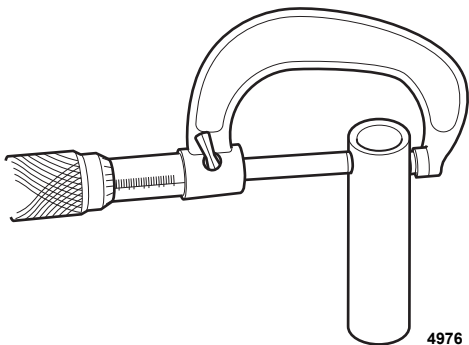
3. Clean the piston oil lubrication holes and slots.
4. Inspect the piston for the following:
 - Eroded areas (1) on the top of the piston
 - Scuffed or damaged skirt (2)
 - Damage to the pin bore (3)
 - Cracks in the piston ring lands, the piston skirt or the pin bosses
 - Piston ring grooves for nicks, burrs or other warping which may cause the piston ring to bind
5. Inspect the piston pin for scoring, wear or other damage



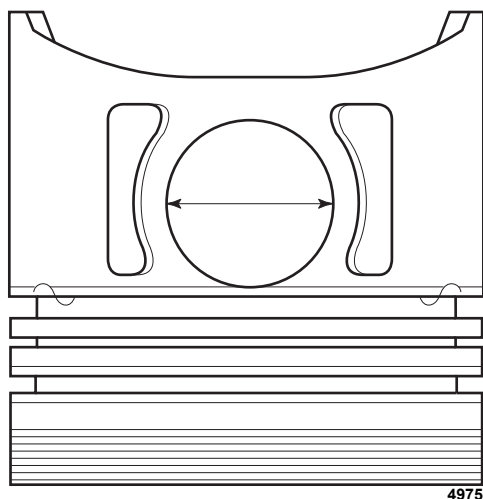
6. Measure the piston ring-to-piston ring groove side clearance.
 - d. Insert the edge of the piston ring into the piston ring groove.
 - e. Roll the piston ring completely around the piston.
 - If binding is caused by a distorted piston ring groove, MINOR imperfections may be removed with a fine file.
 - If binding is caused by a distorted piston ring, replace the piston ring.



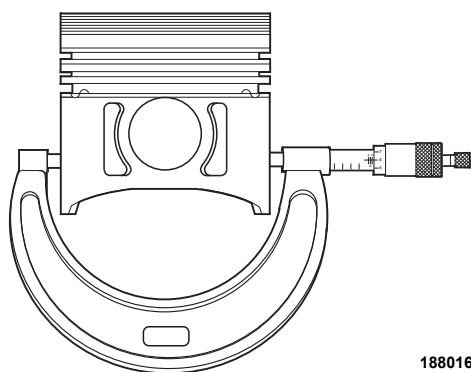
7. Measure the piston ring side clearance with a feeler gauge.
8. If the side clearance is too small, try another piston ring set.
9. If the proper piston ring-to-piston ring groove clearance cannot be achieved, replace the piston and pin assembly.
10. To determine the proper piston ring side clearance, *Engine Specifications 5.0 Litre* on page 139 .



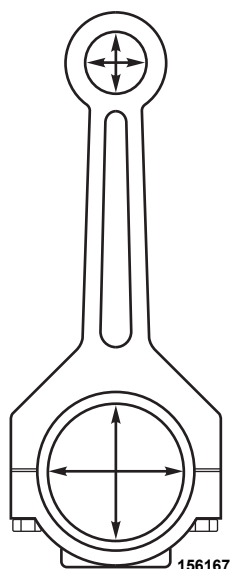
11. To determine piston pin-to-bore clearance, use a micrometer and measure the piston pin.



12. To determine piston pin-to-bore clearance, use an inside micrometer and measure the piston pin bore.
13. To determine the piston pin-to-bore clearance, subtract the piston pin diameter from the piston pin bore diameter. *Engine Specifications 5.0 Litre on page 139*

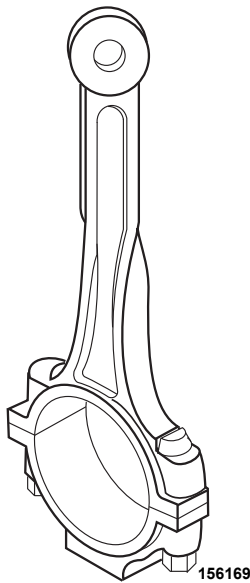


14. Measure the piston with a micrometer at a right angle to the piston pin bore, measure the piston at 11 mm (0.433 in) from the bottom of the skirt. *Engine Specifications 5.0 Litre on page 139*
15. If the piston is not within specifications, replace the piston and pin as an assembly.



16. Inspect the connecting rod for an out-of-round bearing bore. *Engine Specifications 5.0 Litre on page 139*

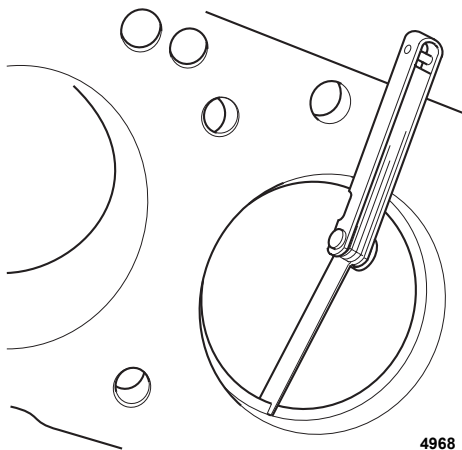
17. Inspect the connecting rod for twisting.
18. Inspect the connecting rod for damage to the bearing cap and bolt threads.



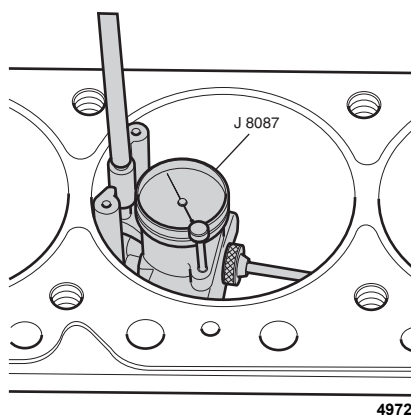
19. Measure the piston compression ring end gap.

NOTICE! Fit each compression ring to the cylinder in which it will be used.

20. Place the compression ring into the cylinder bore.
 - a. Push the compression ring into the cylinder bore to approximately 6.5 mm (0.25 in) above the ring travel. The ring must be square to the cylinder wall.
 - b. Use a feeler gauge in order to measure the end gap.
 - c. Select another size ring set if the end gap exceeds specifications. *Engine Specifications 5.0 Litre* on page 139 .



Piston Selection



Tools Required

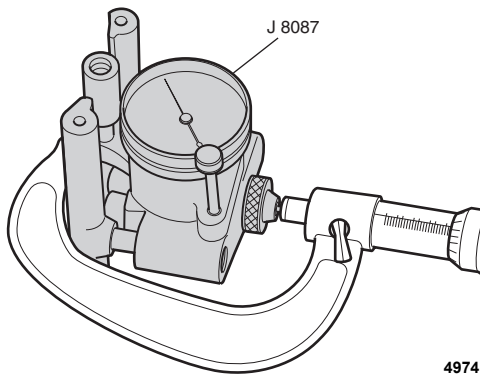
J 8087 Cylinder Bore Gauge

NOTICE! Measurements of all components should be taken with the components at normal room temperature.

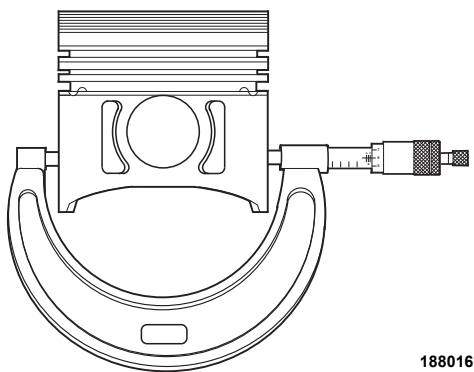
For proper piston fit, the engine block cylinder bores should not have excessive wear or taper.

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

1. Use the J 8087 in order to measure the cylinder bore diameter. Measure at a point 64 mm (2.5 in) from the top of the cylinder bore and 90 degrees to the crankshaft centerline.

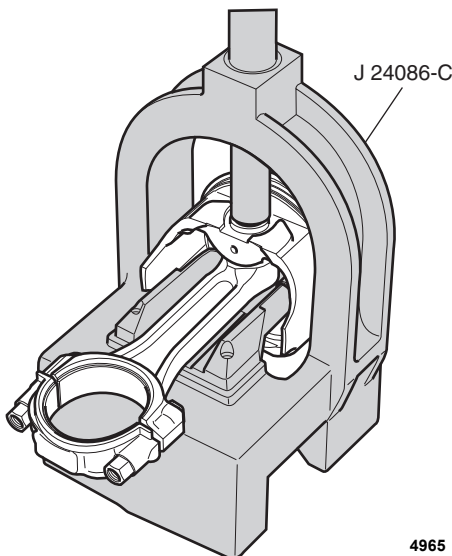


2. Measure the J 8087 with a micrometer and record the reading.



3. With a micrometer or caliper at a right angle to the piston pin bore, measure the piston 11 mm (0.433 in) from the bottom of the skirt.
4. Subtract the piston diameter from the cylinder bore diameter in order to determine piston-to-bore clearance. *Engine Specifications 5.0 Litre* on page 139 .
5. If the proper clearance cannot be obtained, then select another piston and measure the clearances.
6. If the proper fit cannot be obtained, the cylinder bore may require honing or boring.
7. When the piston-to-cylinder bore clearance is within specifications, permanently mark the top of the piston for installation into the proper cylinder.

Piston and Connecting Rod Assemble



Tools Required

J 24086-C Piston Pin Remover/Installer



CAUTION! Avoid contact with **HOT** components. Wear safety glasses and protective gloves to avoid personal injury.

NOTICE! Applying excessive heat to the connecting rod may damage or distort the rod. Rod temperature **SHOULD NEVER** exceed 315°C (600°F). At this temperature, the end of the connecting rod will turn a straw color upon visual inspection.

NOTICE! After the J 24086-C installer hub bottoms on the support assembly, **DO NOT** exceed 35,000 kPa (5,000 psi) or the tool may be damaged.

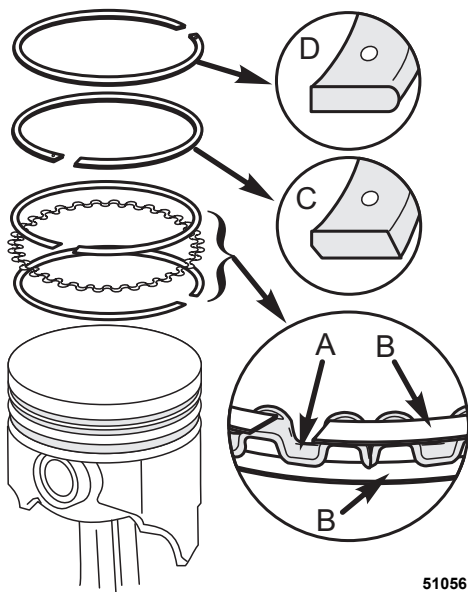
NOTICE! When assembling the piston and connecting rod, the mark on the top of the piston must point to the front of the engine block. The left bank connecting rods should have the flange face toward the front of the engine block. The right bank connecting rods should have the flange face toward the rear of the engine block.

The piston pin has an interference fit into the connecting rod and is full floating in the piston.

1. Install the piston pin and connecting rod assembly.

- Lubricate the piston pin bores with clean engine oil.
- Use a torch and apply MILD heat to the piston pin end of the connecting rod.
- Use the J 24086-C in order to press the piston pin into the piston and connecting rod assembly.
- Inspect for the proper installation of the piston and piston pin. The piston must move freely on the piston pin with no binding or interference.

NOTICE! Use a piston ring expander to install the piston rings. The rings may be damaged if expanded more than necessary.



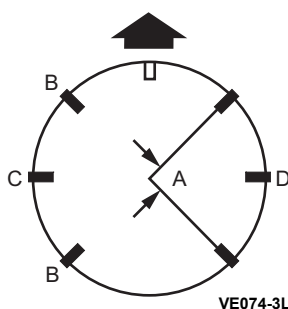
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- Install the piston rings onto the piston.
 - Install the oil control piston ring spacer.
 - Install the lower oil control piston ring.
 - Install the upper oil control piston ring.
 - Install the lower compression piston ring.

The mark on the side of the piston ring should face the top of the piston.

- Install the upper compression piston ring.

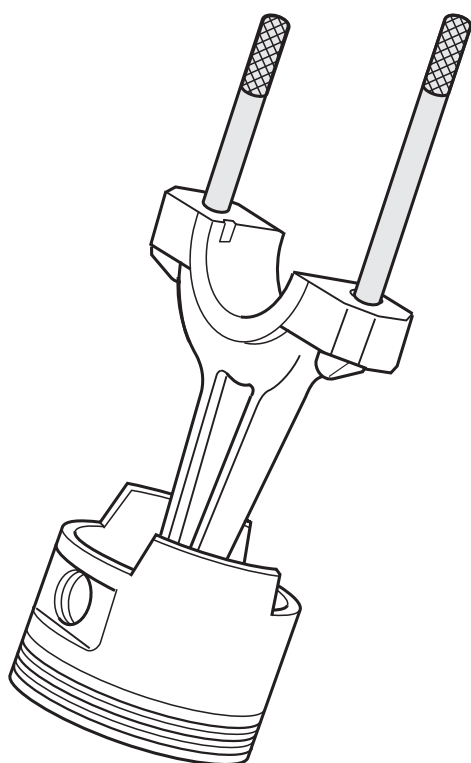
The mark on the side of the piston ring should face the top of the piston.



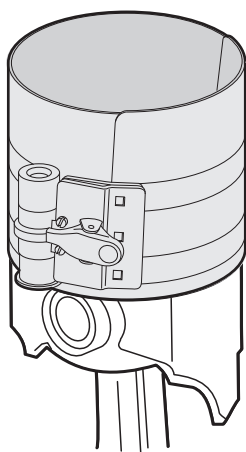
VE074-3L

- Space the compression piston ring end gaps 120 degrees apart.
- Space the oil control piston ring end gaps a minimum of 90 degrees apart.

Installation



1. Apply clean engine oil to the following components:
 - The piston
 - The piston rings
 - The cylinder bore
 - The bearing surfaces
2. Install the J 5239 onto the connecting rod bolts.



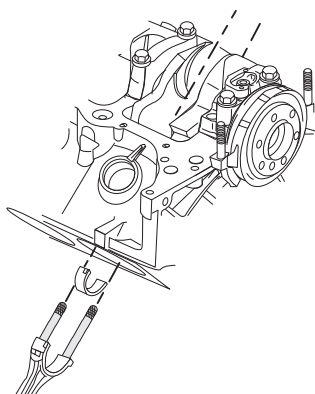
3. Install the J 8037 onto the piston and compress the piston rings.

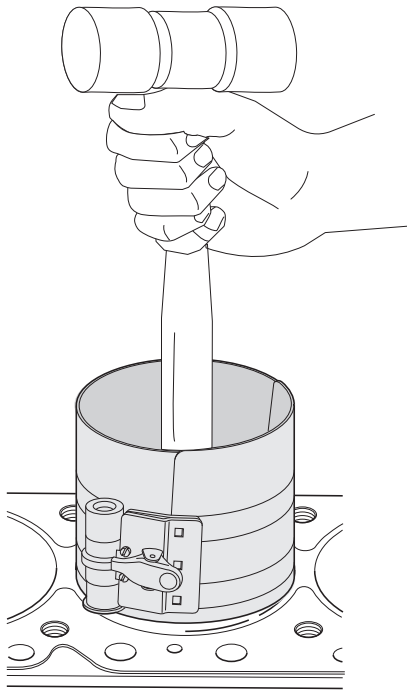
NOTICE! J 8037 has tabs on the bottom of the ring compressor to prevent the tool from sliding into the cylinder with the piston. Make sure the tool is installed with these tabs facing down toward the engine. The compression bands will also be toward the lower portion of the ring compressor. If the tool is used incorrectly, the tool, piston or piston rings could be damaged.

NOTICE! The mark on the top of the piston must face the front of the engine block.

When assembled, the flanges on the connecting rod and connecting rod cap should face to the front of the engine block on the left bank (cyl. 1, 3, 5 and 7), and to the rear of the engine block on the right bank (cyl. 2, 4, 6 and 8).

4. Install the piston and connecting rod assembly, with the J 8037 into the proper cylinder bore.

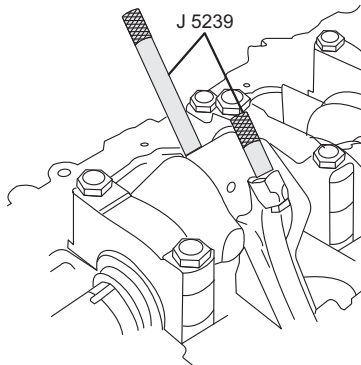




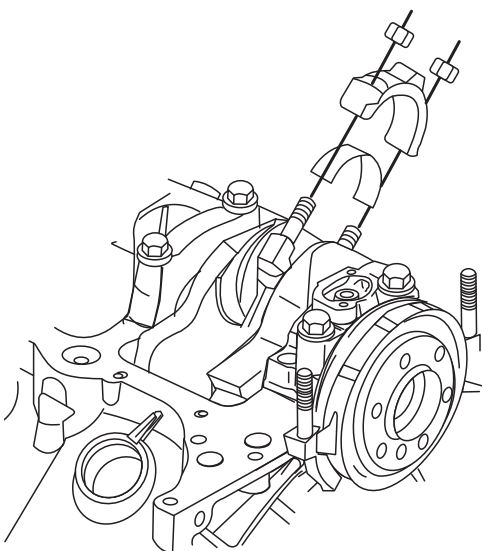
5. Use the J 8037 and the J 5239 and lightly tap the top of the piston with a wooden hammer handle.
 - a. Hold the J 8037 firmly against the engine block until all of the piston rings have entered the cylinder bore.
 - b. Use the J 5239 in order to guide the connecting rod onto the crankshaft journal.

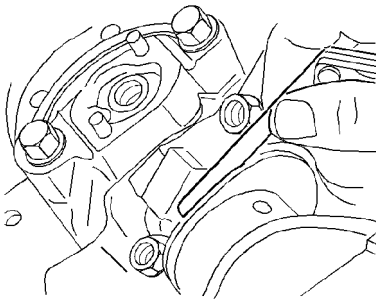
NOTICE! It is extremely important not to damage the surface of the crankshaft connecting rod journal during installation. Be careful guiding the connecting rod into position on the crankshaft. Catastrophic engine failure may result if the crankshaft connecting rod journal is damaged during installation and left uncorrected.

