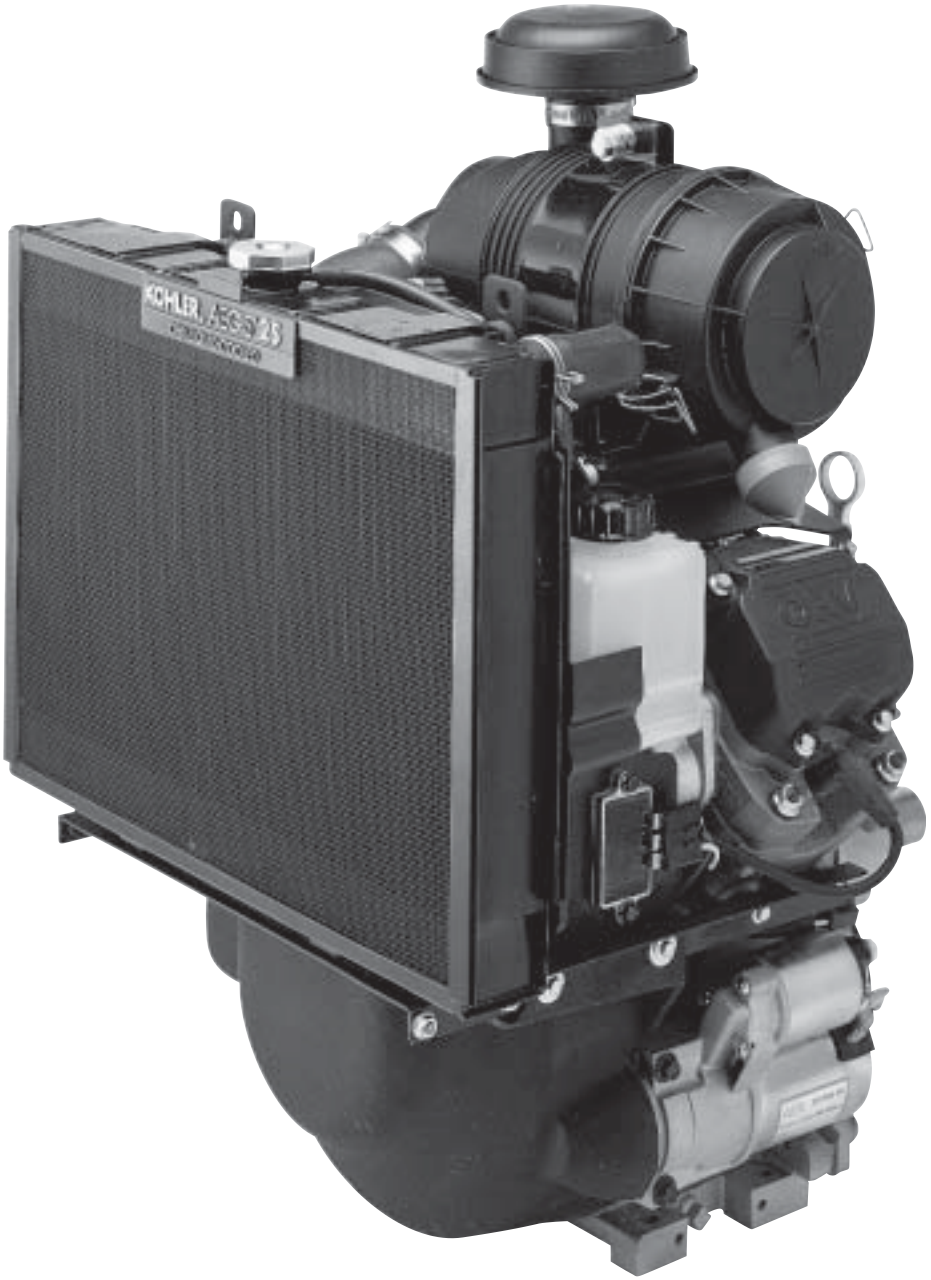
SERVICE MANUAL

KOHLER® AEGIS™ LH630-775

LIQUID-COOLED

HORIZONTAL CRANKSHAFT



KOHLER® ENGINES

Contents

Section 1
Safety and General Information

Safety Precautions

To ensure safe operations please read the following statements and understand their meaning. Also refer to your equipment manufacturer's manual for other important safety information. This manual contains safety precautions which are explained below. Please read carefully.

