Workshop Manual

EFI Repair

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2(0)

4.3GXi, 4.3OSi
5.0GXi, 5.0OSi
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8.1Gi, 8.1GiI, 8.1GXi, 8.1GXiI

Contents

Application

This workshop manual applies the engines listed in the following table. The unit you are servicing may be identified by the specifiction number located on the serial number data plate.

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Section 1: General Information

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 the engine and sterndrive is generally one of three kinds:

- **Normal care and maintenance** - which includes putting a new engine and stern drive into operation, storing, 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 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, Partner Network, 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 contact the Volvo Penta Service Department by calling or through Partner Network 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 malfunction and possible injury to the operator and/or passengers.

Parts Catalogs

Parts Catalogs and the electronic parts catalog (EPC) 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 Partner Network and 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.

2. Visually inspect stern drive unit for leaks, missing parts or other obvious defects. **Replace deteriorated parts.**
3. 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.

⚠ **Caution!**

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.
- Set the Volvo Penta Scan tool to “ECM TESTS” and select “COMPRESSION TEST” before cranking the engine.

⚠ **Caution!**

This test commands the ECM to disable all spark and fuel injector outputs. The test must be properly exited from the Scan Tool to re-enable normal spark and fuel operation. DO NOT perfrom this test in open water. Always perform this test dockside or on a trailer. The engine will be disabled until the test is properly exited.

If the scan tool is disconnected during the COMPRESSION TEST, the engine will remain disabled until the scan tool is reconnected and the COMPRESSION TEST mode is exited properly. Refer to the documentation that comes with the Scan tool for further information on Scan tool operation.

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.

Table 1: Compression Pressure Limit

Max. PSI	Min. PSI	Max. PSI	Min. PSI	Max. PSI	Min. PSI	Max. PSI	Min. PSI
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
- 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.

Intake Manifold Vacuum Testing

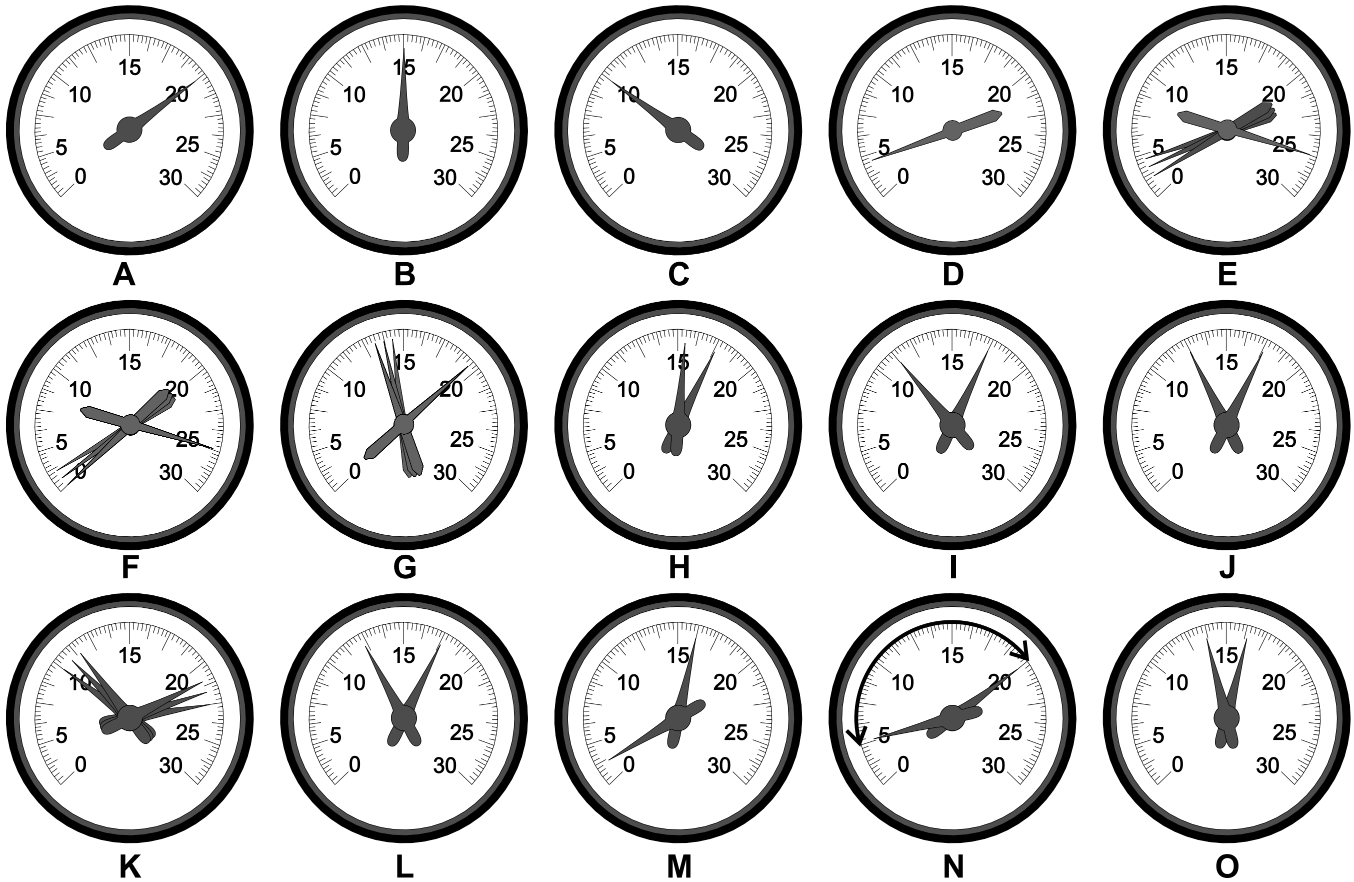
Test Procedures

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 19in. 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.



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.
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.

Caution!

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).

Caution!

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

See the boat's Operators Manual to determine if the boats 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:

- ïThe engine will operate leaner. This may cause engine problems such as vapor lock, low speed stalling, or hard starting.
- ïAlcohol blended fuels attract and hold moisture. Moisture can cause fuel tank corrosion. Inspect fuel tanks at least annually. Replace corroded or leaking fuel tanks.
- ïFrequently 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.

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.

NOTE! The use of multi-viscosity oils, such as 10W-30 or 10W-40, is 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 SH. 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.

Table 2: 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

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

Caution!

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

Table 3: Crankcase Capacities

Model	With Filter
Sterndrive	
4.3GXi/OSi	5.0 qts. (4.7 liters)
5.0GXi/OSi	5.5 qts. (5.2 liters)
5.7Gi/GXi/OSi/OSXi	5.5 qts. (5.2 liters)
8.1Gi/GXi	9.0 qts. (8.5 liters)
Inboards	
5.7GiI/GXiI	5.5 qts. (5.2 liters)
8.1GiI/GXiI	9.0 qts. (8.5 liters)

Oil Filter

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.

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.

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.
Boat manufacturers should follow the gasoline storage mixture section for testing prior to shipment.

Note! Volvo Penta has discontinued the fuel stabilizer #3855832, a suitable replacement can be purchased locally at most automotive 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 manufacturers instructions. This will help prevent the fuel from breaking down and causing reduced engine performance 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.

DANGER!

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

Caution!

Do not run engine out of fuel or run the electric fuel pumps dry more than 10 seconds. Running the electric fuel pumps dry will cause fuel pump damage.

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.

Electric Fuel Pumps and Fuel Cells

Regardless of the ratio of fuel stabilizer to fuel we use, the maximum recommended storage time for gasoline, according to STA-BIL, is six months. During final assembly testing at our Lexington factory, each engine is run on a fuel mix that is stabilized. Each engine is shut off without running the fuel pumps dry and the fuel system is sealed to prevent damage. With the delay in time between the product getting installed in a boat, shipped to you, sold and finally delivered; the six-month time frame can easily be exceeded.

Since delivering a quality, dependable product is one of our highest goals; we work closely with our suppliers to identify the root cause of failure on any parts returned for warranty credit. While there are certainly legitimate failures of fuel pumps, the major portion of them are returned to us due to varnished fuel from long term storage. We would like to offer some advice on dealing with these issues.

Stuck Pumps

If a fuel pump appears stuck and will not operate, you may try briefly reversing the polarity to the pump to turn it in the opposite direction. You should disconnect the electrical plug of one pump at a time on the fuel cell to determine which pump might have a problem.

Noisy Fuel Pumps

Electric pumps will often cavitate and become noisy if they are starving for fuel. On carbureted engines or low-pressure fuel cell pumps, check the fuel supply, quality of the fuel hose, anti-siphon valve, and filter before replacing the fuel pump.

A noisy high-pressure pump on a fuel cell may indicate a low fuel level in the reservoir. Check the fuel supply and low pressure pump operation to be sure the reservoir is receiving the correct volume of fuel. The same information would apply to engines with the earlier vapor separator tank design.

This information may help prevent the needless replacement of pumps in many cases and reduce the repair time for the boat owner.

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.

Caution!

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.

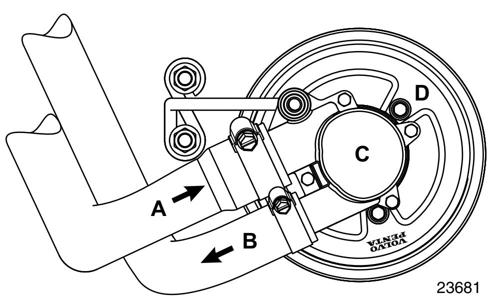
Change Sterndrive Lubricant

Drain and refill with fresh Volvo Penta 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.

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 that 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.



4.3GXi, 4.3OSi

Front

1. Remove inlet (A) and outlet (B) hoses from raw water pump and rotate engine with starter 1-2 revolutions. If engine starts to run, shut off immediately.

Caution!

Do not run engine without water. If engine starts with the water intake hose disconnected, shut off immediately. Allowing the engine to run without water will damage the engine and cooling components.

2. Disconnect the small water by-pass hose at the top of the thermostat housing.
3. Disconnect and drain large hose at the circulation pump.
4. Disconnect the fuel cell water discharge hose. Lower the hose into the bilge to allow draining. Blow out and remaining water with compressed air. Reconnect after draining is complete.

Port

5. Remove cylinder block drain plug. Clear hole with small wire to ensure complete drainage.

6. Remove exhaust manifold drain plug. Clear hole with small wire to ensure complete drainage.

Starboard

7. Remove cylinder block drain plug. Clear hole with small wire to ensure complete drainage.
8. Remove exhaust manifold drain plug. Clear hole with small wire to ensure complete drainage.
9. Reinstall drain plugs after draining is complete to keep the threads of the drain holes from corroding. It will be difficult to install the drain plugs if the plugs are left out over the winter.

5.0GXi, 5.0OSi, 5.7Gi, 5.7OSi, 5.7GXi, 5.7OSXi, 5.7GiI-F, 5.7GXiI-G

Front

1. Remove inlet (A) and outlet (B) hoses from raw water pump and rotate engine with starter 1-2 revolutions. If engine starts to run, shut off immediately.

⚠ **Caution!**

Do not run engine without water. If engine starts with the water intake hose disconnected, shut off immediately. Allowing the engine to run without water will damage the engine and cooling components.

2. Disconnect and drain large hose at the circulation pump.

Port

1. Remove cylinder block drain plug. Clear hole with small wire to ensure complete drainage.
2. Remove exhaust manifold drain plug located at the rear of the exhaust manifold. Clear hole with small wire to ensure complete drainage.

Starboard

1. Remove cylinder block drain plug. Clear hole with small wire to ensure complete drainage.
2. Remove exhaust manifold drain plug located at the rear of the exhaust manifold. Clear hole with small wire to ensure complete drainage.
3. Reinstall drain plugs after draining is complete to keep the threads of the drain holes from corroding. It will be difficult to install the drain plugs if the plugs are left out over the winter.

8.1Gi, 8.1GXi, 8.1OSi, 8.1GiI-G, 8.1GXiI-F

Front

1. Remove inlet (A) and outlet (B) hoses from raw water pump and rotate engine with starter 1-2 revolutions. If engine starts to run, shut off immediately.

⚠ **Caution!**

Do not run engine without water. If engine starts with intake hose disconnected, shut off immediately. Allowing the engine to run without water will damage the engine and cooling components.

2. Disconnect and drain large hose at the circulation pump.

Port

1. Remove cylinder block drain plug. Clear hole with small wire to ensure complete drainage.
2. Remove exhaust manifold drain plug located at the front of the port exhaust manifold, behind the power steering pump. Clear hole with small wire to ensure complete drainage.

Starboard

1. Remove cylinder block drain plug. Clear hole with small wire to ensure complete drainage.
2. Remove exhaust manifold drain plug located at the rear of the exhaust manifold. Clear hole with small wire to ensure complete drainage.
3. Reinstall drain plugs after draining is complete to keep the threads of the drain holes from corroding. It will be difficult to install the drain plugs if the plugs are left out over the winter.

Preparation for Boating After Storage

1. Install all drain plugs if they were left out during storage. 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.**

⚠ **Warning!**

Do not place fingers in the throttle body on electronic throttle equipped engines. The throttle plate has a powerful motor that can cause severe injury if the ignition energized.

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.

⚠ **Danger!**

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.

Caution!

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 frequently 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.

NOTE!

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 piston rings and bearings.

During the remaining first two hours of operation, accelerate 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.

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.

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.

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.

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

2. Watch oil pressure gauge. If indicator fluctuates whenever boat attitude (i.e. turning, climbing on plane, etc.) is changed, 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.

NOTE! 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.

⚠ **Caution**

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

At end of break-in period (20 hours), change the motor oil and replace oil filter. Fill crankcase with recommended motor oil, See “Crankcase Oil” on page 9.

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

Remove engine from water as quickly as possible.

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 actions may allow extensive engine damage.

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

20-Hour Check

1. Change engine oil and oil filter.
2. Check power trim/tilt reservoir for proper fluid level.

3. Change fuel filter/water separator.
4. Check flame arrestor for proper mounting, cleanliness or damage.
5. Start engine and check complete fuel system for leaks.
6. Lubricate steering cable ram with Volvo Penta grease. 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.
8. Inspect exhaust system. Tighten all hose clamps, and check for leaks.
9. Check tension on all drive belts.
10. Check all engine mount screws 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. See engine specifications.

Belt Tension

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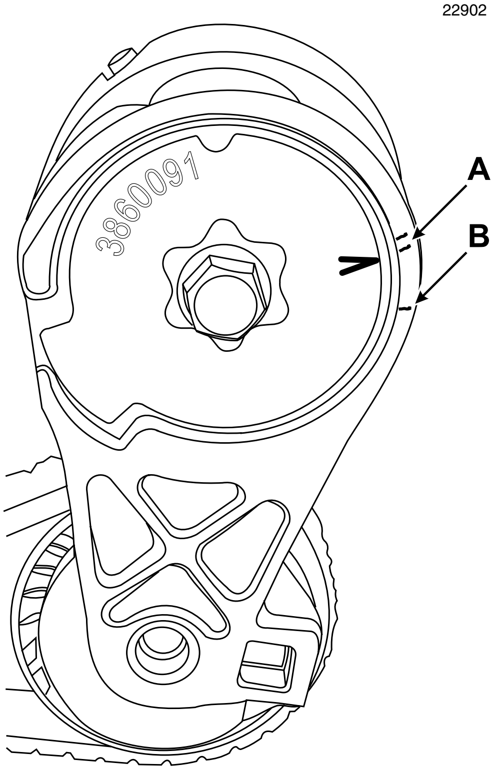


Serpentine belts are tensioned automatically and do not require adjustment. Replace when the tension indicator lines up with the single line on the housing (A).

The Volvo Penta serpentine belts are for heavy-duty marine use. DO NOT replace with automotive belts.

Positive Closed-Type Ventilation System

5.0L and 5.7L engines only

A malfunctioning closed crankcase ventilation system may be indicated by loping or rough engine idle. Do not attempt to compensate for this idle condition by disconnecting the crank-case 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.

NOTE! 8.1 engines have an internal crankcase ventilation system and have no serviceable components.

NOTE! 4.3 engines do not have a PCV valve. The crankcase ventilation is provided by a fixed orifice located in the port valve cover and connected by a hose to the intake manifold.

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

⚠ **Caution!**

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.

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.
	Fuel System	1. Fuel Tank, valves, and lines 2. Fuel pump and filter 3. Boat Fuel System Troubleshooting Chart 4. Engine Fuel System Troubleshooting Chart
Engine Runs Improperly		Check the following: 1. Compression 2. Ignition system 3. Fuel and injection system 4. Lubrication system 5. Cooling System 6. Sterndrive and propeller 7. PCV Valve 8. Engine Troubleshooting Guides

Engine Troubleshooting Guides

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 information. 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

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
- 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

Has Engine Always Done This? Check:

Ask these questions first:

1. Fuel tank antisiphon valve (if equipped)
2. Fuel lines for obstructions
3. For debris inside fuel tank
4. See ***Electrical/Ignition/Fuel System Service Manual***

Was Engine Used For A Long Time? Check:

1. For clean external fuel filters
2. Water in fuel due to condensation
3. Fuel quality deterioration
4. See *Electrical/Ignition/Fuel System Service Manual*

Is This A New Condition? Check:

1. Fuel tank antisiphon valve (if equipped)
2. Fuel system for leaks, dirt, or obstructions
3. Engine and ignition system
4. See ***Electrical/Ignition/Fuel System Service Manual***

Hard Starting - Hot Engine

Has Engine Always Done This? Check:

Ask these questions first:

1. Fuel tank antisiphon valve (if equipped)
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

Ignition coil(s)/ignition module

2. Engine timing
3. Fuel tank antisiphon valve (if equipped)
4. See ***Electrical/Ignition/Fuel System Service Manual***

Engine Runs Rough

If At Slow Speed - Check:

1. Fuel tank antisiphon valve (if equipped)
2. Idle speed
3. Engine timing and spark plugs
4. Fuel pressure
5. Water or contaminants in fuel
6. Manifold vacuum 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. Fuel filter
6. Fuel pump pressure
7. Engine compression
8. Water or contaminants in fuel, water in cylinders
9. See 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. Incorrect spark plugs
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*** section

Mountings

1. Loose, broken or worn engine mounts
2. Loose lag screws holding mounts to stringer
3. Check engine alignment see *Removing and Installing Engine* section

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

1. Actual engine temperature by verifying with an accurate thermometer
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
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 fuel filter
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. 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. Sterndrive for internal damage
2. Oil pressure gauge
3. Crankcase oil level
4. Water in engine or sterndrive oil
5. Temperature gauge and cooling system operation
6. Internal engine components as required

Engine Won’t Reach Operating RPM

1. Fuel type or octane
2. Propeller pitch or diameter, damaged blades, slipping hub
3. Crankcase oil level
4. Marine growth on hull and drive
5. Wrong Sterndrive gear ratio
6. Operating at high altitude
7. Restricted air intake
8. Restricted exhaust outlets in engine, transom bracket or drive
9. Poor cylinder compression
10. Fuel pump pressure and vacuum
11. Boat overloaded, or load improperly placed
12. Engine overheating
13. Engine timing and ignition system operation
14. 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 oil level
10. Incorrect hose routing on remote filter systems
11. 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

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

Abbreviations

Table 4: Abbreviations used in this manual

BP	Barometric Pressure
CAN	Controller Area Network
CKP	Crankshaft Position Sensor
CMP	Camshaft Position Sensor
DBW	Drive-By-Wire
DTC	Diagnostic Trouble Code
DVOM	Digital Voltage and Ohm Meter
ECM	Engine Control Module
ECT	Engine Coolant Temperature Sensor
EGC	Electronic Gas Control System
EGT	Exhaust Gas Temperature
EPC	Electronic Parts Catalog
ET	Electronic Throttle
IAC	Idle Air Control Valve
IAT	Intake Air Temperature Sensor
IVS	Idle Validation Switch
KS	Knock Sensor
LED	Light Emitting Diode
MAP	Manifold Absolute Pressure
MIL	Malfunction Indicator Lamp
PWM	Pulse Width Modulated
TCP	Throttle Control Position Sensor
TPS	Throttle Position Sensor
OBD	On-board Diagnostics
DLC	Data Link Connector
MEFI	Marine Electronic Fuel Injection
IC	Ignition Control
ODM	Output Driver Module
EEPROM	Electrically Erasable Programmable Read-only Memory
EI	Electronic Ignition System
PFI	Port Fuel Injection
ICM	Ignition Control Module
COP	Internal Micro Processor
EVC	Electronic Vessel Control
A/D	Analog/Digital
T-MAP	Manifold Absolute Pressure / Manifold Air Temperature sensor
AC	Alternating Current

NOTES

Section 2: System Description

Visual / Physical Inspection

A careful visual and physical inspection must be performed as part of any diagnostic procedure. This can often lead to fixing a problem without further diagnostics. Inspect all vacuum hoses for correct routing, pinches, cracks or disconnects. Be sure to inspect hoses that are difficult to see. Inspect all the wires in the engine compartment for proper connections, burned or chafed spots, pinched wires or contact with sharp edges or hot manifolds. This visual/physical inspection is very important. It must be done carefully and thoroughly.

Basic Knowledge and Tools Required

To use this manual most effectively, a general understanding of basic electrical circuits and circuit testing tools is required. You should be familiar with wiring diagrams, the meaning of voltage, ohms, amps and the basic theories of electricity. You should also understand what happens if a circuit becomes open, shorted to ground or shorted to voltage.

To perform system diagnostics, several special tools and equipment are required. Please become acquainted with the tools and their use before attempting to diagnose the system. Special tools that are required for system service are illustrated in this section.

Electrostatic Discharge Damage

Electronic components used in control systems are often designed to carry very low voltage, and are very susceptible to damage caused by electrostatic discharge. It is possible for less than 100 volts of static electricity to cause damage to some electronic components. By comparison, it takes as much as 4,000 volts for a person to feel the zap of a static discharge.

There are several ways a person can become statically charged. The most common methods of charging are by friction and by induction. An example of charging by friction is a person sliding across a seat, in which a charge of as much as 25,000 volts can build up. Charging by induction occurs when a person with well insulated shoes stands near a highly charged object and momentarily touches ground. Charges of the same polarity are drained off, leaving the person highly charged with the opposite polarity. Static charges of either type can cause damage. Therefore, it is important to use care when handling and testing electronic components.

Engine Wiring

When it is necessary to move any of the wiring, whether to lift wires away from their harnesses or move harnesses to reach some component, take care that all wiring is replaced in its original position and all harnesses are routed correctly. If clips or retainers break, replace them. Electrical problems can result from wiring or harnesses becoming loose and moving from their original positions, or from being rerouted.

Engine Control Module (ECM) Self-Diagnostics

The Engine Control Module (ECM) performs a continuous self-diagnosis on certain control functions. This diagnostic capability is complemented by the diagnostic procedures contained in this manual. The ECM's language for communicating the source of a malfunction is a system of Diagnostic Trouble Codes (DTC's). The DTC's are two digit numbers that can range from 12 to 81. When a malfunction is detected by the ECM, a DTC is set and the Malfunction Indicator Lamp (MIL) is illuminated.

Malfunction Indicator Lamp (MIL)

The Malfunction Indicator Lamp (MIL) is part of the Diagnostic Trouble Code (DTC) tool, or it can be a dash mounted warning light on some applications.

- If present, it informs the operator that a problem has occurred and that the boat should be taken for service as soon as reasonably possible.
- It displays DTC's stored by the ECM which help the technician diagnose system problems.

As a bulb and system check, the light will come "ON" with the key "ON," engine "OFF." When the engine is started, the light will turn "OFF." If the light remains "ON," the self-diagnostic system has detected a problem. If the problem goes away, the light will go out in most cases after 10 seconds, but a DTC will remain stored in the ECM.

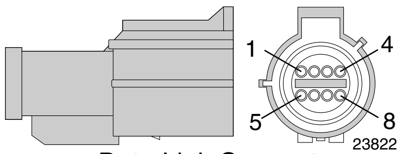
When the light remains "ON" while the engine is running, or when a malfunction is suspected due to a driveability problem, the "On-Board Diagnostic (OBD) System Check" must be performed as the first step. These checks will expose malfunctions which may not be detected if other diagnostics are performed prematurely.

Intermittent Malfunction Indicator Lamp (MIL)

In the case of an "intermittent" problem, the Malfunction Indicator Lamp (MIL) may light for 10 seconds, and then go out. However, the corresponding DTC will be stored in the memory of the ECM. When DTC's are set by an intermittent malfunction, they could be helpful in diagnosing the system.

If an intermittent DTC is cleared, it may or may not reset. If it is an intermittent failure, consult the "Diagnostic Aids" on the facing page of the corresponding DTC table. A physical inspection of the applicable sub-system most often will resolve the problem.

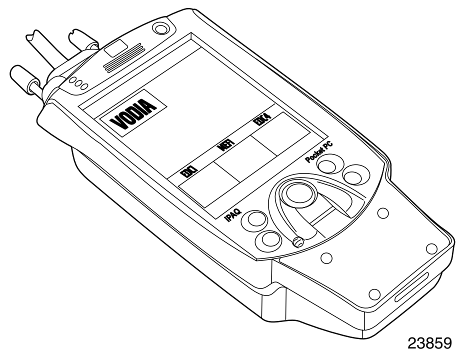
Reading Diagnostic Trouble Codes (DTC's)



Data Link Connector

The provision for communicating with the ECM is the Data Link Connector (DLC). It is part of the engine wiring harness, and is a 8-pin connector, which is electrically connected to the ECM. It is used in the assembly plant to receive information in checking that the engine is operating properly before it leaves the plant. The DTC(s) stored in the ECM's memory can be retrieved with several Diagnostic Trouble Code (DTC) tools listed below.

VODIA Scan Tool

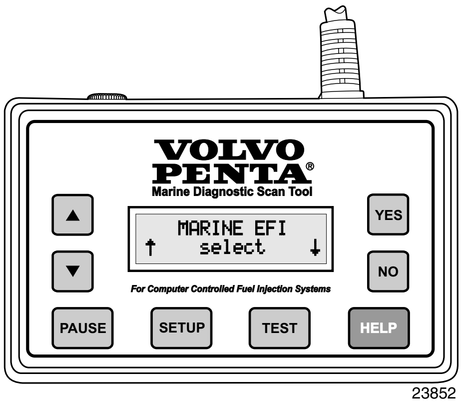


The VODIA tool is an advanced flexible diagnostic tool which is compatible with all Volvo Penta Gas and Diesel engines with electronic control systems, including the new EGC Control System. The VODIA tool is a full-feature scan tool which will read and record all vital engine parameters, read and reset fault codes, and perform engine tests. The tool will also allow access to EVC systems and links to the Volvo Penta Partner Network where updates can be downloaded online for future expansion.

The VODIA tool may only be ordered through the Volvo Penta Partner Network. From the home page, select Service/Warranty and then select VODIA from the menu. Detailed information and pricing may be found on the VODIA website.

Dealers who currently have a VODIA tool can order the connection cable for EGC engines (PN 3883170) from our Parts and Accessories department. The program itself is available for download to all registered users from the VODIA website on the Volvo Penta Partner Network.

Volvo Penta Marine Diagnostic Scan Tool (P/N 3851228)



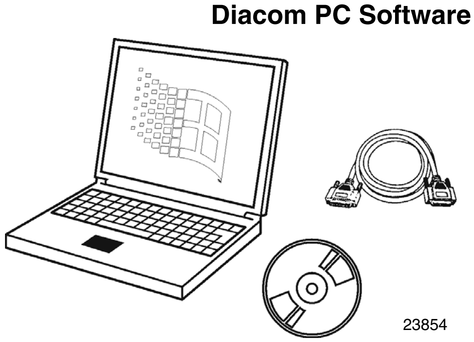
This full-function scan tool will:

- Provide complete access to all vital engine parameters.
- Read and reset fault codes.
- Perform output tests on EGC Control Systems.

The tool is also compatible with all GM based Volvo Penta EFI engines with MEFI 1, 3, 4, and 4B controls. The tool features an easy to use keypad and a high visibility two line text display. The kit includes connectors for EGC and MEFI engines, and a carrying case. Updates

Dealers who currently have earlier versions of this tool with the Techmate faceplate can obtain updated internal software and a connection cable by contacting Rinda Technologies, Chicago, IL, at (773) 736-6633 or by visiting http://www.rinda.com

Diacom PC Software



The Diacom program will provide full access to all vital engine parameters, read and reset fault codes, and perform output tests on EGC Control Systems. The program allows easy access to all vital engine parameters on Windows based PC's. Fault codes can be read and reset, and output tests can be performed. The system can easily record and store test runs. Live or recorded readings may be graphed for analysis and can also be e-mailed to VPA Technical Assistance for review. The software is also compatible with all Volvo Penta General Motors based EFI engines with MEFI 1, 3, 4, and 4b controls. The kit includes connectors for EGC and MEFI engines and may be purchased directly by contacting Rinda Technologies, Chicago, IL, at (773) 736-6633 or by visiting http://www.rinda.com.

Updates Dealers who currently have earlier versions of this software can obtain updated software and an EGC connection cable by contacting Rinda Technologies, Chicago, IL, at (773) 736-6633 or by visiting http://www.rinda.com.

Service Mode

When the Diagnotic tool is installed at the DLC and "service mode" or "ON" is selected, the system will enter what is called the "Service Mode." In this mode, the ECM will:

- Display any stored DTC's.
- The ignition timing is controlled to a fixed timing degree programmed in the ECM. This will allow base timing to be adjusted on distributor ignition engines.

Normal Mode

When the Diagnotic tool is in the "normal mode" or "OFF," it has no affect on the engine operation.

On-Board Diagnostic (OBD) System Check

After the visual/physical inspection, the "On-Board Diagnostic (OBD) System Check" is the starting point for all diagnostic procedures.

The correct procedure to diagnose a problem is to follow two basic steps:

1. Are the on-board diagnostics working? This is determined by performing the "On-Board Diagnostic (OBD) System Check." Since this is the starting point for the diagnostic procedures, always begin here. If the on-board diagnostics are not working, the OBD system check will lead to a diagnostic table to correct the problem. If the on-board diagnostics are working properly, the next step is:
2. Is there a DTC stored? If a DTC is stored, go directly to the number in the DTC table. This will determine if the fault is still present.

DLC Scan Tools

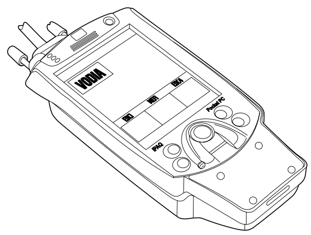
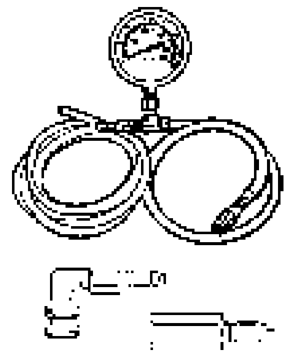
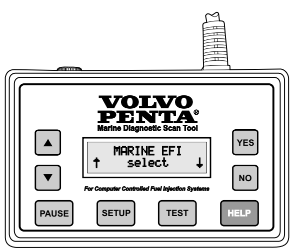
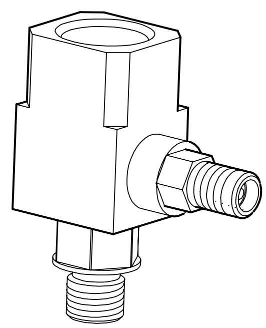
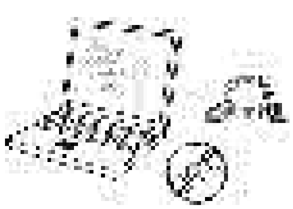
The ECM can communicate a variety of information through the DLC. This data is transmitted at a high frequency which requires a scan tool for interpretation.

With an understanding of the data which the scan tool displays, and knowledge of the circuits involved, the scan tool can be very useful in obtaining information which would be more difficult or impossible to obtain with other equipment.

A scan tool does not make the use of diagnostic tables unnecessary, nor do they indicate exactly where the problem is in a particular circuit. Tables are provided for the use of a scan tool.