6. Remove the J 5239.



7. Install the connecting rod caps, bearings and nuts.
 - a. Tighten the nuts evenly on the first pass to 27 N•m (20 ft. lb.).
 - b. Use the J 36660 or an equivalent angle torque meter to tighten the nuts on the final pass an additional 70 degrees.





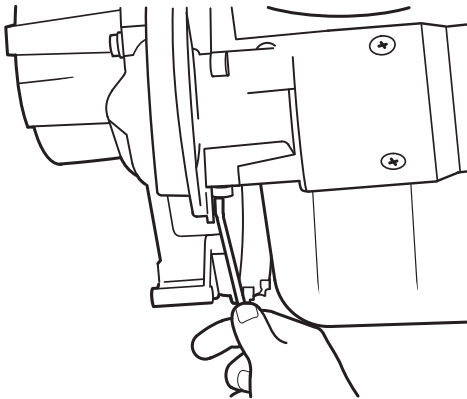
8. After the piston and connecting rod assemblies have been installed, then lightly tap each connecting rod assembly (parallel to the crank pin) in order to ensure that the connecting rods have side clearance.
9. Use a feeler gauge or a dial indicator to measure the connecting rod side clearance between the connecting rod caps. The connecting rod side clearance should be 0.15-0.44 mm (0.006-0.017 in).
10. Install oil pan, *Oil Pan and Oil Pump* on page 74
11. Install cylinder heads, *Cylinder Head* on page 60 .
12. Install engine in boat, *Engine Specifications 5.0 Litre* on page 139

Engine Coupler

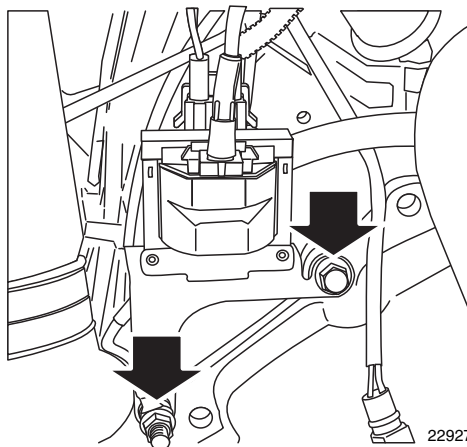
Removal

1. Remove engine from boat, *Engine Specifications 5.0 Litre* on page 139 .

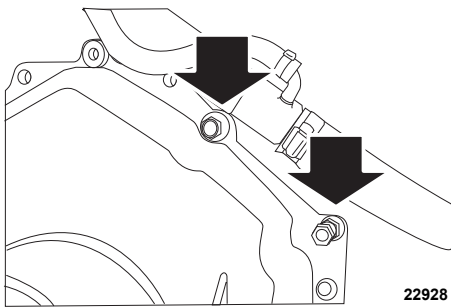
NOTICE! If coupler is being replaced due to coupler failure (rubber hub of splined hub), check engine alignment after installing new coupler. See *Engine Specifications 5.0 Litre* on page 139..



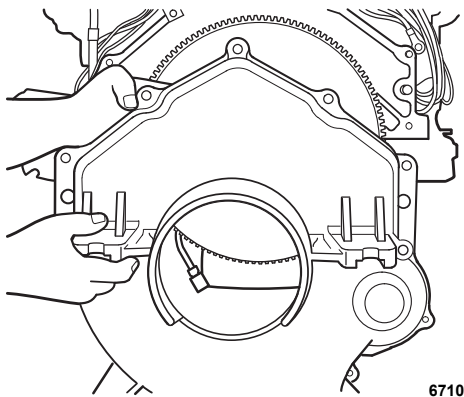
2. Take out screws holding flywheel housing cover, then slide out cover.



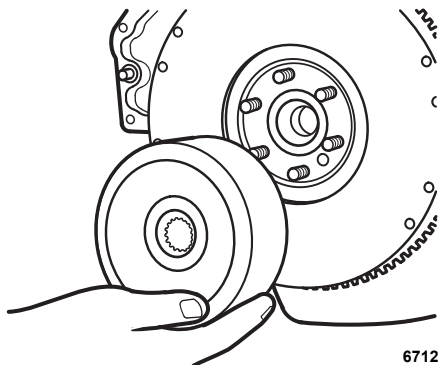
3. Remove nut, lock washer, and ground leads from ground stud and coil bracket. Remove inner nut, lock washer and washer.



4. Remove nut, lock washer, and ground leads from ground stud and power steering cooler bolt.
5. Unscrew remaining flywheel housing bolts, lock washers and washers. Note position of clamps so they can be installed in original position.



6. Lift flywheel housing off engine block and set aside.

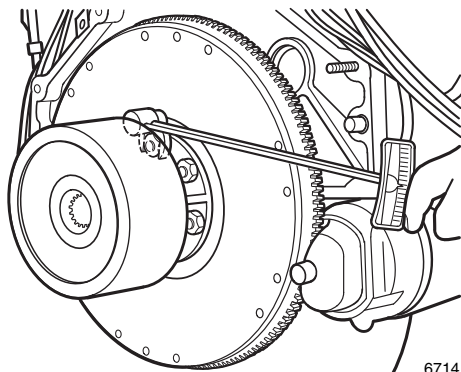


7. Unscrew six locknuts, then pull coupler off flywheel.

Inspection

Inspect the coupler for burnt rubber, chunks missing from the rubber or cracks in the aluminum. Check for melted rubber around outer diameter of aluminum. If any of these conditions are found, replace the coupler.

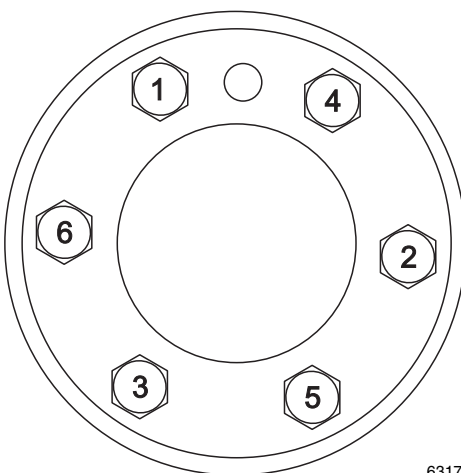
Installation



6714

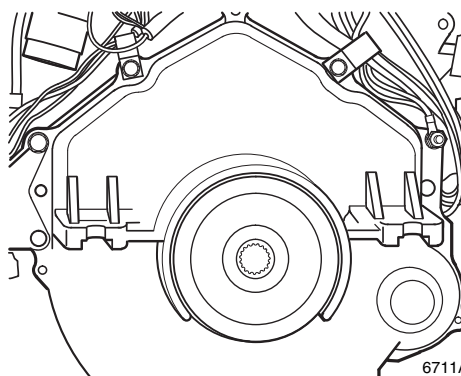
1. Slide coupler onto crankshaft studs. Install new locknuts.

NOTICE! If studs are loose or show any signs of movement they must be replaced. The threaded portion of the stud should not have any play in the crankshaft. If studs are replaced, they must be locked in place using VP P/N 1161075 thread locking compound and torqued to 10-15 ft. lb. before installing coupler.



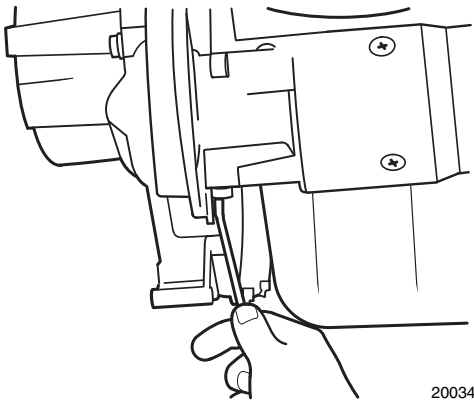
63174

2. Tighten nuts in sequence. Use a crowfoot wrench and tighten nuts to 40-45 ft. lb. (54-61 N•m).



6711A

3. Install flywheel housing. Place clamps in their original positions, and attach coil bracket and power steering cooler. Tighten screws to 38-49 N•m (28-36 ft. lb.)
4. Place washer, lock washer and nut on ground stud. Tighten inner nut to 47-54 N•m (35-40 ft. lb.) Attach electrical leads to ground stud. Install lock washer and tighten outer nut securely. Install ground stud hardware on opposite side of block.

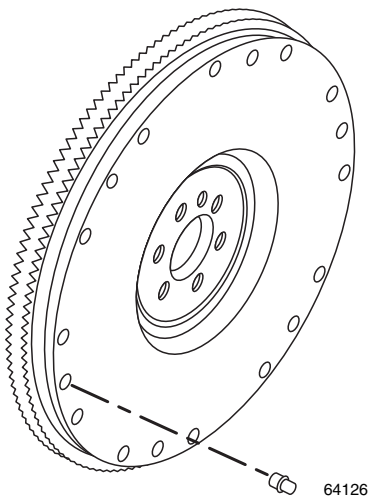
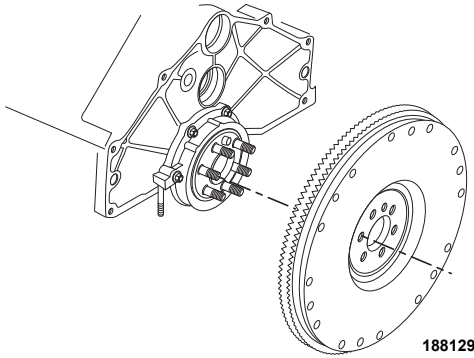


5. Slide flywheel cover into place. Install screws and tighten them to 7-9 N•m (60-84 in. lb.)
6. Install engine, see *Engine Installation and Removal Workshop Manual*.

Flywheel

Removal

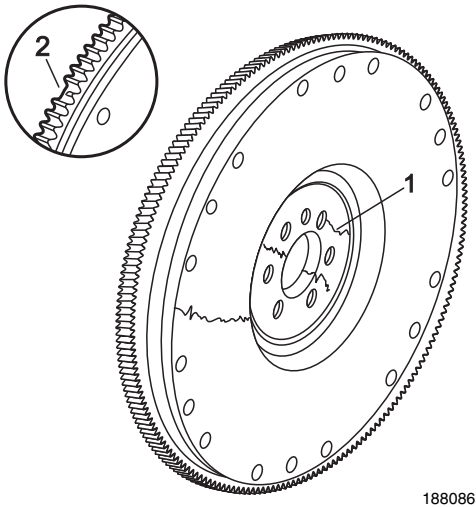
1. Engine coupler, *Engine Coupler* on page 116
2. Remove flywheel from crankshaft studs.



NOTICE! If replacing the engine flywheel, then **NEW** flywheel weights must be installed into the **NEW** engine flywheel in the same location as the old flywheel weights in the old engine flywheel.

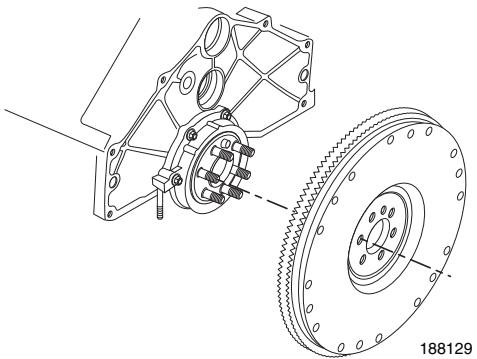
3. Note the position of any flywheel weights for assembly (if applicable).

Inspection



4. Inspect the engine flywheel for the following:
 - Cracks other surface damage (1)
 - Damaged ring gear teeth (2)
 - Loose or improperly positioned ring gear
5. The ring gear has an interference fit onto the engine flywheel and the ring gear should be positioned completely flat against the flange of the engine flywheel.

Installation



6. Install flywheel on crankshaft studs.
7. Install engine coupler, *Engine Coupler* on page 116 .

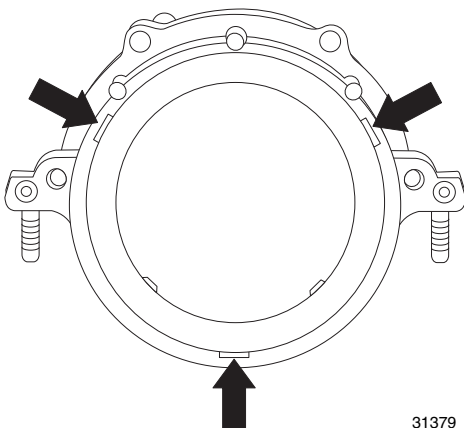
Crankshaft Rear Oil Seal and Housing

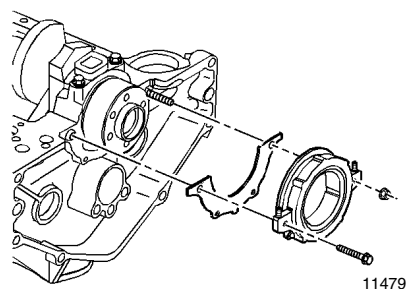
Remove

1. Remove engine from boat. See *Engine Removal and Installation Workshop Manual*.
2. Remove engine coupler, See *Engine Coupler* on page 116..
3. Remove flywheel, See *Flywheel* on page 119..
4. Remove the crankshaft rear oil seal from the crankshaft rear oil seal housing.

Insert a suitable tool into the access notches and then carefully pry the crankshaft rear oil seal from the crankshaft rear oil seal housing.

5. Discard the crankshaft rear oil seal.

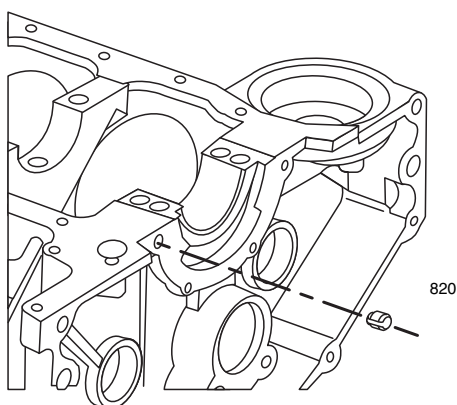




If removing oil seal housing, remove oil pan. See *Oil Pan and Oil Pump* on page 74.

6. Remove the crankshaft rear oil seal housing nut and bolts.
7. Remove the crankshaft rear oil seal housing.
8. Remove the crankshaft rear oil seal housing gasket.
9. Discard the crankshaft rear oil seal housing gasket.

10. If necessary, remove the spring type pin.

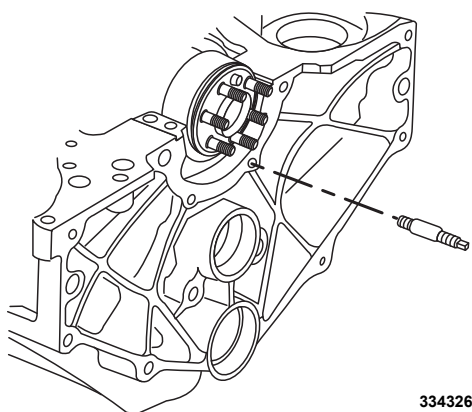


Installation

Tools Required

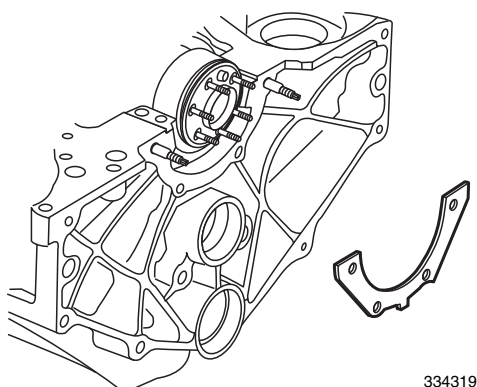
J 35621-B Rear Main Seal Installer

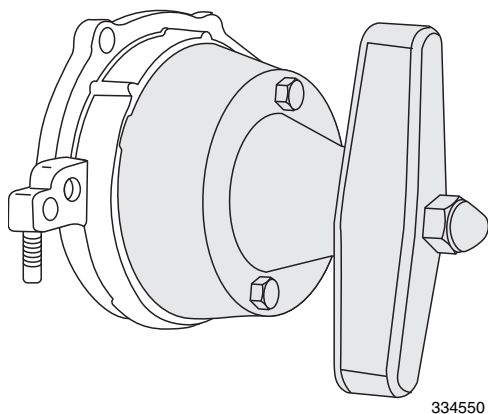
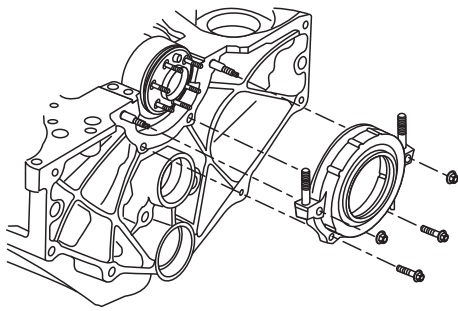
1. Install the crankshaft rear oil seal housing retainer stud and tighten to 6 N•m (53 lb. in).



NOTICE! Always use a **NEW** crankshaft rear oil seal housing gasket when installing the crankshaft rear oil seal housing.

2. Install the **NEW** crankshaft rear oil seal housing gasket.





334550

3. Install the crankshaft rear oil seal housing onto the crankshaft rear oil seal housing retainer stud.
4. Install the crankshaft rear oil seal housing nut and bolts. Tighten nut and bolts to 12 N•m (106 lb. in).

5. Apply a small amount (2 to 3 drops) of clean engine oil to the bore of the crankshaft rear oil seal housing.
6. Apply a small amount (2 to 3 drops) of clean engine oil to the outside diameter of the engine flywheel pilot flange.
7. Apply a small amount (1 drop) of clean engine oil to the outside diameter of the flywheel locator pin.
8. Apply a small amount (2 to 3 drops) of clean engine oil to the crankshaft seal surface.
9. Inspect the J 35621-B flange for imperfections that may damage the crankshaft rear oil seal.

Minor imperfections may be removed with a fine grade emery cloth.

NOTICE! DO NOT allow oil or any other lubricants to contact the seal lip of the crankshaft rear oil seal.

10. Remove the sleeve from the crankshaft rear oil seal.
11. Apply a small amount (2 to 3 drops) of clean engine oil to the outside diameter of the crankshaft rear oil seal.
12. Install the crankshaft rear oil seal onto the J 35621-B.
13. Install the J 35621-B onto the rear of the crankshaft and hand tighten the tool bolts until snug.

NOTICE! Proper alignment of the crankshaft rear oil seal is critical. Install the crankshaft rear oil seal near to flush and square to the crankshaft rear oil seal housing. Failing to do so may cause the crankshaft rear oil seal or the crankshaft rear oil seal installation tool to fail.

14. Install the crankshaft rear oil seal onto the crankshaft and into the crankshaft rear oil seal housing.
 - a. Turn the J 35621-B wing nut clockwise until the crankshaft rear oil seal is installed near to flush and square to the crankshaft rear oil seal housing.

Increased resistance will be felt when the crankshaft rear oil seal has reached the bottom of the crankshaft rear oil seal housing bore.