WARNING

Warning is used to indicate the presence of a hazard that *can* cause *severe* personal injury, death, or substantial property damage if the warning is ignored.

CAUTION

Caution is used to indicate the presence of a hazard that *will* or *can* cause *minor* personal injury or property damage if the caution is ignored.

NOTE

Note is used to notify people of installation, operation, or maintenance information that is important but not hazard-related.

For Your Safety!

These precautions should be followed at all times. Failure to follow these precautions could result in injury to yourself and others.

WARNING

Accidental Starts can cause severe injury or death.

Disconnect and ground spark plug leads before servicing.

WARNING

Rotating Parts can cause severe injury.

Stay away while engine is in operation.

WARNING

Hot Parts can cause severe burns.

Do not touch engine while operating or just after stopping.

Accidental Starts!

Disabling engine. Accidental starting can cause severe injury or death. *Before working on the engine or equipment, disable the engine as follows: 1) Disconnect the spark plug lead(s). 2) Disconnect negative (-) battery cable from battery.*

Rotating Parts!

Keep hands, feet, hair, and clothing away from all moving parts to prevent injury. Never operate the engine with covers, shrouds, or guards removed.

Hot Parts!

Engine components can get extremely hot from operation. To prevent severe burns, do not touch these areas while the engine is running - or immediately after it is turned off. Never operate the engine with heat shields or guards removed.

⚠ WARNING

Explosive Fuel can cause fires and severe burns.

Do not fill the fuel tank while the engine is hot or running.

Explosive Fuel!

Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Do not fill the fuel tank while the engine is hot or running, since spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Do not start the engine near spilled fuel. Never use gasoline as a cleaning agent.

⚠ WARNING

Cleaning Solvents can cause severe injury or death.

Use only in well ventilated areas away from ignition sources.

Flammable Solvents!

Carburetor cleaners and solvents are extremely flammable. Keep sparks, flames, and other sources of ignition away from the area. Follow the cleaner manufacturer's warnings and instructions on its proper and safe use. Never use gasoline as a cleaning agent.

⚠ WARNING

Carbon Monoxide can cause severe nausea, fainting or death.

Avoid inhaling exhaust fumes, and never run the engine in a closed building or confined area.

Lethal Exhaust Gases!

Engine exhaust gases contain poisonous carbon monoxide. Carbon monoxide is odorless, colorless, and can cause death if inhaled. Avoid inhaling exhaust fumes, and never run the engine in a closed building or confined area.

⚠ WARNING

Hot liquid can cause severe burns.

Do not loosen radiator cap while engine is operating or warm to the touch.

Hot Liquid!

The liquid coolant can get extremely hot from operation. Turning the radiator cap when the engine is hot can allow steam and scalding liquid to blow out and burn you severely.

Shut off machine. Only remove radiator cap when cool enough to touch with bare hands. Slowly loosen cap to first stop to relieve pressure before removing completely.

⚠ WARNING

Explosive Gas can cause fires and severe acid burns.

Charge battery only in a well ventilated area. Keep sources of ignition away.

Explosive Gas!

Batteries produce explosive hydrogen gas while being charged. To prevent a fire or explosion, charge batteries only in well ventilated areas. Keep sparks, open flames, and other sources of ignition away from the battery at all times. Keep batteries out of the reach of children. Remove all jewelry when servicing batteries.

Before disconnecting the negative (-) ground cable, make sure all switches are OFF. If ON, a spark will occur at the ground cable terminal which could cause an explosion if hydrogen gas or gasoline vapors are present.

⚠ CAUTION

Electrical Shock can cause injury.

Do not touch wires while engine is running.

Electrical Shock!

Never touch electrical wires or components while the engine is running. They can be sources of electrical shock.

Engine Identification Numbers

When ordering parts, or in any communication involving an engine, always give the **Model, Specification, and Serial Numbers,** including letter suffixes if there are any.

The engine identification numbers appear on a decal, or decals, affixed to the engine. The primary location is on the side of the flywheel cover. See Figure 1-1. Placement may vary due to OEM requirements and specific options involved. An explanation of these numbers is shown in Figure 1-2.