Special Tool and Equipment

Table 1: Special Tools and Equipment

Illustration	Tool Number/ Description	Illustration	Tool Number/ Description
	VODIA Scan Tool The VODIA tool is an advanced flexible diagnostic tool which is compatible with all Volvo Penta Gas and Diesel engines with electronic control systems, including the new EGC Control System. The VODIA tool is a full-feature scan tool which will read and record all vital engine parameters, read and reset fault codes, and perform engine tests.		Fuel Pressure Test Kit (PN 3855533) This kit includes adapter P/N 3862357 for attachment to the larger Schrader valves found on the high-pressure fuel rail on EGC engines, and the smaller Schrader valve adapter P/N 3855354 for low pressure test ports. Each adapter is also available individually.
	Volvo Penta Marine Diagnostic Scan Tool (P/N 3851228) The tool is also compatible with all GM based Volvo Penta EFI engines with MEFI 1, 3, 4, and 4B controls. The tool features an easy to use keypad and a high visibility two line text display. The kit includes connectors for EGC and MEFI engines, and a carrying case.		PN 3861684 Schrader adapter. For checking fuel pump pressure near the high pressure fuel pump (the valve is in the fuel rail)
	Diacom PC Software The Diacom program will provide full access to all vital engine parameters, read and reset fault codes, and perform output tests on EGC Control-Systems. The program allows easy access to all vital engine parameters on Windows based PC's.		

Notes

Section 3: Operation - 4.3L 5.0L 5.7L

General Description

The function of the fuel metering system is to deliver the correct amount of fuel to the engine under all operating conditions. Fuel is delivered to the engine by individual fuel injectors mounted in the intake manifold near each cylinder.

Basic Knowledge Required

Without a basic knowledge of electricity, it will be difficult to use the diagnostic procedures contained in this section. You should understand the basic theory of electricity and know the meaning of voltage (volts), current (amps) and resistance (ohms). You should understand what happens in a circuit with an open or a shorted wire. You should be able to read and understand a wiring diagram.

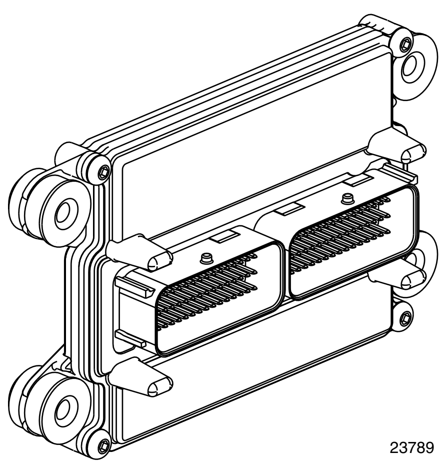
ECM Service Precautions

The ECM is designed to withstand normal current draws associated with normal boat operations. Avoid overloading any circuit. When testing for opens or shorts, do not ground any of the ECM circuits unless instructed. When testing for opens or shorts, do not apply voltage to any of the ECM circuits unless instructed. Only test these circuits with a DVOM while the ECM connector remains connected.

Engine Control Module (ECM)

The engine control module (ECM) of the Volvo Penta Electronic Gas Control system (EGC) is designed to maintain exhaust emission levels while maintaining excellent driveability and fuel efficiency. The ECM controls the following conditions:

- The fuel control
- The ignition control (IC)
- The knock sensor (KS) system
- The idle air control (IAC)
- Various other discrete outputs



The engine control module (ECM) is the control center of the engine and controls the following systems:

- The fuel metering system
- The ignition timing
- The on-board diagnostics

The ECM constantly monitors the information from various sensors and controls the systems that affect performance and emissions. The

ECM also performs the diagnostic functions for those systems. The ECM can recognize operational problems and alert the operator through the malfunction indicator lamp (MIL) and a warning horn when a malfunction has occurred. When a malfunction is detected, the ECM stores a diagnostic trouble code (DTC) or a logged warning which helps to identify problem areas. This is done to aid the technician in making repairs.

The ECM supplies either 5.0 or 12.0 volts to power various sensors and switches. This is done through resistance in the ECM. The resistance is so high in value that a test lamp does not illuminate when connected to the circuit. In some cases, even an ordinary shop voltmeter does not give an accurate reading because the voltmeters resistance is too low. Therefore, a DVOM with a minimum of 10 megaohms input impedance is required to ensure accurate voltage readings.

The ECM controls output circuits such as the fuel injectors, ignition coils, the idle air control (IAC) and various relays by controlling the ground or power feed circuit through transistors or a device called an output driver module (ODM).

Fuel Metering Modes of Operation

The engine control module (ECM) reads voltages from several sensors in order to determine how much fuel to give the engine. The fuel is delivered under one of several conditions called modes. The ECM controls all modes.

Starting Mode

With the ignition switch in the ON position, before engaging the starter, the ECM energizes the fuel pump relay for 5 seconds allowing the fuel pumps to build up pressure. The ECM uses the engine coolant temperature (ECT), the throttle position (TPS) and the manifold absolute pressure (MAP) sensors to determine the proper air/fuel ratio for starting. The ECM controls the amount of fuel delivered in the starting mode by changing the pulse width of the injectors. This is done by pulsing the injectors for very short times.

Run Mode

When the engine is first started and the engine speed is above 400 RPM, the system begins operation. The ECM reads the throttle position sensor TPS voltage every few milliseconds and calculates the difference between the current and last readings. If a large enough change is detected, adjustments are then made to the fuel injector's base pulse width value to provide extra fuel for rapid acceleration or a decrease in fuel for deceleration. The exact TPS voltage is important at idle or wide open throttle, however during normal running conditions it's the change and rate of change in TPS voltage that matters most.

Specified values for the above conditions are mapped for each engine, and are stored in the electrically erasable programmable read-only memory (EEPROM).

Acceleration Mode

When the operator moves the throttle, air flow into the cylinders increases rapidly, while fuel flow tends to lag behind. To prevent possible hesitation, the ECM increases the pulse width to the injectors to provide extra fuel during acceleration. The ECM determines the amount of fuel required based upon the throttle position, the coolant temperature, the manifold pressure and the engine speed.

Deceleration Mode

When the operator retards the throttle, air flow into the engine is reduced. The ECM reads the corresponding changes in throttle position and manifold pressure. The ECM shuts OFF fuel completely if the deceleration is very rapid, or for long periods.

Battery Correction Mode

When the battery voltage is low, the ECM compensates for the weak spark delivered by the ignition system in the following ways:

- Increasing the amount of fuel delivered
- Increasing the idle RPM
- Increasing the ignition dwell time

Fuel Cutoff Mode

The ECM cuts off fuel at the fuel injectors when the following conditions are met in order to protect the engine from damage:

- The ignition is OFF. This prevents engine run-on.
- The ignition is ON but there is no ignition reference signal. This prevents flooding or backfiring.
- Engine speed is too high, above appropriate rev limit.

Electronic Ignition (EI) System

The ignition system consists of the following components or circuits:

- The 8 ignition secondary wires
- The ignition coil
- The distributor
- The ignition control (IC) circuit
- The camshaft position (CMP) sensor
- The crankshaft position (CKP) sensor
- The crankshaft reluctor wheel
- The related connecting wires
- The engine control module (ECM)

Malfunction Indicator Lamp (MIL) - optional

When installed, the malfunction indicator lamp is used as a visual alert to inform the operator of a problem with the engine. It is used in conjunction with a warning horn mounted under the instrument panel. The MIL is used with the Soft and Hard Warnings. However, it is also used without the warning horn to tell the operator of a problem that is not of an immediate nature but should be addressed when the boat is serviced.

Soft Warning

The soft warning is used with the MIL to alert the operator to a minor problem. When the ECM activates a Soft Warning, the MIL light is turned on and the engine alarm is sounded at 5-second intervals. The Soft Warning is designed to alert the operator to serious problem that should be addressed as soon as possible. For certain engine errors, power derate is also enforced. For more specific information See “RPM Reduction and Warnings” on page 48.

Hard Warning

The Hard Warning is designed to alert the operator to a potentially dangerous engine problem that could damage the engine. When the ECM activates a Hard Warning, the MIL light is activated and the warning horn sounds at ¼ second intervals. A Hard Warning is used in conjunction with Power Derate and Forced Idle. The MIL light and warning horn are always actuated with a Hard Warning. For further information See “RPM Reduction and Warnings” on page 48.

RPM Reduction Mode

RPM reduction mode is a function of the ECM that reduces engine power under certain conditions. The RPM reduction has several levels and is used in conjunction with a Hard warning.

Power Derate 2

Power Derate is used in conjunction with the Soft and Hard warnings. When enforced the throttle is limited to 30% throttle angle. Depending on the size of the boat and loading this could be approximately 3000 to 3400 RPM however, the limit is not RPM specific.

Low Rev Limit

Low Rev Limit is used in conjunction with a Hard Warning and is designed to limit engine RPM to 850 if there is a problem with the Drive By Wire (DBW) electronic throttle position sensors.

Input Sensors

The ECM monitors the input sensors for circuit continuity and out-of-range values. This includes performance checking. Performance checking refers to indicating a fault when the signal from a sensor does not seem reasonable, such as a throttle position (TP) sensor that indicates high throttle position at low engine loads or MAP voltage. The input components may include, but are not limited to, the following sensors:

- Manifold air temperature (MAT) sensor
- Manifold absolute pressure (MAP) sensor
- Crankshaft position (CKP) sensor
- Camshaft position (CMP) sensor
- Knock sensor (KS)
- Throttle position (TPS) sensor
- Engine coolant temperature (ECT) sensor
- Exhaust Gas Temperature (EGT) switch

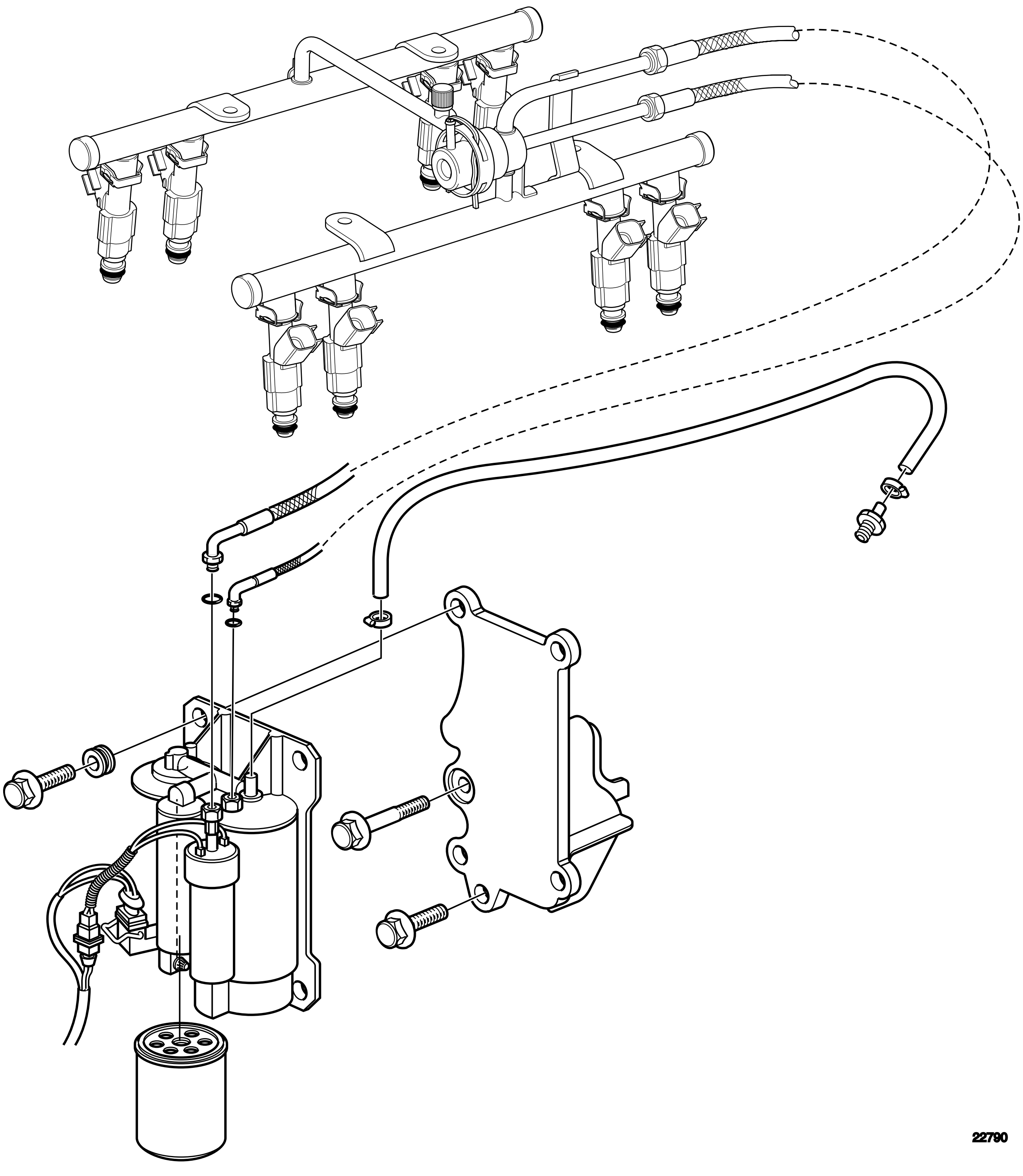
Output Actuators

Diagnose the output components for the proper response to ECM commands. Components where functional monitoring is not feasible, will be monitored for circuit continuity and out-of-range values, if applicable.

Output components to be monitored include the following circuits:

- Idle Air Control Valve
- Fuel Injectors
- Buzzer Control
- Malfunction Indicator Lamp (MIL) control
- Engine and Trim gauge signals

Fuel System



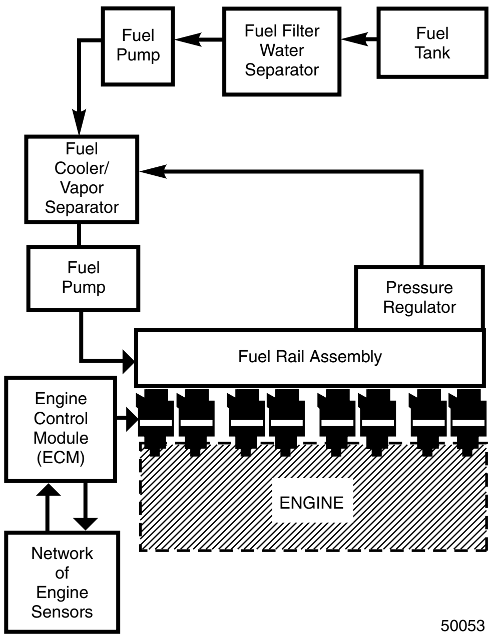
Fuel Metering System Components

The fuel metering system is made up of the following parts:

- Fuel supply components (fuel tank, pump, lines, water separator).
- Fuel pump electrical circuit.
- Fuel rail assembly, including fuel injectors and pressure regulator assembly.

- Throttle body assembly, including an IAC valve and TP sensor.

Fuel Supply Components (Typical)



The fuel supply is stored in the fuel tank. An electric pump, located on the fuel cell assembly, pumps fuel through an in-line fuel filter to the vapor separator tank of the fuel cell where the fuel is cooled and vapor is removed. Then the fuel cell high pressure fuel pump raises the fuel pressure and delivers the fuel to the fuel rail assembly. The high pressure pump is designed to provide fuel at a pressure greater than is needed by the injectors. The pressure regulator, part of the fuel rail assembly, keeps fuel available to the injectors at a regulated pressure. Unused fuel is returned to the fuel cell by a separate line.

Fuel Pump Electrical Circuit

When the ignition switch is turned “ON,” the ECM turns the fuel pump relay “ON” for 5 seconds causing the fuel pump to pressurize the fuel system. When the ignition switch is turned to the crank position, the ECM turns the fuel pump relay “ON” causing the fuel pumps to run.

If the ECM does not receive ignition reference pulses (engine cranking or running), it shuts the fuel pump relay “OFF”, causing the fuel pump to stop. An inoperative fuel pump relay will result in an “Engine Cranks But Will Not Run” condition.

Fuel Feed and Return Pipes

The fuel feed pipe carries fuel from the fuel tank to the fuel rail assembly. The fuel return pipe carries unused fuel from the fuel rail assembly back to the fuel cell.

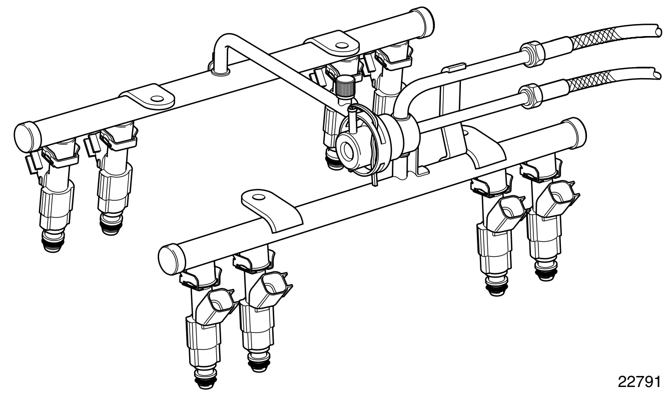
Quick-Connect Fittings

Quick-Connect fittings provide a simplified means of installing and connecting fuel system hoses. The fittings consists of a unique female connector and a compatible male pipe end. O-rings, located inside the female connector, provide the fuel seal. Integral locking tabs inside the female connector hold the fittings together. Fittings on fuel lines with Quick-Connect fittings are not serviceable. If the Quick Connect develops a leak, the fuel line must be replaced.

Fuel Pipe O-Rings

O-rings seal the threaded connections in the fuel system. Fuel system O-ring seals are made of special material. Service the O-ring seals with the correct service part.

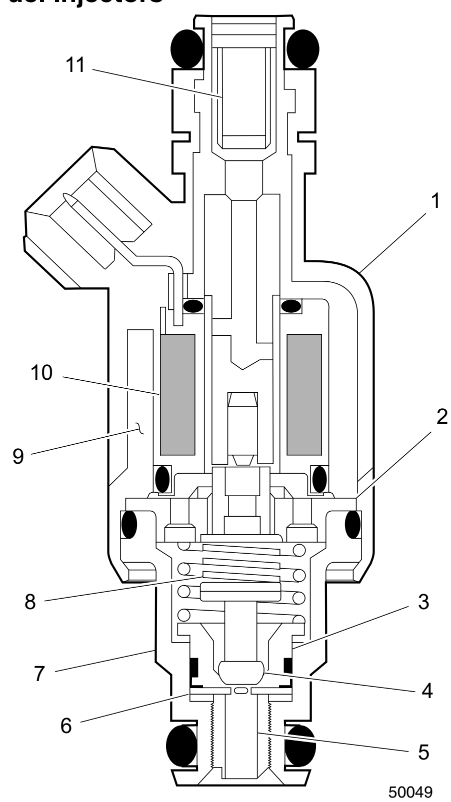
Fuel Rail Assembly



The fuel rail assembly attaches to the engine intake manifold. The fuel rail assembly performs the following functions:

- Positions the injectors in the intake manifold
- Distributes fuel evenly to the injectors
- Integrates the fuel pressure regulator with the fuel metering system

Fuel Injectors



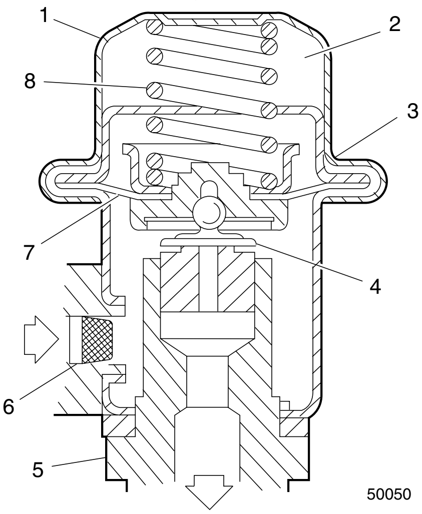
The Port Fuel Injection (PFI) injector assembly is a solenoid operated device, controlled by the ECM, that meters pressurized fuel to a single engine cylinder. The ECM energizes the injector solenoid, which opens a ball valve, allowing fuel to flow past the ball valve, and through a recessed flow director plate. The director plate has six machined holes that control the fuel flow, generating a conical spray pattern of finely atomized fuel at the injector tip. Fuel is directed at the intake valve, causing it to become further atomized and vaporized before entering the combustion chamber.

An injector that is stuck partly open would cause loss of pressure after engine shut down. Consequently, long cranking times would be noticed. Dieseling could also occur, because some fuel could be delivered to the engine after the ignition is turned “OFF.” A fuel injector that does not open, may cause a “no-start” or a misfire.

Table 1: Fuel Injector

Pos	Description	Pos	Desctiption
1	Solenoid Assembly	7	Spray Housing
2	Spacer Guide Assembly	8	Core Spring
3	Core Seat	9	Solenoid Housing
4	Ball Valve	10	Solenoid
5	Spray Tip	11	Fuel Inlet Filter
6	Director Plate		

Fuel Pressure Regulator Assembly



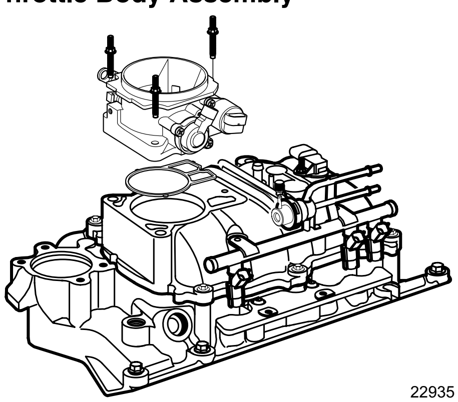
The pressure regulator is a diaphragm-operated relief valve with fuel pump pressure on one side, and regulator spring pressure and intake manifold vacuum on the other side. The regulator's function is to maintain a constant pressure differential across the injectors at all times. The pressure regulator compensates for engine load by increasing fuel pressure as engine vacuum drops.

With the ignition "ON," engine "OFF" (zero vacuum), fuel pressure at the pressure test connection should be 344 - 413 kPa (50 - 60 psi). If the pressure is too low, poor performance or a "no-start" may result. If pressure is too high, excessive odor may result.

Table 2: Fuel Pressure Regulator

Pos	Description	Pos	Description
1	Cover	5	Base Assembly
2	Vacuum Chamber	6	Filter Screen
3	O-ring Seal	7	Diaphram
4	Fuel Pressure Regulator Valve	8	Spring

Throttle Body Assembly



The throttle body assembly is attached to the intake manifold air plenum, and is used to control air flow into the engine, thereby controlling engine output. The throttle plates within the throttle body are opened by the driver through the throttle controls. During engine idle, the throttle plates are closed, and air flow control is handled by the Idle Air Control (IAC) valve, described below.

The throttle body also provides the location for mounting the TP sensor and for sensing changes in engine vacuum due to throttle plates position.

Idle Air Control (IAC) Valve

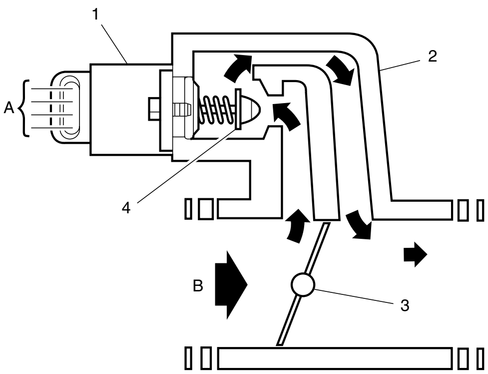


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Table 3: Idle Air Control Valve Function

Pos	Description
1	Idle Air Control Valve (IAC)
2	Throttle Body Assembly
3	Throttle Valve
4	IAC Pintle
A	Electrical Input Signal
B	Air Inlet

The purpose of the IAC valve assembly is to control engine idle speed, while preventing stalls due to changes in engine load. The IAC valve, mounted to the throttle body, controls bypass air around the throttle plates. By moving a conical valve known as a pintle, IN, towards the seat (to decrease air flow); or OUT, away from the seat (to increase air flow), a controlled amount of air moves around the throttle plates. If RPM is too low, more air is bypassed around the throttle plates to increase it. If RPM is too high, less air is bypassed around the throttle plates to decrease it.

The ECM moves the IAC valve in small steps. These can be monitored by scan tool test equipment, which plugs into the Data Link Connector (DLC).

During idle, the proper position of the IAC valve is calculated by the ECM, based on battery voltage, coolant temperature and engine RPM. If the RPM drops below specification and the throttle plates are closed, the ECM senses a near stall condition and calculates a new valve position to prevent stalling.

- Engine idle speed is a function of total air flow into the engine based on IAC valve pintle position plus throttle plates opening.
- “Controlled” idle speed is programmed into the ECM, which determines the correct IAC valve pintle position to maintain the desired idle speed for all engine operating conditions and loads.
- The minimum air rate is set at the factory with a stop screw. This setting allows enough air flow by the throttle plates to cause the IAC valve pintle to be positioned at a calibrated number of steps (counts) from the seat, during “controlled” idle operation. This minimum air rate setting should not be altered by turning the stop screw or bending the linkage. Improper idle control will result.

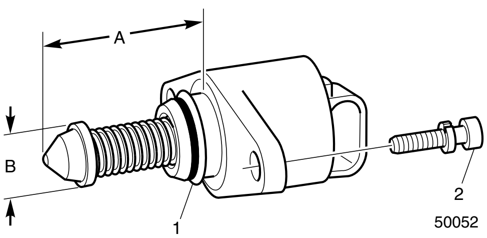

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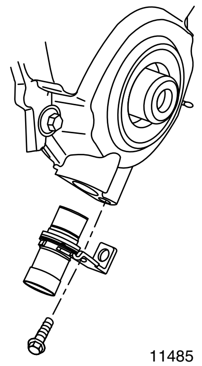
Table 4: IAC Valve

Pos	Description
1	O-Ring - IAC Valve
2	IAC Valve Attaching Screw
A	Distance of Pintle Extension
B	Diameter of Pintle

Distributor Ignition (DI) System

The distributor ignition (DI) system is responsible for producing and controlling a high energy secondary spark. This spark is used to ignite the compressed air/fuel mixture at precisely the correct time. This provides optimal performance, fuel economy, and control of exhaust emissions. This ignition system consists of a single ignition coil and ignition control module (ICM). Spark energy is delivered via a distributor cap, rotor, and secondary spark plug wires. The driver module within the ICM is commanded to operate the coil by the engine control module (ECM), that has complete control over spark timing. The DI system consists of the following components:

Crankshaft Position (CKP) Sensor and Reluctor Wheel



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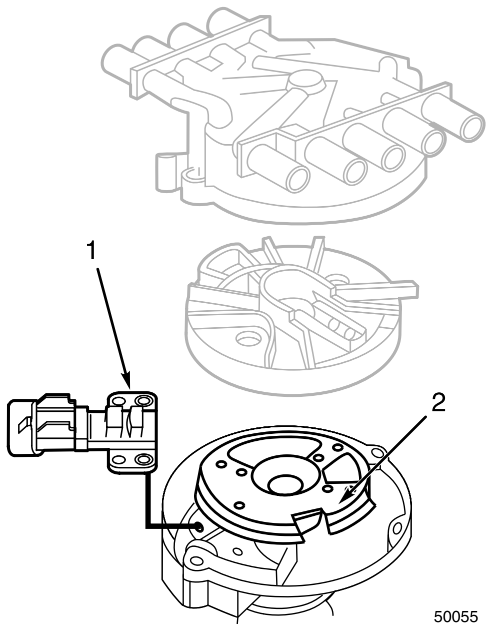
The crankshaft position (CKP) sensor is a magneto resistive type sensor. The CKP sensor works in conjunction with a 24X reluctor wheel. The reluctor wheel is mounted on the rear of the crankshaft. The 24X reluctor wheel uses 2 different width notches that are 15 degrees apart. This pulse width encoded pattern allows cylinder position identification within 90 degrees of crankshaft rotation. In some cases, this can be achieved within 45 degrees of crankshaft rotation. The reluctor wheel also has dual track notches that are 180 degrees out of phase. This design allows for quicker starts and accuracy. The CKP sensor also outputs a 4X signal for spark control, tachometer output and fuel control. All CKP signals are output as a digital waveform.

Camshaft Position (CMP) Sensor and Reluctor Wheel



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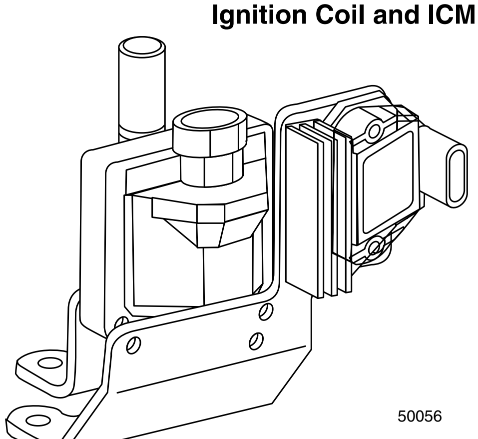
The camshaft position (CMP) sensor (1) works in conjunction with a 1X reluctor wheel (2) mounted in the distributor. The CMP is used to determine the top dead center position of cylinder #1, and will synchronize with the 24X CKP sensor signal for quicker starting. The CMP signals are output as a digital waveform.

Ignition Coil and ICM



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The ICM is connected to the ECM by an ignition control (IC) circuit. The ICM also has a ground circuit and shares an ignition 1 voltage supply with the ignition coil. The coil driver in the ICM controls current through the ignition coil based on signal pulse from the ECM. There is no back-up or by-pass function in the ICM.

Secondary Ignition Components

The distributor is only used as a means to operate the CMP sensor and to distribute spark in the correct sequence. The distributor position is adjustable but has no influence on base timing. If the distributor is rotated, there is a chance of crossfire between terminals due to the proximity of the terminals in the distributor cap. The spark is distributed through marine grade carbon core wires to the spark plugs. The plugs are tipped with platinum for long wear and higher efficiency.

Circuits Affecting Ignition Control

To properly control ignition timing, the ECM relies on the following information:

- The engine load, manifold pressure or vacuum
- The atmospheric, barometric, pressure
- The engine temperature
- The manifold air temperature
- The crankshaft position
- The engine speed (RPM)

The ignition control (IC) system consists of the following components:

- The ignition coil
- The 24X crankshaft position sensor
- The engine control module (ECM)
- All connecting wires

The ignition control utilizes the following to control spark timing functions:

- The 24X signal - The 24X crankshaft position sensor sends a signal to the ECM. The ECM uses this signal to determine crankshaft position.
- The ignition control (IC) circuits - The ECM uses these circuits to trigger the ignition coils.

Noteworthy Ignition Information

There are important considerations to point out when servicing the ignition system. The following noteworthy information will list some of these to help you in servicing the ignition system.

- The ignition coil secondary voltage output capabilities are very high - more than 40,000 volts. Avoid body contact with ignition high voltage secondary components when the engine is running or personal injury may result.
- The 24X crankshaft position (CKP) sensor is the most critical part of the ignition system. If the sensor is damaged so that the pulses are not generated, the engine does not start.
- The CKP sensor clearance is very important. If the interrupter ring is bent or damaged in any way, the CKP sensor may be destroyed. Extreme care must be exercised during removal and installation procedures.
- The ignition timing is not adjustable. There are no timing marks on the crankshaft balancer or the timing chain cover.
- Be careful not to damage the secondary ignition wires or boots when servicing the ignition system. Rotate each boot in order to dislodge the boot from the plug or coil tower before pulling the boot from the spark plug or the ignition coil tower.

Engine Control Module (ECM)

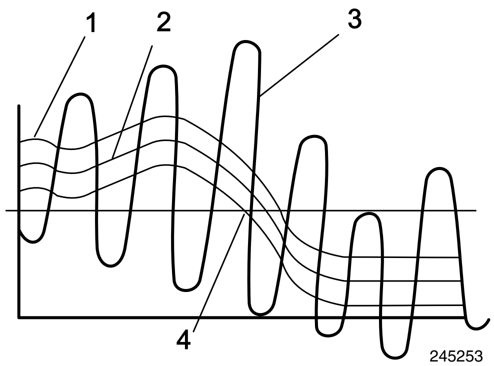
The ECM controls all ignition system functions, and constantly corrects the basic spark timing. The ECM monitors information from various sensor inputs that include the following:

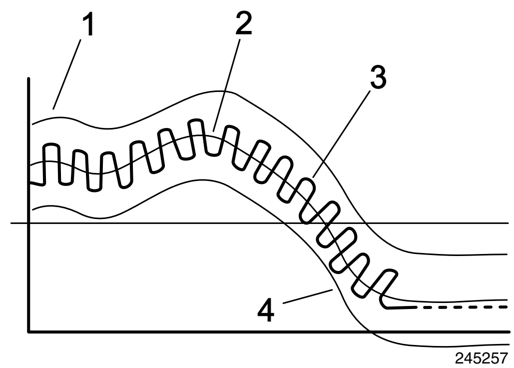
- The throttle position (TP) sensor
- The engine coolant temperature (ECT) sensor
- The manifold air pressure (MAP) sensor
- The manifold air temperature (MAT) sensor
- The engine knock (KS) sensor

Modes of Operation

There is one normal mode of operation, with the spark under ECM control. If the CKP pulses are lost the engine will not run. The loss of a CMP signal may result in a longer crank time since the ECM cannot determine which stroke the pistons are on. Diagnostic trouble codes are available to accurately diagnose the ignition system with a scan tool.