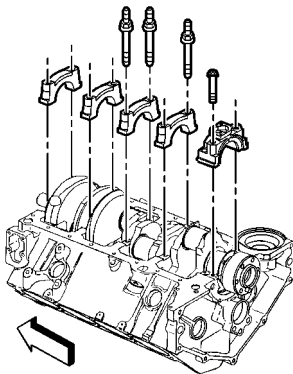
- b. Turn the J 35621-B wing nut counterclockwise to release the J 35621-B from the crankshaft rear oil seal.
15. Remove the J 35621-B from the crankshaft.
16. Wipe off any excess engine oil with a clean rag.
17. Install oil pan if removed. See *Oil Pan and Oil Pump* on page 74.

18. Install flywheel. See *Flywheel* on page 119.
19. Install engine coupler. See *Engine Coupler* on page 116.
20. Install engine in boat. See *Engine Specifications 5.0 Litre* on page 139.

Crankshaft

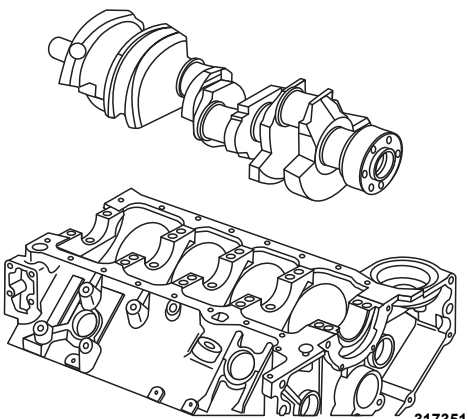
Remove

1. Remove engine from boat. See *Removal and Installation Workshop Manual*.
2. Remove cylinder heads. See *Cylinder Head* on page 60.
3. Remove oil pan. See *Oil Pan and Oil Pump* on page 74.
4. Remove pistons and connecting rods. See *Piston, Connecting Rod, and Bearings* on page 105.
5. Remove timing chain and sprocket. See *Timing Chain and Sprocket* on page 94.
6. Remove starter. See *Starter* on page 39.
7. Remove engine coupler. See *Engine Coupler* on page 116..
8. Mark or identify the crankshaft bearing cap locations, direction and positions for assembly.
9. Remove the crankshaft bearing cap bolts.
10. Remove the crankshaft bearing caps.

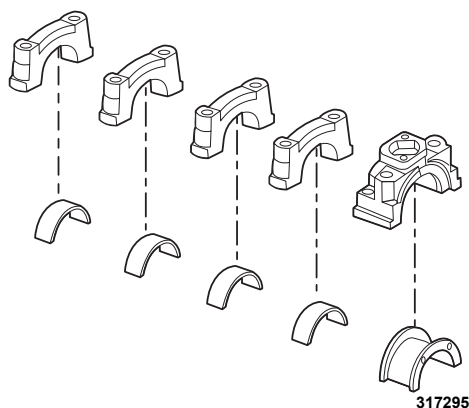


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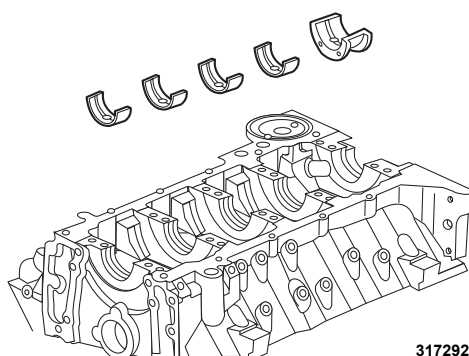
11. Remove the crankshaft.



317351

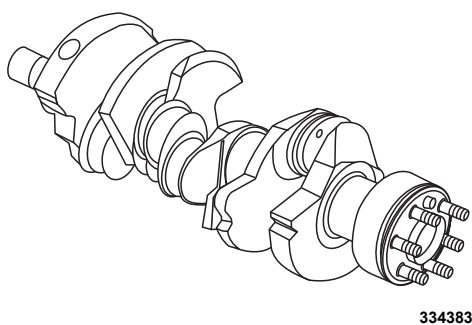


12. Remove the crankshaft bearings from the crankshaft bearing caps.



13. Remove the crankshaft bearings from the engine block.

Crankshaft and Bearings Clean and Inspect



Tools Required

J 7872 Magnetic Base Dial Indicator

J 36660 Electronic Torque Angle Meter



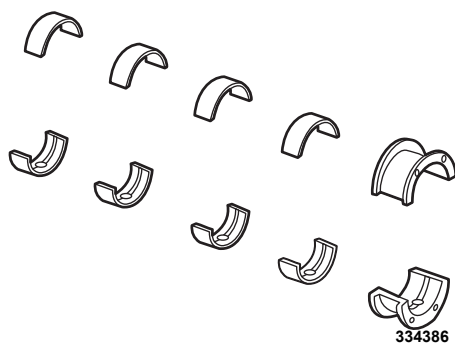
CAUTION! Wear safety glasses.

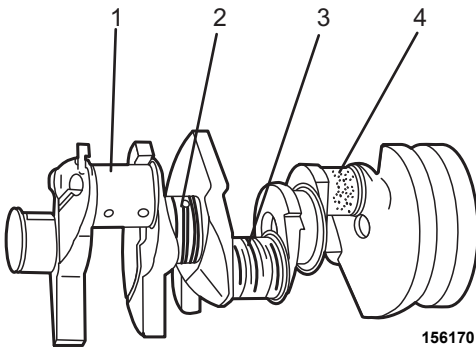
NOTICE! Use care when handling the crankshaft. Avoid damage to the crankshaft bearing surfaces.

1. Clean the crankshaft in cleaning solvent. Remove all sludge or restrictions from the oil passages.
2. Dry the crankshaft with compressed air.
3. Clean the crankshaft bearings in cleaning solvent. Wipe the crankshaft bearings clean with a soft cloth.

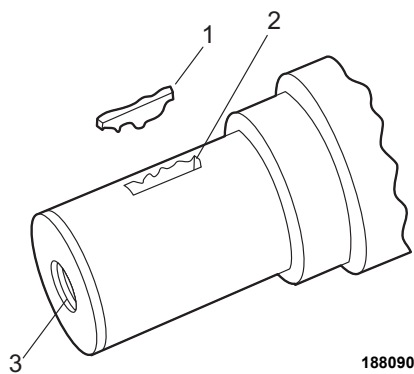
NOTICE! Do not scratch the crankshaft bearing surface.

4. Dry the crankshaft bearings with compressed air.

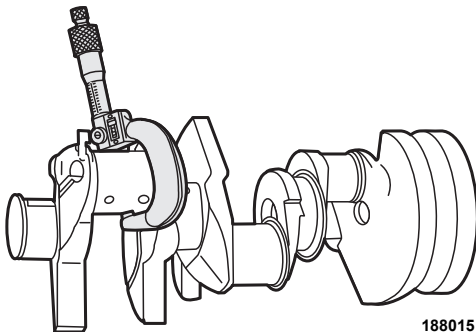




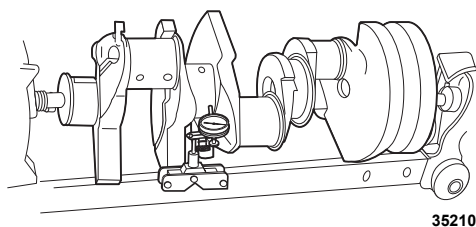
5. Inspect the crankshaft for the following:
 - Crankshaft journals (1) should be smooth with no evidence of scoring or damage.
 - Deep grooves (2)
 - Scratches or uneven wear (3)
 - Pitted surfaces (4)
 - Wear or damage to the thrust journal surfaces
 - Scoring or damage to the rear seal surface
 - Restrictions to the oil passages
 - Damage to the threaded bolt holes



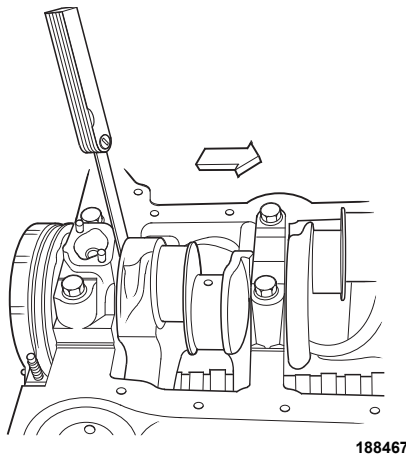
6. Inspect the crankshaft balancer key (1), the keyway (2) and the threaded hole (3) for damage. Repair or replace the crankshaft as necessary.



7. Measure the crank pins for out-of-round and taper. *Engine Specifications 5.0 Litre* on page 139 .



8. Use a suitable support to support the crankshaft on the front and rear journals.
9. Use the J 7872 in order to measure the crankshaft journal run out. The crankshaft run out should not exceed 0.025 mm (0.0010 in).



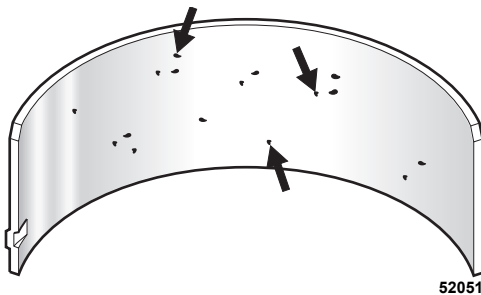
10. Measure the crankshaft end play.

NOTICE! In order to properly measure the crankshaft end play, the crankshaft, the crankshaft bearings and the crankshaft bearing caps, the crankshaft bearing cap bolts must be installed into the engine block and the bolts tightened to specifications.

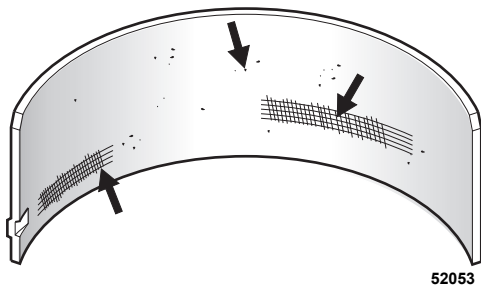
Firmly thrust the crankshaft first rearward, then forward. This will align the crankshaft rear bearings and the crankshaft thrust surfaces.

- With the crankshaft pushed forward, insert a feeler gauge between the crankshaft and the crankshaft bearing surface and then measure the clearance. Refer to Engine Mechanical Specifications.
- If the correct end play cannot be obtained, verify that the correct size crankshaft bearing has been installed. *Engine Specifications 5.0 Litre* on page 139 .
- Inspect the crankshaft for binding. Turn the crankshaft to check for binding. If the crankshaft does not turn freely, then loosen the crankshaft bearing cap bolts, one bearing cap at a time, until the tight crankshaft bearing is located.

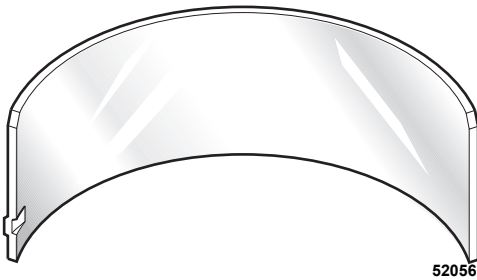
Burrs on the crankshaft bearing cap, foreign matter between the crankshaft bearing and the engine block or crankshaft bearing cap or a faulty crankshaft bearing could cause a lack of clearance at the crankshaft bearing.



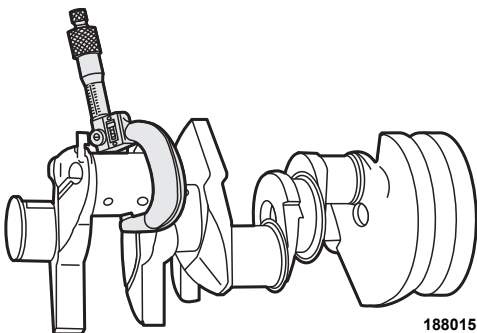
11. Inspect the crankshaft bearings for craters or pockets. Flattened sections on the crankshaft bearing halves also indicate fatigue.



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



Bearing Clearance Measuring Procedures



14. Inspect the crankshaft bearings for improper seating indicated by bright, polished sections of the crankshaft bearings.

- If the lower half of the crankshaft bearing is worn or damaged, both the upper and lower halves of the crankshaft bearing should be replaced.
- Generally, if the lower half of the crankshaft bearing is suitable for use, the upper half of the crankshaft bearing should also be suitable for use.

The crankshaft bearings are of the precision insert type and do not use shims for adjustment. If the clearances are excessive, then new upper and lower crankshaft bearings will be required. The service crankshaft bearings are available in the standard size and an under-size.

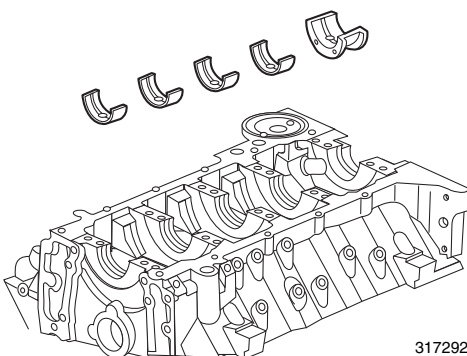
The selective fitting of the crankshaft bearings are necessary in production in order to obtain close tolerances. For this reason, in one journal bore you may use one-half of a standard crankshaft bearing with one-half of an undersize crankshaft bearing

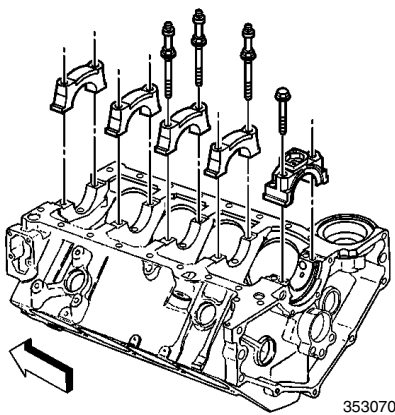
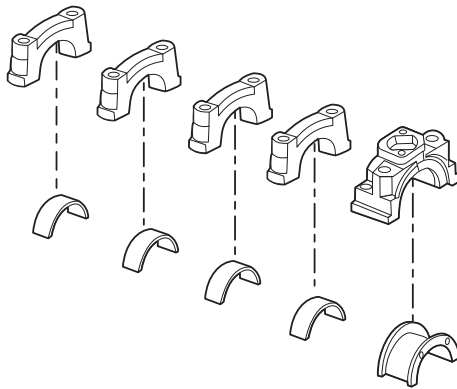
NOTICE! Do not use the plastic gauge method to measure connecting rod bearing clearances. The plastic gauge method for measuring connecting rod bearing clearances will result in unreliable measurements. Use only the micrometer method to correctly determine the connecting rod bearing clearances.

In order to determine the correct replacement crankshaft bearing size, the crankshaft bearing clearance must be measured accurately. Either the micrometer or plastic gauge method may be used; however, the micrometer method gives more reliable results and is preferred.

Micrometer Method for Crankshaft Bearings

1. Measure the crankshaft journal diameter with a micrometer in several places, approximately 90 degrees apart, and then average the measurements.
2. Determine the taper and the out-of-round of the crankshaft journal. See *Engine Specifications 5.0 Litre* on page 139.
3. Install the crankshaft bearings into the engine block.

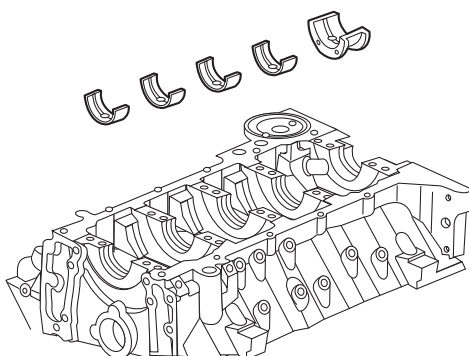




4. Install the crankshaft bearings into the crankshaft bearing caps.

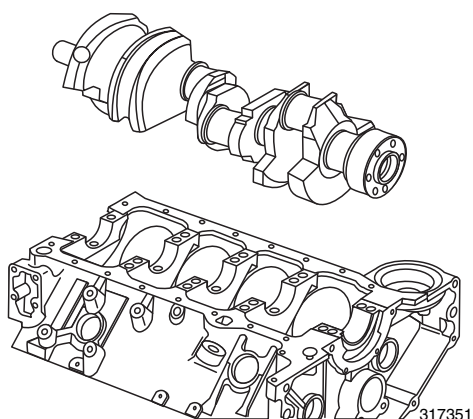
5. Install the crankshaft bearing caps in the original positions and with the arrow on the crankshaft bearing caps in the direction of the front of the engine block.
6. Install the crankshaft bearing cap bolts.
 - a. Tighten the crankshaft bearing cap bolts and the crankshaft bearing cap studs on the first pass to 20 N•m (15 lb. ft.).
 - b. Tighten the crankshaft bearing cap bolts and the crankshaft bearing cap studs on the final pass an additional 73 degrees using the J 36660 angle torque meter.
7. Measure the bearing inside diameter (ID) at two points 90 degrees apart. Average the measurements.
8. In order to determine the bearing clearance, subtract the average journal diameter from the average bearing inside diameter.
9. Compare the crankshaft bearing clearance to the specifications. See *Engine Specifications 5.0 Litre* on page 139.
10. If the crankshaft bearing clearances exceeds specifications, install the new crankshaft bearings as follows:
 - a. Measure the crankshaft bearing inside diameter (ID) at the top and the bottom using an inside micrometer.
 - b. Compare the crankshaft bearing clearance to the specifications. See *Engine Specifications 5.0 Litre* on page 139.
11. Replace or repair the crankshaft if the proper clearances cannot be obtained.

Measuring Crankshaft Bearing Clearances (Plastic Gauge Method)

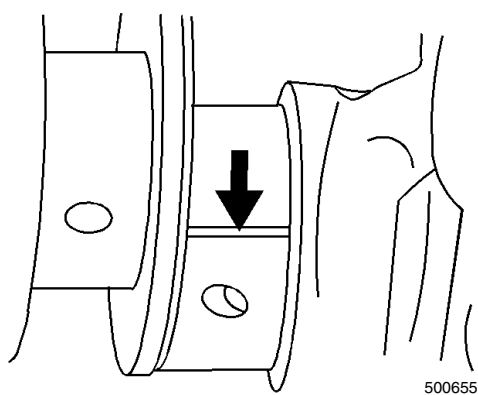


1. Install the crankshaft bearings into the engine block.

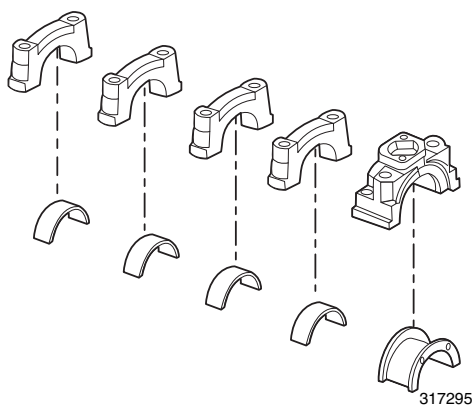
2. Install the crankshaft.