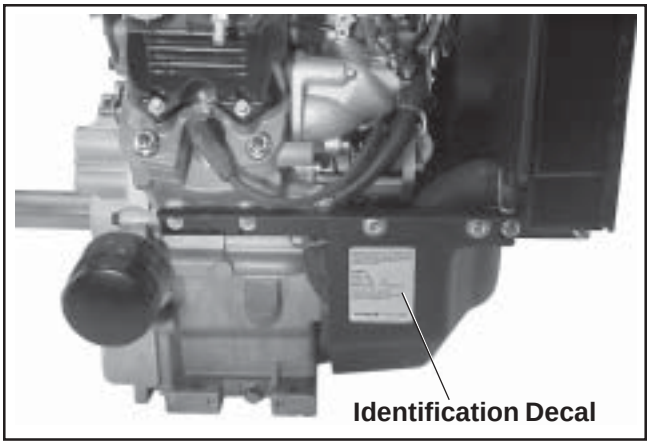


Figure 1-1. Engine Identification Decal Location.

A. Model No. — **L H 685 S**

- **Liquid Cooled**
- **Horizontal Crankshaft**
- **Numerical Designation**
- **Version Code**: S = Electric Start

B. Spec. No. — **LH685-0001**

Complete Spec. Number (Incorporating Model No. with Variation No. of Basic Spec.)

Model		
LH630-0001	LH750-0001	
LH640-0001	LH755-0001	
LH685-0001	LH760-0001	
LH690-0001	LH775-0001	

C. Serial No. — **31 05810334**

- **Year Manufactured Code**
- **Factory Code**

Code	Year
31	2001
32	2002
33	2003
34	2004
35	2005
36	2006
37	2007

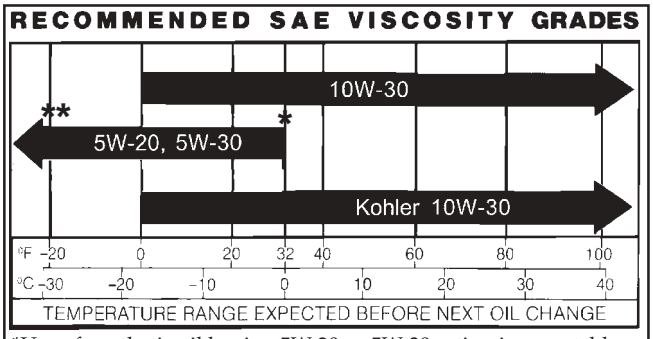
Figure 1-2. Explanation of Engine Identification Numbers.

Oil Recommendations

Using the proper type and weight of oil in the crankcase is extremely important. So is checking oil daily and changing oil regularly. Failure to use the correct oil, or using dirty oil, causes premature engine wear and failure.

Oil Type

Use high-quality detergent oil of **API (American Petroleum Institute) Service Class SG, SH, SJ or higher**. Select the viscosity based on the air temperature at the time of operation as shown in the following table.



*Use of synthetic oil having 5W-20 or 5W-30 rating is acceptable, up to 4°C (40°F).
**Synthetic oils will provide better starting in extreme cold below 23°C (-10°F).

NOTE: Using other than service class SG, SH, SJ or higher oil or extending oil change intervals longer than recommended can cause engine damage.

NOTE: Synthetic oils meeting the listed classifications may be used with oil changes performed at the recommended intervals. However to allow piston rings to properly seat, a new or rebuilt engine should be operated for at least 50 hours using standard petroleum based oil before switching to synthetic oil.

A logo or symbol on oil containers identifies the API service class and SAE viscosity grade. See Figure 1-3.

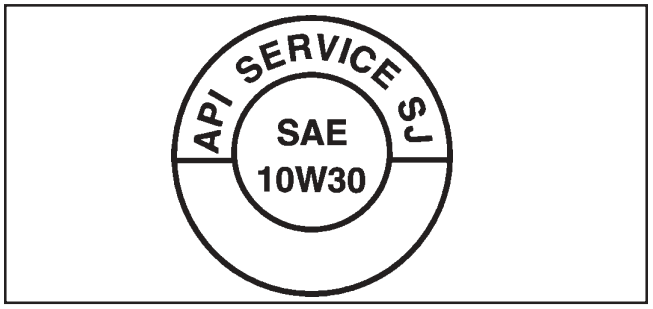


Figure 1-3. Oil Container Logo.

Refer to Section 6 - "Lubrication System" for detailed procedures on checking the oil, changing the oil and changing the oil filter.