Knock Sensor (KS) System





Purpose

To control spark knock (detonation), a knock sensor (KS) system is used. This system is designed to retard spark timing when excessive spark knock is detected in the engine. The KS system allows the engine to use maximum spark advance for optimal driveability and fuel economy under all operating conditions.

Operation

The ECM uses a knock sensor(s) to detect abnormal vibration in the engine (detonation/spark knock). Mounted on the engine block, the knock sensor(s) produces an AC voltage signal at all engine speeds and loads. The ECM then adjusts the spark timing based on the amplitude and frequency of the KS signal. The ECM uses the KS signal to calculate an average voltage. Then, the ECM assigns a voltage range above and below the average voltage value. The ECM checks the KS and related wiring by comparing the actual knock signal to the assigned voltage range. A normal KS signal should vary outside the assigned voltage range as shown in the NORMAL KS figure. If the ECM detects a KS signal within the assigned voltage range as shown in the ABNORMAL KS figure, the applicable DTC will set.

4. Upper fail region
5. Knock sensor calculated average
6. Knock sensor signal
7. Lower fail region

RPM Reduction and Warnings Table

Table 5: RPM Reduction and Warnings

System	Fault	MIL	Soft Warning	Hard Warning	Power Derate	Low Rev Limit
IAT	IAT high voltage	X				
	IAT low voltage	X				
Oil Pressure	Oil pressure low (sender type)	X		X		
	Oil pressure sender high voltage	X	X			
	Oil pressure sender low voltage	X	X			
ECT	ECT high voltage	X	X			
	ECT low voltage	X				
	ECT higher than expected 1	X	X			
	ECT higher than expected 2	X		X	X	
MAP	MAP high pressure	X				
	MAP low voltage	X				
EGT	Exhaust gas temperature high (Exhaust Manifold over-heat)	X		X	X	
Baro Pressure	BP high pressure	X				
	BP low pressure	X				
Knock Sensors	Knock 1 sensor open	X				
	Knock 2 sensor open	X				
	Knock 1 excessive signal	X				
	Knock 2 excessive signal	X				
Battery Voltage	Voltage high	X	X			
	Voltage low	X	X			
5V External	5V External 1 high voltage	X	X			
	5V External 1 low voltage	X	X			
	5V External 2 high voltage	X	X			
	5V External 2 low voltage	X	X			
	5V External 1/2 simultaneous out-of-range	X		X		

Table 5: RPM Reduction and Warnings

System	Fault	MIL	Soft Warning	Hard Warning	Power Derate	Low Rev Limit
Throttle Position Sensor (TPS)	TPS high voltage	X		X		
	TPS low voltage	X		X		
Engine Speed	Max Governor Override Speed	X				
	Engine Speed - Fuel rev limit	X				
	Engine Speed - Spark rev limit	X				
Fuel Injector Driver	Injector Driver Open	X				
	Injector Driver Shorted	X				
Fuel Pump Relay Control/ Coil	Fuel Pump relay control ground short	X				
	Fuel pump relay coil open	X				
	Fuel pump relay coil short to power	X				
Ignition Relay Control/ Coil	Ignition Relay control ground short	X				
	Ignition Relay coil open	X				
	Ignition Relay coil short to power	X				
Buzzer Control	Buzzer control ground short	X				
	Buzzer open	X				
	Buzzer control short to power	X				
MIL Control	MIL control ground short	X	X			
	MIL open	X	X			
	MIL control short to power	X	X			
IAC	IAC ground short	X				
	IAC coil open/short	X				
Gauge Diagnostics	Water Temperature Gauge open / ground short	X				
	Water Temperature Gauge short to power	X				
	Oil Pressure Gauge open / ground short	X				
	Oil Pressure Gauge short to power	X				
	Trim Position Gauge open / ground short	X				
	Trim Position Gauge short to power	X				

Table 5: RPM Reduction and Warnings

System	Fault	MIL	Soft Warning	Hard Warning	Power Derate	Low Rev Limit
Cam/ Crank Sensors	Cam loss	X	X			
	Crank loss	X	X			
	Cam sync noise	X	X			
	Crank sync noise	X	X			
	Never crank synced at start	X	X			
Internal Processor Diagnostics	COP failure	X		X		X
	Invalid interrupt	X		X		X
	A/D loss	X		X		X
	RTI 1 loss	X		X		X
	Flash checksum invalid	X		X		X
	RAM failure	X		X		X
	RTI 2 loss	X		X		X
	RTI 3 loss	X		X		X
J1939 Network (EVC)	CAN address conflict failure	X				

ECM Pin Function

Table 6: ECM pin function 4.3L, 5.0L, 5.7L

Pin	Function	Pin	Function	PIN	Function	PIN	Function
1	OPEN	24	CAM —	47	SHIFT INTER-RUPT	70	OPEN
2	OPEN	25	SPEED +	48	TP CONTROL	71	IGNITION RELAY
3	OPEN	26	SPEED —	49	OPEN	72	OPEN
4	OPEN	27	KNOCK 1 +	50	5V RTN	73	OPEN
5	IAC Coil B+	28	KNOCK 1 —	51	OPEN	74	OPEN
6	IAC Coil B-	29	KNOCK 2 +	52	OPEN	75	OPEN
7	MAP	30	KNOCK 2 —	53	OIL PRESS IN	76	ALARM
8	OPEN	31	IC circuit	54	MASTER/ SLAVE DUAL STATION	77	OPEN
9	TPS Signal	32	OPEN	55	DLC Pin 3	78	OPEN
10	TCP 2 IN	33	OPEN	56	DLC Pin 4	79	ECM POWER
11	OPEN	34	OPEN	57	OPEN	80	MIL
12	OPEN	35	OPEN	58	TACH OUTPUT	81	GROUND
13	CAN TERM +	36	OPEN	59	OPEN	82	IAC Coil A+
14	CAN1 +	37	OPEN	60	ECM POWER	83	IAC Coil A-
15	CAN1 —	38	OPEN	61	INJECTOR 1	84	FUEL PUMP RELAY
16	CAN2 —	39	IAT IN	62	INJECTOR 2	85	OPEN
17	CAN2 +	40	ECT IN	63	INJECTOR 3	86	TRIM GAUGE
18	CAN TERM2 +	41	EGT IN	64	INJECTOR 4	87	WATER TEMP GAUGE
19	5V EXT 1 (5V REF)	42	MASTER/ SLAVE	65	INJECTOR 5	88	OIL PRES-SURE GAUGE
20	5V RTN	43	OPEN	66	INJECTOR 6	89	OPEN
21	CRANK +	44	OPEN	67	INJECTOR 7	90	OPEN
22	CRANK —	45	IGN RELAY	68	INJECTOR 8		
23	CAM +	46	TRIM SENDER INPUT	69	GROUND		

NOTES

Section 4: On Board Repair - 4.3L, 5.0L, and 5.7L

Repair Instructions

⚠ **Caution!**

To reduce the risk of fire and personal injury, relieve fuel system pressure before servicing fuel system components.

After relieving fuel pressure, a small amount of fuel may be released when servicing fuel lines or connections. To reduce the chance of personal injury, cover fuel line fittings with a shop towel before disconnecting to catch any fuel that may leak out. Place the towel in an approved container when disconnection is completed.

Fuel Control On-Board Service

The following is general information required when working on the fuel system:

- Always keep a dry chemical fire extinguisher near the work area.
- Fuel pipe fittings require new O-rings when assembling.
- Do not replace fuel pipe with fuel hose.
- Always bleed off fuel pressure before servicing any fuel system components.
- Do not do any repairs on the fuel system until you have read the instructions and checked the figures relating the repair.
- Observe all notices and cautions.

Fuel Pressure Relief Procedure

Tool Required:

J 34730-1, Fuel Pressure Gauge

Important!

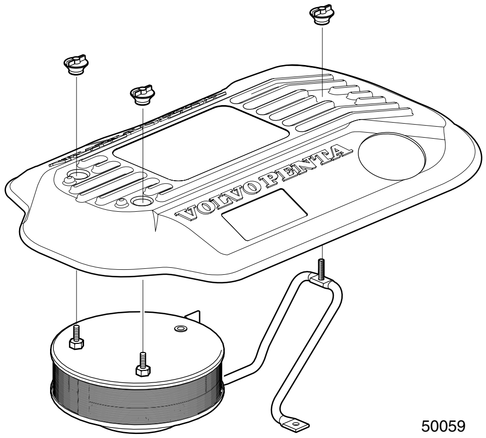
Refer to manufacturer's warnings and cautions before proceeding.

1. Disconnect negative battery cable to avoid possible fuel discharge if an accidental attempt is made to start the engine.
2. Connect fuel pressure gauge J 34730-1 to fuel pressure connector assembly. Wrap a shop towel around fitting while connecting the gauge to avoid any spillage.
3. Install bleed hose into an approved container and open valve to bleed system pressure. Fuel connections are now safe for servicing.
4. Drain any fuel remaining in the gauge into an approved container.

Engine Cover

Remove

1. Turn Ignition OFF.
2. Thumb screw nuts.
3. Engine cover.



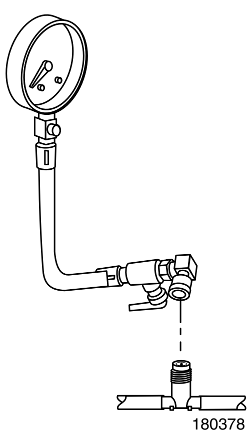
Install

1. Place engine cover on studs
2. Thumb screws nuts.
3. Finger tighten thumb screw nuts securely.

⚠ **Caution!**

Do not use tools to tighten the thumb screw nuts. The screws my be damaged and the cover will be difficult to remove.

Fuel Pressure Relief Procedure



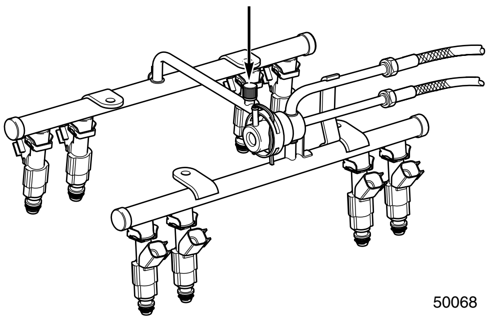
⚠ **Caution!**

To reduce the risk of fire and personal injury, relieve fuel system pressure before servicing fuel system components. After relieving fuel pressure, a small amount of fuel may be released when servicing fuel lines or connections. To reduce the chance of personal injury, cover fuel line fittings with a shop towel before disconnecting to catch any fuel that may leak out. Place the towel in an approved container when disconnection is completed.

The following is general information required when working on the fuel system:

- Always keep a dry chemical fire extinguisher near the work area.
- Do not replace fuel pipe with fuel hose.
- Always bleed off fuel pressure before servicing any fuel system components.
- Do not do any repairs on the fuel system until you have read the instructions and checked the figures relating the repair.
- Observe all notices and cautions.

1. Turn the ignition OFF.



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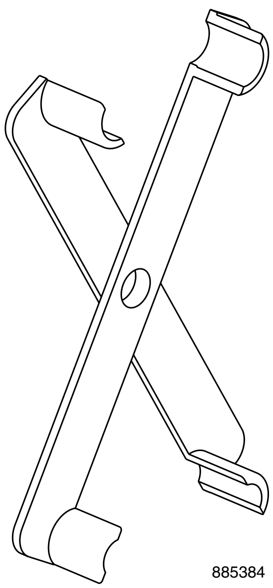
2. Disconnect the negative battery cable in order to avoid possible fuel discharge if an accidental attempt is made to start the engine.
3. Remove the engine cover See “Engine Cover” on page 55.
4. Connect the 3855353 fuel pressure gauge to the fuel pressure valve. Wrap a shop towel around the fitting while connecting the gauge in order to avoid spillage.
5. Install the bleed hose of the gauge into an approved container.
6. Open the valve on the gauge to bleed the system pressure. The fuel connections are now safe for servicing.
7. Drain any fuel remaining in the gauge into an approved container.

Quick Connect Fittings Service

Tools Required

Volvo Penta 885384 Fuel Line Disconnect Tool



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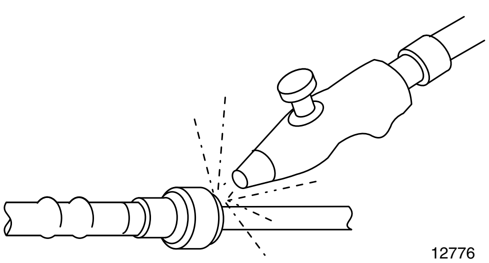
Removal

1. Relieve the fuel system pressure before servicing an fuel system connection. See “Fuel Pressure Relief Procedure” on page 55.
2. Remove the retainer from the quick-connect fitting.

⚠ **Caution! Wear safety glasses to avoid eye damage.**



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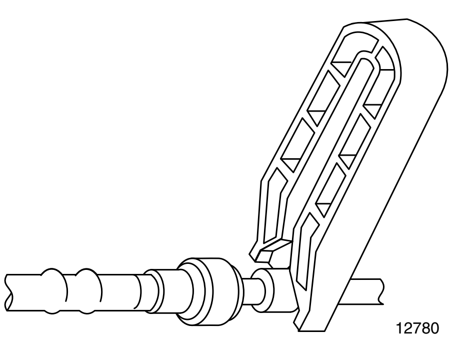
3. Blow dirt out of the fitting using compressed air.



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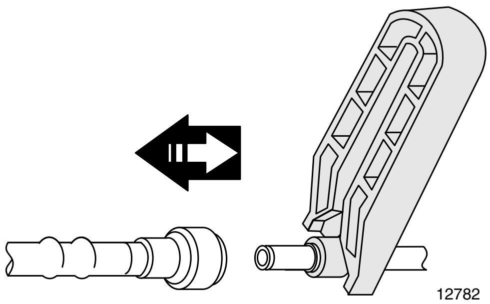
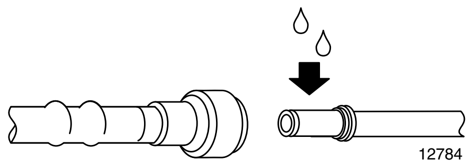
4. Using Volvo Penta 885384 Fuel Line Disconnect Tool, insert the tool into the female connector, then push inward in order to release.

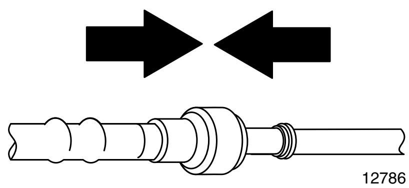


5. Pull the connection apart.
6. Use a clean shop towel in order to wipe off the male pipe end.
7. Inspect both ends of the fitting for dirt and burrs. Clean or replace the components as required.

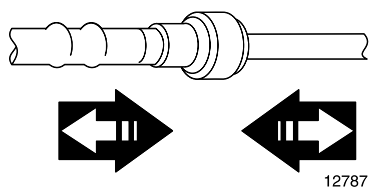
Installation



1. Apply a few drops of clean engine oil to the male pipe end.

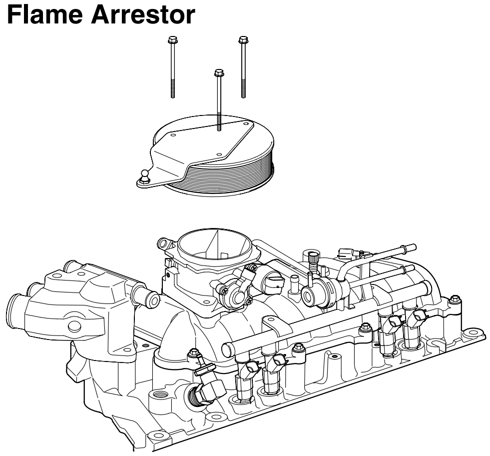


2. Push both sides of the fitting together in order to snap the retaining tabs into place.



3. Once installed, pull on both sides of the fitting in order to make sure the connection is secure.
4. Install the retainer to the quick-connect fitting.

Flame Arrestor



Remove

1. Engine cover See “Engine Cover” on page 55.
2. Flame arrestor retaining screws.
3. Flame arrestor.

Inspect

- Flame arrestor element for dust, dirt or water. Replace if required.

Install or Connect

1. Flame arrestor to throttle body.
2. Flame arrestor retaining screws to flame arrestor.
3. Tighten screws to 14-16 in. lb.

Engine Control Module (ECM)

⚠ **Caution!**

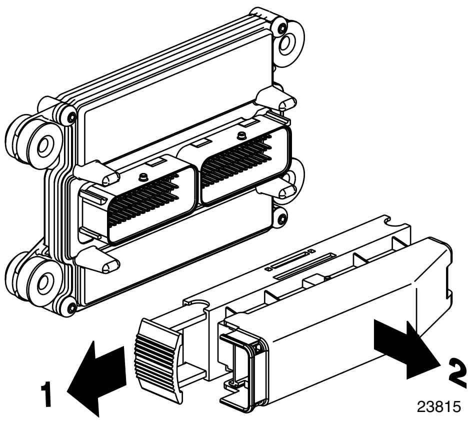
When replacing the ECM, the ignition must be “OFF” and disconnect the battery before disconnecting or reconnecting the ECM “90 Pin” connector to prevent internal damage to the ECM.

⚠ **Caution!**

To prevent possible electrostatic discharge damage to the ECM, do not touch the connector pins. The ECM is an electrical component. Do Not soak in any liquid cleaner or solvent, as damage may result.

Removal

1. Shut the battery power switch OFF or, Disconnect the negative battery cable if a battery switch is unavailable.
2. Disconnect the connector from ECM.
3. Remove the four ECM mounting screws.
4. Remove the ECM from mounting bracket.



Installation

⚠ **Caution!**

Make sure the new ECM has the same part number as the old ECM, to ensure proper engine performance.

1. Install the new ECM to the mounting bracket.
2. Install the three ECM mounting screws. Tighten the screw to 10-14 Nm (88-124 lb in).
3. Reconnect the connector to the ECM.
4. Turn ON the battery switch if equipped or, reconnect the negative battery cable.

System/Ignition Relay

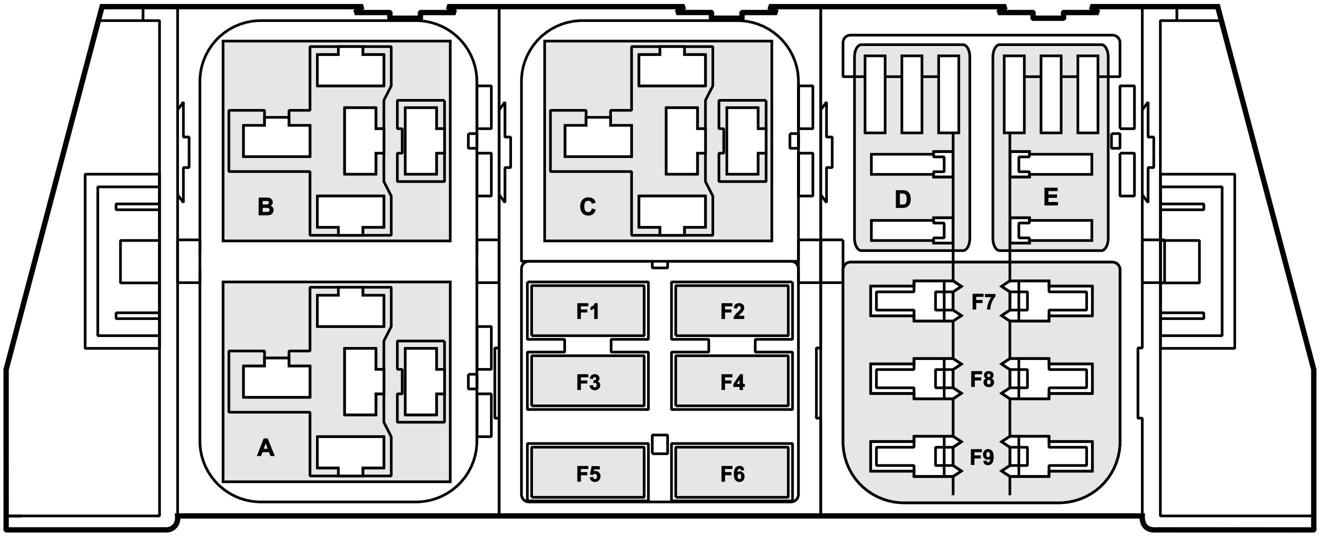


Table 1: Fuse Box

Pos	Description	Pos	Desctiption
A	Trim Down Relay	F3	20 Amp Fuse (Fuel Pump)
B	Trim Up Relay	F4	15 Amp Fuse (Ignition)
C	Starter Relay	F5	5 Amp Fuse (Vessel Switch)
D	Fuel Pump Relay	F6	10 Amp Fuse (Trim Control)
E	Ignition Relay	F7	40 Amp Fuse (Instrument Panel)
F1	15 Amp Fuse (EVC)	F8	50 Amp Circuit Breaker (Trim Pump
F2	20 Amp Fuse (ECM)	F9	20 Amp Fuse (Starter)

Removal

1. Turn the ignition OFF.
2. Open the cover.
3. Remove the system/ignition relay (E) from the socket.

⚠ **Caution! The ignition relay is an electrical component. Do Not soak in any liquid or solvent as damage may result.**

Installation

1. Install the system relay in the socket.
2. Close the cover.

Fuel Pump Relay

Removal

1. Turn the ignition OFF.
2. Open the cover.
3. Remove the fuel pump relay (D) from the socket.

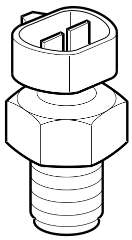
⚠ **Caution! The fuel pump relay is an electrical component. Do Not soak in any liquid or solvent as damage may result.**

Installation

1. Install the fuel pump relay.

2. Close the cover.

Engine Coolant Temperature Sensor (ECT)



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⚠ **Caution! Care must be taken when handling the ECT sensor. Damage to the sensor will affect proper operation of the EFI system.**

Removal

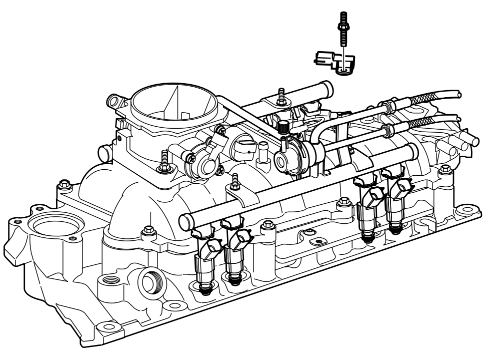
1. Turn OFF the ignition.
2. Drain the cooling system below the level of the ECT sensor if equipped with closed cooling.
3. Disconnect the ECT electrical connector.
4. Remove the ECT sensor.

Installation

Important: Coat ECT sensor threads with Teflon® tape sealant prior to installation.

1. Install the ECT sensor. Tighten the ECT sensor to 20 Nm (15 ft. lb.)
2. Reconnect the ECT electrical connector.
3. Refill the cooling system if equipped with closed cooling.

T-MAP Sensor



Removal

1. Loosen the fasteners from the engine cover.
2. Remove the engine cover. See “Engine Cover” on page 55.
3. Disconnect the manifold absolute pressure (MAP) sensor electrical connector.
4. Remove the T-MAP sensor retaining bolt and washer.
5. Remove the T-MAP sensor from the intake manifold.
6. Inspect the T-MAP sensor seal for wear or damage and replace as necessary.

Installation

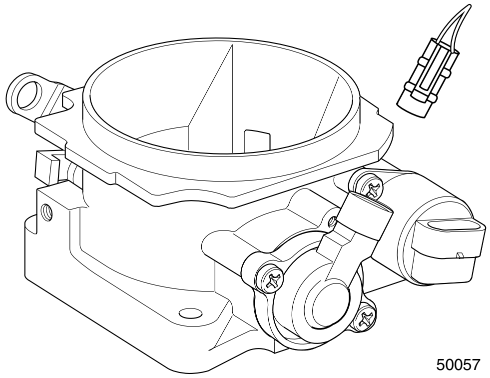
Important! Lightly coat the MAP sensor seal with motor oil before installing the sensor. The lubricant should be applied with a sponge or brush. To prevent blockage, avoid dipping the sensor port directly into the lubricant.

1. Install the T-MAP sensor.
2. Install the T-MAP sensor retaining bolt and washer. Tighten the MAP sensor retaining bolt to 12 Nm (106 in. lb.)
3. Connect the T-MAP sensor electrical connector.
4. Install the intake manifold engine cover. Tighten the engine cover fasteners.

Throttle Position Sensor (TPS)

Removal

1. Turn OFF ignition and remove the keys to prevent someone from inadvertently starting the engine
2. Remove the engine cover. See “Engine Cover” on page 55.
3. Disconnect the throttle position sensor wiring harness connector.



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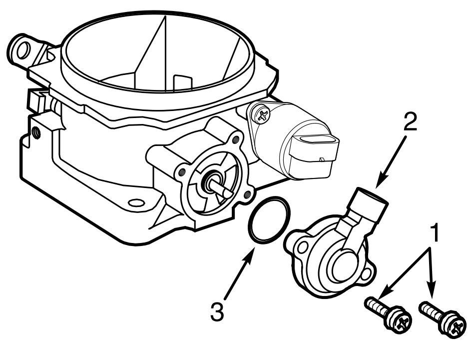
4. Remove the mounting screws (1) from the TP sensor.

NOTE! The TP sensor is an electrical component. Do not soak the TP sensor in any liquid cleaner or solvent, as damage may result.

5. Remove the TP sensor (2) and gasket (3) from the throttle body assembly.



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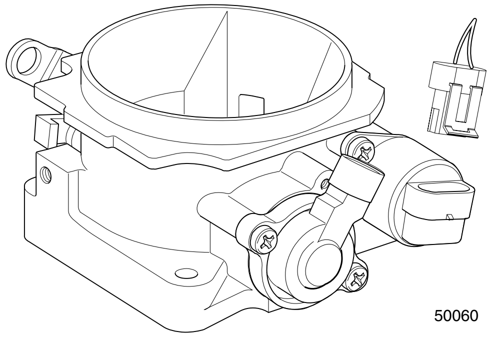
Installation

1. With the throttle valve closed, install the TP sensor on the throttle shaft. Rotate the TP sensor counter-clockwise in order to align the mounting holes.
2. Install the TP sensor mounting screws. Tighten the screws to 2 Nm (18 in. lb.)
3. Connect the TP sensor harness
4. Install the engine cover

Idle Air Control Valve (IAC)

Removal

1. Turn OFF ignition and remove the keys to prevent someone from inadvertently starting the engine
2. Remove the engine cover. See “Engine Cover” on page 55.



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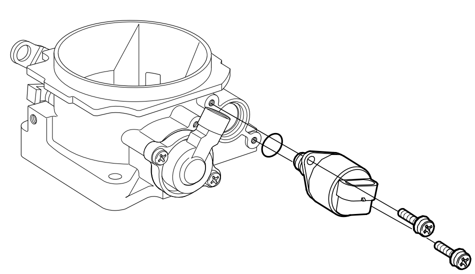
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3. Remove the IAC valve attaching screws.

NOTE! If the IAC valve has been in service: DO NOT push or pull on the IAC valve pintle. The force required to move the pintle may damage the threads on the worm drive. Also, DO NOT soak the IAC valve in any liquid cleaner or solvent, as damage may result.

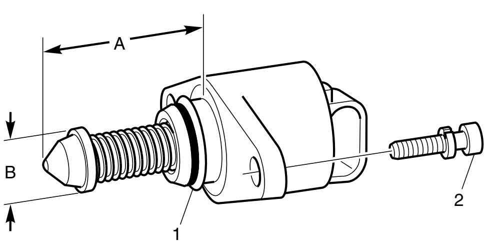
4. Remove the IAC valve assembly.
5. Remove the O-ring.

Cleaning and Inspection

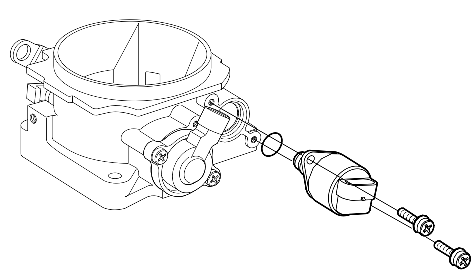
1. 1. Clean the IAC valve O-ring sealing surface, the pintle valve seat, and the air passage.
   a. Use a carburetor cleaner and a parts cleaning brush in order to remove any carbon deposits. Follow the instructions on the container.
   b. Do not use a cleaner that contains methyl ethyl ketone. MEK is an extremely strong solvent and not necessary for this type of deposit.
   c. Shiny spots on the pintle or seat are normal and do not indicate misalignment or a bent pintle shaft.
   d. If the air passage has heavy deposits, remove the throttle body for a complete cleaning. Refer to Throttle Body Assembly and to Throttle Body Cleaning Procedure.
2. Inspect the IAC valve O-ring for cuts, cracks, or distortion. Replace the O-ring if damaged.

Installation

Important! If you are installing a new IAC valve, replace the valve with an identical part. The IAC valve pintle shape and diameter are designed for the specific application.



1. Measure the distance between tip of the IAC valve pintle and the mounting flange. If the distance (A) is more than 28 mm (1.10 in), use finger pressure in order to slowly retract the pintle. The force required to retract the pintle of a new valve will not cause damage to the valve.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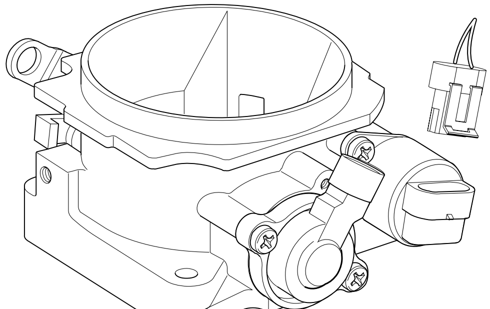
2. Lubricate the IAC valve O-ring with clean engine oil.
3. Install the IAC valve assembly.
4. Install the attaching screws. Tighten the IAC valve screws to 3 Nm (27 in. lb.)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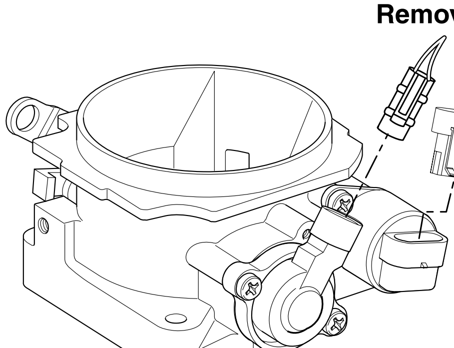
5. Connect the IAC wire harness connector.
6. Install the engine cover. See “Engine Cover” on page 55.
7. Reset the IAC valve pintle position.

IAC Valve Reset Procedure

a. Turn ON the ignition for 5 seconds, leaving the engine OFF.
b. Turn OFF the ignition for 10 seconds.
c. Start the engine.
d. Check for the proper idle speed.