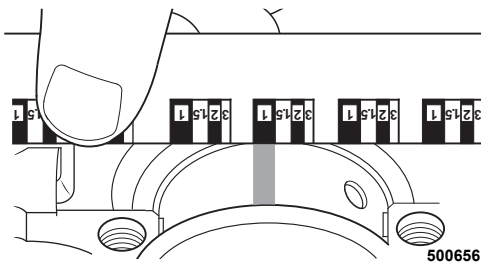
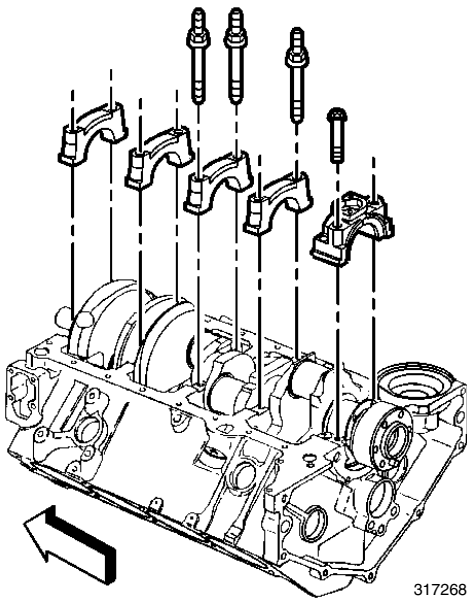


3. Install the gauging plastic the full width of the journal.



4. Install the crankshaft bearings into the crankshaft bearing caps.





5. Install the crankshaft bearing caps in the original positions and with the arrow on the crankshaft bearing caps in the direction of the front of the engine block.
6. Install the crankshaft bearing cap bolts.
 - a. Tighten the crankshaft bearing cap bolts on the first pass to 20 N•m (15 lb. ft.).
 - b. Tighten the crankshaft bearing cap bolts on the final pass an additional 73 degrees using the J 36660.
7. Remove the crankshaft bearing cap bolts.
8. Remove the crankshaft bearing caps. The gauging plastic may adhere to either the crankshaft-bearing journal or the crankshaft-bearing surface.

9. Without removing the gauging plastic, measure the compressed width at the widest point using the graduated scale on the edge of the gauging plastic envelope.

If the flattened gauging plastic tapers toward the middle or the ends, there may be a difference in clearance indicating taper, low spot or other irregularity of the crankshaft bearing or the crankshaft-bearing journal.

- Normally the crankshaft bearing journals wear evenly and are not out-of-round. However, if a crankshaft bearing is being fitted to an out-of-round 0.0254 mm (0.0010 in) (maximum) crankshaft bearing journal, be sure to fit to the maximum diameter of the crankshaft bearing journal. If the crankshaft bearing is fitted to the minimum diameter and the crankshaft bearing journal is excessively out-of round, the interference between the crankshaft bearing and the crankshaft bearing journal will result in rapid crankshaft bearing failure.
- If the crankshaft bearing clearance is within specifications, the crankshaft bearing is satisfactory. If the clearance is not within specifications, replace the crankshaft bearing. Always replace both the upper and lower crankshaft bearings as a unit.
- A standard or undersize crankshaft bearing combination may result in the proper clearance. If the proper crankshaft bearing clearance cannot be achieved using the standard or the undersize crankshaft bearings, it may be necessary to repair or replace the crankshaft.

NOTICE! Do not shim, scrape or file bearing inserts. Do not touch the bearing surface of the insert with bare fingers. Skin oil and acids will etch the bearing surface.

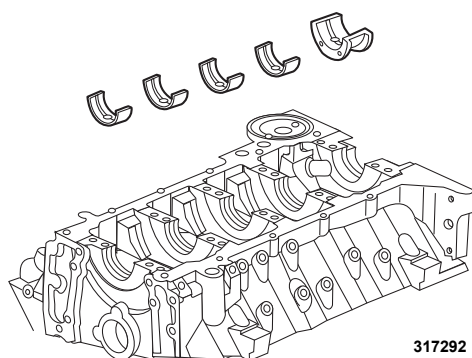
10. Remove the flattened gauging plastic.
11. Measure the remaining crankshaft bearing journals.

Crankshaft and Bearings Installation

Tools Required

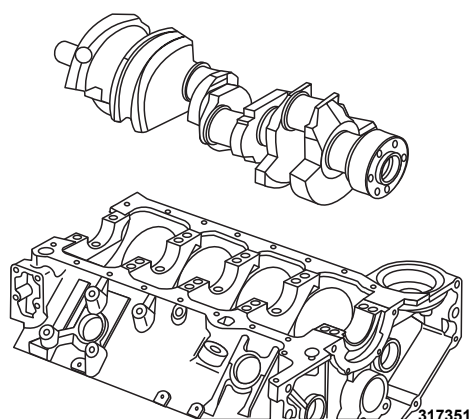
J 36660 Electronic Torque Angle Meter

1. Install the crankshaft bearings into the engine block.
2. Apply clean engine oil to the crankshaft bearings.



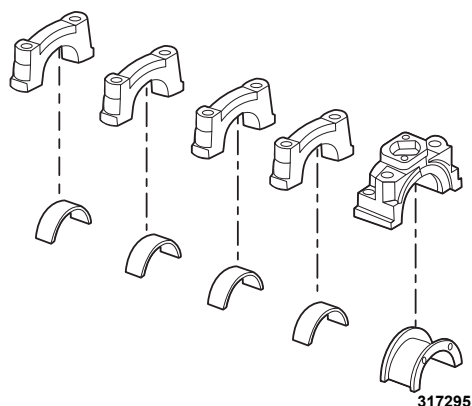
317292

3. Apply clean engine oil to the crankshaft bearing journals.
4. Install the crankshaft.

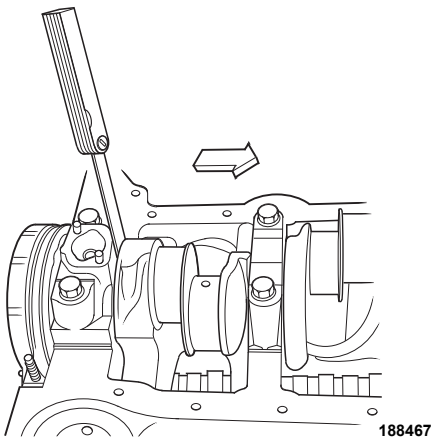
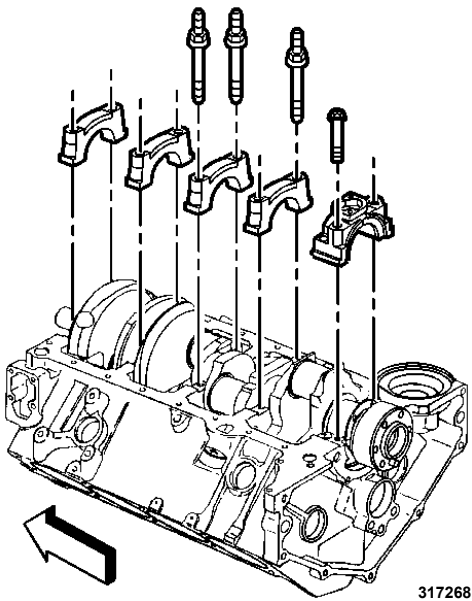


317351

5. Install the crankshaft bearings into the crankshaft bearing caps.
6. Apply clean engine oil to the crankshaft bearings.



317295



7. Install the crankshaft bearing caps in the original position and with the arrow on the crankshaft bearing caps in the direction of the front of the engine block.
8. Install the crankshaft bearing cap bolts and the crankshaft bearing cap studs.
9. Thrust the crankshaft rearward in order to set and align the crankshaft thrust bearings and the crankshaft bearing caps.
10. Thrust the crankshaft forward in order to align the rear faces of the crankshaft thrust bearings.
11. Look to ensure that the crankshaft bearing caps are fully seated in the engine block crankshaft bearing cap channel and that the crankshaft bearing caps are centered on the engine block bulkheads.
12. Tighten the crankshaft bearing cap bolts.
 - a. Tighten the crankshaft bearing cap bolts on the first pass to 20 N•m (15 lb. ft.).
 - b. Tighten the crankshaft bearing cap bolts on the final pass an additional 73 degrees using the J 36660.
13. Measure the crankshaft end play.
 - a. Firmly thrust the crankshaft rearward, and then forward. This will align the crankshaft rear bearing thrust surfaces.
 - b. With the crankshaft pushed forward, insert a feeler gauge between the crankshaft and the crankshaft rear bearing thrust surface to measure the clearance. Crankshaft end play 0.05-0.20 mm (0.002-0.008 in)
14. Rotate the crankshaft in order to check for binding.

A bent crankshaft or lack of proper crankshaft bearing clearance may cause binding.
15. If the crankshaft does not turn freely, loosen the crankshaft bearing cap bolts on 1 crankshaft bearing cap at a time in order to determine the location of the binding.

A lack of proper crankshaft bearing clearance may be caused by the following:

 - Burrs on the crankshaft bearing cap
 - Foreign material between the crankshaft bearing and the engine block
 - Foreign material between the crankshaft bearing and the crankshaft bearing cap
 - Damaged crankshaft bearing
 - Improper size crankshaft bearing
16. Install pistons and connecting rods. See *Piston, Connecting Rod, and Bearings* on page 105.
17. Install cylinder heads. See *Cylinder Head* on page 60.
18. Install intake manifold. See *Intake Manifold* on page 41.
19. Install oil pan. See *Oil Pan and Oil Pump* on page 74.
20. Install timing chain and sprocket. See *Timing Chain and Sprocket* on page 94.

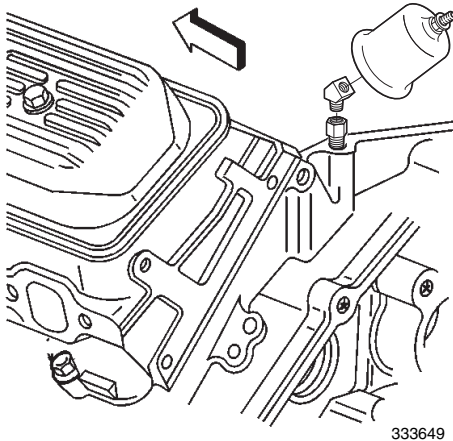
21. Install flywheel. See *Flywheel* on page 119.
22. Install engine coupler. See *Engine Coupler* on page 116.
23. Install starter. See *Starter* on page 39.
24. Install engine in boat. See *Removal and Installation Workshop Manual*.

Recondition Engine Block

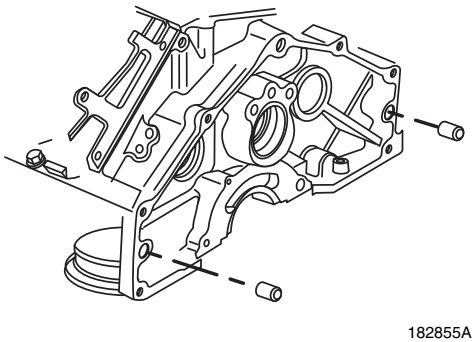
Engine Block Plug

Removal

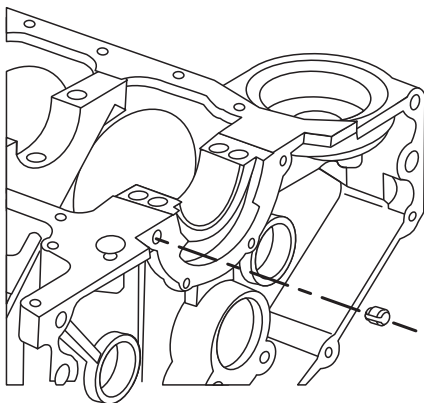
1. Remove the engine oil pressure sensor and fitting.

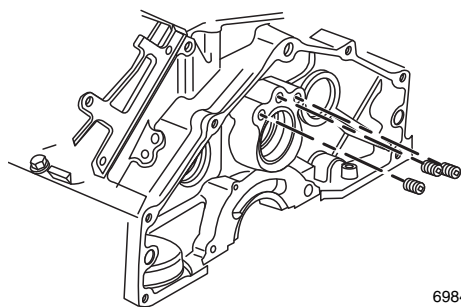


2. Remove the dowel straight pins (if required).



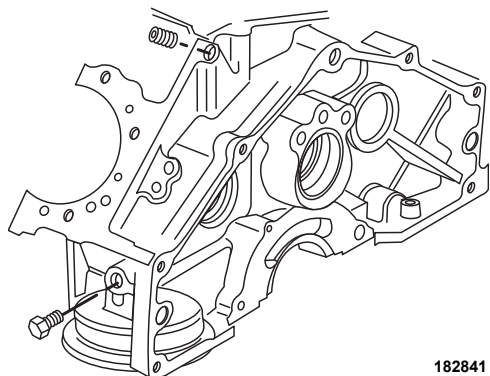
3. Remove the S type pin.





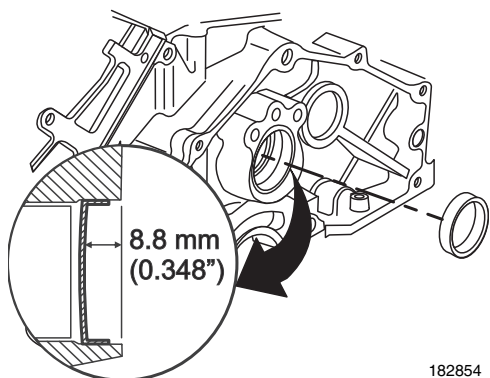
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4. Remove the square socket plugs (engine block oil gallery) from the rear of the engine block.



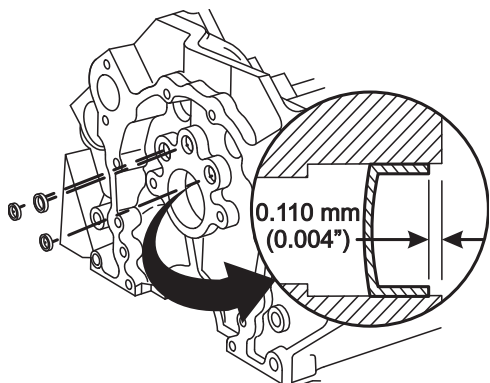
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5. Remove the left side rear and left rear top engine block oil gallery plugs.



182854

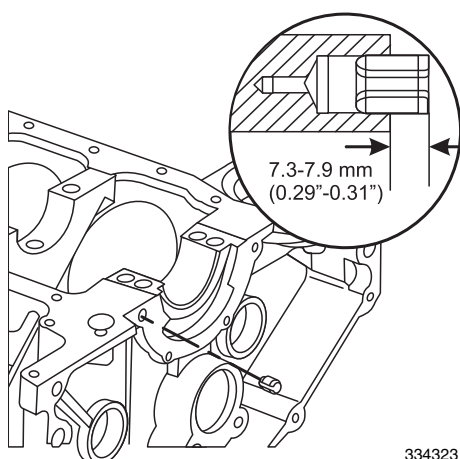
6. Remove the expansion cup plug (camshaft rear bearing hole) and discard.



7. Remove the engine block oil gallery plugs (front) from the engine block and discard.

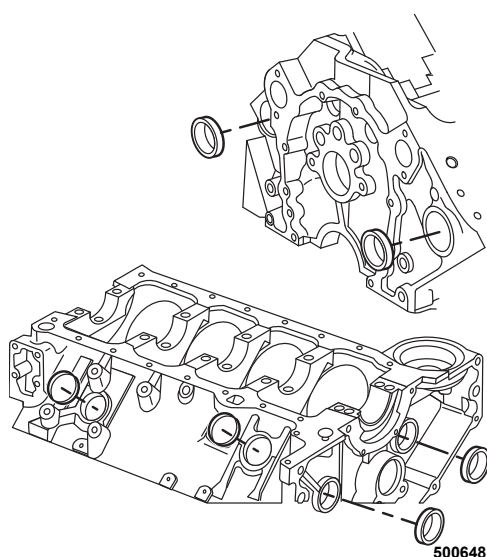
Insert a 3/8 x 26 in. rod into the rear oil gallery holes in order to drive out the front engine block oil gallery plugs.

8. Remove the spring type S pin (crankshaft rear oil seal housing locator if required).



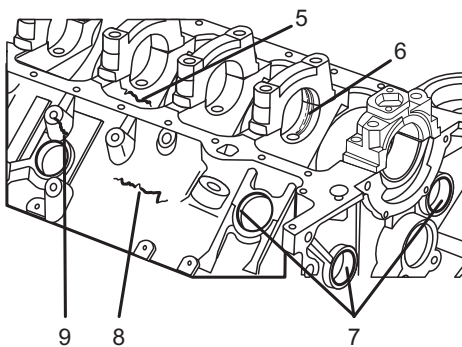
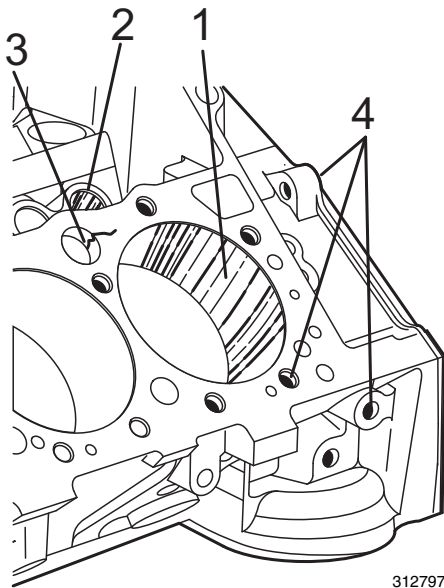
334323

9. Remove the engine block core hole plugs.
 - a. Use a suitable tool in order to drive the engine block core hole plugs into the coolant jacket.
 - b. Use a suitable tool in order to pull the engine block core hole plugs from the coolant jacket.
 - c. Discard the engine block core hole plugs.



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Engine Block Clean and inspect



Tools Required

J 8087 Cylinder Bore Gauge

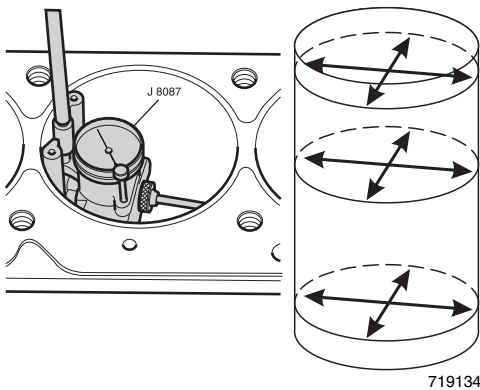


CAUTION! Wear safety glasses.

1. Clean all the remaining sealing or gasket material from the sealing surfaces.
2. Clean the engine block with cleaning solvent.
3. Flush the engine block with clean water or steam.
4. Clean the cylinder bores.
5. Clean the oil galleries and the oil passages.
6. Clean the scale and the deposits from the coolant passages.