Coolant Recommendations

Use equal parts of ethylene glycol and water only. Distilled or deionized water is recommended, especially in areas where the water contains a high mineral content. Propylene glycol based antifreeze is not recommended.

This mixture will provide protection from -37°C (-34°F) to 108°C (226°F). For protection and use outside the indicated temperature limits, follow the antifreeze manufacturer's instructions on the container, but do not exceed 70% antifreeze.

DO NOT use antifreeze with stop-leak additive(s), or put any other additives in the cooling system.

Fuel Recommendations

WARNING: Explosive Fuel!

Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Do not fill the fuel tank while the engine is hot or running, since spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Do not start the engine near spilled fuel. Never use gasoline as a cleaning agent.

General Recommendations

Purchase gasoline in small quantities and store in clean, approved containers. A container with a capacity of 2 gallons or less with a pouring spout is recommended. Such a container is easier to handle and helps eliminate spillage during refueling.

Do not use gasoline left over from the previous season, to minimize gum deposits in your fuel system and to ensure easy starting.

Do not add oil to the gasoline.

Do not overfill the fuel tank. Leave room for the fuel to expand.

Fuel Type

For best results, use only clean, fresh, unleaded gasoline with a pump sticker octane rating of 87 or higher. In countries using the Research method, it should be 90 octane minimum.

Unleaded gasoline is recommended as it leaves less combustion chamber deposits and reduces harmful exhaust emissions. Leaded gasoline is not recommended and **must not** be used on EFI engines, or on other models where exhaust emissions are regulated.

Gasoline/Alcohol blends

Gasohol (up to 10% ethyl alcohol, 90% unleaded gasoline by volume) is approved as a fuel for Kohler engines. Other gasoline/alcohol blends are not approved.

Gasoline/Ether blends

Methyl Tertiary Butyl Ether (MTBE) and unleaded gasoline blends (up to a maximum of 15% MTBE by volume) are approved as a fuel for Kohler engines. Other gasoline/ether blends are not approved.

Periodic Maintenance

WARNING: Accidental Starts!

Disabling engine. Accidental starting can cause severe injury or death. *Before working on the engine or equipment, disable the engine as follows: 1) Disconnect the spark plug lead(s). 2) Disconnect negative (-) battery cable from battery.*

Maintenance Schedule

These required maintenance procedures should be performed at the frequency stated in the table. They should also be included as part of any seasonal tune-up.

Frequency	Maintenance Required	Refer to:
Daily or Before Starting Engine	• Fill fuel tank. • Check oil level. • Check coolant level. • Check air cleaner for dirty[1], Loose, or damaged parts. • Check the screen, radiator, and cooling areas, clean as necessary[1].	Section 5 Section 6 Section 7 Section 4 Section 7
Every 100 Hours	• Clean and check cooling areas[1].	Section 7
Annually or Every 200 Hours	• Change oil and oil filter (more frequently under severe conditions). • Check spark plug condition and gap. • Change fuel filter (carbureted models).	Section 6 Section 5 Section 8
Every 250 Hours	• Replace air cleaner element and check inner element[1].	Section 4
Annually or Every 500 Hours	• Replace spark plugs.	Section 8
Every 2 Years or Every 1000 Hours	• Change engine coolant.	Section 7
Every 1500 Hours	• Replace fuel filter[1] (EFI engines).	Section 5B

[1]*Perform these maintenance procedures more frequently under extremely dusty, dirty conditions.*

Storage

If the engine will be out of service for two months or more, use the following storage procedure:

1. Clean the exterior surfaces of the radiator and engine. On EFI engines, avoid spraying water at the wiring harness or any of the electrical components.

2. Change the oil and filter while the engine is still warm from operation. See “Change Oil and Filter” in Section 6.

3. The coolant (anti-freeze) mixture should be in good condition and tested to guard against freezing in cold temperatures. The recommended 50/50 mixture will normally provide protection down to temperatures of -37°C (-34°F). If storage temperatures will fall below this, the cooling system should be drained completely. A note should then be attached to the equipment and/or engine as a reminder to refill the cooling system before starting.

4. The fuel system must be completely emptied, or the gasoline must be treated with a stabilizer to prevent deterioration. If you choose to use a stabilizer, follow the manufacturers recommendations, and add the correct amount for the capacity of the fuel system. Fill the fuel tank with clean, fresh gasoline. Run the engine for 2-3 minutes to get stabilized fuel into the carburetor. Close fuel shut-off valve when unit is being stored or transported.