Throttle Body Assembly

Removal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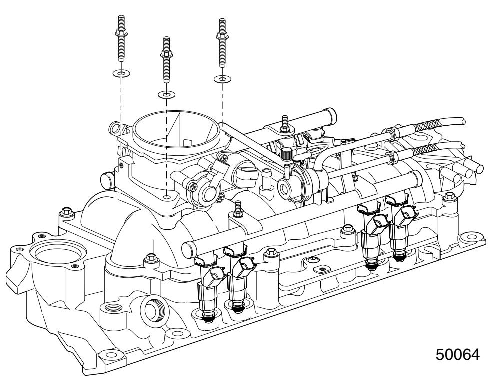
1. Turn OFF ignition and remove the keys to prevent someone from inadvertently starting the engine
2. Remove the engine cover. See “Engine Cover” on page 55.
3. Remove the flame arrestor. See “Fuel Pressure Relief Procedure” on page 55.
4. Remove throttle linkage.
5. Disconnect the IAC and TP sensor wiring harness connectors.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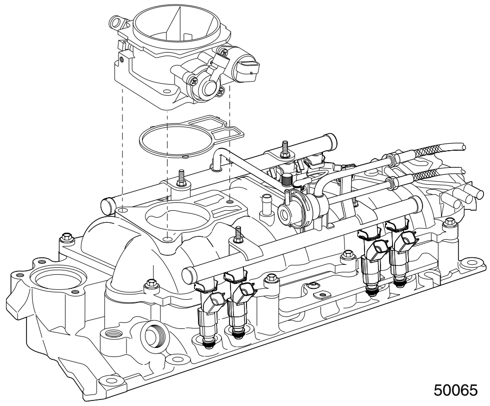
6. Remove the throttle body retaining screws.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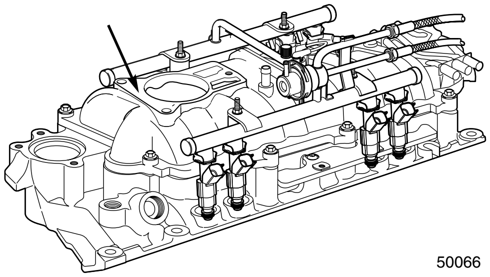
7. Remove the throttle body assembly.
8. Discard the throttle body seal.



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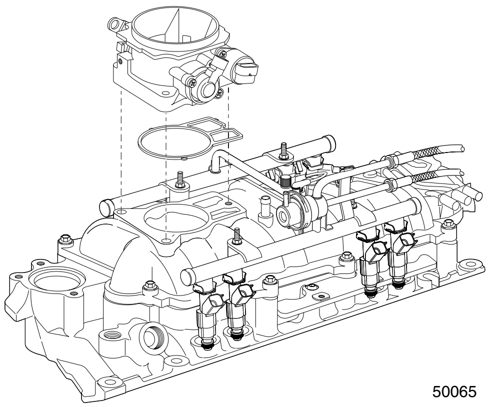
9. Clean the gasket surface on the intake manifold.

Installation



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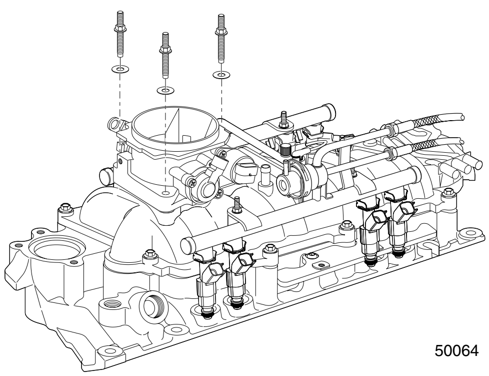
1. Install the throttle body assembly with a new seal.



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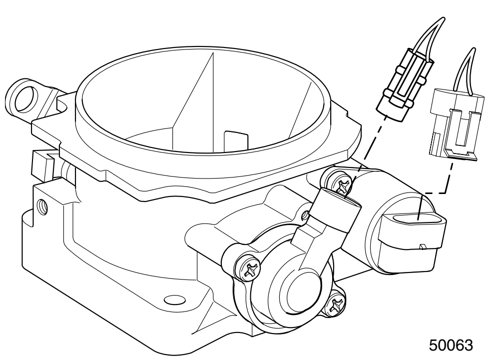
2. Install the throttle body assembly retaining studs.
3. Tighten the studs to 9 Nm (80 in. lb.)



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4. Connect the IAC and TP sensor wire harness connectors.
5. Reconnect the throttle linkage.
6. Install the flame arrestor. See “Fuel Pressure Relief Procedure” on page 55.
7. Install the engine cover. See “Engine Cover” on page 55.

Throttle Body Cleaning

1. Inspect the throttle body bore and the throttle valve plate for deposits. You must open the throttle valve in order to inspect all of the surfaces.

⚠ **Caution!**

Do not subject a throttle body assembly which contains the following components to an immersion cleaner or a strong solvent:

- **Throttle position (TP) sensor**
- **Idle air control (IAC) valve**
- **Sealed throttle shaft bearings**

The cleaners will damaged the electric components or sensors.

The cleaners will damage some of these components that contain seals or O-rings. Solvents can wash away or break down the grease used on non-serviceable throttle shaft bearings.

Never use a wire brush or scraper to clean the throttle body. A wire brush or sharp tools may damage the throttle body components.

⚠ **Caution!**

Do not use a cleaner that contains methyl ethyl ketone. This extremely strong solvent may damage components and is not necessary for this type of cleaning.

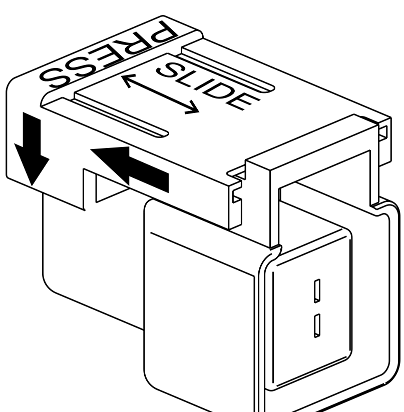
2. Clean the throttle body bore and the throttle valve plate using a clean shop towel with commercially available Throttle Body Cleaner.
3. If the deposits are excessive, remove and disassemble the throttle body for cleaning. Refer to the following procedures:
   - Throttle Body Assembly page 63.
   - Throttle Position (TP) Sensor page 61.
   - Idle Air Control (IAC) Valve page 61.
4. After disassembly, clean the throttle body using a parts cleaning brush. DO NOT immerse the throttle body in any cleaning solvent.
5. 5. If you removed and disassembled the throttle body for cleaning, assemble and install the throttle body. Refer to the following procedures:
   - Throttle Position (TP) Sensor page 61
   - Idle Air Control (IAC) Valve page 61

Fuel Rail Assembly

Removal

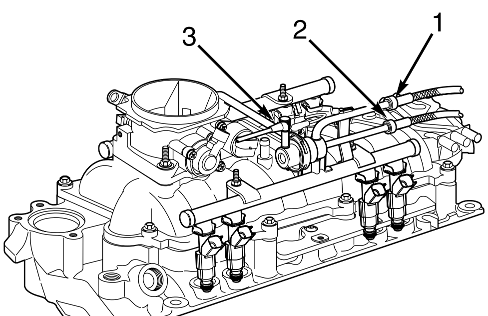
An eight digit identification number is located on the fuel rail assembly. Refer to this model identification number if servicing or part replacement is required.

1. Relieve the fuel system pressure. See “Fuel Pressure Relief Procedure” on page 54.
2. Remove the engine cover.
3. Before removal, clean the fuel rail assembly with a spray type engine cleaner, if necessary. Do not soak fuel rails in liquid cleaning solvent.
4. Remove the upper engine wiring harness bracket studs and position the upper engine wire harness aside.
5. Identify the connectors to their corresponding injectors to ensure correct injector firing order after re-assembly.
6. Slide the top portion of the injector connector up until it clicks. There should be a click when the slide reaches the end of its stroke. Do not pull the top portion of the connector past the stop tabs.
7. Press the tab on the upper portion of the injector connector in order to release the connector from the injector.
8. Repeat steps 6 and 7 for each injector connector.



22531

9. Disconnect the fuel feed and return pipes (1), (2) from the fuel rail. See “Quick Connect Fittings Service” on page 56
10. Disconnect the fuel pressure regulator vacuum line (3)



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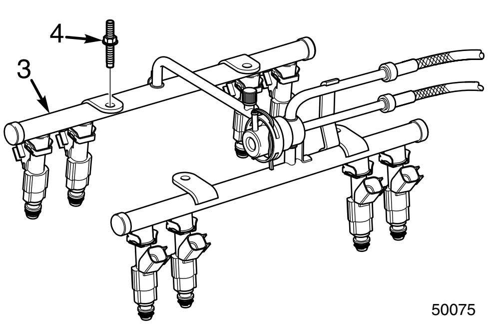
11. Remove the fuel rail attaching bolts (4).
12. Remove the fuel rail assembly (3).



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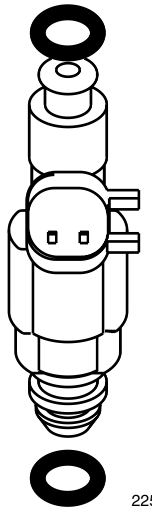

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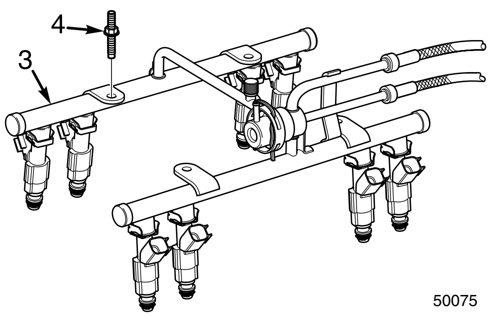
13. Remove the injector lower O-ring seal from the spray tip end of each injector.
14. Discard the O-ring seals.

Installation

1. Lubricate the new lower injector O-ring seals with clean engine oil.
2. Install the new O-ring seals on the spray tip end of each injector.



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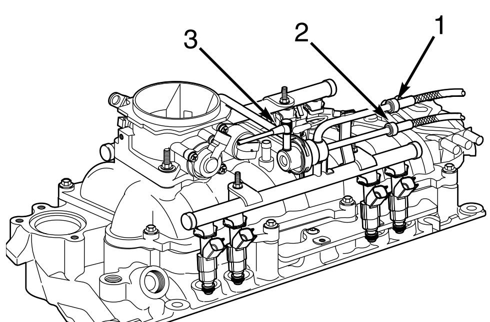
3. Install the fuel rail assembly (1) to the intake manifold.
4. Apply a 5 mm (0.020 in) band of Volvo Penta 8701528 or Loctite® 243 threadlock to the threads of the fuel rail attaching bolts.
5. 5. Install the fuel rail attaching bolts (2). Tighten the fuel rail attaching bolts to 12 Nm (106 lb in).



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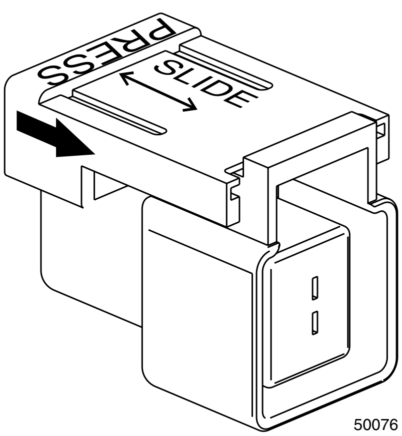
6. Connect the fuel pressure regulator vacuum line (3).
7. Connect the fuel feed and return lines (2) and (1) to the fuel rail. See “Quick Connect Fittings Service” on page 56.



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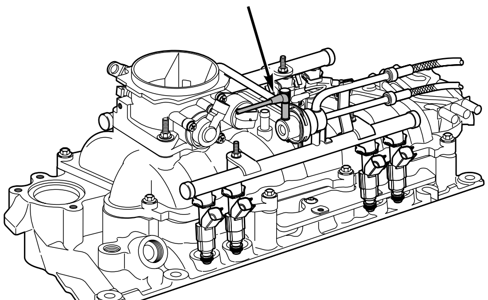
8. Connect the injector electrical connectors as follows:
   a. Install each connector on the proper injector to ensure correct injector firing order.
   b. Rotate the injectors as required to avoid stretching the wire harness.
9. Reconnect engine power
10. Inspect for leaks.
    a. Turn the ignition ON for 5 seconds.
    b. Turn the ignition OFF for 10 seconds.
    c. Turn the ignition ON.
    d. Inspect for fuel leaks.

11. Install the engine cover. See “Engine Cover” on page 55.

Fuel Pressure Regulator

Removal

1. Relieve the fuel system pressure. See “Fuel Pressure Relief Procedure” on page 55.
2. Disconnect the pressure regulator vacuum line.



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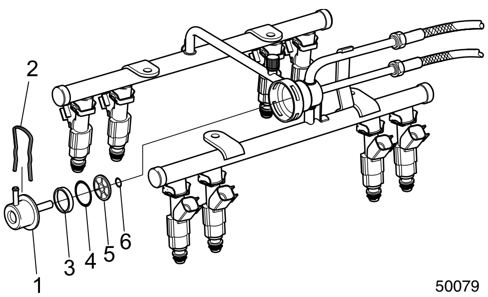


50079

3. Clean any dirt from the fuel pressure regulator retainer and the surrounding area.
4. Remove the fuel pressure regulator retainer (2).
5. Remove the fuel pressure regulator (1) from its housing.

Clean and Inspect

Clean and inspect the fuel screen (5) and O-rings (3) and (6). Replace the O-rings if they are deteriorated or damaged.

Installation

1. Install the backup ring (3) on the fuel pressure regulator (if equipped.)
2. Install the large O-ring (4) onto the fuel pressure regulator.
3. Install the filter screen (5) onto the fuel pressure regulator.
4. Install the small O-ring (6) onto the fuel pressure regulator.
5. Lubricated the fuel pressure regulator O-rings with a small amount of clean engine oil.
6. Push the fuel pressure regulator in its housing on the fuel rail.
7. Install a new fuel pressure regulator retainer (2).
8. Connect the fuel pressure regulator vacuum line.
9. Reconnect the battery power to the engine.
10. Inspect for leaks.
    a. Turn the ignition ON for 5 seconds.
    b. Turn the ignition OFF for 10 seconds
    c. Turn the ignition ON.
    d. Inspect for fuel leaks.
11. Install the engine cover. See “Engine Cover” on page 55.

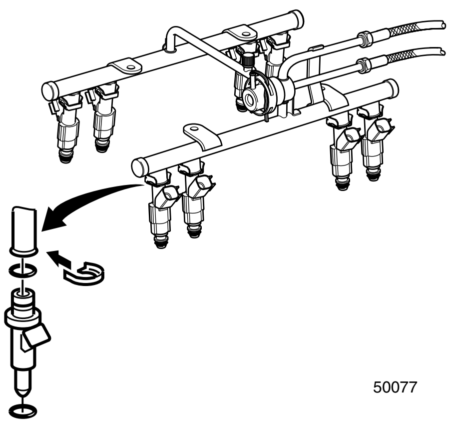
Fuel Injector

Removal

Important: The engine oil may be contaminated with fuel if the fuel injectors leaking.

1. Relieve the fuel pressure. See “Fuel Pressure Relief Procedure” on page 54.

2. Remove the fuel rail assembly. See “Fuel Rail Assembly” on page 66.
3. Remove the injector retainer clip.



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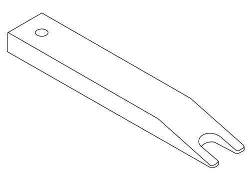
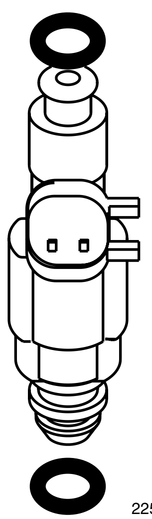


J 43013

4. Insert the fork of tool J 43013 between the fuel rail pod and the 3 protruding retaining clip edges. Use a prying potion while inserting the tool to force the injector out of the pod.
5. Discard the injector retaining clip.



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6. Remove the injector O-ring seals from both ends of the injector. Discard the O-ring seals.

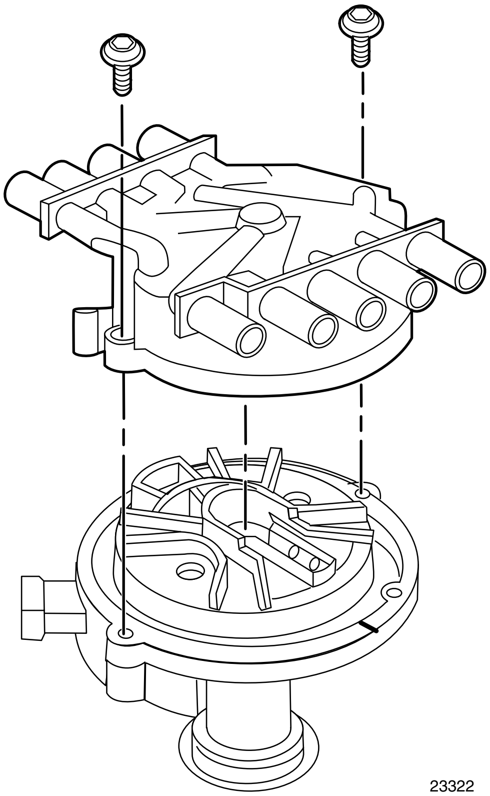
Installation

> **Important: When ordering new fuel injectors, be sure to order the correct part number for the application being serviced.**

7. Lubricate the new O-ring seals with clean engine oil.
8. Install the new injector O-ring seals on the injector.
9. Install a new retainer clip on the injector.
10. Push the fuel injector into the fuel rail socket with the electrical connector facing outwards. The retainer clip locks on to a flange on the fuel rail injector socket.
11. Install the fuel rail assembly. Fuel Rail Assembly” on page 66.

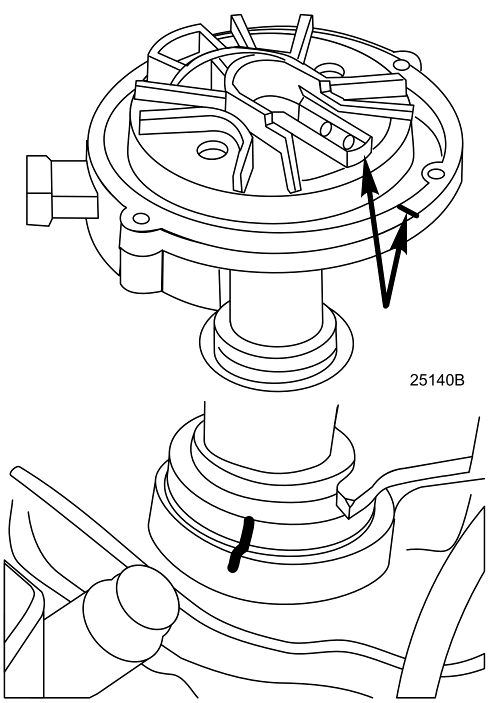
Distributor

Removal



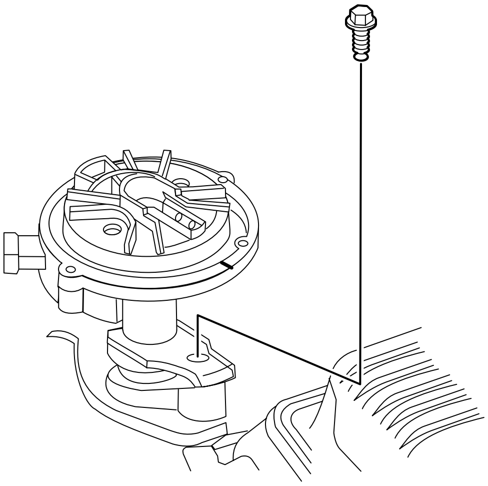
23322

1. Turn OFF the ignition.
2. Remove the engine cover. See “Engine Cover” on page 55.
3. Remove the spark plug wires from the distributor cap.
   - Twist each spark plug 1/2 turn.
   - Pull only on the wire boot in order to remove the wire from the distributor cap.
4. Remove the electrical connector from the base of the distributor.
5. Remove the 2 screws that retain the distributor cap to the housing.
6. Discard the screws.
7. Remove the distributor cap from the housing.

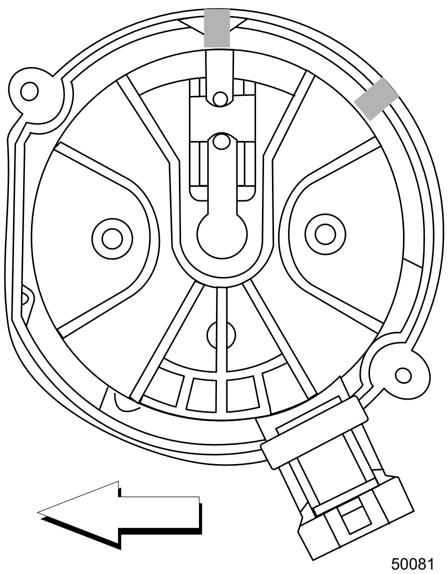


25140B

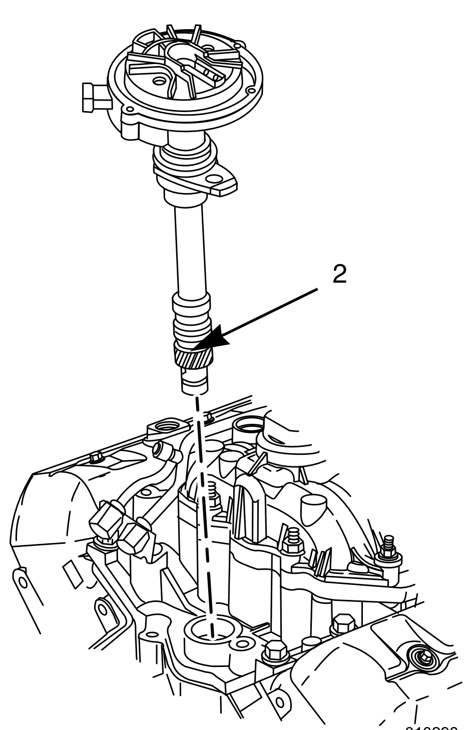
8. Use a grease pencil in order to mark the position of the rotor in relation to the distributor housing (1).
9. Mark the distributor housing and the intake manifold with the grease pencil.



10. Remove the mounting clamp hold-down bolt.



11. As the distributor is being removed from the engine, watch the rotor move in a counter-clockwise direction about 42 degrees. This will appear as slightly more than one clock position.
12. Note the position of the rotor segment.

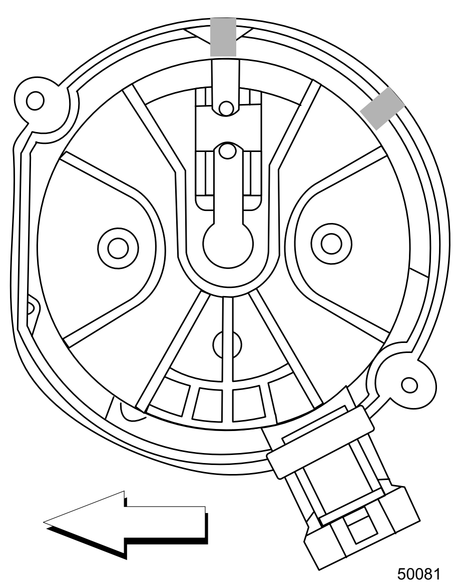


310298

13. Remove the distributor.
14. Place a second mark on the base of the distributor (2). This will aid in achieving the proper rotor alignment during the distributor installation.

Installation

1. If installing a new distributor assembly, place 2 marks on the new distributor housing in the same location as the marks on the original housing.
2. Remove the new distributor cap, if necessary.
3. Align the rotor with the second mark (2).
4. Guide the distributor into the engine.
5. Align the hole in the distributor hold-down base over the mounting hole in the intake manifold.
6. As the distributor is being installed, observe the rotor moving in a clockwise direction about 42 degrees.
7. Once the distributor is completely seated, the rotor segment should be aligned with the mark on the distributor housing.
   a. If the rotor segment is not aligned with the mark, the driven gear teeth and the camshaft have meshed one or more teeth out of alignment.
   b. In order to correct this condition, remove and reinstall the distributor.



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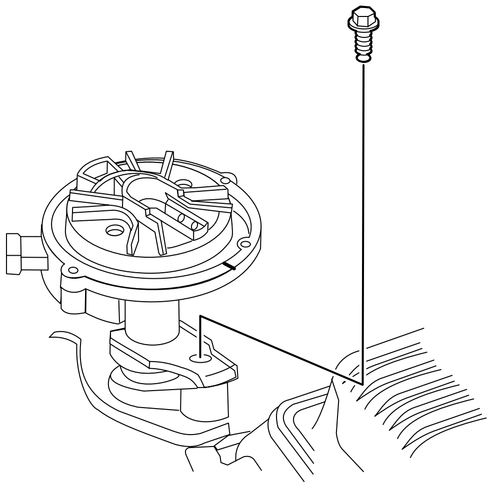
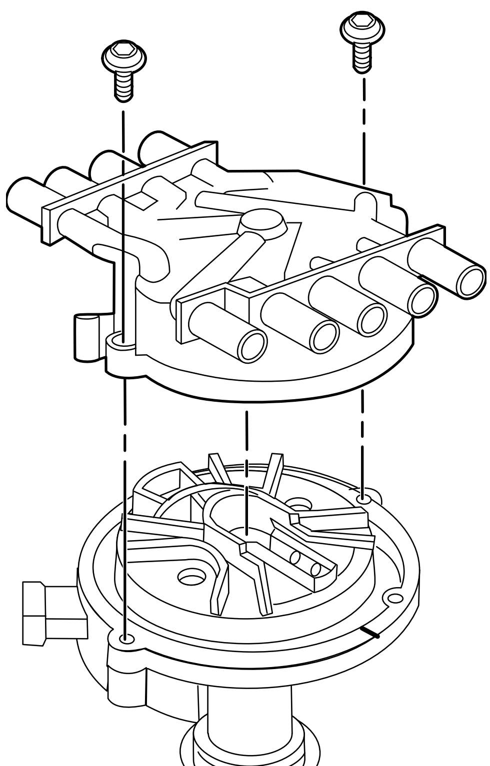


8. Install the distributor mounting clamp bolt. Tighten the bolt to 25 Nm (18 ft. lb.)



23322

9. Install the distributor cap.
10. Install the new distributor cap screws. Tighten the screws to 2.4 Nm (21 in. lb.)
11. Install the electrical connector to the distributor.
12. Install the spark plug wires to the distributor cap.
13. Install the ignition coil wire to the distributor cap

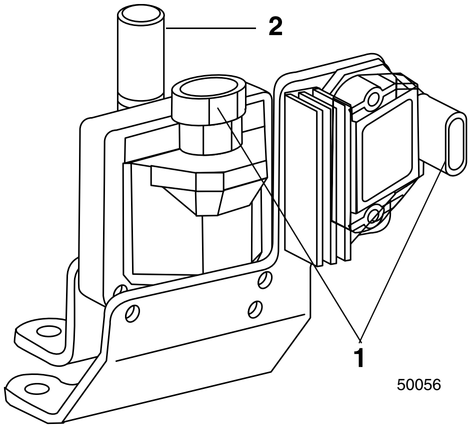
    Important: If the malfunction indicator lamp illuminates after installing the distributor and a DTC is set, the distributor has been installed incorrectly.

    Check the cam angle with a scan tool to ensure the cam angle is 45° ±5°

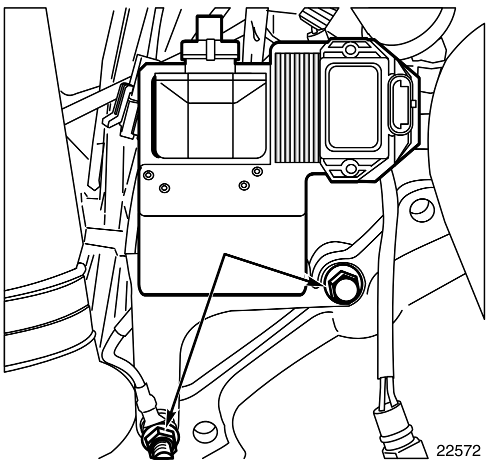
14. Install the engine cover. See "Engine Cover" on page 55.

Ignition Coil

Removal

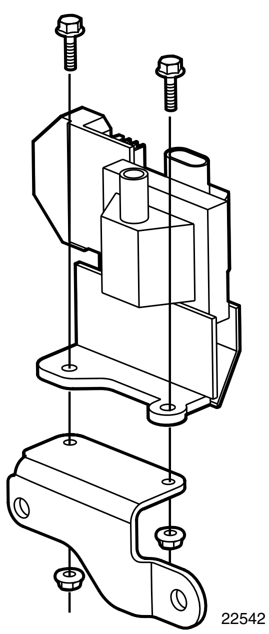


1. Remove the engine cover. See “Engine Cover” on page 55.
2. Disconnect the electrical connectors from the ignition coil and ignition module (1).
3. Remove the ignition coil wire (2).



4. Remove the nut and bolt holding the bracket and the ignition coil to the flywheel housing.
5. Remove the bracket and the ignition coil assembly.

Installation



1. Install the ignition coil to the bracket with the 2 screws. **7-9 Nm (5-7 ft. lb.)**
2. Install the ignition coil and the bracket to the intake manifold with studs. Tighten the nut and screw to **34-39 Nm (20-25 ft. lb.)**
3. Install the ignition coil wire (2).

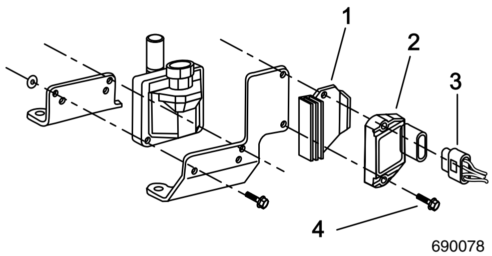
⚠ **DANGER!**

The wire must not touch anything like the steering or exhaust system. Chafing the insulation will cause a short to ground and sparking in the engine compartment. This could cause fire or an explosion if gas fumes are present

4. Install the electrical connectors.
5. Install the engine cover. See “Engine Cover” on page 55.

Ignition Control Module

Removal



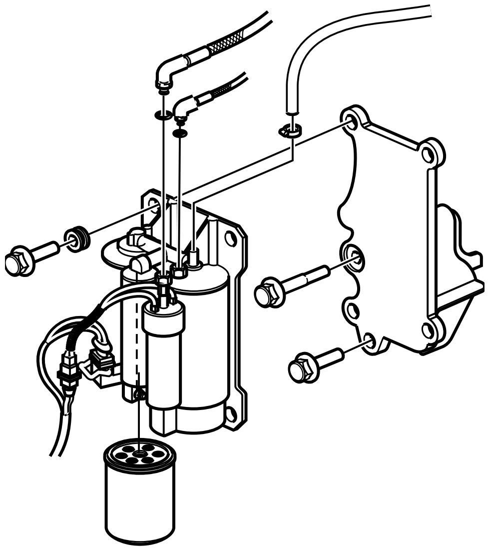
1. Remove the engine cover. See “Engine Cover” on page 55.
2. Disconnect the electrical connector (3).
3. Remove the screws (4) holding the ignition control module (2) and the heat sink (1) to the bracket.
4. Remove the ignition control module and the heat sink.

Installation

1. Install the ignition control module (2) and the heat sink (1) on the bracket with the screws (4). Tighten the screws to 3.5 Nm (31 in. lb.)
2. Reconnect the electrical connector (3).
3. Install the engine cover. See “Engine Cover” on page 55.

Fuel Cell

Removal



1. Disconnect negative battery cable.
2. Relieve the fuel system pressure before servicing any fuel system component. See “Fuel Pressure Relief Procedure” on page 55.
3. Clean all the fuel fitting connections and the surrounding areas before disconnecting the fuel pipes in order to avoid possible contamination of the fuel system.
4. Disconnect the threaded fittings from the fuel cell.

⚠ **Caution!**

Be sure to counter-hold the fittings whenever loosening or torquing fuel lines. The pump or fuel cell could be damaged.

5. Cap the fuel pipes in order to prevent possible fuel system contamination.
6. Disconnect the fuel pump electrical connectors.
7. Disconnect the cooling lines to the fuel cell.
8. Remove the fuel filter and dispose of it in an approved manner.
9. Remove the 4 retaining screws and retain for installation on the new fuel cell.
10. Remove the fuel cell.

Installation

Important! Make sure to replace the fuel cell with the identical part number.