NOTICE! Clean all debris, dirt and coolant from the engine block cylinder head bolt holes. Failure to remove all foreign material may result in damaged threads, improperly tightened fasteners or damage to the components.

7. Clean the engine block cylinder head bolt holes.
8. After cleaning the engine block, spray or wipe the cylinder bores and the machined surfaces with clean engine oil.
9. Inspect the following areas:
 - Coolant jackets (3) for cracks
 - Cylinder bores (1) for scratches or gouging
 - Valve lifter bores (2) for excessive scoring or wear
 - Threaded holes (4) for damage
 - Crankshaft bearing webs (5) for cracks
 - Crankshaft bearing caps (6) and the crankshaft bearing bores (7) for damage
 - The crankshaft bearing bores should be round and uniform when measuring the inside diameter (ID).
 - The surface where the crankshaft bearings contact the crankshaft bearing bore should be smooth.
 - If a crankshaft bearing cap is damaged and requires replacement, replace the crankshaft bearing cap first, then rebore the engine block crankshaft bearing bores and check for proper alignment. Finally, check the crankshaft for the proper clearances.
 - Engine block core hole plug bores (8) for damage
 - Engine block (9) for cracks or damage
 - Engine mount bosses (10) for damage

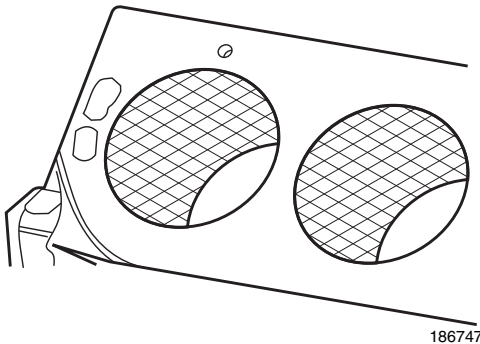


10. Measure the cylinder bores for taper and out-of-round.

- Depress the plunger on the J 8087 7 mm (0.275 in) or until the J 8087 enters the cylinder bore.
- Center the J 8087 in the cylinder bore and turn the indicator dial to 0.
- Move the J 8087 up and down the cylinder bore to determine the cylinder bore taper. See *Engine Specifications 5.0 Litre* on page 139.
- Turn the J 8087 to different points around the cylinder bore to determine the cylinder bore out-of-round condition. See *Engine Specifications 5.0 Litre* on page 139.

Cylinder Boring and Honing

Honing Procedure

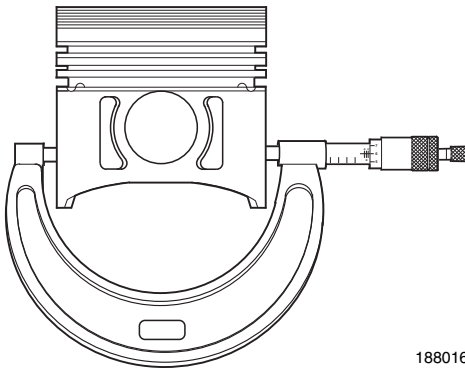


CAUTION! Wear safety glasses.

- When honing the cylinder bores, follow the manufacturer's recommendations for equipment use, cleaning and lubrication.
 - Use only clean sharp stones of the proper grade for the amount of material to be removed.
 - Dull, dirty stones cut unevenly and generate excessive heat.
 - DO NOT hone to a final grade with a coarse or medium-grade stone.
 - Leave sufficient metal so that all the stone marks will be removed with the fine grade stones.
 - Perform the final honing with a fine-grade stone and hone the cylinder bore in a crosshatch pattern at 45-65 degrees to obtain the proper clearance.
- During the honing operation, thoroughly check the cylinder bore.
 - Repeatedly check the cylinder bore fit with the selected piston.
 - All measurements of the piston or cylinder bore should be made with the components at normal room temperature.
- When honing to eliminate taper in the cylinder bore, use full strokes the complete length of the cylinder bore.
- Repeatedly check the measurement at the top, the middle and the bottom of the cylinder bore.
 - The finish marks should be clean but not sharp.
 - The finish marks should be free from imbedded particles or torn or folded material.
- By measuring the selected piston at the sizing point and then by adding the average of the clearance specification, the final cylinder bore honing dimension required can be determined.
- When finished, the reconditioned cylinder bores should have less than or meet the specified out-of-round and taper requirements.
- After the final honing and before the piston is checked for fit, clean the cylinder bore with hot water and detergent.

- a. Scrub the cylinder bores with a stiff bristle brush.
- b. Rinse the cylinder bores thoroughly with clean hot water.
- c. Dry the cylinder bores with a clean rag.
- d. Do not allow any abrasive material to remain in the cylinder bores.
 - Abrasive material may cause premature wear of the new piston rings and the cylinder bores.
 - Abrasive material will contaminate the engine oil and may cause premature wear of the bearings.
8. Perform final measurements of the piston and the cylinder bore.
9. Permanently mark the top of the piston for the specified cylinder to which it has been fitted.
10. Apply clean engine oil to each cylinder bore in order to prevent rusting.

Boring Procedure



188016



CAUTION! Wear safety glasses.

1. Before starting the honing or boring operation, measure all the new pistons with the micrometer contacting at points exactly 90 degrees from the piston pin centerline.
2. Thoroughly clean the top of the cylinder block in order to remove any dirt or burrs before using any type of boring bar.
3. Follow the instructions furnished by the manufacturer regarding the use of the boring equipment.
4. When boring the cylinders, make sure all the crankshaft bearing caps are installed in the original position and direction.
5. Tighten the crankshaft bearing caps to the proper torque specifications in order to avoid distortion of the cylinder bores in the final assembly.
6. When making the final cut with the boring bar, leave 0.03 mm (0.001 in) on the cylinder bore diameter for finish honing. This gives the required position to the cylinder clearance specifications. (Carefully perform the honing and boring operation in order to maintain the specified clearances between the pistons, the piston rings and the cylinder bores).

Engine Specifications 5.0 Litre

Engine Mechanical Specifications 5.0 litre

Application	Metric	English
General Data		
Engine Type	V-8	
Displacement	5.0 L	305 CID
Bore	94.89 mm	3.737 in.
Stroke	88.39	3.480
Compression Ratio	9.4:1	
Firing Order	1-8-4-3-6-5-7-2	
Spark Plug Gap	1.52 mm	0.060 in.
Oil Pressure (Minimum) at Normal Operating Temperature	42 kPa @ 1,000 r/m 125 kPa @ 2,000 r/m 166 kPa at 4,000 r/m	6.0 psi @ 1,000 r/m 18.0 psi @ 2,000 r/m 24.0 psi @ 4,000 r/m
Camshaft		
End Play	0.05-0.30 mm	0.002-0.012 in
Journal Diameter	47.440-47.490 mm	1.8677-1.8696 in
Journal Diameter Out-of-Round (maximum)	0.025 mm	0.0010 in
Lobe Lift (Exhaust)	7.20-7.30 mm	0.283-0.287 in
Lobe Lift (Intake)	6.97-7.07 mm	0.274-0.278 in
Runout (maximum)	0.065 mm	0.0026 in
Connecting Rod		
Connecting Rod Bearing Clearance (Production)	0.033-0.078 mm	0.0015-0.0031 in
Connecting Rod Bearing Clearance (Service)	0.025-0.063 mm	0.0010-0.0025 in
Connecting Rod Side Clearance	0.15-0.68 mm	0.006-0.027 in
Connecting Rod Journal Diameter	53.304-53.334 mm	2.0986-2.0998 in
Connecting Rod Journal Taper (Production)	0.007 mm (Max)	0.00030 in (Max)
Connecting Rod Journal Taper (Service)	0.025 mm (Max)	0.0010 in (Max)
Connecting Rod Journal Out-of-Round (Production)	0.007 mm (Max)	0.0003 in (Max)
Connecting Rod Journal Out-of-Round (Service)	0.025 mm (Max)	0.0010 in (Max)
Crankshaft		
Crankshaft Bearing Clearance (Journal #1-Production)	0.018-0.053 mm	0.0007-0.0021 in
Crankshaft Bearing Clearance (Journal #2, #3 and #4-Production)	0.030-0.068 mm	0.0012-0.0027 in
Crankshaft Bearing Clearance (Journal #5-Production)	0.020-0.060 mm	0.0008-0.0024 in

Engine Mechanical Specifications 5.0 litre

Application	Metric	English
Crankshaft Bearing Clearance (Journal #1-Service)	0.025-0.051 mm	0.0010-0.0020 in
Crankshaft Bearing Clearance (Journal #2, #3 and #4-Service)	0.025-0.064 mm	0.0010-0.025 in
Crankshaft Bearing Clearance (Journal #5-Service)	0.038-0.063 mm	0.0015-0.0025 in
Crankshaft End Play	0.050-0.20 mm	0.002-0.008 in
Crankshaft Journal Diameter (Journal #1)	62.189-62.212 mm	2.4484-2.4493 in
Crankshaft Journal Diameter (Journal #2, #3 and #4)	62.181-62.207 mm	2.4481-2.4491 in
Crankshaft Journal Diameter (Journal #5)	62.185-62.207 mm	2.4482-2.4491 in
Crankshaft Journal Out-of-Round (Production)	0.005 mm (Max)	0.0002 in (Max)
Crankshaft Journal Out-of-Round (Service)	0.025 mm (Max)	0.0010 in (Max)
Crankshaft Journal Taper (Production)	0.005 mm (Max)	0.0002 in (Max)
Crankshaft Journal Taper (Service)	0.025 mm (Max)	0.0010 in (Max)
Crankshaft Runout at Rear Flange	0.038mm (Max)	0.0015 in (Max)
Cylinder Bore		
Diameter	94.894-94.947 mm	3.7360-3.7381 in
Out-of-Round (Production)	0.025 mm (Max)	0.0010 in (Max)
Out-of-Round (Service)	0.05 mm (Maximum)	0.002 in (Maximum)
Taper (Production-Relief Side)	0.025 mm (Max)	0.0010 in (Max)
Taper (Production-Thrust Side)	0.012 mm (Max)	0.0005 in (Max)
Taper (Service Limit)	0.025 mm (Max)	0.0010 in (Max)
Cylinder Head		
Surface Flatness (Engine Block Deck)	0.10 mm (Max)	0.004 in (Max)
Surface Flatness (Exhaust Manifold Deck)	0.05 mm (Max)	0.004 in (Max)
Surface Flatness (Intake Manifold Deck)	0.10 mm (Max)	0.004 in (Max)
Exhaust Manifold		
Surface Flatness (Flange to Flange)	0.25 mm (Max)	0.010 in (Max)
Surface Flatness (Individual Flange)	0.05 mm (Max)	0.002 in (Max)
Intake Manifold		
Surface Flatness	0.10 mm (Max)	0.004 in (Max)
Piston		
Piston Bore Clearance (Production)	0.018-0.053 mm	0.0007-0.002 in
Piston Bore Clearance (Service)	0.018-0.053 mm	0.0007-0.002 in
Piston Pin		
Clearance in Piston (Production)	0.013-0.023 mm	0.0005-0.0009 in

Engine Mechanical Specifications 5.0 litre

Application	Metric	English
Clearance in Piston (Service)	0.013-0.023 mm	0.0005-0.0009 in
Diameter	23.545-23.548 mm	0.9270-0.9271 in
Fit in Connecting Rod	0.021-0.040 mm (Interference)	0.0008-0.0016 in (Interference)
Piston Rings (End Gap Measured in Cylinder Bore)		
Piston Compression Ring Gap (Top Groove)	0.25-0.40 mm	0.010-0.016 in
Piston Compression Ring Gap (2nd Groove)	0.46-0.66 mm	0.018-0.026 in
Piston Compression Ring Groove Clearance (Top Groove)	0.030-0.070 mm	0.0012-0.0027 in
Piston Compression Ring Groove Clearance (2nd Groove)	0.040-0.080 mm	0.0015-0.0031 in
Piston Oil Ring Gap (Production)	0.25-0.76 mm	0.010-0.029 in
Piston Oil Ring Gap (Service)	0.25-0.90mm	0.010-0.035 in
Piston Oil Ring Groove Clearance (Production)	0.051-0.17 mm	0.002-0.006 in
Piston Oil Ring Groove Clearance (Service)	0.051-0.22 mm	0.002-0.009 in
Valve System		
Valve Face Angle	45 Degrees	
Valve Head Edge Margin	0.79 mm (Minimum)	0.031 in (Minimum)
Valve Lash	Rotate the Valve Rocker Arm Nut Clockwise 360° (1 turn) from Zero Lash.	
Valve Lifter	Hydraulic Roller Type	
Valve Rocker Arm	Roller Pivot Type	
Valve Rocker Arm Ratio	1.5:1	
Valve Seat Angle	46 Degrees	
Valve Seat Runout	0.05 mm (Max)	0.002 in (Max)
Valve Seat Width (Exhaust)	1.65-2.49 mm	0.065-0.098 in
Valve Seat Width (Intake)	1.14-1.78 mm	0.045-0.070 in
Valve Spring Free Length	51.3 mm	2.02 in
Valve Spring Installed Height (Exhaust)	42.92-43.43 mm	1.670-1.700 in
Valve Spring Installed Height (Intake)	42.92-43.43 mm	1.670-1.700 in
Valve Spring Pressure (Valve closed position)	338-374 N at 43.2 mm	76-84 lb. at 1.70 in
Valve Spring Pressure (Valve open position)	832-903 N at 32.3 mm	187-203 lb. at 1.27 in
Valve Stem Clearance (Exhaust-Production)	0.025-0.069 mm	0.0010-0.0027 in
Valve Stem Clearance (Intake-Production)	0.025-0.069 mm	0.0010-0.0027 in

Engine Mechanical Specifications 5.0 litre

Application	Metric	English
Valve Stem Clearance (Exhaust-Service)	0.025-0.094 mm	0.0010-0.0037 in
Valve Stem Clearance (Intake-Service)	0.025-0.094 mm	0.0010-0.0037 in
Valve Stem Diameter	8.661-8.679 mm	0.3410-0.3416 in
Valve Stem Oil Seal Installed Height (Measured from the Top of the Large Diameter Valve Guide Bevel to the Bottom of the Valve Stem Oil Seal)	1-2 mm	0.03937-0.07874 in

Engine Specifications 5.7 Litre

Engine Mechanical Specifications 5.7 litre

Application	Metric	English
General Data		
Engine Type	V-8	
Displacement	5.7 L	350 CID
Bore	101.63 mm	4.0012 in.
Stroke	88.39	3.480
Compression Ratio	9.4:1	
Firing Order	1-8-4-3-6-5-7-2	
Spark Plug Gap	1.52 mm	0.060 in.
Oil Pressure (Minimum) at Normal Operating Temperature	42 kPa @ 1,000 r/m 125 kPa @ 2,000 r/m 166 kPa at 4,000 r/m	6.0 psi @ 1,000 r/m 18.0 psi @ 2,000 r/m 24.0 psi @ 4,000 r/m
Camshaft		
End Play	0.05-0.30 mm	0.002-0.012 in
Journal Diameter	47.440-47.490 mm	1.8677-1.8696 in
Journal Diameter Out-of-Round (maximum)	0.025 mm	0.0010 in
Lobe Lift (Exhaust)	7.20-7.30 mm	0.283-0.287 in
Lobe Lift (Intake)	6.97-7.07 mm	0.274-0.278 in
Runout (maximum)	0.065 mm	0.0026 in
Connecting Rod		
Connecting Rod Bearing Clearance (Production)	0.033-0.078 mm	0.0015-0.0031 in
Connecting Rod Bearing Clearance (Service)	0.025-0.063 mm	0.0010-0.0025 in
Connecting Rod Side Clearance	0.15-0.68 mm	0.006-0.027 in
Connecting Rod Journal Diameter	53.304-53.334 mm	2.0986-2.0998 in
Connecting Rod Journal Taper (Production)	0.007 mm (Max)	0.00030 in (Max)
Connecting Rod Journal Taper (Service)	0.025 mm (Max)	0.0010 in (Max)
Connecting Rod Journal Out-of-Round (Production)	0.007 mm (Max)	0.0003 in (Max)
Connecting Rod Journal Out-of-Round (Service)	0.025 mm (Max)	0.0010 in (Max)
Crankshaft		
Crankshaft Bearing Clearance (Journal #1-Production)	0.018-0.053 mm	0.0007-0.0021 in
Crankshaft Bearing Clearance (Journal #2, #3 and #4-Production)	0.030-0.068 mm	0.0012-0.0027 in
Crankshaft Bearing Clearance (Journal #5-Production)	0.020-0.060 mm	0.0008-0.0024 in

Engine Mechanical Specifications 5.7 litre

Application	Metric	English
Crankshaft Bearing Clearance (Journal #1-Service)	0.025-0.051 mm	0.0010-0.0020 in
Crankshaft Bearing Clearance (Journal #2, #3 and #4-Service)	0.025-0.064 mm	0.0010-0.025 in
Crankshaft Bearing Clearance (Journal #5-Service)	0.038-0.063 mm	0.0015-0.0025 in
Crankshaft End Play	0.050-0.20 mm	0.002-0.008 in
Crankshaft Journal Diameter (Journal #1)	62.189-62.212 mm	2.4484-2.4493 in
Crankshaft Journal Diameter (Journal #2, #3 and #4)	62.181-62.207 mm	2.4481-2.4491 in
Crankshaft Journal Diameter (Journal #5)	62.185-62.207 mm	2.4482-2.4491 in
Crankshaft Journal Out-of-Round (Production)	0.005 mm (Max)	0.0002 in (Max)
Crankshaft Journal Out-of-Round (Service)	0.025 mm (Max)	0.0010 in (Max)
Crankshaft Journal Taper (Production)	0.005 mm (Max)	0.0002 in (Max)
Crankshaft Journal Taper (Service)	0.025 mm (Max)	0.0010 in (Max)
Crankshaft Runout at Rear Flange	0.038mm (Max)	0.0015 in (Max)
Cylinder Bore		
Diameter	101.618-101.643 mm	4.0007-4.0017 in
Out-of-Round (Production)	0.025 mm (Max)	0.0010 in (Max)
Out-of-Round (Service)	0.05 mm (Maximum)	0.002 in (Maximum)
Taper (Production-Relief Side)	0.025 mm (Max)	0.0010 in (Max)
Taper (Production-Thrust Side)	0.012 mm (Max)	0.0005 in (Max)
Taper (Service Limit)	0.025 mm (Max)	0.0010 in (Max)
Cylinder Head		
Surface Flatness (Engine Block Deck)	0.10 mm (Max)	0.004 in (Max)
Surface Flatness (Exhaust Manifold Deck)	0.05 mm (Max)	0.004 in (Max)
Surface Flatness (Intake Manifold Deck)	0.10 mm (Max)	0.004 in (Max)
Exhaust Manifold		
Surface Flatness (Flange to Flange)	0.25 mm (Max)	0.010 in (Max)
Surface Flatness (Individual Flange)	0.05 mm (Max)	0.002 in (Max)
Intake Manifold		
Surface Flatness	0.10 mm (Max)	0.004 in (Max)
Piston		
Piston Bore Clearance (Production)	0.018-0.053 mm	0.0007-0.002 in
Piston Bore Clearance (Service)	0.018-0.053 mm	0.0007-0.002 in
Piston Pin		
Clearance in Piston (Production)	0.013-0.023 mm	0.0005-0.0009 in