   To empty the system, run the engine until the tank and system are empty.

5. Remove the spark plugs. Add one tablespoon of engine oil into each spark plug hole. Install plugs, but do not connect the plug leads. Crank the engine two or three revolutions.

6. On units with EFI engines, disconnect the negative (-) battery cable or use a "battery minder" trickle charger while the unit is in storage.

7. Store the engine in a clean, dry place.

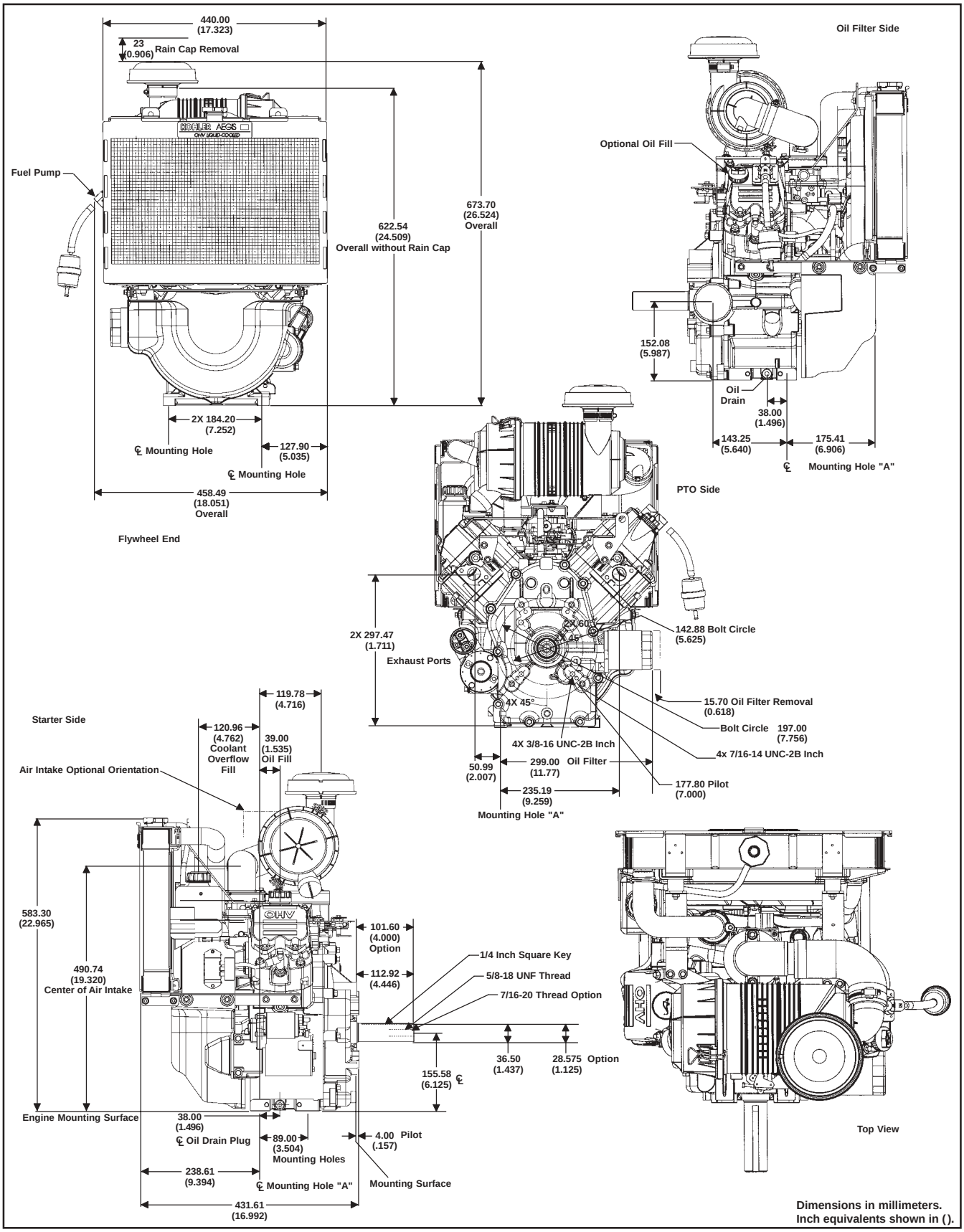


Figure 1-4. Typical Engine Dimensions.