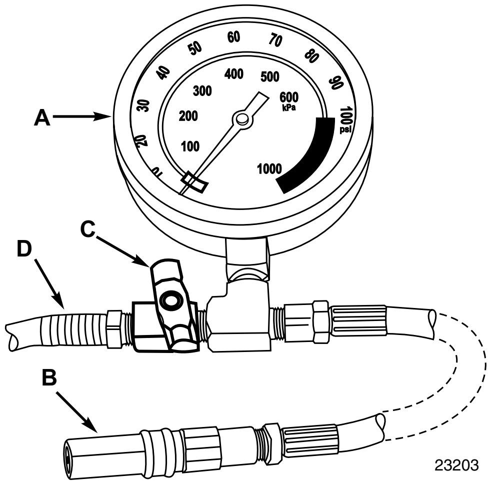
1. Install the fuel cell.
2. Reconnect the fuel pump electrical connectors.
3. Remove the caps from the fuel pipes.
4. Reconnect the threaded fittings into the fuel pump. Tighten the fittings to 25 Nm (18 ft. lb.)

⚠ **Caution!**

Be sure to counter-hold the fittings whenever loosening or torquing fuel lines. The pump or fuel cell could be damaged.

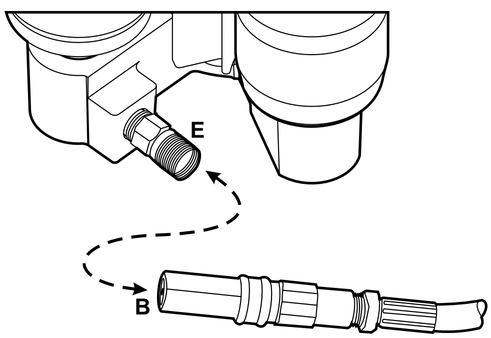
5. Reconnect the cooling lines.
6. If a fuel filter does not come installed on the new fuel cell, install a new fuel filter.
7. Connect the negative battery cable.
8. Inspect for leaks.
   a. Turn the ignition ON for 5 seconds.
   b. Turn the ignition OFF for 10 seconds.
   c. Turn the ignition ON.
   d. Inspect for fuel leaks.

High Pressure Fuel Pump Replacement



23203

1. Disconnect the negative battery cable.
2. Relieve the fuel system pressure before servicing any fuel system component. See “Fuel Pressure Relief Procedure” on page 55.
3. Clean all the fuel fitting connections and the surrounding areas before disconnecting the fuel pipes in order to avoid possible contamination of the fuel system.
4. Use a small container or shop towel an place below the high pressure fuel pump to catch any fuel that will be spilled when the pump is removed.



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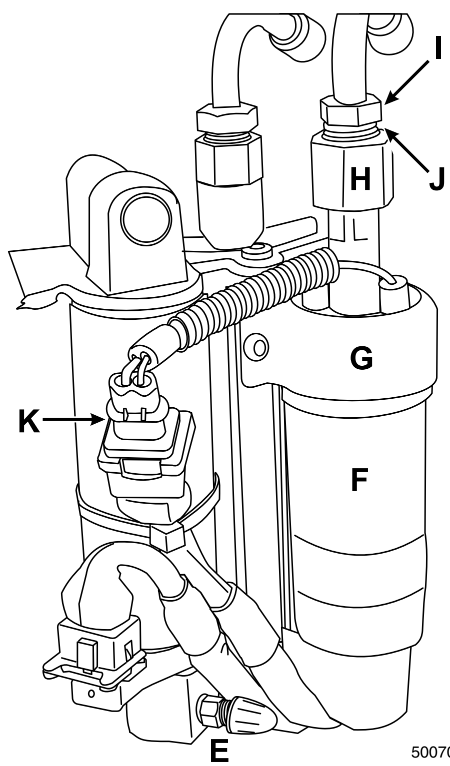
5. Using fuel pressure test kit P/N 3855533 connect hose (B) of the tester to the fuel pressure test port on the fuel cell. Open the bleed valve on the pressure tester (C) and drain the fuel cell into an approved container.

   Important! Always dispose of waste or contaminated fuel in accordance with all local regulations.



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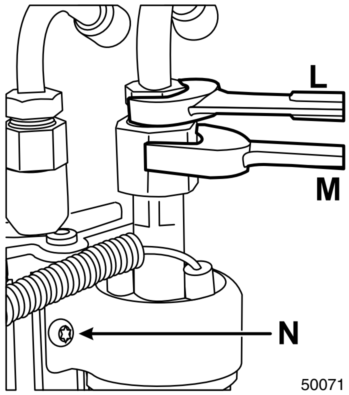
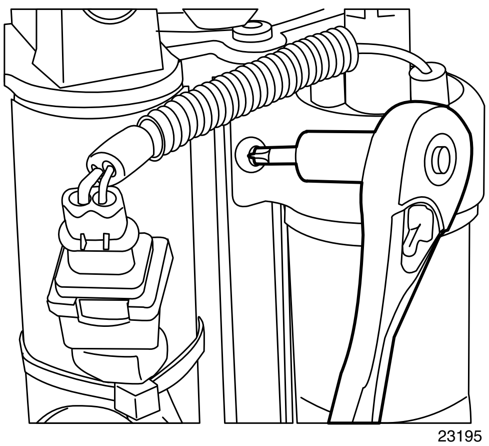
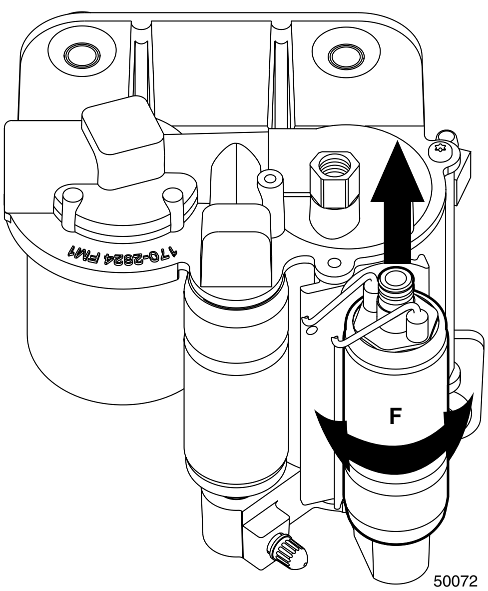
6. Disconnect the high pressure fuel pump’s electrical connector (K).



7. Disconnect the fuel line (I) using a 7/8 inch wrench (M) to support the pump outlet (H) and a 5/8 inch wrench (L) to disconnect the fuel line nut (I).

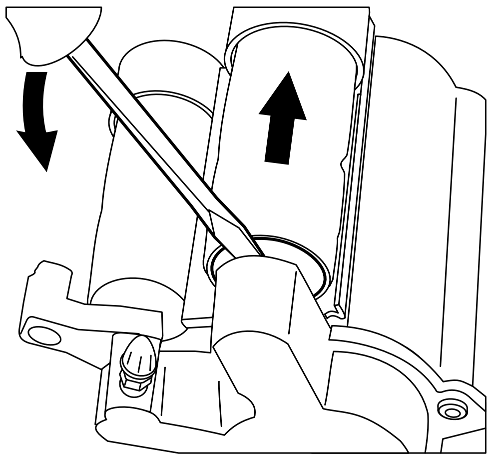


8. Using a T-20 Torx® screwdriver head in a ratchet wrench, remove the retaining bracket screw (N).
9. Remove the fuel pump retaining bracket (G).



10. Remove the pump by twisting and pulling upward on the pump by hand.

⚠ **Caution! Always replace the O-ring with a new one when a fuel component is removed.**



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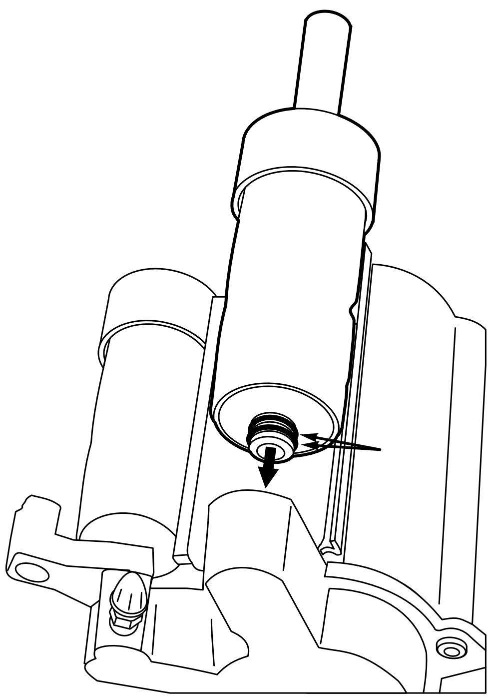
11. If you are unable to remove the fuel pump by twisting and pulling up on the fuel pump by hand, you may use a screwdriver to CAREFULLY pry up on the fuel pump to remove it. Pry down on the screwdriver so that the broad side of the blade contacts the fuel cell. Be careful not to damage the fuel cell or the fuel pump seat.

Installation



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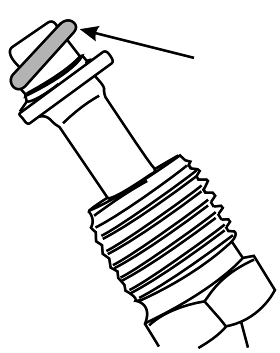
1. Remove the new fuel pump for its packaging and inspect the ends of the pump for damage. Be sure that the O-rings are installed. If they are not installed, use the O-rings that come with the pump.

⚠ **WARNING! Do not substitute O-rings with anything other material. Leakage may occur and cause an explosion hazard in the bilge.**

2. Lubricate the O-rings with 1 drop of clean engine oil.
3. Place the new high pressure fuel pump onto the fuel cell housing by sliding into place. Be sure the pump is fully seated.

⚠ **DANGER! Be careful not to pinch the O-rings during assembly. A pinched and damaged O-ring will cause a leak and explosion hazard.**

4. Install fuel pump clamp and install a new Torx head screw. Tighten to 5.1-6.2 Nm (45-55 in. lb.)



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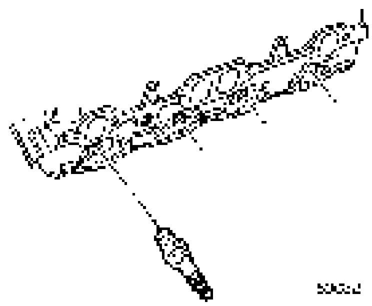
5. Install a new O-ring on the fuel line and re-attach the fuel line. Using a 7/8 in wrench to counter-hold the regulator housing, tighten the nut to 16.9-20.3 Nm (12-15 ft.lb.) with a 5/8 in wrench.
6. Reconnect the electrical connection.
7. Reconnect the negative battery cable.

⚠ **Caution! Be sure to test for leaks before running the engine.**

Spark Plug

Removal

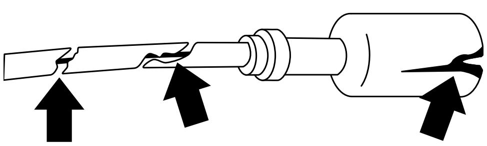


1. Remove the spark plug wires. See “Spark Plug Wire Replacement” on page 80.
2. Loosen each spark plug one or two turns.
3. Brush or air blast away any dirt from around the spark plugs.
4. Remove the spark plugs one at a time and place each plug in a tray marked with the corresponding cylinder numbers.

Installation

1. Inspect each spark plug gap. Adjust each plug gap as needed. Spark plug gap: 1.524 mm (0.060 in)
2. Install the spark plugs. Tighten the spark plugs to 20 Nm (15 ft. lb.)
3. Install the spark plug wires. See “Spark Plug Wire Replacement” on page 80.

Spark Plug Wire Inspection



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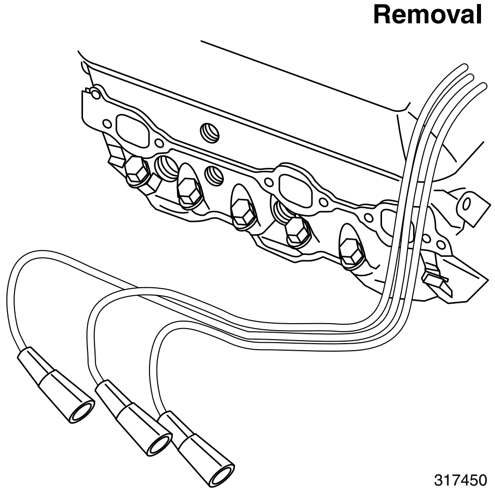
Spark plug wire integrity is vital for proper engine operation. A thorough inspection will be necessary to accurately identify conditions that may affect engine operation. Inspect for the following conditions:

1. Correct routing of the spark plug wires. Incorrect routing may cause cross-firing.
2. Any signs of cracks or splits in the wires.
3. Inspect each boot for the following conditions:
   a. Tearing
   b. Piercing
   c. Arcing
   d. Carbon tracking
   e. Corroded terminal

If corrosion, carbon tracking or arcing are indicated on a spark plug wire boot or on a terminal, replace the wire and the component connected to the wire.

Spark Plug Wire Replacement

Removal



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1. Disconnect the spark plug wire at each spark plug.
   a. Twist each spark plug wire 1/2 turn.
   b. Pull only on the boot in order to remove the wire from each spark plug.
2. Disconnect the spark plug wire from each ignition coil.
   a. a) Twist each spark plug wire 1/2 turn.
   b. b) Pull only on the boot in order to remove the wire from each ignition coil.

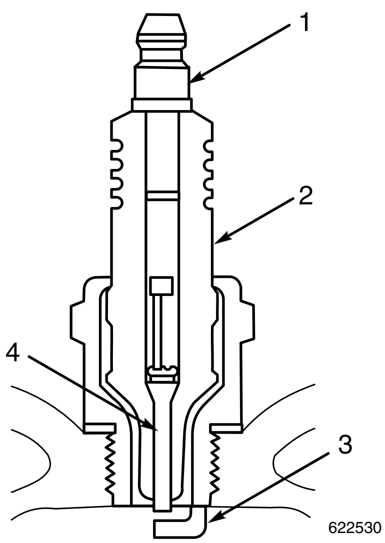
Installation

1. Install the spark plug wire at each ignition coil.
2. Install the spark plug wire at each spark plug.
3. Inspect the wires for proper installation:

a. Push sideways on each boot in order to inspect the seating.

b. Reinstall any loose boot.

Spark Plug Inspection

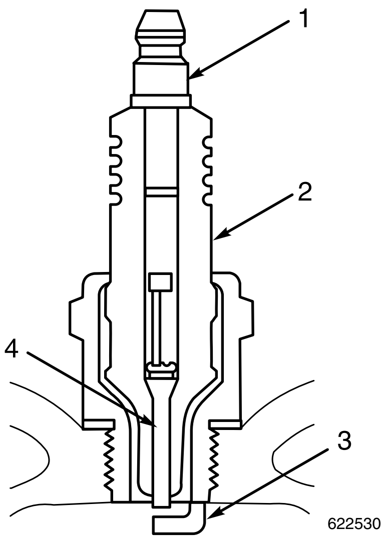


Spark Plug Usage

1. Ensure that the correct spark plug is installed. An incorrect spark plug causes driveability conditions.
2. Ensure that the spark plug has the correct heat range. An incorrect heat range causes the following conditions:
   a. Spark plug fouling - colder plug.
   b. Pre-ignition causing spark plug and/or engine damage - hotter plug.
3. Inspect the terminal post (1) for damage.
   a. Inspect for a bent or broken terminal post (1).
   b. Inspect the spark plug boot for damage.
   c. Inspect the spark plug recess area of the cylinder head for moisture, such as oil, coolant or water. A spark plug boot that is saturated causes arcing to ground.
4. Inspect the insulator (2) for cracks. All or part of the electrical charge may arc through the crack instead of the electrodes (3, 4).
5. 5.Inspect for evidence of improper arcing.
   a. Measure the gap between the center electrode (4) and the side electrode (3) terminals. An excessively wide electrode gap can prevent correct spark plug operation.
   b. Inspect for the correct spark plug torque. Insufficient torque can prevent correct spark plug operation. An over torqued spark plug may cause the insulator (2) to crack.
   c. Inspect for signs of tracking that occurred near the insulator tip instead of the center electrode (4).
   d. Inspect for a broken or worn side electrode (3).
   e. Inspect for a broken, worn or loose center electrode (4) by shaking the spark plug.
6. A rattling sound indicates internal damage.
7. A loose center electrode (4) reduces the spark intensity.
   a. Inspect for bridged electrodes (3, 4). Deposits on the electrodes (3, 4) reduce or eliminates the gap.
   b. Inspect for worn or missing platinum pads on the electrodes (3, 4), if equipped.
   c. Inspect for excessive fouling.
8. Inspect the spark plug recess area of the cylinder head for debris. Dirty or damaged threads can cause the spark plug not to seat correctly during installation.

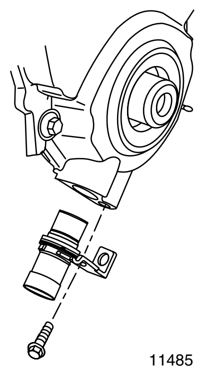
Spark Plug Visual Inspection

1. Normal Operation - Brown to greyish-tan with small amounts of white powdery deposits are normal combustion by-products from fuels with additives.
2. Carbon Fouled - Dry, fluffy black carbon, or soot caused by rich fuel mixtures.



3. Leaking fuel injectors
4. Excessive fuel pressure
5. Restricted flame arrestor/air filter element
6. Incorrect combustion. Reduced ignition system voltage output.
7. Weak coil(s)
8. Worn ignition wires
9. Incorrect spark plug gap. Excessive idling or slow speeds under light loads can keep spark plug temperatures so low that normal combustion deposits may not burn off
10. Inspect for evidence of improper arcing.
    a. Measure the gap between the center electrode (4) and the side electrode (3) terminals. An excessively wide electrode gap can prevent correct spark plug operation.
    b. Inspect for the correct spark plug torque. Insufficient torque can prevent correct spark plug operation. An over torqued spark plug may cause the insulator (2) to crack.
    c. Inspect for signs of tracking that occurred near the insulator tip instead of the center electrode (4).
    d. Inspect for a broken or worn side electrode (3).
    e. Inspect for a broken, worn or loose center electrode (4) by shaking the spark plug.
11. A rattling sound indicates internal damage.
12. A loose center electrode (4) reduces the spark intensity.
    a. Inspect for bridged electrodes (3, 4). Deposits on the electrodes (3, 4) reduce or eliminates the gap.
    b. Inspect for worn or missing platinum pads on the electrodes (3, 4), if equipped.
    c. Inspect for excessive fouling.
13. Inspect the spark plug recess area of the cylinder head for debris. Dirty or damaged threads can cause the spark plug not to seat correctly during installation.

Crankshaft Position (CKP) Sensor



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Removal

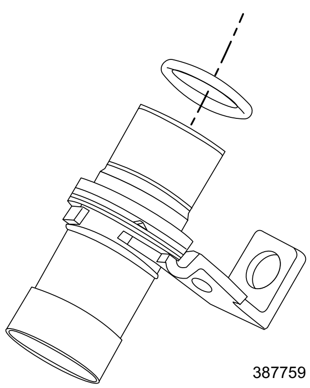
1. Disconnect the negative battery cable.
2. Disconnect the CKP sensor harness connector.
3. Remove the CKP sensor mounting bolt.
4. Remove the CKP sensor.

Installation

NOTE! When installing the CKP sensor, make sure the sensor is fully seated before tightening the mounting bolt. A poorly seated CKP sensor may perform erratically and may set false DTCs.

⚠ **Caution!**

Do not reuse the original O-ring.



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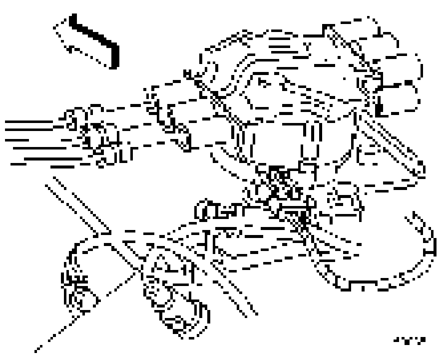
1. Replace the CKP sensor O-ring.
2. Lubricate the O-ring with clean engine oil before installing the CKP sensor.

   NOTE! Make sure the CKP sensor mounting surface is clean and free of burrs.

3. Install the CKP sensor.
4. Install the CKP sensor mounting bolt. Tighten the CKP sensor mounting bolt to 9 Nm (80 in. lb.)
5. Connect the CKP sensor harness connector.

Camshaft Position Sensor (CMP)

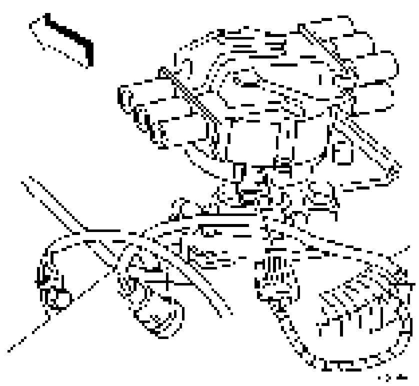
Removal



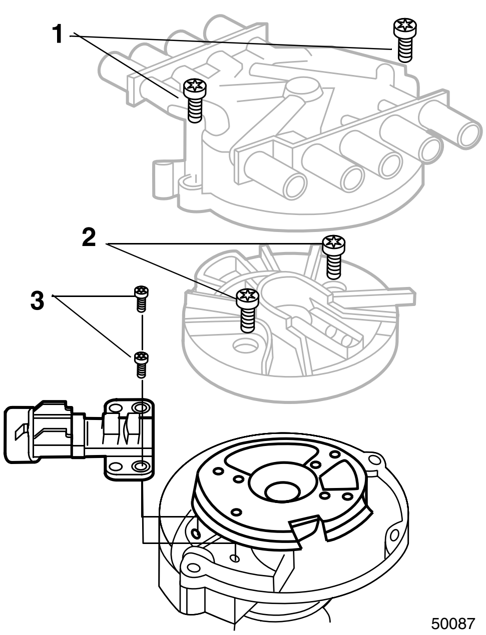
1. Remove the engine cover. See “Engine Cover” on page 55.

   Important! Mark the spark plug wires before removing from distributor cap to ensure the correct position during reinstallation.

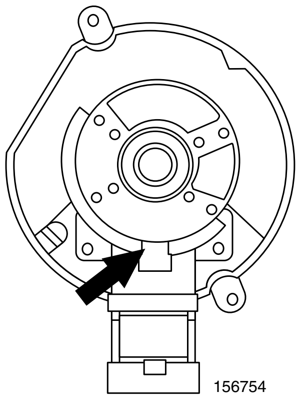
2. Disconnect the spark plug wires and ignition coil wire from the distributor. See “Spark Plug Wire Replacement” on page 80.



3. Disconnect the camshaft position (CMP) sensor harness connector from the distributor.



4. Remove the distributor cap screws (1). See “Distributor” on page 70.
5. Remove the distributor cap.
6. Remove the rotor screws (2)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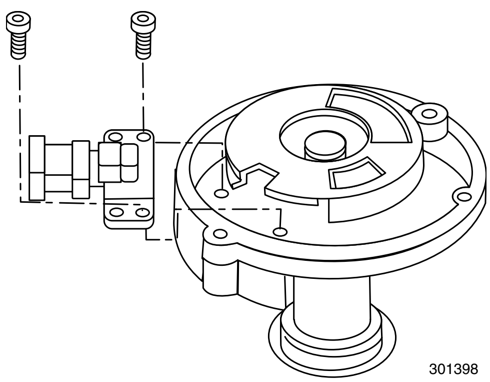
7. Align the square slot in the reluctor wheel with the CMP sensor.
8. Remove CMP sensor screws (3).
9. Remove the CMP sensor.

Installation

Important: Do not use the old cap, CMP sensor, and rotor screws. Use the replacement screws that have been coated with a thread locking compound.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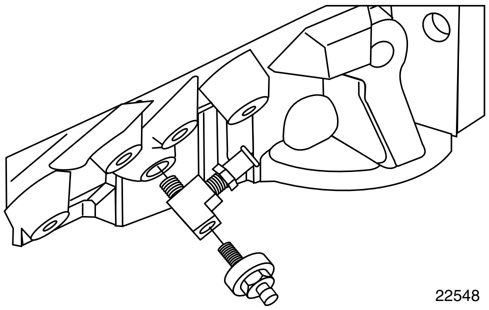
1. Insert the CMP sensor through the reluctor wheel slot.
2. Install new CMP mounting screws. Tighten the screws to 2.2 Nm (19 in. lb.)
3. Install the rotor onto the reluctor wheel.
4. Install new rotor screws. Tighten the screws to 2 Nm (18 in. lb.)
5. Install distributor cap. See “Distributor” on page 70.
6. Reinstall the spark plug wires in their original locations.
7. Install engine cover. See “Engine Cover” on page 55.

Knock Sensor

Removal

1. Disconnect the negative battery cable.
2. Remove the engine cover. See “Engine Cover” on page 55.
3. Disconnect the knock sensor harness connector.
4. Remove the knock sensor from drain tee.



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Installation

1. Install the knock sensor in drain tee.
2. Tighten the sensor to 18 Nm (13 ft. lb.)
3. Connect the knock sensor harness connector.
4. Connect the negative battery cable.

Temperature v. Resistance IAT and ECT

°C	°F	Ohms	°C	°F	Ohms
100	212	177	25	77	2796
90	194	241	20	68	3520
80	176	332	15	59	4450
70	158	467	10	50	5670
60	140	667	5	41	7280
50	122	973	0	32	9420
45	133	1188	-5	23	12300
40	104	1459	-10	14	16180
35	95	1820	-15	5	21450
30	86	2238	-20	-4	28680
25	77	2796	-30	-22	52700
20	68	3520	-40	-40	100700

Ignition System Specifications - 4.3L

Application	Specifications	
	Metric	English
Firing Order	1-6-5-4-3-2	
Spark Plug Wire Resistance	10,000 Ohms/ft.	
Spark Plug Torque	27 Nm	20 ft. lb.
Spark Plug Gap	1.524 mm	0.060
Spark Plug Type	Volvo Penta P/N 3861632	
Cam retard angle	42 degrees	

Ignition System Specifications - 5.0L and 5.7L

Application	***Specifications***	
	Metric	English
Firing Order	1-8-4-3-6-5-7-2	
Spark Plug Wire Resistance	5,000 Ohms/ft.	
Spark Plug Torque	27 Nm	20 ft. lb.
Spark Plug Gap	1.524 mm	0.060
Spark Plug Type	Volvo Penta P/N 3861632	
Cam retard angle	42 degrees	

Fuel System Specifications

Application	***Specifications***	
	Metric	English
Low pressure test	55 kPa	8 psi
High pressure test	344-413 kPa	50-60 psi

Fastener Tightening Specifications

Application	***Specifications***	
	Metric	English
Camshaft Position Sensor (CMP) page 84	2.2 Nm	19 in. lb.
Crankshaft Position Sensor (CKP) page 83	9 Nm	80 in. lb.
Distributor Cap Screws page 70	2.4 Nm	21 in. lb.
Distributor Mounting Bolt page 70	25 Nm	18 ft. lb.
Distributor Rotor Screws	2 Nm	18 in. lb.
Engine Control Module (ECM) Mounting Screws page 57	7-11 Nm	61-97in. lb
Engine Coolant Temperature Sensor (ECT) page 60	20 Nm	15 ft. lb.
Flame Arrestor Attaching Screws page 55	1.5-1.8 Nm	14-16 in. lb.
Fuel Pump Clamp Torx head screw page 76	5.1-6.2 Nm	45-55 in. lb.
Fuel Rail Attachment Bolts page 66	12 Nm	106 in. lb.
High Pressure Fuel line to Fuel Cell	16.9-20.3 Nm	12-15 ft. lb.
IAC attaching screws page 61	3 Nm	27 in. lb.
Ignition Coil to Bracket Screws page 74	7-9 Nm	5-7 ft. lb.
Ignition Module to Coil Bracket Screws page 75	3.5 Nm	31 in. lb.
Knock Sensor page 86	18 Nm	13 ft. lb.
Throttle Body Attaching Bolts	15 Nm	11 ft. lb.
Throttle body attaching studs page 63	9 Nm	80 in. lb.
Throttle Position Sensor Screws page 61	2 Nm	18 in. lb.
T-MAP Sensor Attaching Screw page 60	12 Nm	106 in. lb.

Notes

Section 5: Operation - 8.1L

General Description

The function of the fuel metering system is to deliver the correct amount of fuel to the engine under all operating conditions. Fuel is delivered to the engine by individual fuel injectors mounted in the intake manifold near each cylinder.

Basic Knowledge Required

Without a basic knowledge of electricity, it will be difficult to use the diagnostic procedures contained in this section. You should understand the basic theory of electricity and know the meaning of voltage (volts), current (amps) and resistance (ohms). You should understand what happens in a circuit with an open or a shorted wire. You should be able to read and understand a wiring diagram.

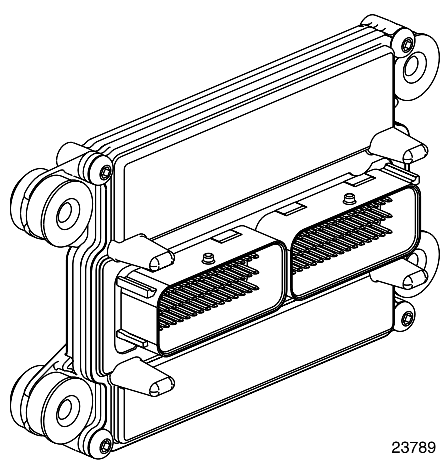
ECM Service Precautions

The ECM is designed to withstand normal current draws associated with normal boat operations. Avoid overloading any circuit. When testing for opens or shorts, do not ground any of the ECM circuits unless instructed. When testing for opens or shorts, do not apply voltage to any of the ECM circuits unless instructed. Only test these circuits with a DVOM while the ECM connector remains connected.

Engine Control Module (ECM)

The engine control module (ECM) of the Volvo Penta Electronic Gas Control system (EGC) is designed to maintain exhaust emission levels while maintaining excellent driveability and fuel efficiency. The ECM controls the following conditions:

- The fuel control
- The ignition control (IC)
- The knock sensor (KS) system
- Throttle Position Sensor (TPS) system
- Various other discrete outputs



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The engine control module (ECM) is the control center of the engine and controls the following systems:

- The fuel metering system
- The ignition timing
- The on-board diagnostics

The ECM constantly monitors the information from various sensors and controls the systems that affect performance and emissions. The

ECM also performs the diagnostic functions for those systems. The ECM can recognize operational problems and alert the operator through the malfunction indicator lamp (MIL) and a warning horn when a malfunction has occurred. When a malfunction is detected, the ECM stores a diagnostic trouble code (DTC) or a logged warning which helps to identify problem areas. This is done to aid the technician in making repairs.

The ECM supplies either 5.0 or 12.0 volts to power various sensors and switches. This is done through resistance in the ECM. The resistance is so high in value that a test lamp does not illuminate when connected to the circuit. In some cases, even an ordinary shop voltmeter does not give an accurate reading because the voltmeters resistance is too low. Therefore, a DVOM with a minimum of 10 megaohms input impedance is required to ensure accurate voltage readings.

The ECM controls output circuits such as the fuel injectors, ignition coils, Throttle Position and various relays by controlling the ground or power feed circuit through transistors or a device called an output driver module (ODM).

Malfunction Indicator Lamp (MIL)

The malfunction indicator lamp is used as a visual alert to inform the operator of a problem with the engine. It is used in conjunction with a warning horn mounted under the instrument panel. The MIL is used with the Soft and Hard Warnings. However, it is also used without the warning horn to tell the operator of a problem that is not of an immediate nature but should be addressed when the boat is serviced.

Soft Warning

The soft warning is used with the MIL to alert the operator to a minor problem. When the ECM activates a Soft Warning, the MIL light is turned on and the engine alarm is sounded at 5-second intervals. The Soft Warning is designed to alert the operator to serious problem that should be addressed as soon as possible. For certain engine errors, power derate is also enforced. For more specific information See “RPM Reduction and Warnings” on page 100.

Hard Warning

The Hard Warning is designed to alert the operator to a potentially dangerous engine error that could damage the engine. When the ECM activated a Hard Warning, the MIL light is activated and the warning horn sounds at ¼ second intervals. A Hard Warning is used in conjunction with Power Derate, Forced Idle, or Engine Shutdown. The MIL light and warning horn are always actuated with a Hard Warning. For further information See “RPM Reduction and Warnings” on page 100.