Engine Mechanical Specifications 5.7 litre

Application	Metric	English
Clearance in Piston (Service)	0.013-0.023 mm	0.0005-0.0009 in
Diameter	23.545-23.548 mm	0.9270-0.9271 in
Fit in Connecting Rod	0.021-0.040 mm (Interference)	0.0008-0.0016 in (Interference)
Piston Rings (End Gap Measured in Cylinder Bore)		
Piston Compression Ring Gap (Top Groove)	0.25-0.40 mm	0.010-0.016 in
Piston Compression Ring Gap (2nd Groove)	0.46-0.66 mm	0.018-0.026 in
Piston Compression Ring Groove Clearance (Top Groove)	0.030-0.070 mm	0.0012-0.0027 in
Piston Compression Ring Groove Clearance (2nd Groove)	0.040-0.080 mm	0.0015-0.0031 in
Piston Oil Ring Gap (Production)	0.25-0.76 mm	0.010-0.029 in
Piston Oil Ring Gap (Service)	0.25-0.90mm	0.010-0.035 in
Piston Oil Ring Groove Clearance (Production)	0.046-0.096 mm	0.0018-0.0037 in
Piston Oil Ring Groove Clearance (Service)	0.046-0.100 mm	0.0018-0.0039 in
Valve System		
Valve Face Angle	45 Degrees	
Valve Head Edge Margin	0.79 mm (Minimum)	0.031 in (Minimum)
Valve Lash	Rotate the Valve Rocker Arm Nut Clockwise 360° (1 turn) from Zero Lash.	
Valve Lifter	Hydraulic Roller Type	
Valve Rocker Arm	Roller Pivot Type	
Valve Rocker Arm Ratio	1.5:1	
Valve Seat Angle	46 Degrees	
Valve Seat Runout	0.05 mm (Max)	0.002 in (Max)
Valve Seat Width (Exhaust)	1.50-2.56 mm	0.059-0.101 in
Valve Seat Width (Intake)	1.02-1.65 mm	0.040-0.065 in
Valve Spring Free Length	51.3 mm	2.02 in
Valve Spring Installed Height (Exhaust)	42.92-43.43 mm	1.670-1.700 in
Valve Spring Installed Height (Intake)	42.92-43.43 mm	1.670-1.700 in
Valve Spring Pressure (Closed)	338-374 N at 43.2 mm	76-84 lb. at 1.70 in
Valve Spring Pressure (Open)	832-903 N at 32.3 mm	187-203 lb. at 1.27 in
Valve Stem Clearance (Exhaust-Production)	0.025-0.069 mm	0.0010-0.0027 in
Valve Stem Clearance (Intake-Production)	0.025-0.069 mm	0.0010-0.0027 in

Engine Mechanical Specifications 5.7 litre

Application	Metric	English
Valve Stem Clearance (Exhaust-Service)	0.025-0.094 mm	0.0010-0.0037 in
Valve Stem Clearance (Intake-Service)	0.025-0.094 mm	0.0010-0.0037 in
Valve Stem Diameter	8.661-8.679 mm	0.3410-0.3416 in
Valve Stem Oil Seal Installed Height (Measured from the Top of the Large Diameter Valve Guide Bevel to the Bottom of the Valve Stem Oil Seal)	1-2 mm	0.03937-0.07874 in

Fastener Tightening Specifications

Fastener Tightening Specifications

Application	Metric (N•m)	English
Camshaft Retainer Bolt	12	106 in. lb.
Camshaft Sprocket Bolt	25	18 ft. lb.
Connecting Rod Nut		
First Pass	27	20 ft. lb.
Final Pass	55 Degrees	
Crankshaft Balancer Bolt	95	70 ft. lb.
Crankshaft Bearing Cap Bolt (Preferred Method)		
First Pass	20	15 ft. lb.
Final Pass	73 Degrees	
Crankshaft Bearing Cap Bolt	105	77 ft. lb.
Crankshaft Position Sensor Bolt	9	80 in. lb.
Crankshaft Oil Deflector Nut	40	30ft. lb.
Crankshaft Pulley Bolt	58	43 ft. lb.
Crankshaft Rear Oil Seal Housing Bolt and Nut	12	106 in. lb.
Crankshaft Rear Oil Seal Housing Retainer Stud	6	53 in. lb.
Cylinder Head Bolt (Preferred Method)		
All Bolts First Pass in Sequence	30	22 ft. lb.
Long Bolts Final Pass in Sequence	75 Degrees	
Medium Bolts Final Pass in Sequence	65 Degrees	
Short Bolts Final Pass in Sequence	55 Degrees	
Cylinder Head Core Hole Plug	20	15 ft. lb.
Distributor Cap Bolt	2.4	21 in. lb.
Distributor Clamp Bolt	25	18 ft. lb.
Drive Belt Tensioner Bolt	50	37 ft. lb.
Engine Block Left Side Oil Galley Plug	20	15 ft. lb.
Engine Block Left Rear Oil Galley Plug	30	22 ft. lb.
Engine Block Right Rear Oil Galley Plug	20	15 ft. lb.
Engine Block Coolant Drain Plug	20	15 ft. lb.
Engine Block Oil Galley Plug	20	15 ft. lb.

Fastener Tightening Specifications

Application	Metric (N•m)	English
Engine Coolant Temperature Sensor	20	15 ft. lb.
Engine Flywheel and Coupler Nut	54 - 61	40-45 ft. lb.
Engine Front Cover Bolt	12	106 in. lb.
Engine Mount Bracket Bolt to Engine	34-39	25-29 ft. lb.
Engine Mount Flexible to Engine Mount Bracket		
Top Nut	136-163	100-120 ft. lb.
Middle Nut	54-68	40-50 ft. lb.
Bottom Nut	81-102	60-75 ft. lb.
Engine Oil Pressure Gauge Sensor	30	22 ft. lb.
Engine Oil Pressure Gauge Sensor Fitting (angle)	15	11 ft. lb.
Engine Oil Pressure Warning Switch Fitting	19	14 ft. lb.
Engine Oil Pressure Warning Switch	16	12 ft. lb.
Exhaust Manifold Bolt to Engine		
First Pass	15	11 ft. lb.
Final Pass	30	22 ft. lb.
Exhaust Riser Bolt to Exhaust Manifold		
First Pass	15	11 ft. lb.
Final Pass	36	27 ft. lb.
Circulating Water Pump Pulley	32	24 ft. lb.
Generator and Drive Belt Tensioner Bracket Bolt to Engine	36	27 ft. lb.
Generator and Drive Belt Tensioner Bracket Stud Nut	32	24 ft. lb.
Ground Wire Nut on Flywheel housing	8	6 ft. lb.
Ignition Coil Bolt to Mounting Bracket	8	6 ft. lb.
Ignition Coil Mounting Bracket Bolt to Flywheel Housing	31	23 ft. lb.
Knock Sensor	20	15 ft. lb.
Lower Intake Manifold		
First Pass	3	27 in. lb.
Second Pass	12	106 in. lb.
Final Pass	15	11 ft. lb.
Oil Filter Adapter Fitting Bolt	35-40	26-30 ft. lb.

Fastener Tightening Specifications

Application	Metric (N•m)	English
Oil Pan Baffle Bolt	12	106 in. lb.
Oil Pan Stud	6	53 in. lb.
Oil Pan Stud Nut	25	18 ft. lb.
Oil Pan Bolt or Stud	12	106 in. lb.
Oil Pan Dipstick Adapter (Drain Hole)	50	37 ft. lb.
Oil Pump Bolt to Rear Crankshaft Bearing Cap	90	66 ft. lb.
Oil Pump Cover Bolt	12	106 in. lb.
Power Steering Pump Bolt	50	37 ft. lb.
Spark Plug		
Initial Installation (NEW Cylinder Head)	30	22 ft. lb.
All Subsequent Installations	15	11 ft. lb.
Throttle Body Stud	9	80 in. lb.
Upper Intake Manifold Stud		
First Pass	5	44 in. lb.
Final Pass	9	80 in. lb.
Valve Lifter Pushrod Guide Bolt	16	12 ft. lb.
Valve Rocker Arm Bolt	30	22 ft. lb.
Valve Rocker Arm Cover Bolt	12	106 in. lb.
Water Pump Bolt	45	33 ft. lb.

Sealants, Adhesives and Lubricants

Sealants, Adhesives and Lubricants

Application	Type of Material	Part No.
Camshaft Retainer Bolt	Threadlock	1161053
Crankshaft Balancer Keyway	Adhesive	1161277
Cylinder Head Bolt	Sealant	1141570
Engine Block to the Crankshaft Rear Oil Seal Housing Junction at the Oil Pan Sealing Surfaces	Adhesive	1161277
Engine Block to the Engine Front Cover Junction at the Oil Pan Sealing Surfaces	Adhesive	1161277
Engine Block at the Lower Intake Manifold Sealing Surfaces	Adhesive	1161277
Engine Block Core Hole Plug	Threadlock	1161053
Engine Block Oil Gallery Plug	Sealant	1141570
Engine Coolant Temperature (ECT) Sensor	Sealant	1141570
Engine Coolant Temperature (ECT) Gauge Sensor	Sealant	1141570
Engine Oil Pressure Sensor	Sealant	1141570
Engine Oil Pressure Sensor Fitting	Sealant	1141570
Engine Oil Supplement	Lubricant	1052367 GM Part No.
Exhaust Manifold Bolt/Stud	Threadlock	1161053
Expansion Cup Plug (Camshaft Rear Bearing Hole)	Sealant	1141570
Lower Intake Manifold Bolt	Threadlock	1161053
Throttle Body Stud	Threadlock	1161053
Valve Train Component Prelube	Lubricant	12345501 GM Part No.
Water Pump Bolt	Sealant	1141570

Tune Up Specifications

Tune Up Specifications 5.0GL, 5.7GL

Model	Item	Specification
5.0GL, 5.7GL	Fuel Pump Pressure	5-7 PSI (34-48 kPa)
	Oil Capacity	5 qts w/o filter, 6 with filter
	Oil Pressure	6 - 30 PSI (41 - 207 kPa) @ 800 RPM 40 - 60 PSI (276 - 414 kPa) @ 3000 RPM
	Idle RPM	550 - 650 RPM
	Full Throttle	4400 - 4800 RPM

Tune Up Specifications 5.0GL, 5.7GL

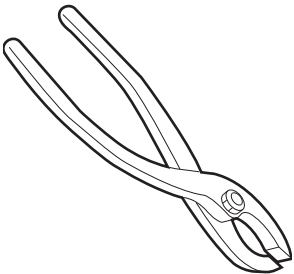
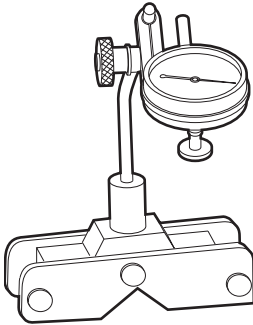
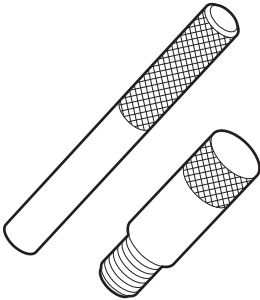
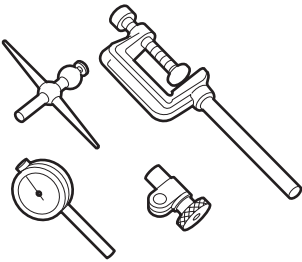
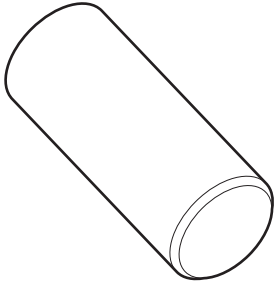
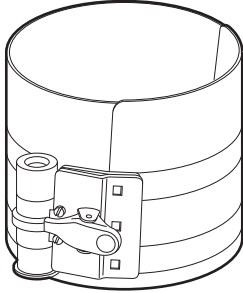
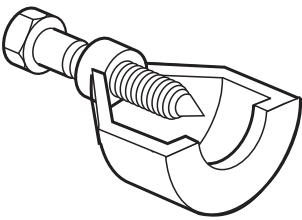
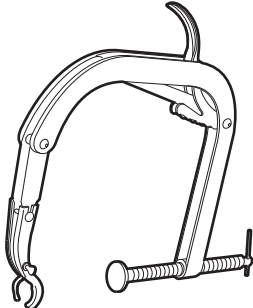
Model	Item	Specification
5.0GL	Ignition Timing	10° BTDC (Shunt P/N 885163 required)
5.7GL	Ignition Timing	12° BTDC (Shunt P/N 885163 required)
5.0, 5.7GL	Spark Plug	Volvo Penta P/N 3861632

Tune Up Specifications 5.0GXi, 5.0OSi, 5.7Gi, 5.7OSi, 5.7GXi, 5.7OSXi

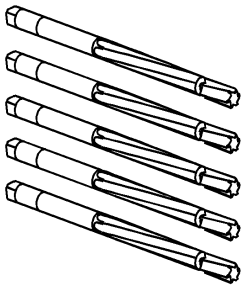
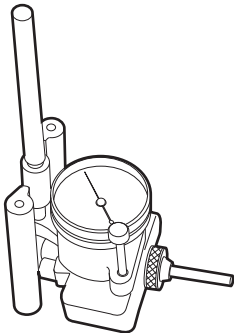
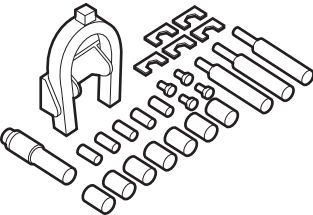
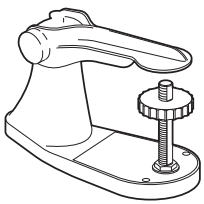
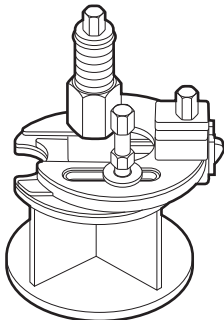
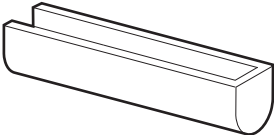
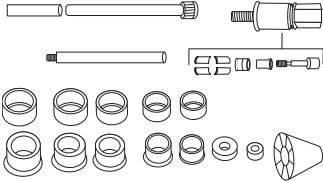
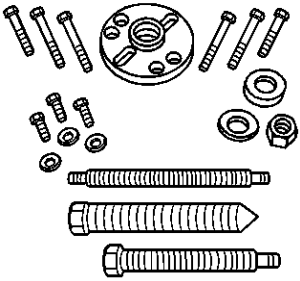
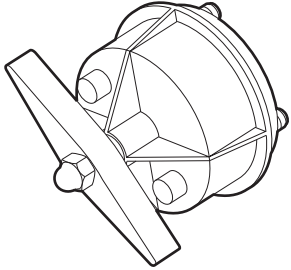
Model	Item	Specification
5.0GXi 5.0OSi 5.7Gi 5.7GXi 5.7OSi 5.7OSXi	Low Pressure Fuel Pump	8 PSI $\pm$ 4 (55 kPa $\pm$ 27)
	High Pressure Fuel Pump	50-60 PSI $\pm$ 2 (344-413 kPa $\pm$ 13)
	Oil Capacity	5 qts w/o filter, 6 with filter
	Idle RPM	600 RPM
	Full Throttle	4600-5000 RPM
	Ignition Timing	10° BTDC (set by calibration, not adjustable)
	Spark Plug	Volvo Penta P/N 3861632
	Oil Pressure	6 - 30 PSI (41 - 207 kPa) @ 800 RPM 40 - 60 PSI (276 - 414 kPa) @ 3000 RPM

Special Tools

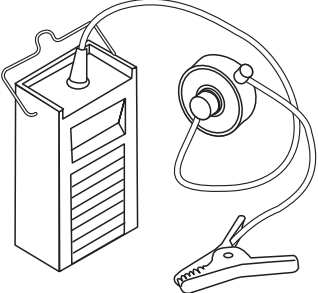
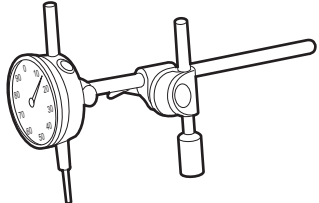
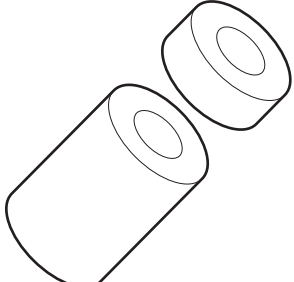
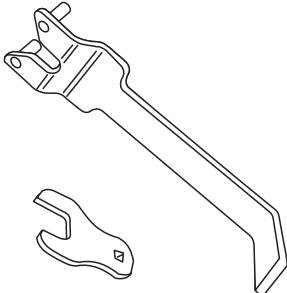
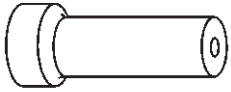
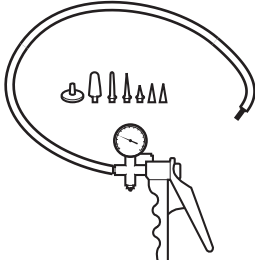
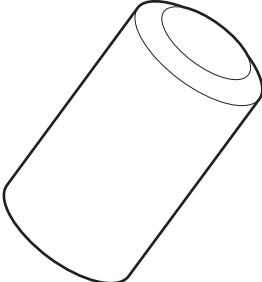
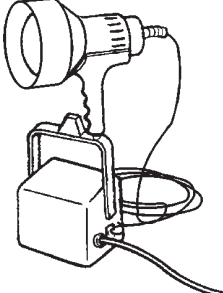
General Motors Special Tools

	J 3049-A Valve Lifter Remover		J 7872 Magnetic Base Dial Indicator
	J 5239 Connecting Rod Bolt Guide Set		J 8001 Dial Indicator
	J 5590 Crankshaft Gear Installer		J 8037 Piston Ring Compressor
	J 5825-A Crankshaft Gear Remover		J 8062 Valve spring compressor (head off the engine)

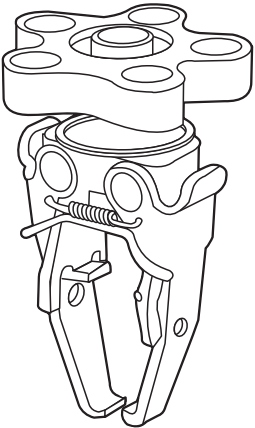
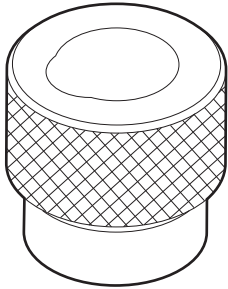
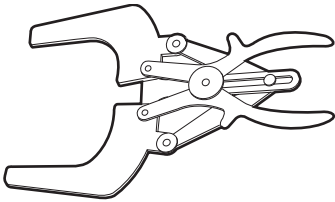
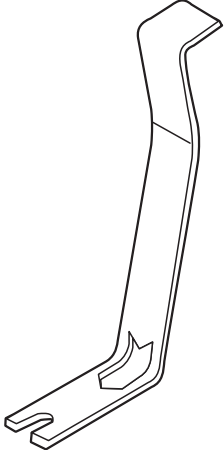
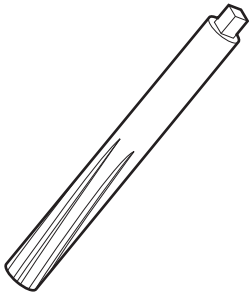
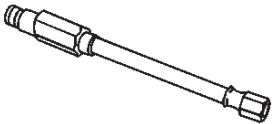
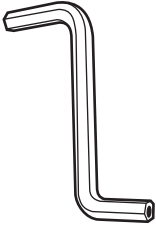
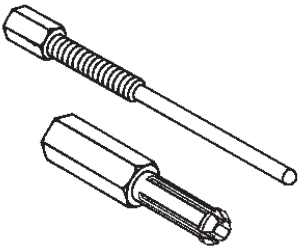
General Motors Special Tools

	J 5830-02 Valve Guide Reamer Set		J 8087 Cylinder Bore Gauge
	J 8089 Carbon removing brush.		J 24086-C Piston Pin Remover/Installer Set
	J 9666 Valve Spring Tester		J 24270 Ridge Reamer
	J 21882 Oil Suction Pipe Installer		J 33049 Camshaft Bearing Service Kit
	J 23523-F Balancer Remover and Installer		J 35621-B Crankshaft Rear Oil Seal Installer

General Motors Special Tools

	J 36660 Electronic Torque Angle Meter		J 8520 Camshaft Lobe Lift Indicator
	J 5802-01 Rocker Arm Stud Remover		J 41240 Fan Clutch Remover and Installer
	J 42073 Valve Stem Seal Installer		J 23738-A Vacuum pump
	J 6880 Rocker Arm Stud Installer		J 28428-E High Intensity Black Light Kit

General Motors Special Tools

	J 38606 Valve spring compressor (head on the engine)		J 35468 Engine Front Cover Aligner and Oil Seal Installer
	J 3936-03 Piston Ring Groove Cleaner		J 5892-D Valve Spring Compressor
	J 5715 or J 6036 Reamer		J 22794 Spark Plug Port Adapter
	Volvo Penta Special Tool 888863 Distributor hold down tool		J 43276 Clutch Pilot Bearing Remover

Order Directly from:

Kent-Moore Tool Division
28635 Mound Road
Warren, MI 48092
(800) 345-2233
<http://www.spxkentmoore.com>

Price and ordering information are available from Kent-Moore Tool Division.

For additional service information not covered in this manual, obtain the appropriate Chevrolet Engine Service Manual from:

Helm Inc.
P. O. Box 07130
Detroit, MI 48207
(800) 782-4356
<http://www.helminc.com>

Material Required

Molykote Lubricant	Permatex [®] No. 2
Volvo Penta Gasket Sealing Compound P/N 1161059	GM Super Engine Oil Supplement
3M Adhesive	Plastigage (Green)
RTV Sealer	API "SJ" SAE 30 Heavy Duty Synthetic Motor Oil

Safety Section

Part A

Marine Products and Safety of People Who Use Them	S-2
Sterndrive Shift System	S-3
Sterndrive Throttle Control System	S-4
Sterndrive Steering System	S-5
Sterndrive Fuel, Electrical System	S-7

Part B

Marine Products and Safety of People Who Fix Them	S-11
Handling Engines	S-11
Handling Lead Acid Batteries	S-12
Gasoline! Handle with Care	S-13
Hazardous Products	S-14

Part A - Marine Products and safety of People Who Use Them

Enjoyable boating is the goal of people who design and build marine products. To reach this goal, manufacturers are careful to make sure...

- Product User is informed. . .
- Products are safe and reliable. . .

It's up to you, the People who. . .

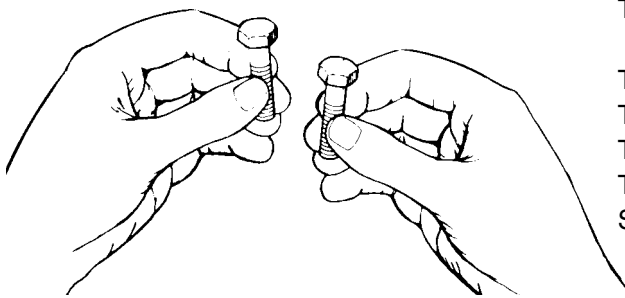
- Install accessories. . .
 - Service and Maintain the boat. . .
 - Service and maintain the sterndrive. . .
- . . . to keep the products safe and reliable.

This section talks about safe boating and how you can help keep it safe. Some things you may know . . . but others you may not.

First!

A word about fasteners . . . plain . . . special . . . all screws, nuts, washers and bolts.

Do Not Substitute Fasteners



They look the same, but . . . are they?

- The Same Size?
- The Same Strength?
- The Same Material?
- The Same Type?
- Standard or Metric Thread?

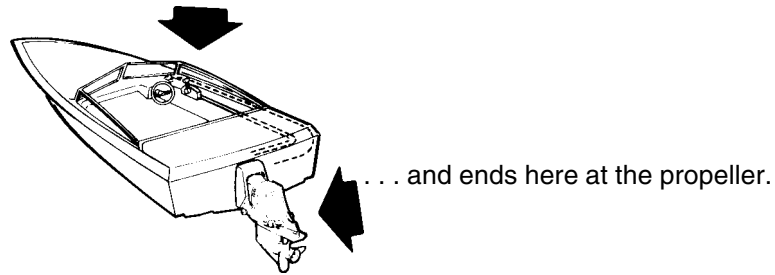
Don't substitute unless you know they are the same in all characteristics.

Second!

- Special locking screws and nuts are often used to attach steering, and remote control components to the sterndrive.
- When you remove any part from the sterndrive, keep track of special screws and nuts. Don't mix with other parts
- When reassembling the sterndrive, use only the special screws and nuts intended to hold steering, and control cables, plus related parts.
- Service with parts of known quality that meet Marine Industry (BIA/ABYC) Standard.

Sterndrive Shift System

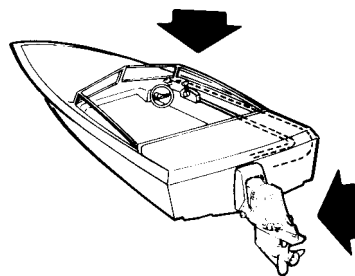
The Shift System starts
here at the remote control lever. . .



What's Most Important?

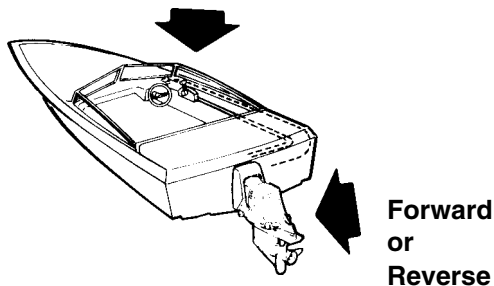
When the control lever is in Forward,
Neutral or Reverse position . .

. . . Shift mechanism must match
control lever position.



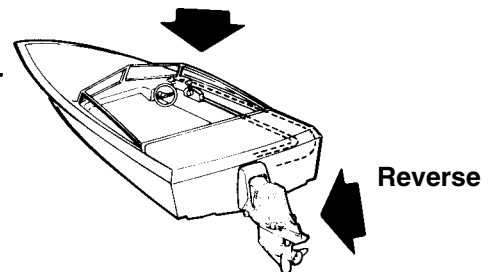
What Could Happen?

● If . . . Neutral



. . . Propeller is still powered (turning)
unknown to operator, or engine will
start in gear, boat will move unexpectedly.

● If . . . Forward



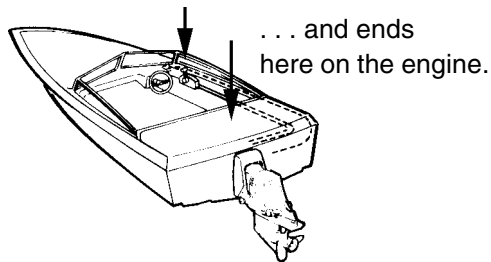
. . . boat will move opposite to di-
rection intended by operator.

How Can Loss of Shift Control be Minimized? In pre-delivery inspection and when servicing . . .

- Read, understand and follow manufacturers instructions.
- Closely follow the warnings marked with  . . .
- Assemble parts and make adjustments carefully . . .
- Test your work. Don't guess. Make sure propeller does what the operator wants and nothing else.

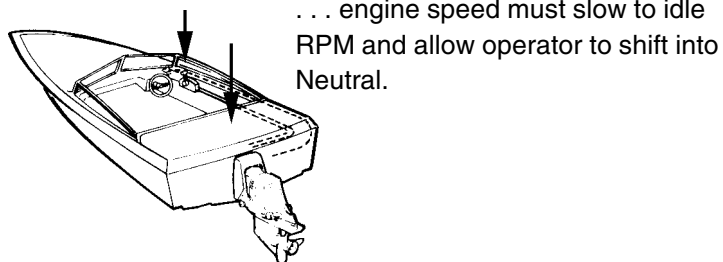
Sterndrive Throttle Control System

The throttle Control System starts here and the remote control lever . . .



What's Most Important?

When the control lever is moved from Forward (or Reverse) to Neutral . . .



Operator must be able to stop propeller.

What Could Happen?

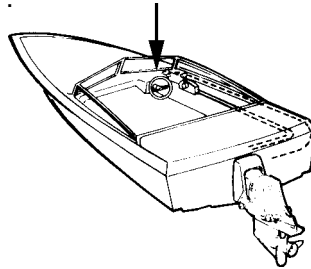
If operator cannot slow the engine to idle RPM and shift into neutral, (stop propeller), operator could panic and lose control of boat.

How Can Loss of Throttle Control be Minimized? In pre-delivery inspection and when servicing . . .

- Read, understand, and follow manufacturers instructions.
- Closely follow the warnings marked with  . . .
- Assemble parts and make adjustments carefully . . .
- Test your work. Don't guess. Make sure engine throttle response is smooth.
- Make sure full throttle operating RPM can be reached so operator won't overload engine

Sterndrive Steering System

The Steering System starts here at the helm . . .



What's Most Important?

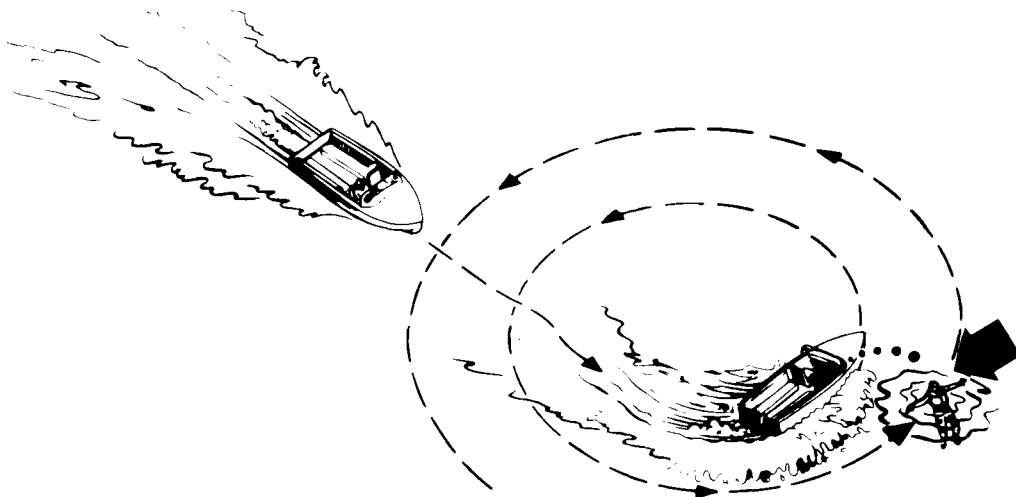
. . . and ends here at the propeller on the sterndrive

The Steering System . . .

- must be installed properly
- must be adjusted properly
- must be lubricated

What Could Happen?

- . . . if steering system comes apart, boat would turn suddenly and circle . . . passengers and/or operator may be thrown into water and could be hit.



- . . . if steering jams, operator may not be able to avoid obstacles. Operator could panic.
- . . . if steering is loose, operator may not be able to maintain a true course, and could result in loss of boat control.

How Can Loss of Steering Control be Minimized?

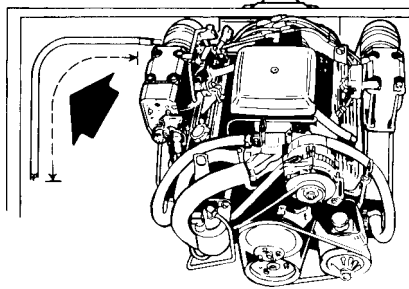
In pre-delivery inspection and when servicing

- use steering components which meet marine industry (ABYC) standards . . .
- Read, understand, and follow manufacturer's instructions.
- Assemble parts and make adjustments carefully . . .
- Closely follow the warnings marked with  . . .
- Keep parts moving freely . . . lubricate parts as soon as shown in manuals
- Use bolts, nuts, and washers supplied with steering attachment kits

When power assisted or mechanical steering systems are used, check to uncover possible trouble!

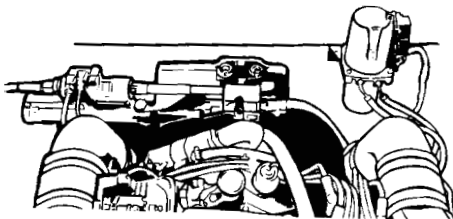
- Cable housing in this area must not be restricted

Why? Unit may go to full turn without turning steering wheel (Power assist models)

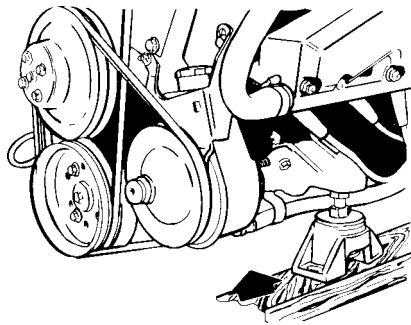


- Steering components must not bind

Why? Possible jamming of steering system.



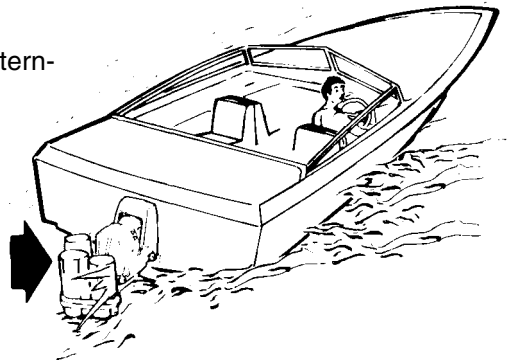
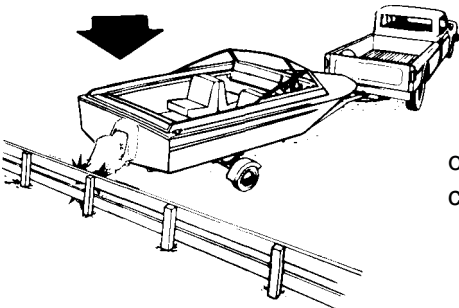
Power steering parts and push/pull cable must be free to move in order to actuate power steering valve when operator turns steering wheel



Engine stringer must not interfere with power steering pump and pulley

Maintain proper belt tension.

- Check for damaged parts . . . impacts to the stern-drive like this

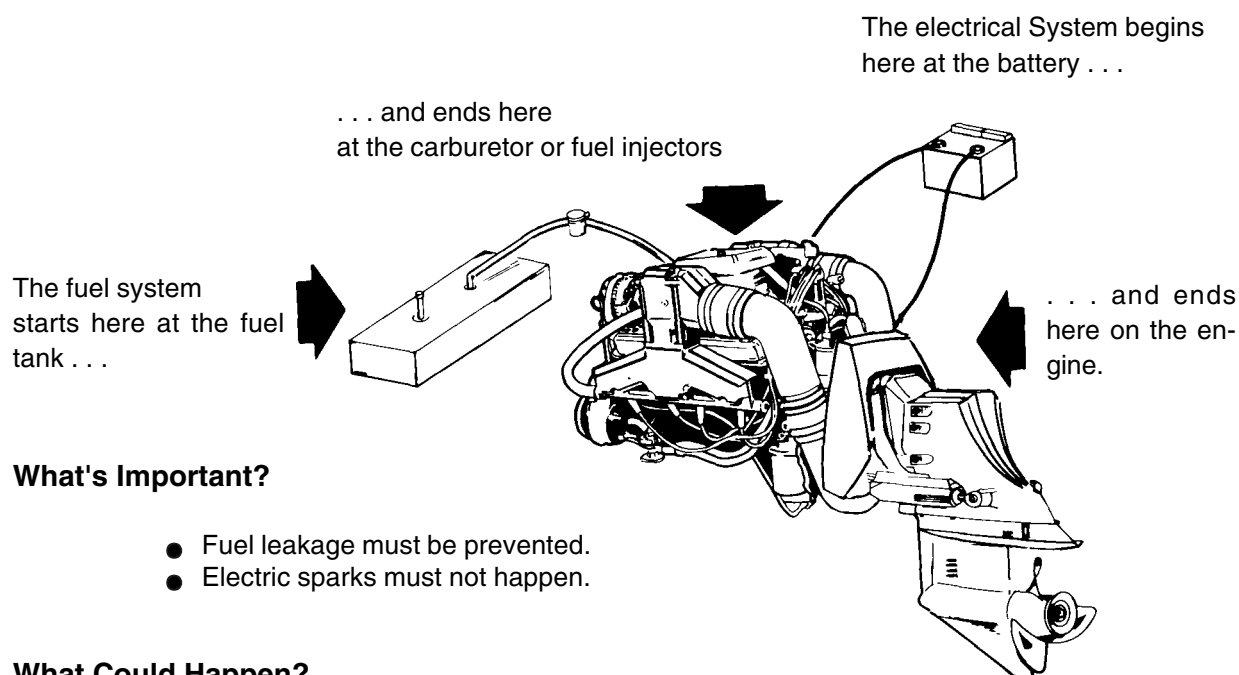


or this . . . or ???
can put stress on steering components. Look for . . .