RPM Reduction Mode

RPM reduction mode is a function of the ECM that reduces engine power under certain conditions. The RPM reduction has several levels and is used in conjunction with a Hard warning.

Power Derate

Power Derate is used in conjunction with the Soft and Hard warnings. When enforced the throttle is limited to 30% throttle angle. Depending on the size of the boat and loading this could be approximately 3000 to 3400 RPM however, the limit is not RPM specific.

Low Rev Limit

Low Rev Limit is used in conjunction with a Hard Warning and is designed to limit engine RPM to 850 if there is a problem with the Drive By Wire (DBW) electronic throttle position sensors.

Forced Idle

Forced Idle is also used in conjunction with a Hard Warning to prevent engine run away in the unlikely event of un-commanded throttle movement. Forced Idle will limit the engine to 750 RPM by overriding all throttle commands and close the throttle. If the engine RPM is still not responding to the closed throttle condition, the ignition is shut off to each ignition coil until the RPM is at the desired level. If the engine RPM does not respond, the fuel is shut off to each fuel injector until the desired RPM level is reached.

Engine Shutdown

Engine Shutdown is only used for DTC 2135, a condition where both throttle position sensors are out of range and are giving unreliable throttle position. In this case the ECM does not have accurate throttle position information and rather than have an un-commanded Wide Open Throttle, the ECM with shut off the fuel and ignition system. The engine will not be allowed to start until the conditions is repaired.

Input Sensors

The ECM monitors the input sensors for circuit continuity and out-of-range values. This includes performance checking. Performance checking refers to indicating a fault when the signal from a sensor does not seem reasonable, such as a throttle position (TP) sensor that indicates high throttle position at low engine loads or MAP voltage. The input components may include, but are not limited to, the following sensors:

- Manifold air temperature (MAT) sensor
- Manifold absolute pressure (MAP) sensor
- Crankshaft position (CKP) sensor
- Camshaft position (CMP) sensor
- Knock sensor (KS)
- Throttle position (TPS) sensor
- Throttle control position (TCP) sensor
- Engine coolant temperature (ECT) sensor
- Exhaust manifold Gas Temperature (EGT) sensor
- Exhaust Temperature Switches

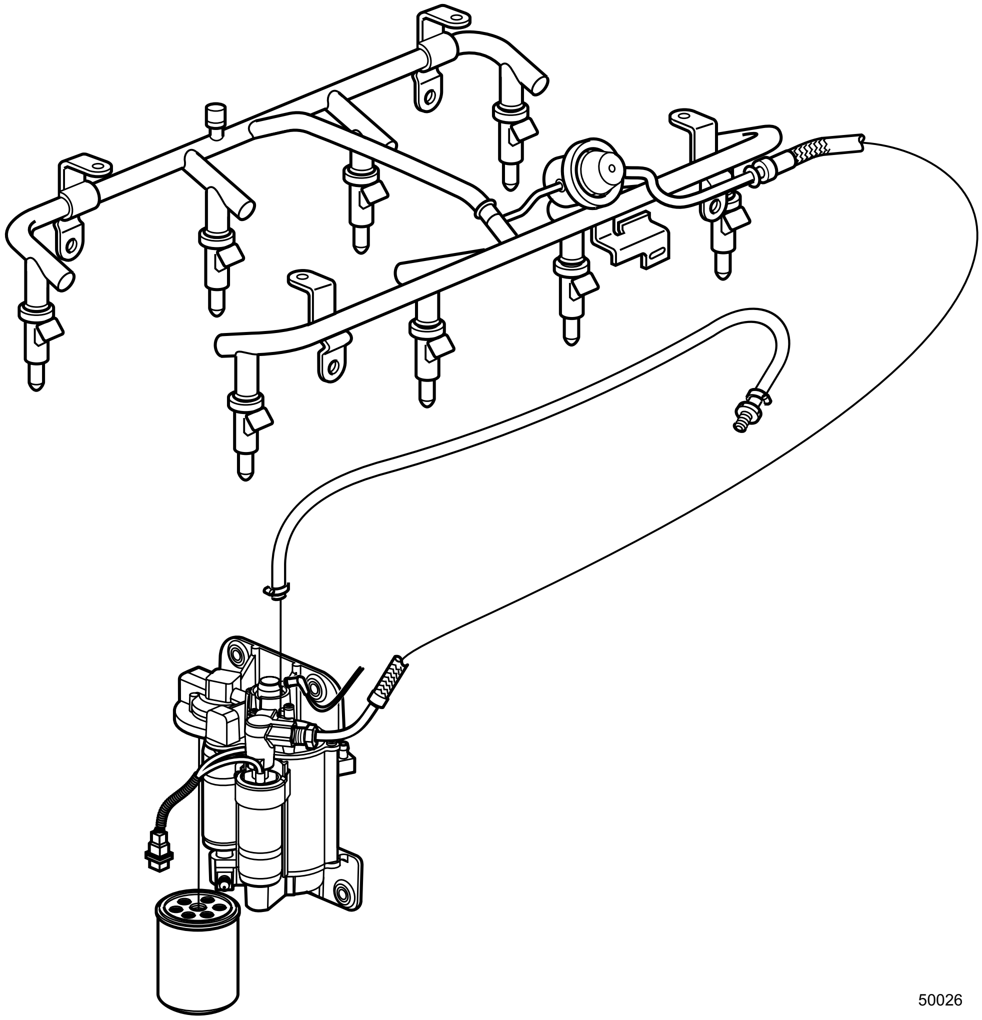
Output Actuators

Diagnose the output actuators for the proper response to ECM commands. Actuators where functional monitoring is not feasible, will be monitored for circuit continuity and out-of-range values, if applicable.

Output actuators to be monitored include the following circuit:

- Throttle Position Actuator
- Fuel Injectors

Fuel System



The fuel tank stores the fuel supply. The low pressure fuel pump contained in the Fuel Cell draws fuel through a replaceable fuel filter mounted on the fuel cell. It then sends the filtered fuel into a cooling venting/chamber where the fuel is cooled and any vapor is collected for venting to the intake manifold for burning in the combustion process. Any fuel that is not demanded by the fuel injectors is re-circulated through the cooling/venting chamber. The high pressure pump, which is integral to the fuel cell, then draws fuel from the cooling/venting chamber and supplies fuel at the required volume to the injectors. The fuel pressure regulator, part of the fuel cell assembly, keeps fuel available to the fuel injectors at a regulated pressure. The fuel pressure regulator sends excess fuel to fuel cell cooling/venting chamber. The engine control module (ECM) controls the fuel pump operation through a fuel pump relay. Both the high pressure and low pressure fuel pumps share a common relay.

Fuel Feed Pipe

The fuel feed pipe carries fuel from the fuel tank to the fuel cell. There is no return pipe to the fuel tank.

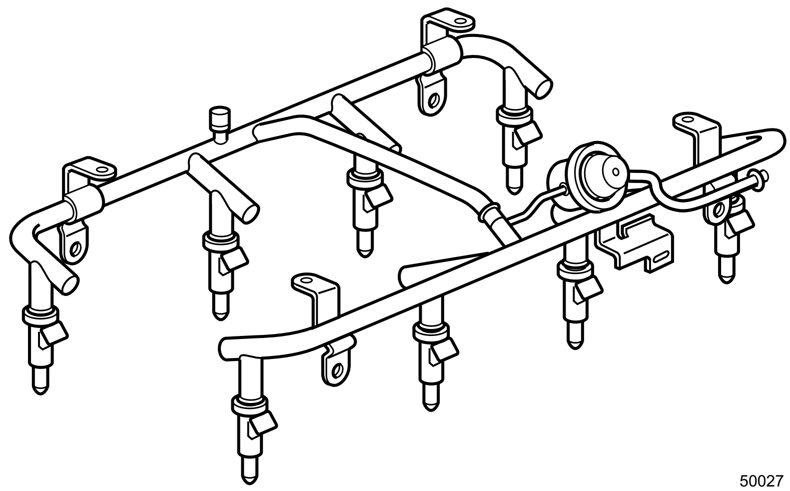
Quick-Connect Fittings

Quick-Connect fittings provide a simplified means of installing and connecting fuel system hoses. The fittings consists of a unique female connector and a compatible male pipe end. O-rings, located inside the female connector, provide the fuel seal. Integral locking tabs inside the female connector hold the fittings together.

Fuel Pipe O-Rings

O-rings seal the threaded connections in the fuel system. Fuel system O-ring seals are made of special material. Service the O-ring seals with the correct service part.

Fuel Rail Assembly



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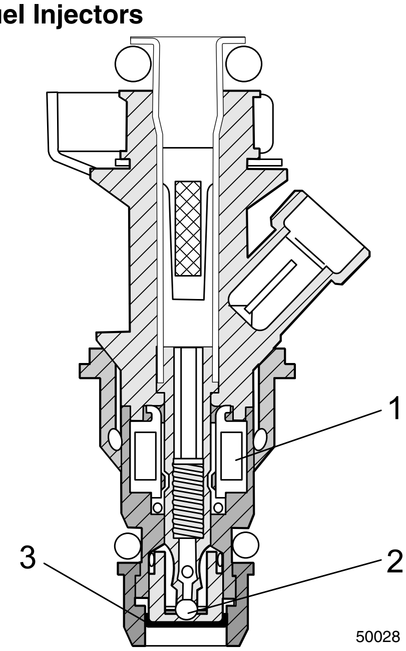
The fuel rail assembly attaches to the engine intake manifold. The fuel rail assembly performs the following functions:

- Positions the injectors in the intake manifold
- Distributes fuel evenly to the injectors

Fuel Injectors



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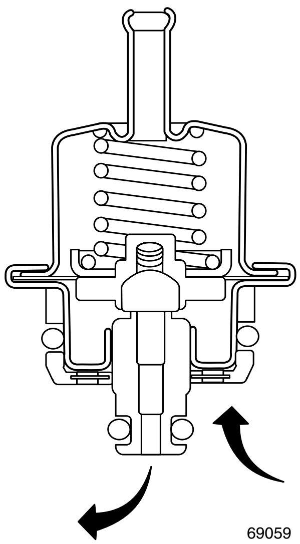
The Multitec 2 fuel injector assembly is a solenoid operated device, controlled by the ECM, that meters pressurized fuel to a single engine cylinder. The ECM energizes the high-impedance (12.2 ohms) injector solenoid (1) to open a normally closed ball valve (2). This allows fuel to flow, past the ball valve and through a director plate (3) at the injector outlet. The director plate has four machined holes that control the fuel flow, generating a spray of finely atomized fuel at the injector tip. Fuel from the injector tip is directed at the intake valve, causing it to become further atomized and vaporized before entering the combustion chamber. An injector stuck partly open can cause a loss of pressure after engine shutdown. Consequently, long engine cranking times would be noticed on some engines because of a flooded condition.

FUel Pressure Regulator Assembly



The fuel pressure regulator is a vacuum operated diaphragm relief valve with fuel pump pressure on one side and regulator spring pressure and intake manifold vacuum on the other side. The fuel pressure regulator maintains an adequate pressure differential across the injectors at all times. The pressure regulator compensates for engine load by increasing fuel pressure as the engine vacuum drops.

Fuel Metering Modes of Operation

The engine control module (ECM) reads voltages from several sensors in order to determine how much fuel to give the engine. The fuel is delivered under one of several conditions called modes. The ECM controls all modes.

Starting Mode

With the ignition switch in the ON position, before engaging the starter, the ECM energizes the fuel pump relay for 5 seconds allowing the fuel pumps to build up pressure. The ECM uses the engine coolant temperature (ECT), the throttle position (TP) and the manifold absolute pressure (MAP) sensors to determine the proper air/fuel ratio for starting. The ECM controls the amount of fuel delivered in the starting mode by changing the pulse width of the injectors. This is done by pulsing the injectors for very short times.

Run Mode

When the engine is first started and the engine speed is above 400 RPM, the system begins Open Loop operation. The ECM reads the TPS voltage every few milliseconds and calculates the difference between the current and last readings. If a large enough change is detected, adjustments are then made to the fuel injector's base pulse width value to provide extra fuel for rapid acceleration or a decrease in fuel for deceleration. The exact TPS voltage is important at idle or wide open throttle, however during normal running conditions it's the change and rate of change in TPS voltage that matters most.

Specified values for the above conditions are mapped for each engine, and are stored in the electrically erasable programmable read-only memory (EEPROM).

Acceleration Mode

When the operator moves the throttle, air flow into the cylinders increases rapidly, while fuel flow tends to lag behind. To prevent possible hesitation, the ECM increases the pulse width to the injectors to provide extra fuel during acceleration. The ECM determines the amount of fuel required based upon the throttle position, the coolant temperature, the manifold pressure and the engine speed.

Deceleration Mode

When the operator retards the throttle, air flow into the engine is reduced. The ECM reads the corresponding changes in throttle position and manifold pressure. The ECM shuts OFF fuel completely if the deceleration is very rapid, or for long periods.

Battery Correction Mode

When the battery voltage is low, the ECM compensates for the weak spark delivered by the ignition system in the following ways:

- Increasing the amount of fuel delivered
- Increasing the idle RPM
- Increasing the ignition dwell time

Fuel Cutoff Mode

The ECM cuts off fuel at the fuel injectors when the following conditions are met in order to protect the engine from damage:

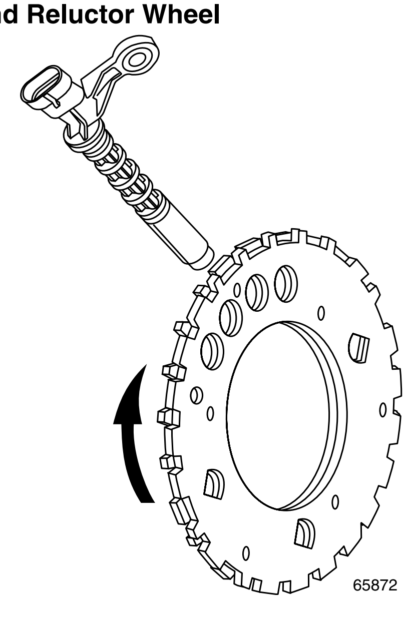
- The ignition is OFF. This prevents engine run-on.
- The ignition is ON but there is no ignition reference signal. This prevents flooding or backfiring.
- Engine speed is too high, above appropriate rev limit.

Electronic Ignition (EI) System

The ignition system consists of the following components or circuits:

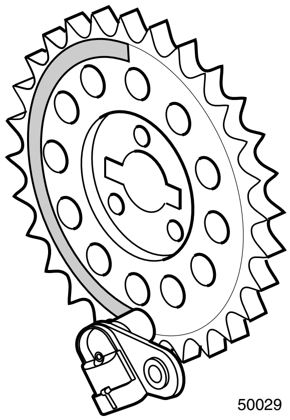
- The 8 ignition secondary wires
- The 8 ignition coils
- The 8 ignition control (IC) circuits
- The camshaft position (CMP) sensor
- The camshaft reluctor wheel
- The crankshaft position (CKP) sensor
- The crankshaft reluctor wheel
- The related connecting wires
- The engine control module (ECM)

Crankshaft Position (CKP) Sensor and Reluctor Wheel



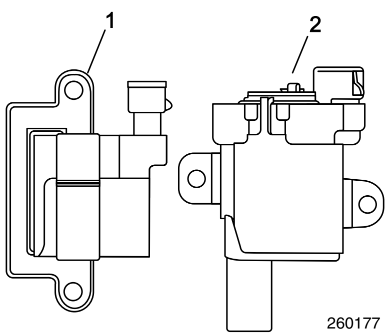
The crankshaft position (CKP) sensor is a magneto resistive type sensor. The CKP sensor works in conjunction with a 24X reluctor wheel. The reluctor wheel is mounted on the rear of the crankshaft. The 24X reluctor wheel uses 2 different width notches that are 15 degrees apart. This pulse width encoded pattern allows cylinder position identification within 90 degrees of crankshaft rotation. In some cases, this can be achieved within 45 degrees of crankshaft rotation. The reluctor wheel also has dual track notches that are 180 degrees out of phase. This design allows for quicker starts and accuracy. The CKP sensor also outputs a 4X signal for spark control, tachometer output and fuel control. All CKP signals are output as a digital waveform.

Camshaft Position (CMP) Sensor and Reluctor Wheel



The camshaft position (CMP) sensor works in conjunction with a 1X reluctor wheel mounted at the front of the camshaft. The CMP is used to determine the top dead center position of cylinder #1, and will synchronize with the 24X CKP sensor signal for quicker starting. The CMP signals are output as a digital waveform.

Ignition Coils



The ignition system on this engine features a multiple coil configuration and is known as coil near plug. There are two styles of ignition coil assemblies (1, 2). The engine could have either style. The ignition coil mounting bracket is attached to the rocker cover.

The 8 ignition coils are individually mounted above each cylinder on the rocker covers, the coils are fired sequentially. There is an ignition control (IC) circuit for each ignition coil. The 8 ignition control circuits are connected to the ECM. The ECM triggers each ignition coil individually and makes all timing decisions. The ignition coils are supplied with the following circuits:

- The ignition voltage circuit
- The ignition control circuit
- The ground circuit
- The reference low circuit

The ignition voltage circuits also supply the power for the fuel injectors. Each coil is serviced separately.

This system puts out very high ignition energy for plug firing. Less energy is lost to ignition wire resistance because the ignition wires are much shorter than in a conventional ignition system.

Circuits Affecting Ignition Control

To properly control ignition timing, the ECM relies on the following information:

- The engine load, manifold pressure or vacuum
- The atmospheric, barometric, pressure
- The engine temperature
- The manifold air temperature, if applicable
- The crankshaft position
- The engine speed (RPM)

The ignition control (IC) system consists of the following components:

- The ignition coils
- The 24X crankshaft position sensor
- The engine control module (ECM)

- All connecting wires

The ignition control utilizes the following to control spark timing functions:

- The 24X signal - The 24X crankshaft position sensor sends a signal to the ECM. The ECM uses this signal to determine crankshaft position.
- The ignition control (IC) circuits - The ECM uses these circuits to trigger the ignition coils.

Noteworthy Ignition Information

There are important considerations to point out when servicing the ignition system. The following noteworthy information will list some of these to help the technician in servicing the ignition system.

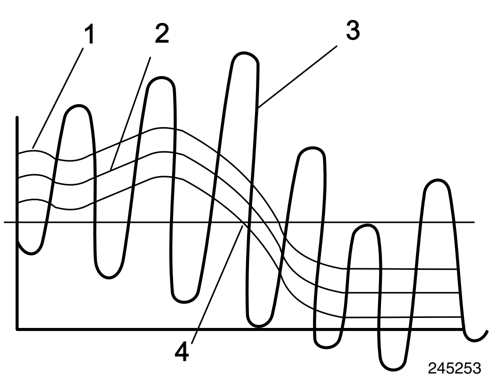
- The ignition coils secondary voltage output capabilities are very high - more than 40,000 volts. Avoid body contact with ignition high voltage secondary components when the engine is running or personal injury may result.
- The 24X crankshaft position (CKP) sensor is the most critical part of the ignition system. If the sensor is damaged so that the pulses are not generated, the engine does not start.
- The CKP sensor clearance is very important. If the interrupter ring is bent or damaged in any way, the CKP sensor may be destroyed. Extreme care must be exercised during removal and installation procedures.
- The ignition timing is not adjustable. There are no timing marks on the crankshaft balancer or the timing chain cover.
- Be careful not to damage the secondary ignition wires or boots when servicing the ignition system. Rotate each boot in order to dislodge the boot from the plug or coil tower before pulling the boot from the spark plug or the ignition coil tower.

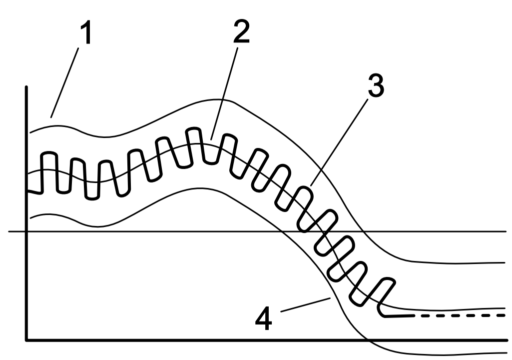
Engine Control Module (ECM)

The ECM is responsible for maintaining proper spark and fuel injection timing for all operating conditions. To provide optimum operation and emissions, the ECM monitors input signals from the additional following components in calculating ignition control (IC) spark timing:

- The engine coolant temperature (ECT) sensor
- The manifold air temperature (MAT) sensor
- The throttle position (TP) sensor

Knock Sensor (KS) System





Purpose

To control spark knock (detonation), a knock sensor (KS) system is used. This system is designed to retard spark timing when excessive spark knock is detected in the engine. The KS system allows the engine to use maximum spark advance for optimal driveability and fuel economy under all operating conditions.

Operation

The ECM uses a knock sensor(s) to detect abnormal vibration in the engine (detonation/spark knock). Mounted on the engine block, the knock sensor(s) produces an AC voltage signal at all engine speeds and loads. The ECM then adjusts the spark timing based on the amplitude and frequency of the KS signal. The ECM uses the KS signal to calculate an average voltage. Then, the ECM assigns a voltage range above and below the average voltage value. The ECM checks the KS and related wiring by comparing the actual knock signal to the assigned voltage range. A normal KS signal should vary outside the assigned voltage range as shown in the NORMAL KS figure. If the ECM detects a KS signal within the assigned voltage range as shown in the ABNORMAL KS figure, the applicable DTC will set.

6. Upper fail region
7. Knock sensor calculated average
8. Knock sensor signal
9. Lower fail region

RPM Reduction and Warnings Table

Table 1: RPM Reduction and Warnings

System	Fault	MIL	Soft Warning	Hard Warning	Power Derate	Low Rev Limit	Forced Idle	Engine Shutdown
IAT	IAT high voltage	X						
	IAT low voltage	X						
Oil Pressure	Oil pressure low (sender type)	X		X				
	Oil pressure sender high voltage	X	X					
	Oil pressure sender low voltage	X	X					
ECT	ECT high voltage	X	X					
	ECT low voltage	X						
	ECT higher than expected 1	X	X					
	ECT higher than expected 2	X		X	X			
MAP	MAP high pressure	X						
	MAP low voltage	X						
EGT	Exhaust gas temperature high (Exhaust Manifold over-heat)	X		X	X			
Baro Pressure	BP high pressure	X						
	BP low pressure	X						
Knock Sensors	Knock 1 sensor open	X						
	Knock 2 sensor open	X						
	Knock 1 excessive signal	X						
	Knock 2 excessive signal	X						
Battery Voltage	Voltage high	X	X					
	Voltage low	X	X					
5V External	5V External 1 high voltage	X	X					
	5V External 1 low voltage	X	X					
	5V External 2 high voltage	X	X					
	5V External 2 low voltage	X	X					
	5V External 1/2 simultaneous out-of-range	X		X				

Table 1: RPM Reduction and Warnings

System	Fault	MIL	Soft Warning	Hard Warning	Power Derate	Low Rev Limit	Forced Idle	Engine Shutdown
Throttle Position Sensor (TPS)	TPS1 high voltage	X		X				
	TPS1 low voltage	X		X				
	TPS2 high voltage	X		X		X	X	
	TPS2 low voltage	X		X		X	X	
	TPS1 higher than TPS2	X		X		X	X	
	TPS1 lower than TPS2	X		X		X	X	
	Unable to reach higher TPS	X		X		X	X	
	Unable to reach lower TPS	X		X		X	X	
	TPS1/2 simultaneous voltages out of range	X		X				X
Throttle Control Position Sensor (TCP)	TCP1 high voltage	X	X		X			
	TCP1 low voltage	X	X		X			
	TCP2 high voltage	X	X		X			
	TCP2 low voltage	X	X		X			
	TCP1 higher than IVS limit	X	X		X			
	TCP1 lower than IVS limit	X	X		X			
	TCP2 higher than IVS limit	X	X		X			
	TCP2 lower than IVS limit	X	X		X			
	TCP1 higher than TCP2	X	X		X			
	TCP1 lower than TCP2	X	X		X			
	“IVS stuck at-idle, TCP1/2 match”	X	X		X			
	“IVS stuck off-idle, TCP1/2 match”	X	X		X			
	TCP1/2 simultaneous voltages out of range (redundancy lost)	X		X			X	
	TCP1 invalid voltage and TCP2 disagrees with IVS (redundancy lost)	X		X			X	
	TCP2 invalid voltage and TCP1 disagrees with IVS (redundancy lost)	X		X			X	
	TCP1/2 do not match each other or the IVS (redundancy lost)	X		X			X	

Table 1: RPM Reduction and Warnings

System	Fault	MIL	Soft Warning	Hard Warning	Power Derate	Low Rev Limit	Forced Idle	Engine Shutdown
Engine Speed	Max Governor Override Speed	X						
	Engine Speed - Fuel rev limit	X						
	Engine Speed - Spark rev limit	X						
Fuel Injector Driver	Injector Driver Open	X						
	Injector Driver Shorted	X						
Fuel Pump Relay Control/ Coil	Fuel Pump relay control ground short	X						
	Fuel pump relay coil open	X						
	Fuel pump relay coil short to power	X						
Ignitiion Relay Control/ Coil	Ignition Relay control ground short	X						
	Ignition Relay coil open	X						
	Ignition Relay coil short to power	X						
Buzzer Control	Buzzer control ground short	X						
	Buzzer open	X						
	Buzzer control short to power	X						
MIL Control	MIL control ground short	X	X					
	MIL open	X	X					
	MIL control short to power	X	X					
Gauge Diagnostics	Water Temperature Gauge open / ground short	X						
	Water Temperature Gauge short to power	X						
	Oil Pressure Gauge open / ground short	X						
	Oil Pressure Gauge short to power	X						
	Trim Position Gauge open / ground short	X						
	Trim Position Gauge short to power	X						

Table 1: RPM Reduction and Warnings

System	Fault	MIL	Soft Warning	Hard Warning	Power Derate	Low Rev Limit	Forced Idle	Engine Shutdown
Cam/ Crank Sensors	Cam loss	X	X					
	Crank loss	X	X					
	Cam sync noise	X	X					
	Crank sync noise	X	X					
	Never crank synced at start	X	X					
Internal Processor Diagnostics	COP failure	X		X				
	Invalid interrupt	X		X				
	A/D loss	X		X				
	RTI 1 loss	X		X				
	Flash checksum invalid	X		X				
	RAM failure	X		X				
	RTI 2 loss	X		X				
	RTI 3 loss	X		X				
J1939 Network (EVC)	CAN address conflict failure	X						

ECM Pinout

Table 2: ECM pin function 8.1L

Pin	Function	Pin	Function	PIN	Function	PIN	Function
1	OPEN	24	CAM —	47	SHIFT INTER-RUPT	70	OPEN
2	OPEN	25	SPEED +	48	TP CONTROL	71	IGNITION RELAY
3	OPEN	26	SPEED —	49	5V EXT 2	72	OPEN
4	OPEN	27	KNOCK 1 +	50	5V RTN	73	OPEN
5	TPS 1 IN	28	KNOCK 1 —	51	OPEN	74	OPEN
6	TPS 2 IN	29	KNOCK 2 +	52	OPEN	75	OPEN
7	MAP	30	KNOCK 2 —	53	OIL PRESS IN	76	ALARM
8	OPEN	31	IGN COIL 1C	54	MASTER/ SLAVE DUAL STATION	77	OPEN
9	TCP 1 IN	32	IGN COIL 6C	55	DLC Pin 3	78	OPEN
10	TCP 2 IN	33	IGN COIL 8C	56	DLC Pin 4	79	ECM POWER
11	OPEN	34	IGN COIL 5C	57	OPEN	80	MIL
12	OPEN	35	IGN COIL 7C	58	TACH OUTPUT	81	GROUND
13	CAN TERM +	36	IGN COIL 4C	59	OPEN	82	THROTTLE MOTOR +
14	CAN1 +	37	IGN COIL 2C	60	ECM POWER	83	THROTTLE MOTOR –
15	CAN1 —	38	IGN COIL 3C	61	INJECTOR 1	84	FUEL PUMP RELAY
16	CAN2 —	39	IAT IN	62	INJECTOR 2	85	OPEN
17	CAN2 +	40	ECT IN	63	INJECTOR 3	86	TRIM GAUGE
18	CAN TERM2 +	41	EGT IN	64	INJECTOR 4	87	WATER TEMP GAUGE
19	5V EXT 1	42	MASTER/ SLAVE	65	INJECTOR 5	88	OIL PRES-SURE GAUGE
20	5V RTN	43	OPEN	66	INJECTOR 6	89	OPEN
21	CRANK +	44	OPEN	67	INJECTOR 7	90	OPEN
22	CRANK —	45	IGN RELAY	68	INJECTOR 8		
23	CAM +	46	TRIM SENDER INPUT	69	GROUND		

Section 6: On Board Repair - 8.1L

Engine Control Module (ECM)

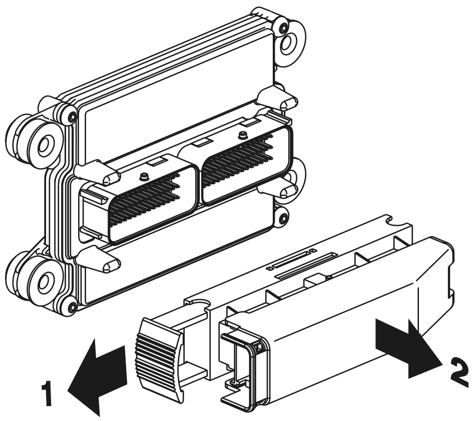
⚠ **Caution!**

When replacing the ECM, the ignition must be “OFF” and the battery disconnected before disconnecting or reconnecting the ECM connector to prevent internal damage to the ECM.

⚠ **Caution!**

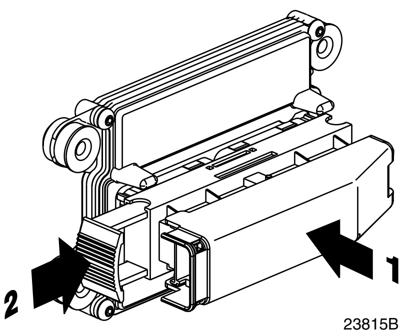
To prevent possible electrostatic discharge damage to the ECM, do not touch the connector pins. The ECM is an electrical component. Do Not soak in any liquid cleaner or solvent, as damage may result.

Removal



1. Disconnect battery power from the engine.
2. Slide the connector lock to the unlocked position (1).
3. Disconnect the connector from ECM (2).
4. Remove four ECM mounting screws.
5. Remove the ECM from mounting bracket.

Installation



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Important! Make sure the new ECM has the same part number and service number as the old ECM, to ensure proper engine performance.

1. Install the new ECM to the mounting bracket.
2. Install the four ECM mounting screws. Tighten the screw to 10-14 Nm (88-124 lb in).
3. Reconnect the connector to the ECM (2).
4. Slide the connector lock to the locked position (2)
5. Reconnect battery power to the engine.

System/Ignition Relay

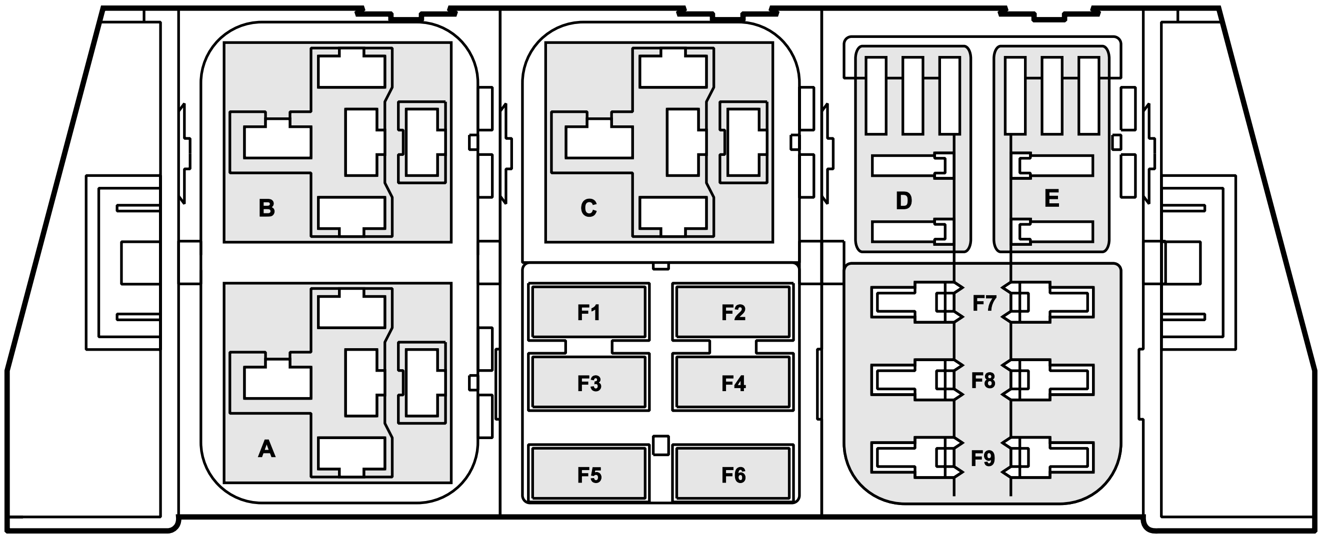


Table 1: Fuse Box

Pos	Description	Pos	Desctiption
A	Trim Down Relay	F3	20 Amp Fuse (Fuel Pump)
B	Trim Up Relay	F4	15 Amp Fuse (Ignition)
C	Starter Relay	F5	5 Amp Fuse (Vessel Switch)
D	Fuel Pump Relay	F6	10 Amp Fuse (Trim Control)
E	Ignition Relay	F7	40 Amp Fuse (Instrument Panel)
F1	15 Amp Fuse (EVC)	F8	50 Amp Circuit Breaker (Trim Pump
F2	20 Amp Fuse (ECM)	F9	20 Amp Fuse (Starter)

Removal

1. Turn the ignition OFF.
2. Open the cover.
3. Remove the system/ignition relay (E) from the socket.

⚠ **Caution! The ignition relay is an electrical component. Do Not soak in any liquid or solvent as damage may result.**

Installation

1. Install the system relay in the socket.
2. Close the cover.

Fuel Pump Relay

Removal

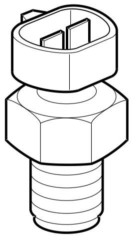
1. Turn the ignition OFF.
2. Open the cover.
3. Remove the fuel pump relay (D) from the socket.

⚠ **Caution! The fuel pump relay is an electrical component. Do Not soak in any liquid or solvent as damage may result.**

Installation

1. Install the fuel pump relay.
2. Close the cover.

Engine Coolant Temperature Sensor (ECT)



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Caution! Care must be taken when handling the ECT sensor. Damage to the sensor will affect proper operation of the EFI system.

Removal

1. Turn OFF the ignition.
2. Drain the cooling system below the level of the ECT sensor if equipped with closed cooling.
3. Disconnect the ECT electrical connector.
4. Remove the ECT sensor.

Installation

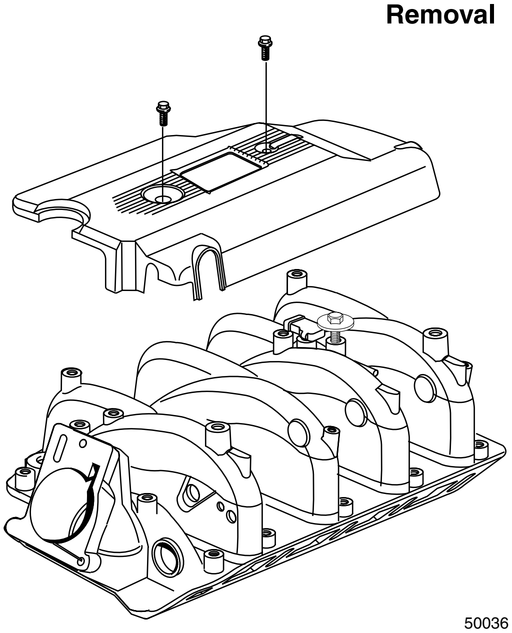
Important: Coat ECT sensor threads with Teflon® tape sealant prior to installation.

1. Install the ECT sensor. Tighten the ECT sensor to 20 Nm (15 ft. lb.)
2. Reconnect the ECT electrical connector.
3. Refill the cooling system if equipped with closed cooling.

Engine Cover

Removal

1. Turn engine OFF and remove key from ignition to prevent inadvertent starting.
2. Using a 10 mm socket and ratchet, remove the engine cover retaining screws.
3. Remove the engine cover.



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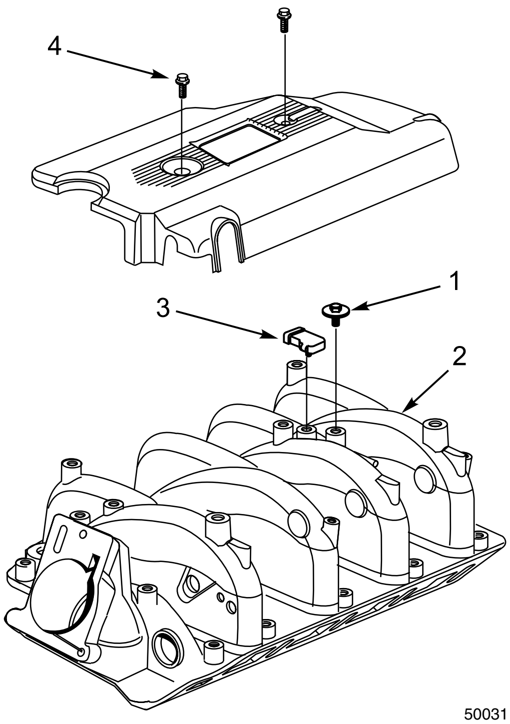
Installation

1. Place engine cover on intake manifold and align mounting holes with the engine cover.
2. Install the engine cover retaining screws.
3. Tighten the engine cover retaining screws to 6-10 Nm (53-88 in. lb.)

(MAP) Manifold Absolute Pressure



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Removal

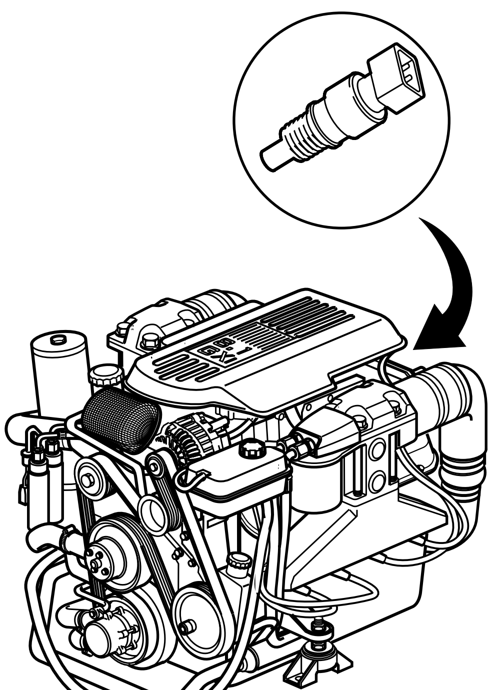
1. Loosen the fasteners (4) from the intake manifold engine cover.
2. Remove the engine cover from the intake manifold (2).
3. Disconnect the manifold absolute pressure (MAP) sensor electrical connector.
4. Remove the MAP sensor retaining bolt and washer (1).
5. Remove the MAP sensor (3) from the intake manifold (2).
6. Inspect the MAP sensor seal for wear or damage and replace as necessary.

Installation

Important! Lightly coat the MAP sensor seal with motor oil before installing the sensor. The lubricant should be applied with a sponge or brush. To prevent blockage, avoid dipping the sensor port directly into the lubricant.

1. Install the MAP sensor (3).
2. Install the MAP sensor retaining bolt and washer (1). Tighten the MAP sensor retaining bolt to 12 Nm (106 lb. in.)
3. Connect the MAP sensor electrical connector (2).
4. Install the intake manifold engine cover (1). Tighten the engine cover fastener to 10 Nm (89 lb in).

(MAT) Manifold Air Temperature Sensor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Removal

1. Disconnect the manifold air temperature (MAT) sensor electrical connector.
2. Using a 19 mm (3/4 in.) wrench, remove the MAT sensor from the rear of the intake manifold.

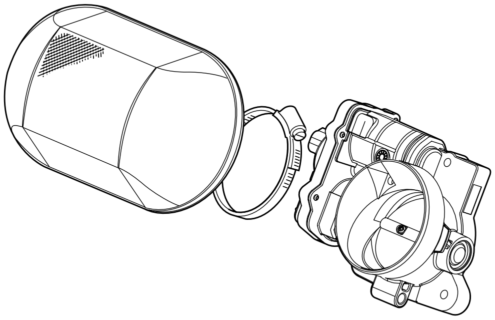
Installation

1. Coat the threads of the new MAT sensor with Volvo Penta P/N 1141570.

Caution! Do not allow sealer to cover end of sensor. This will cause inaccurate readings for the ECM, poor running engine and high fuel consumption.

2. Install sensor in the intake manifold.
3. Tighten the sensor to 40 Nm (29 ft. lb.)
4. Reconnect electrical connector.

Flame Arrestor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Removal

1. Turn ignition OFF.
2. Loosen the flame arrestor element retaining clamp.
3. Remove the flame arrestor element.

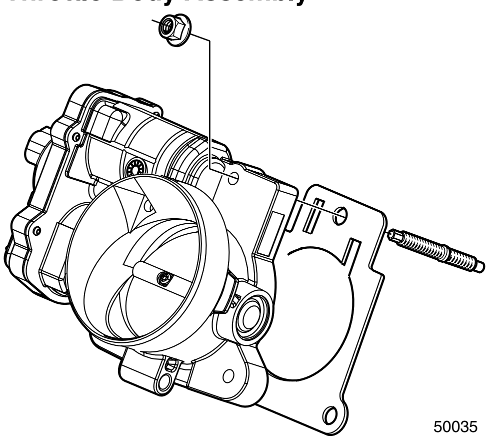
⚠ **Warning! This engine is equipped with an electronic throttle body. The throttle plate is actuated by an electric motor controlled by the ECM. Do not place fingers or any body parts in the vicinity of the throttle plate while the throttle body is energized. Sever cuts or amputation may occur.**

Important: Inspect the flame arrestor for dust, dirt or damage. Clean or Replace as required.

Installation

1. Install the flame arrestor element to the throttle body.
2. Tighten the flame arrestor retaining clamp to flame arrestor element.

Throttle Body Assembly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Removal

Warning! This engine is equipped with an electronic throttle body. The throttle plate is actuated by an electric motor controlled by the ECM. Do not place fingers or any body parts in the vicinity of the throttle plate while the throttle body is energized. Sever cuts or amputation may occur.

1. Disconnect the negative battery cable.
2. Disconnect the wiring harness connector
3. Remove the flame arrestor (if applicable).
4. Remove the throttle body assembly attaching nuts.
5. Remove the throttle body assembly and gasket.
6. Discard the gasket.

⚠ **Caution!**

None of the components on the throttle body are serviceable. If troubleshooting has indicated a component failure, replace the throttle body.

Important: Stuff a rag in the intake manifold opening to prevent foreign material from entering the engine while throttle body is removed.

Inspect

- Manifold bore for loose parts and foreign material.
- Manifold mating surface for cleanliness or burrs that could affect gasket sealing.

⚠ **Caution!**

Clean the throttle body bore using throttle body cleaner with the engine running. Take care not to spray any cleaner directly into the throttle shaft opening where the throttle shaft enters the throttle drive mechanism. Do Not use a cleaner that contains methyl ethyl ketone (MEK), an extremely strong solvent, and not necessary for this type of deposit.

⚠ **Warning!**

Safety glasses must be worn when using compressed air, as flying dirt particles may cause eye injury.

- Clean all metal parts thoroughly and blow dry with compressed air. Be sure that all fuel and air passages are free of dirt and burrs.
- Inspect the mating surfaces for damage that could affect gasket sealing.
- Inspect throttle body for cracks in casting.
- Use Loctite® 262 or equivalent when thread locking is required.

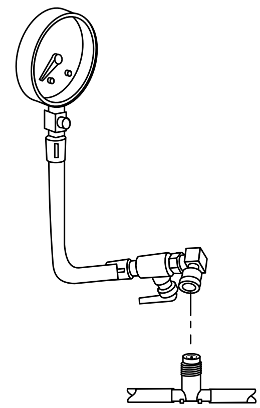
⚠ **Caution!**

When pre-coating the mounting bolts, do not use a higher strength locking compound than recommended. This may cause the removal of the bolts to be very difficult.

Installation

1. Install a new throttle body gasket.
2. Install the throttle body assembly and the throttle body assembly attaching nuts. Tighten the throttle body assembly attaching nuts to 10 Nm (89 lb in).
3. Reconnect the electrical connector.
4. Install the flame arrestor.
5. Reconnect the negative battery cable.

Fuel Pressure Relief Procedure



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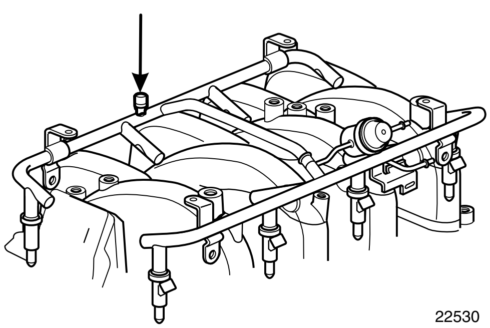
Caution!

To reduce the risk of fire and personal injury, relieve fuel system pressure before servicing fuel system components. After relieving fuel pressure, a small amount of fuel may be released when servicing fuel lines or connections. To reduce the chance of personal injury, cover fuel line fittings with a shop towel before disconnecting to catch any fuel that may leak out. Place the towel in an approved container when disconnection is completed.

The following is general information required when working on the fuel system:

- Always keep a dry chemical fire extinguisher near the work area.
- Do not replace fuel pipe with fuel hose.
- Always bleed off fuel pressure before servicing any fuel system components.
- Do not do any repairs on the fuel system until you have read the instructions and checked the figures relating the repair.
- Observe all notices and cautions.



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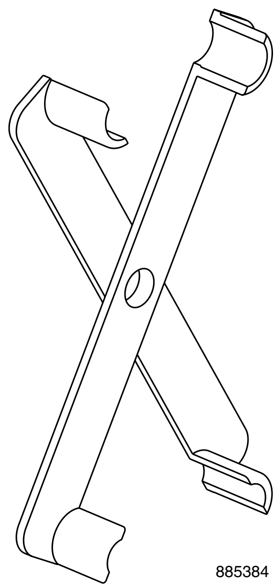
1. Turn the ignition OFF.
2. Disconnect the negative battery cable in order to avoid possible fuel discharge if an accidental attempt is made to start the engine.
3. Remove the engine cover See “Engine Cover” on page 108.
4. Connect the 3855353 fuel pressure gauge to the fuel pressure valve. Wrap a shop towel around the fitting while connecting the gauge in order to avoid spillage.
5. Install the bleed hose of the gauge into an approved container.
6. Open the valve on the gauge to bleed the system pressure. The fuel connections are now safe for servicing.
7. Drain any fuel remaining in the gauge into an approved container.

Quick Connect Fittings Service



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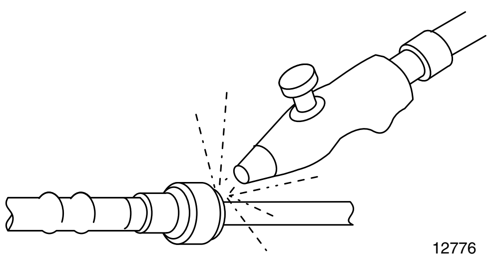
Tools Required

Volvo Penta 885384 Fuel Line Disconnect Tool

Removal

1. Relieve the fuel system pressure before servicing an fuel system connection. See “Fuel Pressure Relief Procedure” on page 112.
2. Remove the retainer from the quick-connect fitting.

⚠ **Caution! Wear safety glasses to avoid eye damage.**



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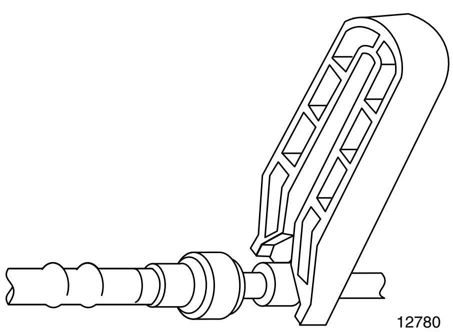
3. Blow dirt out of the fitting using compressed air.



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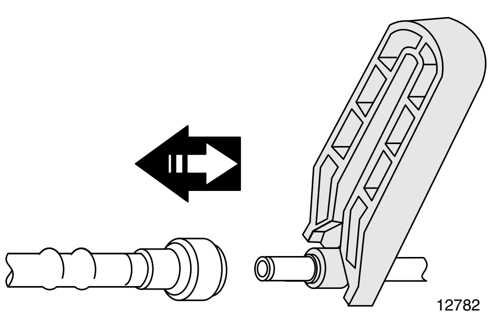
4. Using Volvo Penta 885384 Fuel Line Disconnect Tool, insert the tool into the female connector, then push inward in order to release.



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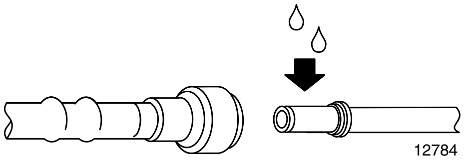
5. Pull the connection apart.
6. Use a clean shop towel in order to wipe off the male pipe end.
7. Inspect both ends of the fitting for dirt and burrs. Clean or replace the components as required.

Installation



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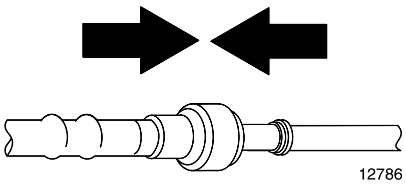
1. Apply a few drops of clean engine oil to the male pipe end.



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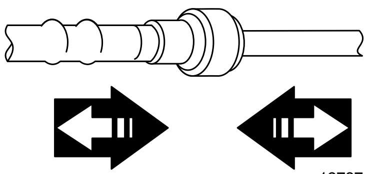
2. Push both sides of the fitting together in order to snap the retaining tabs into place.



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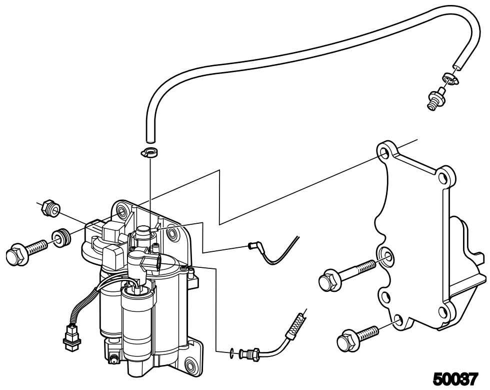
3. Once installed, pull on both sides of the fitting in order to make sure the connection is secure.
4. Install the retainer to the quick-connect fitting.

Fuel Cell



NOTE! Only the high pressure fuel pump is serviceable. The entire fuel cell must be replaced should the low pressure fuel pump fail.

Removal

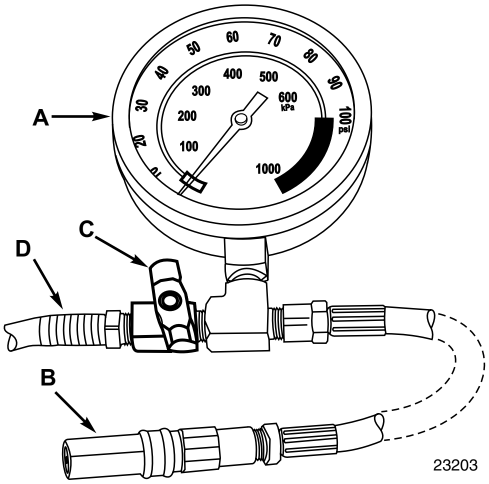
1. Disconnect negative battery cable.
2. Relieve the fuel system pressure before servicing any fuel system component. See "Fuel Pressure Relief Procedure" on page 112.
3. Clean all the fuel fitting connections and the surrounding areas before disconnecting the fuel pipes in order to avoid possible contamination of the fuel system.
4. Disconnect the threaded fittings from the fuel cell.
5. Cap the fuel pipes in order to prevent possible fuel system contamination.
6. Disconnect the fuel pump electrical connectors.
7. Disconnect the cooling lines to the fuel cell.
8. Remove the fuel filter and dispose of it in an approved manner.
9. Remove the 4 retaining screws and retain for installation on the new fuel cell.
10. Remove the fuel cell.

Installation

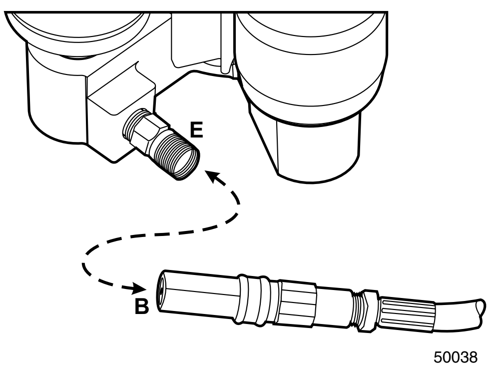
Important! Make sure to replace the fuel cell with the identical part number.

1. Install the fuel cell.
2. Reconnect the fuel pump electrical connectors.
3. Remove the caps from the fuel pipes.
4. Reconnect the threaded fittings into the fuel pump. Tighten the fittings to 25 Nm (18 ft. lb.)
5. Reconnect the cooling lines.
6. If a fuel filter does not come installed on the new fuel cell, install a new fuel filter.
7. Connect the negative battery cable.
8. Inspect for leaks.
   a. Turn the ignition ON for 5 seconds.
   b. Turn the ignition OFF for 10 seconds.
   c. Turn the ignition ON.
   d. Inspect for fuel leaks.

High Pressure Fuel Pump Replacement

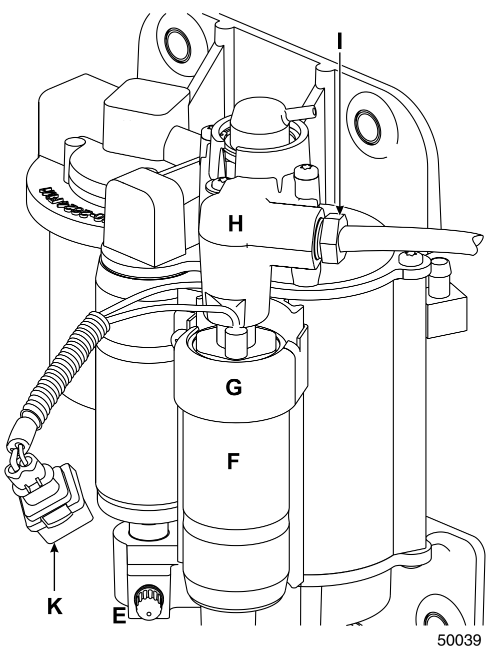


1. Disconnect the negative battery cable.
2. Relieve the fuel system pressure before servicing any fuel system component. See “Fuel Pressure Relief Procedure” on page 112.
3. Clean all the fuel fitting connections and the surrounding areas before disconnecting the fuel pipes in order to avoid possible contamination of the fuel system.
4. Use a small container or shop towel an place below the high pressure fuel pump to catch any fuel that will be spilled when the pump is removed.

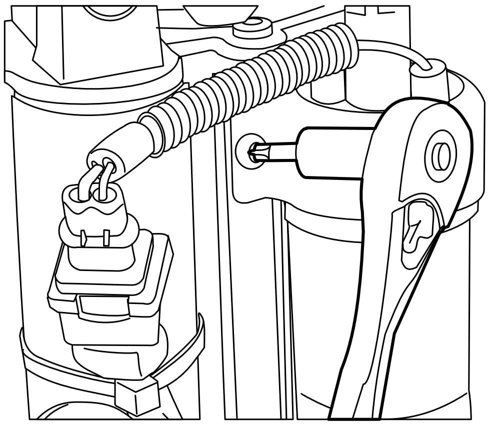


5. Using fuel pressure test kit P/N 3855533 connect hose (B) of the tester to the fuel pressure test port on the fuel cell. Open the bleed valve on the pressure tester (C) and drain the fuel cell into an approved container.

   Important! Always dispose of waste or contaminated fuel in accordance with all local regulations.



6. Disconnect the high pressure fuel pump’s electrical connector (K).
7. Disconnect the fuel line (I) using a 7/8 inch wrench to support the pump outlet (H) and a 5/8 inch wrench to disconnect the fuel line nut (I).



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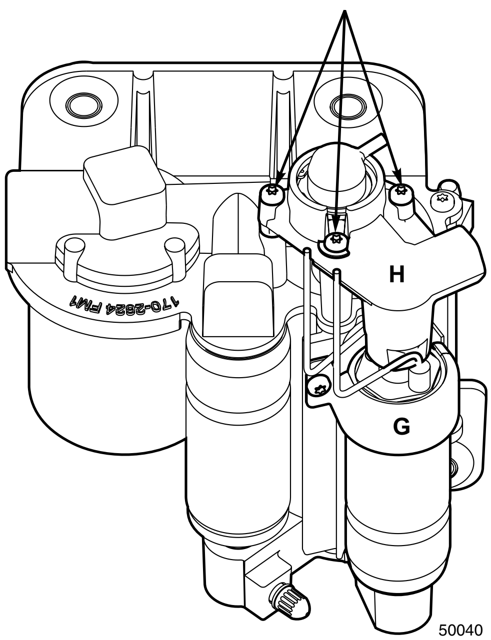
8. Using a T-20 Torx® screwdriver head in a ratchet wrench, remove the retaining bracket screw



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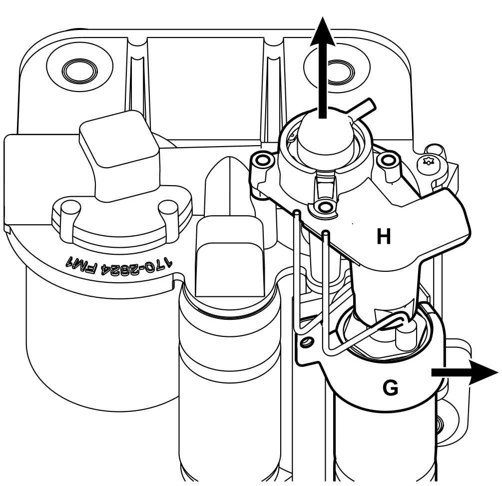
9. Using a Torx® T-20 screwdriver socket and a ratchet, remove three retaining screws holding the pressure regulator to the fuel cell.

   NOTE! Discard these screws. Use the new screws provided with the replacement pump kit.



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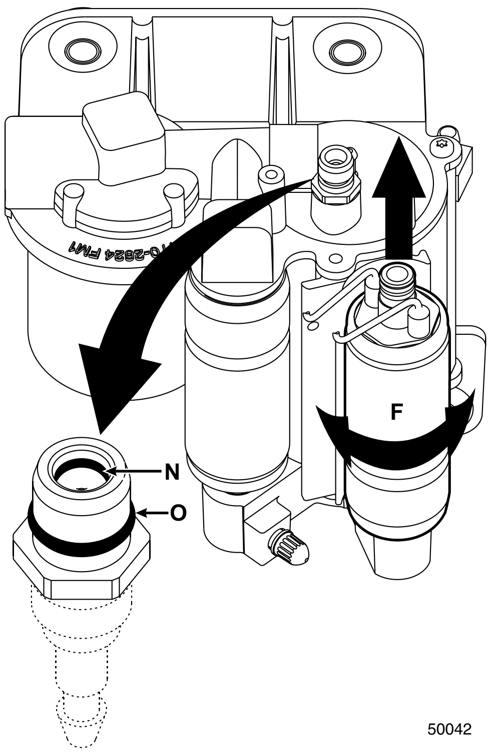
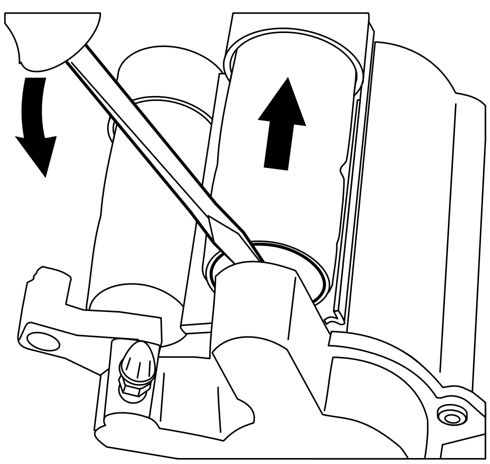
10. Remove the pressure regulator (H) and the fuel pump retaining clamp (G).



11. Remove the fuel pump. Remove the pump by twisting and pulling upward on the pump by hand.
12. Replace the O-ring (O) on the return fitting under the pressure regulator casting.

⚠ **Caution! Always use a new O-ring when a fuel component is removed.**

13. Inspect the regulator O-ring (N) without removing it. If it is damaged, the fuel pressure regulator must be replaced P/N 3861279.



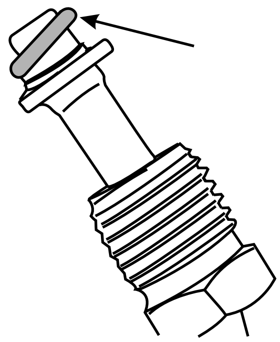
14. If you are unable to remove the fuel pump by twisting and pulling up on the fuel pump, you may use a screwdriver to CAREFULLY pry up on the fuel pump to remove it.

Installation

1. Remove the new fuel pump for its packaging and inspect the ends of the pump for damage. Be sure that the O-rings are installed. If they are not installed, use the O-rings that come with the pump.

⚠ **WARNING! Do not substitute O-rings with anything other material. Leakage may occur and cause an explosion hazard in the bilge.**

2. Place the new high pressure fuel pump onto the fuel cell housing by sliding into place. Be sure the pump is fully seated.
3. Install fuel pump clamp and install a new Torx head screw. Tighten to 5.1-6.2 Nm (45-55 in. lb.)
4. Install the pressure regulator casting using new Torx head screws. Tighten screws to 4.5-5.6 Nm (40-50 in. lb.)



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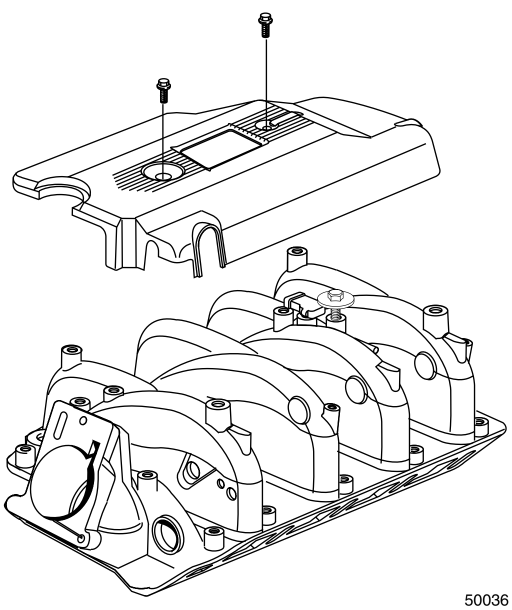
5. Install a new O-ring on the fuel line and re-attach the fuel line. Using a 7/8 in wrench to counter-hold the regulator housing, tighten the nut to 16.9-20.3 Nm (12-15 ft.lb.) with a 5/8 in wrench.
6. Reconnect the electrical connection.
7. Reconnect the negative battery cable.

⚠ **Caution! Be sure to test for leaks before running the engine.**

Fuel Rail Assembly

Removal

1. Relieve the fuel system pressure. See “Fuel Pressure Relief Procedure” on page 112.
2. Before removal, clean the fuel rail assembly with a spray type engine cleaner, if necessary. Do not soak fuel rails in liquid cleaning solvent.
3. Remove the engine cover and brackets.
4. Identify and mark the connectors to their corresponding injectors to ensure correct injector firing order after re-assembly.



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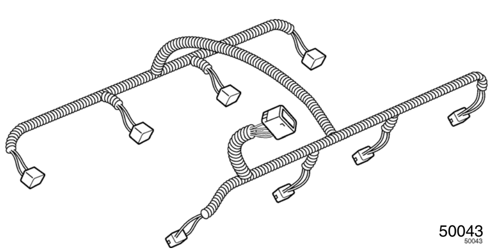
5. Identify the connectors to their corresponding injectors to ensure correct injector firing order after re-assembly.