- Cracked parts
- Bent parts
- Loose fasteners

Replace damaged parts. If weakened, parts could fail later . . . on the water . . . when least expected.

Sterndrive Fuel and Electrical Systems



What's Important?

- Fuel leakage must be prevented.
- Electric sparks must not happen.

What Could Happen?

Gasoline can explode and/ or burn easily:

- When boating, fuel leaking in the engine compartment could be ignited by a spark from a loose wire connection, or a damaged or deteriorated electrical component.

How Can Fire and Explosion Be Minimized?

- Read, understand and follow manufacturers instructions.
- Closely follow the warnings marked with  . . .
- Do not substitute fuel or electrical parts with other parts which may look the same. These parts are designed and manufactured to meet special U. S. Coast Guard safety regulations to prevent fire and explosion.

If you work on marine engines, you must understand these U.S. Coast Guard requirements. If you don't have them, write to . . .

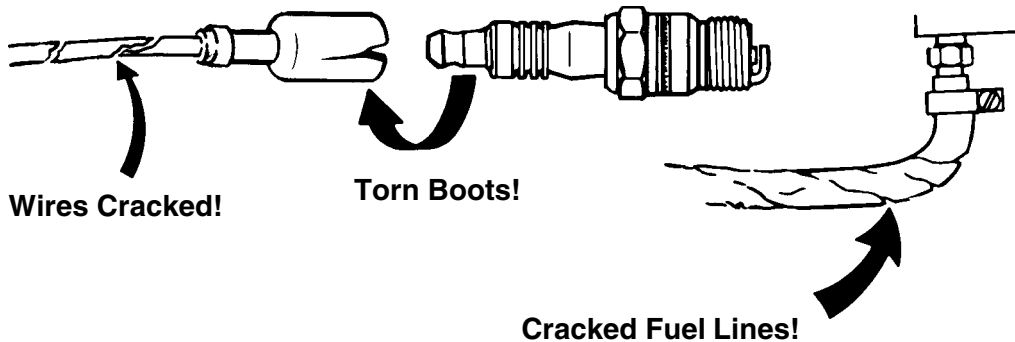
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National Technical Information Service Springfield, Virginia 22161	

. . . and ask for copies of:

- (1) Electrical System Compliance Guideline (AD/A-049-638)
- (2) Fuel System Compliance Guideline (AD/A-047-767)

These are concise guidelines - easy to read and understand. They explain what must be done to prevent fire and explosions.

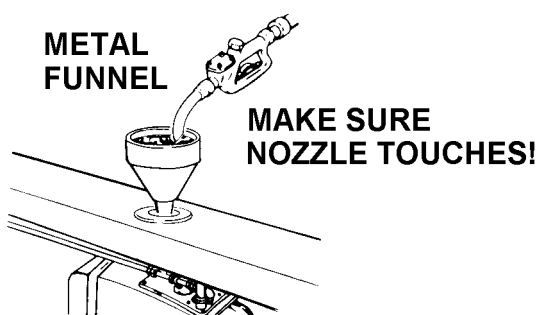
- Always use replacement parts specified by the manufacturer. They meet the U.S. Coast Guard requirements. Most automotive parts do not, especially electrical components that must meet ignition protection requirements of the U.S. Coast Guard regulations.
- When nonmetallic parts look to be in poor shape . . . replace them!



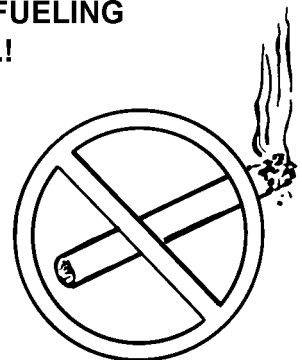
Using parts which meet U.S. Coast guard requirements is only half the job. The other half is your job . . .

It's time for replacement BEFORE sparks and/or fuel leaks occur.

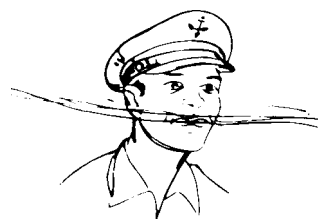
- Replace parts carefully. Make sure nuts and bolts are tight especially when they anchor electrical wires (to prevent sparking). If lock washers are specified - use them. No short cuts or missing parts with either of these CRITICAL safety related systems.
- When refueling, always ground fuel nozzle to the inlet fitting on the boat to prevent the buildup of electrostatic sparks. If you use a funnel, make sure it's metal and ground the fuel nozzle to the funnel.



**WHEN REFUELING
NEVER . . .!**



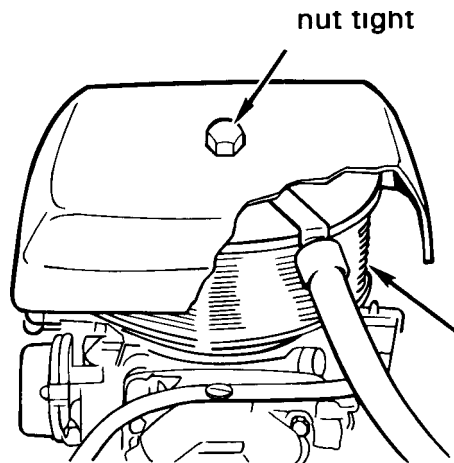
- If you smell gasoline in the engine compartment . . . find its source and stop the leakage.



- Follow "Starting Procedure" outlined in the operator's manual.

Always make sure there are no gasoline fumes in the engine compartment before starting the engine. Open the compartment and use your nose. Don't gamble.

- **Backfire flame arrestor** must be in place and securely attached to the air intake.



Do not alter the backfire flame arrestor.

If loose, damaged, or altered, an engine "backfire" may pass through the flame arrestor assembly into the engine compartment. If fumes are present in compartment, fire and explosion could result.

Summing Up

Now you know some things that can take the joy out of enjoyable boating.

No doubt about it . . . it takes time!

- Reading and understanding instructions.
- Reading and understanding warnings marked with  . . .
- Putting parts together correctly . . .
- Making correct adjustments . . .
- Testing you work.

and making sure

- Worn or damaged parts are replaced,
- Replaced parts are like originals . . . in every way.
- Customer is told of things which need attention . . .

But do you really want the alternative?

Part B - Marine Products and Safety of People* Who Fix Them

Part A talked about safe boating and how you, the mechanic, can help keep it safe for the boater. But what about you? Mechanics can be hurt while . . .

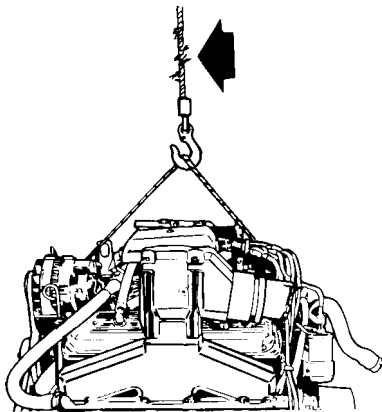
- Servicing boats
- Servicing sterndrives
- Troubleshooting problems
- Testing their work

Some items you'll know . . . others you may not.

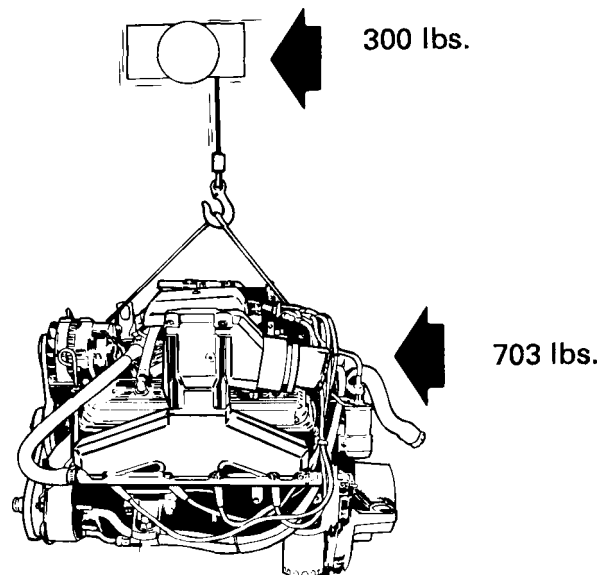
When Lifting Engines

If hoist is poor shape . . . or too small for the job

- Engine may drop suddenly



DR3471



DR3469

- Make sure shop aids have extra capacity — and keep them in good repair!

When Running Engine with Engine Compartment Cover Removed

The engine compartment cover is a guard. When you remove the cover / guard to work on the engine, remember:

- Loose clothing (open shirt sleeves, neckties), long hair, jewelry (rings, watches, bracelets), hands, arms, belts can be caught by moving belts or spinning pulleys
- Handle high voltage ignition components carefully. They can shock you and may cause you to recoil into moving parts.

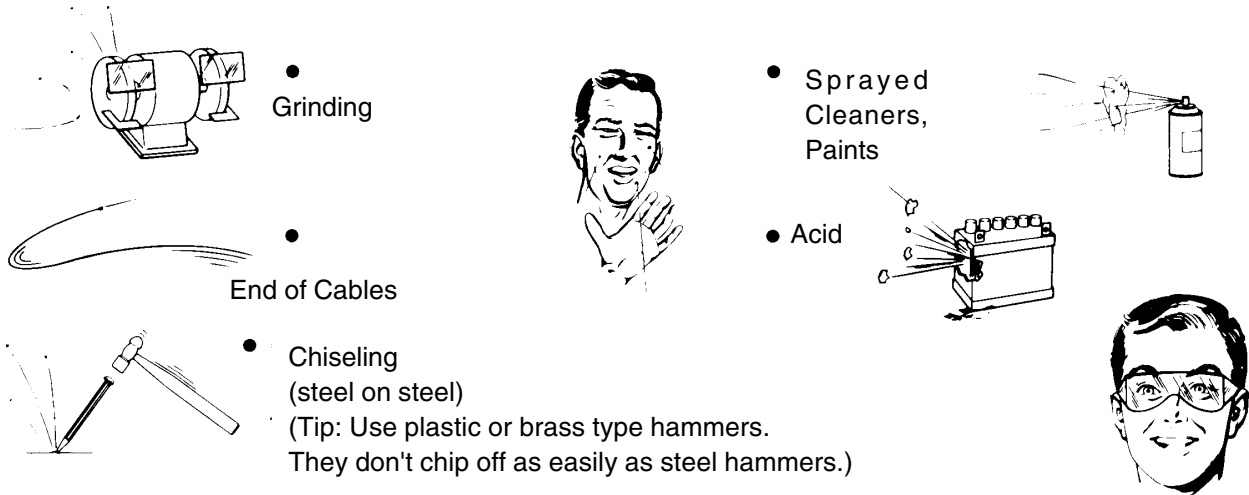
Two people working together on a running engine must look out for each other. Never, ever, hit the key to start the engine before signalling to your partner. (He may be leaning over the engine with his hands on a belt, or a "hot" electrical part, near the propeller, etc.) **Remove the key(s) while working on the engine to prevent accidental starting.**

*Mechanics, technicians, backyard do-it-yourselfers.

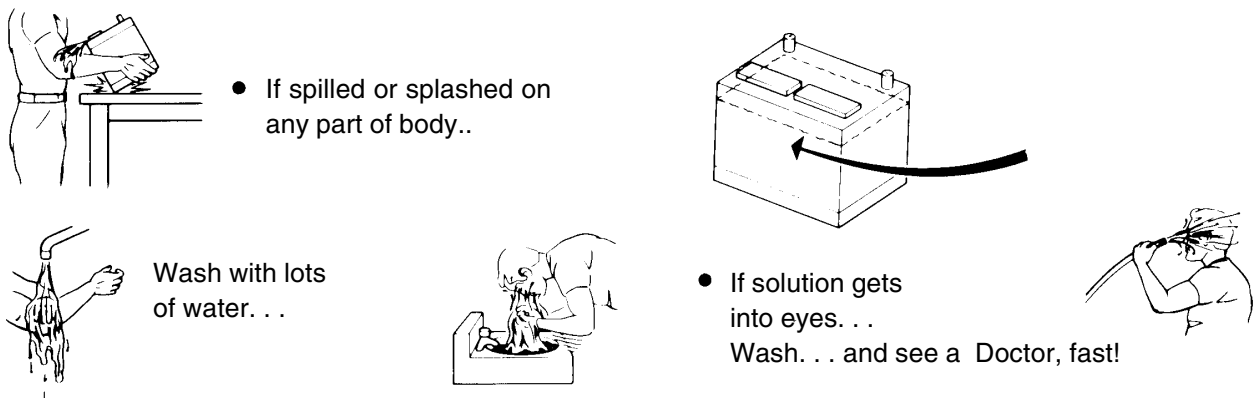
- Exhaust gasses of running engines contain carbon monoxide. . . you can't see it. . . you can't smell it. . . you can't taste it. . . but it's there whenever an engine runs. . . and it's deadly!

When you smell the other gasses in the exhaust, you are inhaling carbon monoxide. Run engines only in well ventilated areas.

Eyes Need help

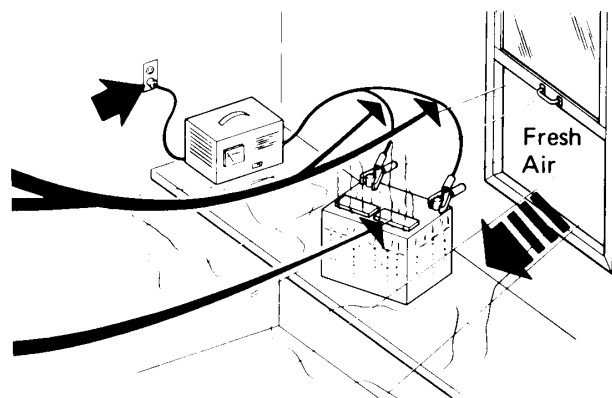


Handling Lead Acid Batteries



Charging Lead Acid Batteries

- 1** Attach and remove these cables with charger unplugged from 110 volt wall socket. (Prevents shocks if the charger is defective.)
- 2** Observe correct polarity when connecting these charger leads.
- 3** Always charge in a well ventilated area. Charging causes acid solution to give off hydrogen gas through the vents in the caps. . . Make sure vents are open. If clogged, pressure inside may build. . . battery may explode.



Battery gas is explosive!
While charging or discharging,
remember. . .

No Smoking
No Flames
No Sparks



Never yank cables off
battery posts. . . it's a sure
way to make lots of
sparks. . . surrounded by bat-
tery gas

Don't check battery condition
by placing metal objects
across posts.

You're sure to make sparks
and serious burns are
possible.

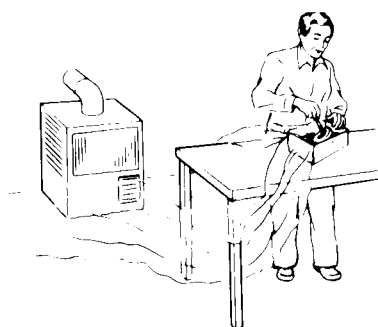
After Charging. . .



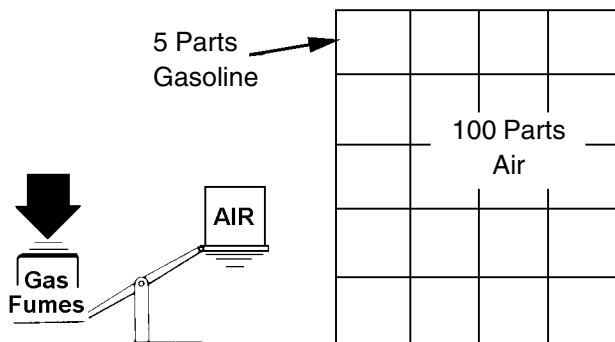
- Shut off charger
- Remove charger plug from wall socket
Then. . .
- Take charger cable off battery posts

Gasoline! Handle With Care

- When you smell any odor of gasoline,
explosion is possible
- Gasoline fumes are heavier than air and will sink
to the lowest point in the boat or room,
and will stay there. . . waiting
- If the air around you is quiet . . . the pilot light in
the heater may
ignite the heavy fumes
before your nose ever
smells the fumes . .



Gasoline explodes easily and violently
when mixed with air



What Can you Do?

Store in sturdy,
sealed gas can
. . . and . . .
keep outside



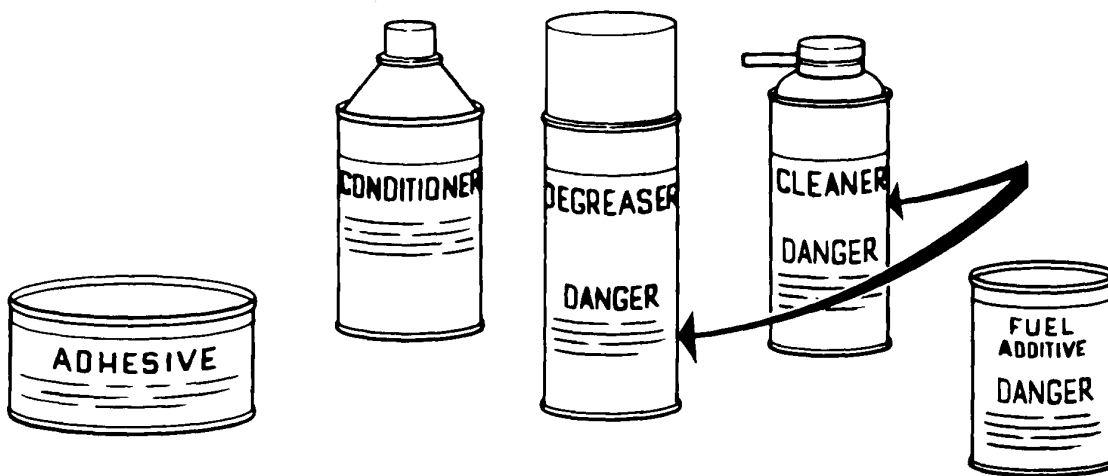
- Store properly . . .
- Fill portable tanks outside boat to prevent spillage in
boat
- Use fuel for fuel . . . not for a solvent
- If fumes are smelled (in shop, basement, garage), immediately:
 - Put out open flames, cigarettes, sparking devices
 - Wipe up spill or leak; get towels, rags outside fast
 - Check lowest area for fumes; open doors or
windows

● Know items in and around repair area which can ignite gasoline fumes . . . Control them if fumes are smelled.

- Matches, cigarettes, torches, welders
- Electric motors (with unsealed cases)
- Electric generators (with unsealed cases)
- Light switches
- Appliance pilot lights (furnace, dryer, water heater)
- ??????????

How many of these are in your area?

Hazardous Products



Read the container label. It tells you . . .

- "How, and where, to use,"
- "How to give First Aid," and have "recommended" first aid materials on hand- should an emergency arise
- "How to dispose of can,"

Remember: Little children are very curious and will try to taste everything, so . . .

. . . yummmmmmmmmmm



Keep containers away
from children