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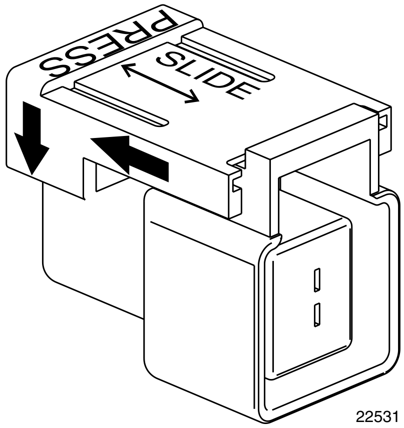

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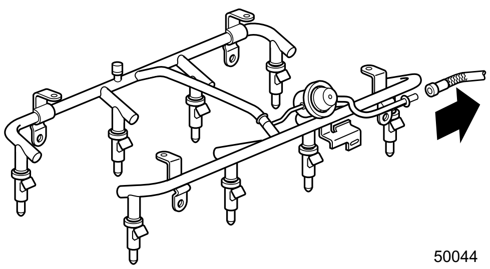
6. Pull the top portion of the injector connector up. Do not pull the top portion of the connector past the top of the white portion.
7. Push the tab labeled "*PRESS*" on the lower side of the injector connector in order to release the connector from the injector.
8. Repeat step 9 and step 10 for each injector connector.



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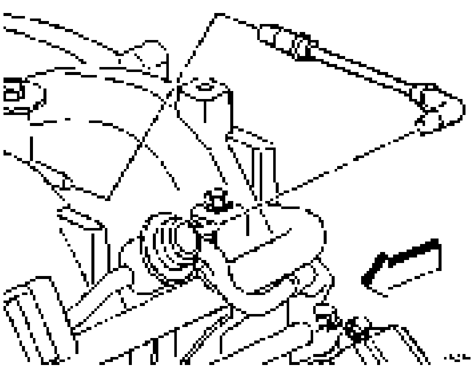
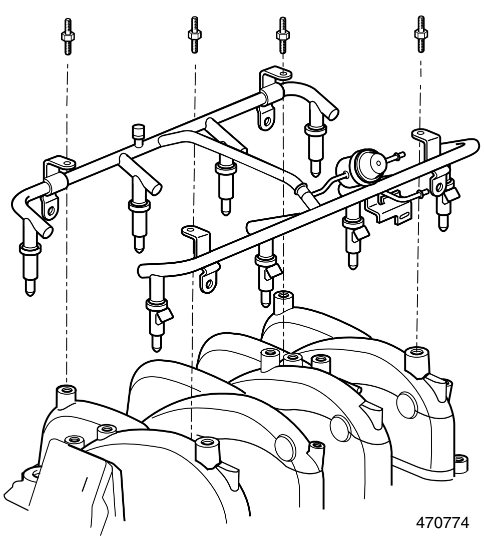
9. Disconnect the fuel feed from the fuel rail.



10. Disconnect the fuel pressure regulator vacuum line



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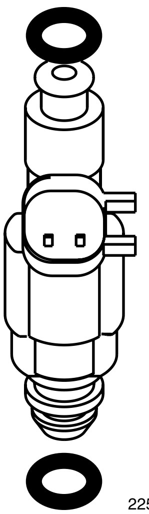
11. Remove the fuel rail attaching bolts.
12. Remove the fuel rail assembly.


22540

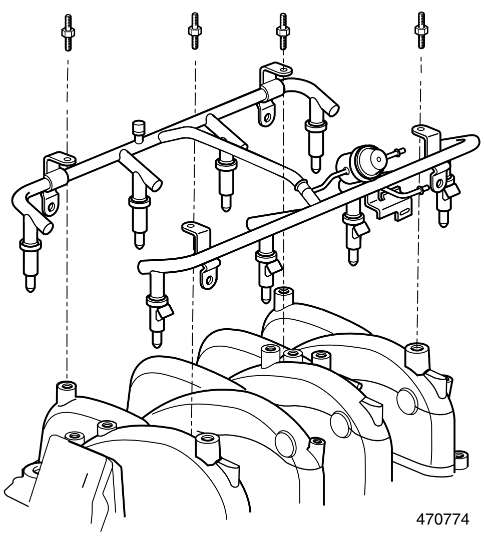
13. Remove injector lower O-ring seal (4) from the spray tip end of each injector.

Caution!

Make note of the O-ring locations. The injectors have different O-rings on top and bottom.

14. Discard the O-ring seals.

Installation

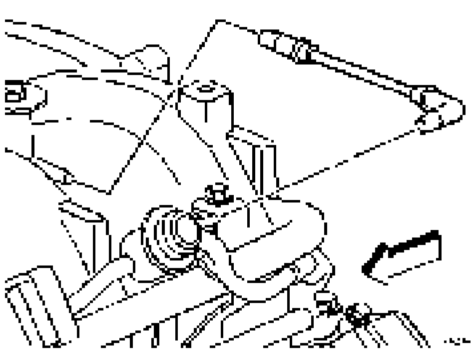

470774

1. Lubricate the new lower injector O-ring seals with clean engine oil.
2. Install the new O-ring seals on the spray tip end of each injector.

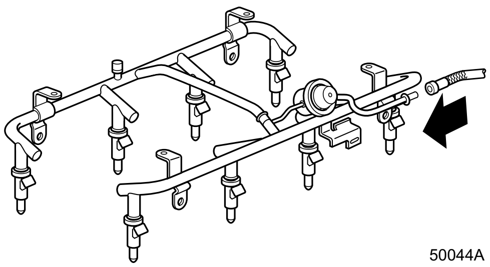
Caution!

The top and bottom o-rings are different and should not be mixed. Be sure they are used in their correct locations

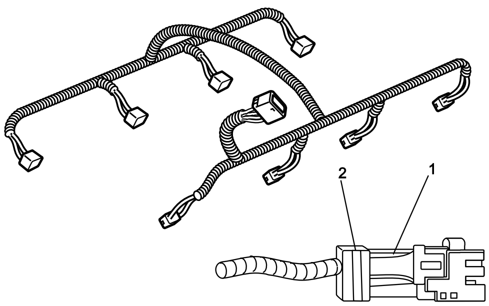
3. Install the fuel rail assembly to the intake manifold.
4. Apply a 5 mm (0.020 in) band of Volvo Penta P/N 1161053 Threadlocking compound to the threads of the fuel rail attaching bolts.
5. Install the fuel rail attaching bolts. Tighten the fuel rail attaching bolts to 12 Nm (106 lb in).



6. Connect the fuel pressure regulator vacuum line.

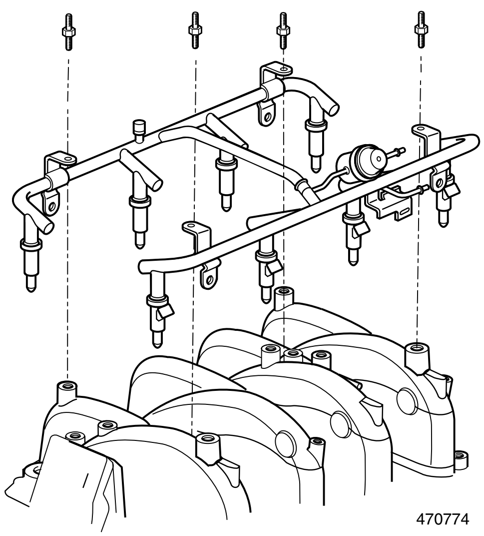

50044A

7. Connect the fuel feed line to the fuel rail.



372749

8. Connect the injector electrical connectors as follows:
   a. Install each connector on the proper injector in order to ensure correct injector firing order.
   b. Rotate the injectors as required in order to avoid stretching the wire harness.
9. Install the upper engine wire harness bracket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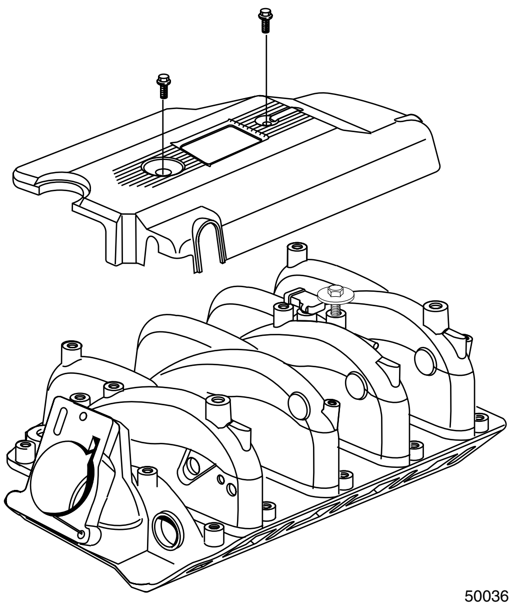
10. Install the retainer studs to the upper engine wire harness. Tighten the nut to 10 Nm (89 lb in).



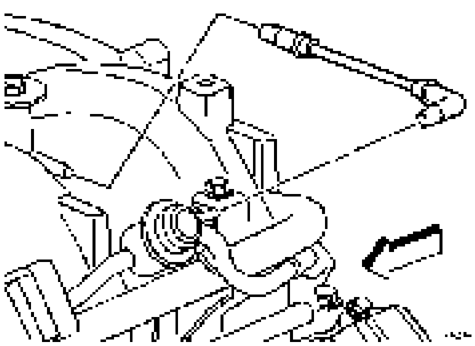
50036

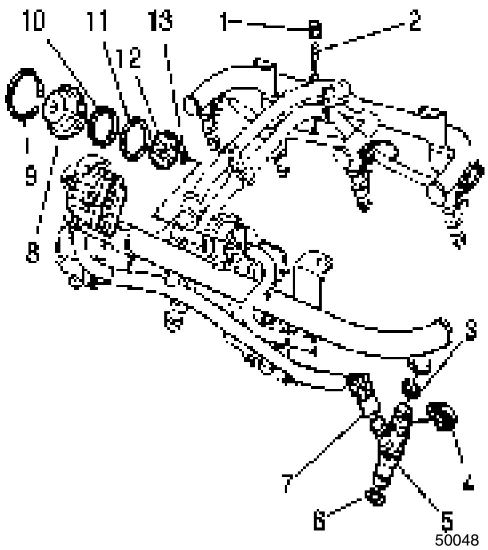
11. Install the engine cover. Tighten the bolts 10 Nm (89 lb in).
12. Connect the negative battery cable.
13. Inspect for leaks.
    a. Turn the ignition ON for 5 seconds.
    b. Turn the ignition OFF for 10 seconds.
    c. Turn the ignition ON.
    d. Inspect for fuel leaks.

Fuel Pressure Regulator

Removal

1. Relieve the fuel system pressure. Fuel Pressure Relief Procedure” on page 112.
2. Disconnect the fuel pressure regulator vacuum line.

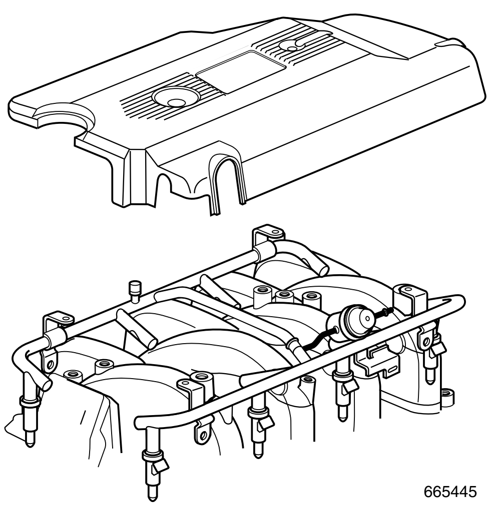




3. Clean any dirt from the fuel pressure regulator retainer and the surrounding area.
4. Remove the fuel pressure regulator retainer (9).
5. Remove the fuel pressure regulator (8) from the fuel pressure regulator housing.

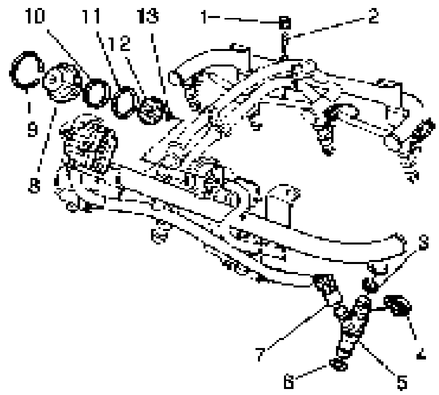
Installation

1. Install the backup ring (10) on the fuel pressure regulator (8).
2. Install the new large O-ring (11) on the fuel pressure regulator.
3. Install the regulator filter (12) on the fuel pressure regulator.
4. Install the new small O-ring (13) on the fuel pressure regulator.
5. Lubricate the fuel pressure regulator large O-ring and the small O-ring with clean engine oil.
6. Push the fuel pressure regulator into the regulator housing on the fuel rail.
7. Install a new fuel pressure regulator retainer (9).
8. Connect the fuel pressure regulator vacuum line.
9. Connect the negative battery cable.
10. Inspect for leaks.
    a. Turn the ignition ON for 5 seconds.
    b. Turn the ignition OFF for 10 seconds.
    c. Turn the ignition ON.
    d. Inspect for fuel leaks.
11. Install the engine cover.



Fuel Injector Replacement

Removal



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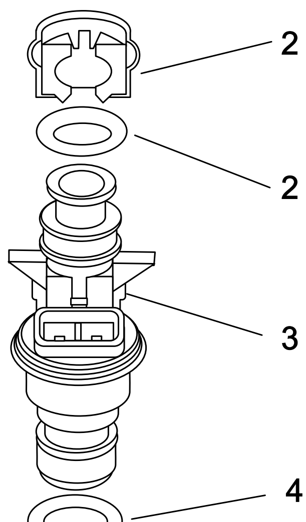
Important: The engine oil may be contaminated with fuel if the fuel injectors are leaking.

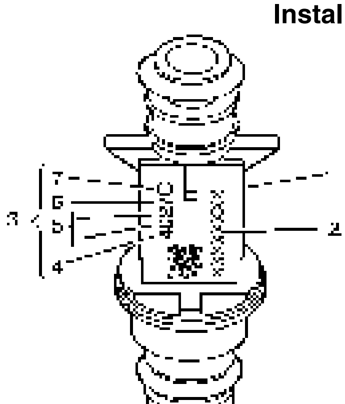
1. Remove the fuel rail assembly. Fuel Pressure Relief Procedure” on page 112.
2. Remove the injector retainer clip (4).



351185

3. Insert the fork of J 43013, the fuel injector assembly removal tool, between the fuel rail pod and the 3 protruding retaining clip ledges. Use a prying motion while inserting the tool in order to force the injector out of the fuel rail pod.
4. Discard the injector retainer clip (1).
5. Remove the injector O-ring seals (2), (4) from both ends of the injector. Discard the O-ring seals.

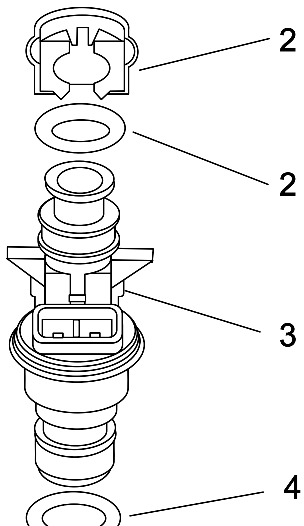
Installation



351196

Important: When ordering new fuel injectors, be sure to order the correct injector for the application being serviced.

The fuel injector assembly (1) is stamped with a part number identification (2). A four digit build date code (3) indicates the month (4), day (5), year (6) and the shift (7) that built the injector.



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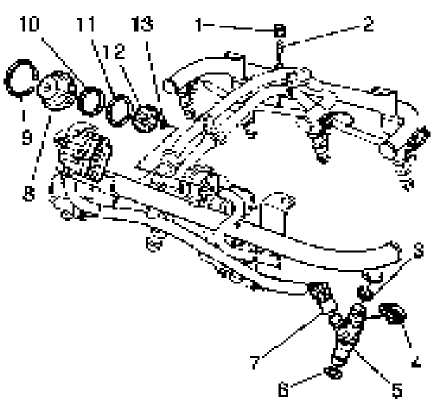
1. Lubricate the new O-ring seals (2), (4) with clean engine oil.
2. Install the new injector O-ring seals on the injector.
3. Install a new retainer clip (1) on the injector.



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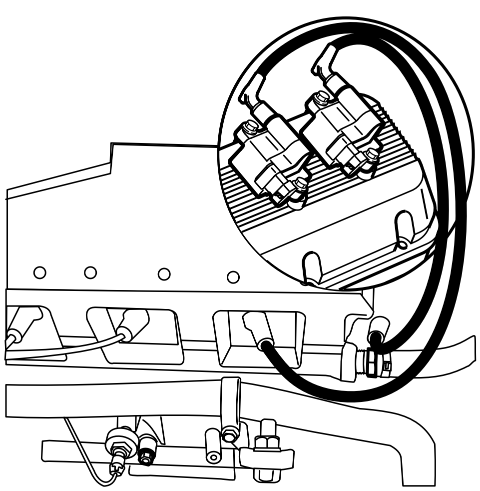
4. Push the fuel injector (5) into the fuel rail injector socket with the electrical connector facing outwards. The retainer clip (4) locks on to a flange on the fuel rail injector socket.
5. Install the fuel rail assembly. See “Fuel Rail Assembly” on page 119.

Ignition Coil(s)

Removal

1. Disconnect the spark plug wires at the ignition coils. See “Spark Plug Wire Replacement” on page 127.
2. Disconnect the ignition coil harness connector.
3. Remove the ignition coil mounting bolts.
4. Remove the ignition coil.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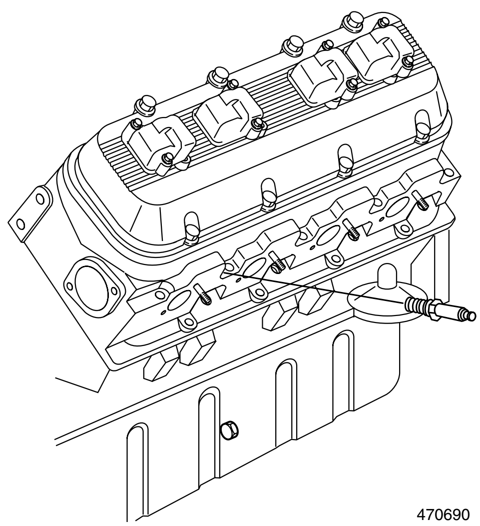
Installation

1. 1.Install the ignition coil.

2. Install the ignition coil mounting bolts. Tighten the ignition coil mounting bolts to 12 Nm (106 lb in).
3. Connect the ignition coil harness connector.
4. Connect the spark plug wires at the ignition coils. See “Spark Plug Wire Replacement” on page 127.

Spark Plug

Removal



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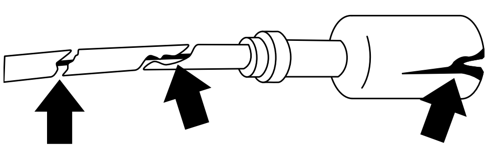
1. Remove the spark plug wires. See “Spark Plug Wire Replacement” on page 127.
2. Loosen each spark plug one or two turns.
3. Brush or air blast away any dirt from around the spark plugs.
4. Remove the spark plugs one at a time and place each plug in a tray marked with the corresponding cylinder numbers.

Installation

1. Inspect each spark plug gap. Adjust each plug gap as needed. Spark plug gap: 1.524 mm (0.060 in)
2. Install the spark plugs. Tighten the spark plugs to 20 Nm (15 ft. lb.)
3. Install the spark plug wires. See “Spark Plug Wire Replacement” on page 127.

Spark Plug Wire Inspection



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Spark plug wire integrity is vital for proper engine operation. A thorough inspection will be necessary to accurately identify conditions that may affect engine operation. Inspect for the following conditions:

1. Correct routing of the spark plug wires. Incorrect routing may cause cross-firing.
2. Any signs of cracks or splits in the wires.
3. Inspect each boot for the following conditions:
   a. Tearing
   b. Piercing
   c. Arcing
   d. Carbon tracking
   e. Corroded terminal

If corrosion, carbon tracking or arcing are indicated on a spark plug wire boot or on a terminal, replace the wire and the component connected to the wire.

Spark Plug Wire Replacement

Removal

1. Disconnect the spark plug wire at each spark plug.
   a. Twist each spark plug wire 1/2 turn.
   b. Pull only on the boot in order to remove the wire from each spark plug.
2. Disconnect the spark plug wire from each ignition coil.

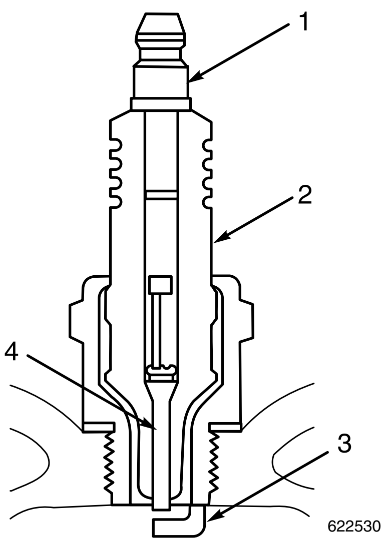
a. a) Twist each spark plug wire 1/2 turn.

b. b) Pull only on the boot in order to remove the wire from each ignition coil.

Installation

1. Install the spark plug wire at each ignition coil.
2. Install the spark plug wire at each spark plug.
3. Inspect the wires for proper installation:
   a. Push sideways on each boot in order to inspect the seating.
   b. Reinstall any loose boot.

Spark Plug Inspection



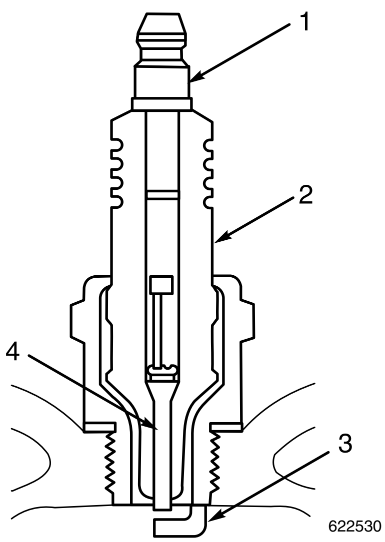
Spark Plug Usage

1. Ensure that the correct spark plug is installed. An incorrect spark plug causes driveability conditions.
2. Ensure that the spark plug has the correct heat range. An incorrect heat range causes the following conditions:
   a. Spark plug fouling - colder plug.
   b. Pre-ignition causing spark plug and/or engine damage - hotter plug.
3. Inspect the terminal post (1) for damage.
   a. Inspect for a bent or broken terminal post (1).
   b. Inspect the spark plug boot for damage.
   c. Inspect the spark plug recess area of the cylinder head for moisture, such as oil, coolant or water. A spark plug boot that is saturated causes arcing to ground.
4. Inspect the insulator (2) for cracks. All or part of the electrical charge may arc through the crack instead of the electrodes (3, 4).
5. 5.Inspect for evidence of improper arcing.
   a. Measure the gap between the center electrode (4) and the side electrode (3) terminals. An excessively wide electrode gap can prevent correct spark plug operation.
   b. Inspect for the correct spark plug torque. Insufficient torque can prevent correct spark plug operation. An over torqued spark plug may cause the insulator (2) to crack.
   c. Inspect for signs of tracking that occurred near the insulator tip instead of the center electrode (4).
   d. Inspect for a broken or worn side electrode (3).
   e. Inspect for a broken, worn or loose center electrode (4) by shaking the spark plug.
6. A rattling sound indicates internal damage.
7. A loose center electrode (4) reduces the spark intensity.
   a. Inspect for bridged electrodes (3, 4). Deposits on the electrodes (3, 4) reduce or eliminates the gap.
   b. Inspect for worn or missing platinum pads on the electrodes (3, 4), if equipped.
   c. Inspect for excessive fouling.

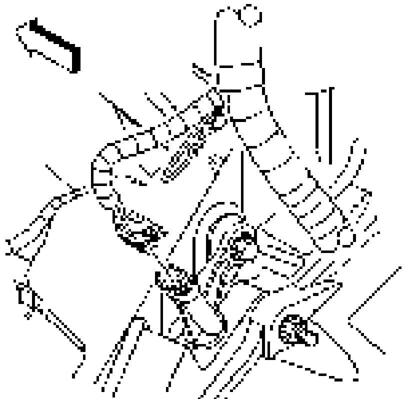
8. Inspect the spark plug recess area of the cylinder head for debris. Dirty or damaged threads can cause the spark plug not to seat correctly during installation.

Spark Plug Visual Inspection

1. Normal Operation - Brown to greyish-tan with small amounts of white powdery deposits are normal combustion by-products from fuels with additives.
2. Carbon Fouled - Dry, fluffy black carbon, or soot caused by rich fuel mixtures.
3. Leaking fuel injectors
4. Excessive fuel pressure
5. Restricted flame arrestor/air filter element
6. Incorrect combustion. Reduced ignition system voltage output.
7. Weak coil(s)
8. Worn ignition wires
9. Incorrect spark plug gap. Excessive idling or slow speeds under light loads can keep spark plug temperatures so low that normal combustion deposits may not burn off
10. Inspect for evidence of improper arcing.
    a. Measure the gap between the center electrode (4) and the side electrode (3) terminals. An excessively wide electrode gap can prevent correct spark plug operation.
    b. Inspect for the correct spark plug torque. Insufficient torque can prevent correct spark plug operation. An over torqued spark plug may cause the insulator (2) to crack.
    c. Inspect for signs of tracking that occurred near the insulator tip instead of the center electrode (4).
    d. Inspect for a broken or worn side electrode (3).
    e. Inspect for a broken, worn or loose center electrode (4) by shaking the spark plug.
11. A rattling sound indicates internal damage.
12. A loose center electrode (4) reduces the spark intensity.
    a. Inspect for bridged electrodes (3, 4). Deposits on the electrodes (3, 4) reduce or eliminates the gap.
    b. Inspect for worn or missing platinum pads on the electrodes (3, 4), if equipped.
    c. Inspect for excessive fouling.
13. Inspect the spark plug recess area of the cylinder head for debris. Dirty or damaged threads can cause the spark plug not to seat correctly during installation.



Crankshaft Position (CKP) Sensor



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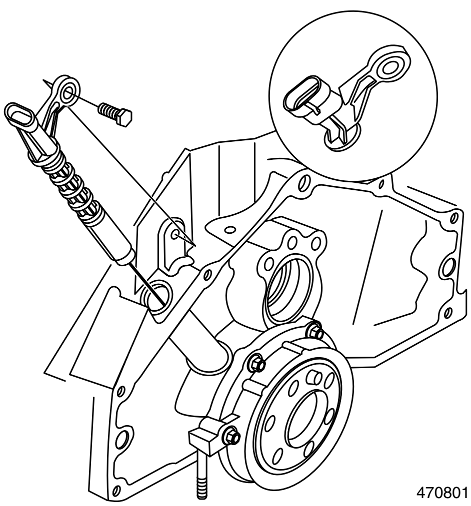
Removal

1. 1.Disconnect the crankshaft position (CKP) sensor harness connector at the CKP sensor.



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2. Remove the CKP sensor retaining bolt.
3. Remove the CKP sensor.

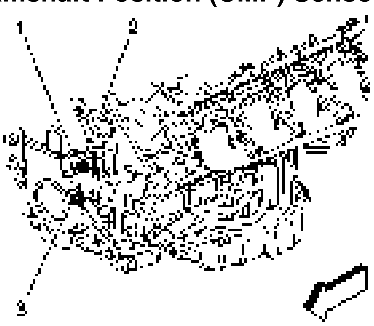
Installation

⚠ **Caution!**

Inspect the CKP sensor O-ring for wear or damage. If a problem is found, replace the O-ring. Lubricate the new O-ring with clean engine oil before installing.

1. Install the CKP sensor.
2. Install the CKP sensor retaining bolt. Tighten the bolt 10 Nm (88 lb in).
3. Connect the CKP sensor harness connector.

Camshaft Position (CMP) Sensor



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Removal

1. Disconnect the camshaft position (CMP) sensor harness connector (3) from the CMP sensor (1).
2. Remove the CMP sensor retaining bolt (2).
3. Remove the CMP sensor (1).
4. Inspect the CMP sensor for wear, cracks or leakage if the sensor is not being replaced.

Installation

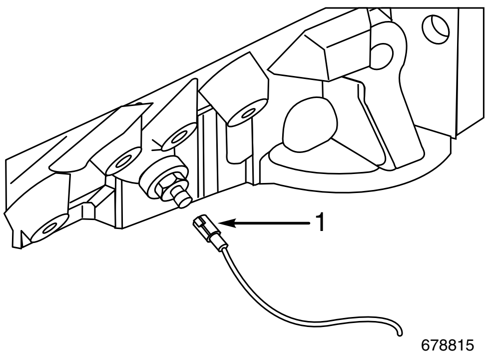
⚠ **Caution!**

Inspect the CMP sensor O-ring for wear or damage. If a problem is found, replace the O-ring. Lubricate the new O-ring with clean engine oil before installing.

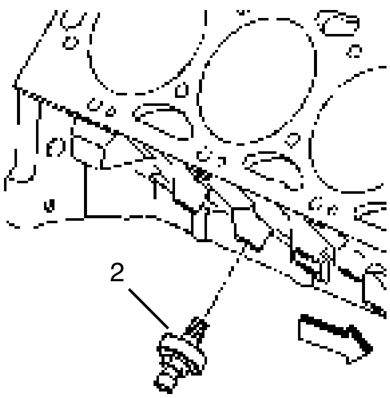
1. Install the CMP sensor (1).
2. Install the CMP sensor retaining bolt (2). Tighten the bolt 10 Nm (88 lb in).
3. Connect the CMP sensor harness connector (3).

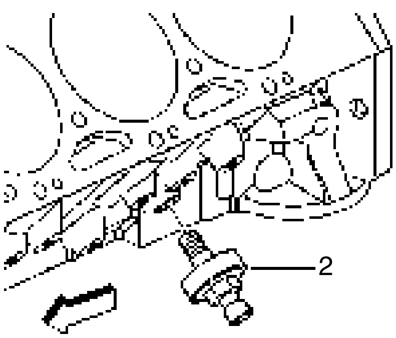
Knock Sensor (KS)

Removal



1. .Remove the wiring harness connector (1) from the knock sensor (2).





2. Remove the knock sensor (2) from the engine block. Use 7/8 inch deep socket.

Installation

1. Install the knock sensor into the engine block. Tighten the knock sensor to 19 Nm (14 ft. lb.)
2. Connect the knock sensor harness connector (1) to the knock sensor (2).

Specifications

Temperature v. Resistance IAT and ECT

°C	°F	Ohms	°C	°F	Ohms
100	212	177	25	77	2796
90	194	241	20	68	3520
80	176	332	15	59	4450
70	158	467	10	50	5670
60	140	667	5	41	7280
50	122	973	0	32	9420
45	133	1188	-5	23	12300
40	104	1459	-10	14	16180
35	95	1820	-15	5	21450
30	86	2238	-20	-4	28680
25	77	2796	-30	-22	52700
20	68	3520	-40	-40	100700

Ignition System Specifications

Application	Specifications	
	Metric	English
Firing Order	1-8-7-2-6-5-4-3	
Spark Plug Wire Resistance	5,000 Ohms/ft.	
Spark Plug Torque	15 Nm	11 ft. lb.
Spark Plug Gap	1.52 mm	
Spark Plug Type	Volvo Penta P/N 3861325	

Fastener Tightening Specifications

Application	Specifications	
	Metric	English
Camshaft Position Sensor (CMP)	10 Nm	88 in. lb.
Crankshaft Position Sensor (CKP)	10 Nm	88 in. lb
Engine Control Module (ECM) Mounting Screws	7-11 Nm	61-97in. lb
Engine Coolant Temperature Sensor (ECT)	20 Nm	15 ft. lb.
Fuel Rail Attachment Bolts	10 Nm	89 in. lb.
Ignition Coil Attachment Bolts	12 Nm	106 in. lb
Knock Sensor	19 Nm	14 ft. lb.
Throttle Body Attaching Bolts	9 Nm	80 in. lb.