General Specifications[1]

Power (@3600 RPM, exceeds Society of Automotive Engineers-Small Engine Test Code J1940.)

LH630	Maximum	16.4 kW (22 HP)
	Recommended	13.9 kW (18.7 HP)
LH640	Maximum	17.9 kW (24 HP)
	Recommended	15.2 kW (20.4 HP)
LH685	Maximum	18.6 kW (25 HP)
	Recommended	15.9 kW (21.3 HP)
LH690	Maximum	19.4 kW (26 HP)
	Recommended	16.5 kW (22.1 HP)
LH750	Maximum	20.1 kW (27 HP)
	Recommended	17.1 kW (22.9 HP)
LH755	Maximum	20.9 kW (28 HP)
	Recommended	17.7 kW (23.8 HP)
LH760	Maximum	21.6 kW (29 HP)
	Recommended	18.4 kW (24.7 HP)
LH775	Maximum	23.1 kW (31 HP)
	Recommended	19.7 kW (26.4 HP)

Peak Torque

LH630 @ 2200 RPM	48.0 N·m (35.4 ft. lb.)
LH640 @ 2400 RPM	51.9 N·m (38.3 ft. lb.)
LH685 @ 2200 RPM	54.3 N·m (40.1 ft. lb.)
LH690 @ 2400 RPM	58.1 N·m (42.9 ft. lb.)
LH750 @ 2200 RPM	61.0 N·m (45 ft. lb.)
LH755 @ 2800 RPM	61.5 N·m (45.4 ft. lb.)
LH760 @ 2600 RPM	61.7 N·m (45.5 ft. lb.)
LH775 @ 2400 RPM	64.6 N·m (47.7 ft. lb.)

Bore

LH630,LH640	77 mm (3.03 in.)
LH685,LH690	80 mm (3.15 in.)
LH750,LH755,LH760,LH775	83 mm (3.3 in.)

Stroke

LH630,LH640,LH685,LH690	67 mm (2.64 in.)
LH750,LH755,LH760,LH775	69 mm (2.7 in.)

Displacement

LH630,LH640	624 cc (38.1 cu. in.)
LH685,LH690	674 cc (41.1 cu. in.)
LH750,LH755,LH760,LH775	747 cc (45.6 cu. in.)

[1]Values are in Metric units. Values in parentheses are English equivalents. Lubricate threads with engine oil prior to assembly.

NOTE: All listed dimensions and tolerances are measured at 20°C (68°F).

General Specifications[1] cont.

Compression Ratio
- LH630,LH640,LH685,LH690 ..... 8.5:1
- LH750,LH755,LH760,LH775 ..... 8.7:1

Dry Weight
- LH630,LH640,LH685,LH690,LH755 ..... 51.7 kg (114 lb.)
- LH760,LH775 ..... 52.6 kg (116 lb.)

Oil Capacity (w/filter) - approximate,
determined by oil filter used: ..... 1.6-1.8 L (1.7-1.9 U.S. qt.)

Coolant Capacity (equal parts of water and ethylene glycol) ..... 2.0 L (2.18 U.S. qt.)

Angle of Operation - Maximum (At Full Oil Level) All Directions ..... 20°

Camshaft

End Play (With Shim) ..... 0.076/0.127 mm (0.0030/0.0050 in.)

Running Clearance ..... 0.025/0.063 mm (0.0010/0.0025 in.)

Bore I.D.
- New ..... 20.000/20.025 mm (0.7874/0.7884 in.)
- Max. Wear Limit ..... 20.038 mm (0.7889 in.)

Camshaft Bearing Surface O.D.
- New ..... 19.962/19.975 mm (0.7859/0.7864 in.)
- Max. Wear Limit ..... 19.959 mm (0.7858 in.)

Carburetor and Intake Manifold

Intake Manifold Fastener Torque (torque in 2 increments) ..... first to 7.4 N·m (66 in. lb.)
finally to 9.9 N·m (88 in. lb.)

Thermostat Housing Mounting Fastener Torque ..... 6.2-7.3 N·m (55-65 in. lb.)

Carburetor Mounting Fastener Torque ..... 9.9 N·m (88 in. lb.)

Connecting Rod

Cap Fastener Torque (torque in increments) ..... 11.3 N·m (100 in. lb.)

Connecting Rod-to-Crankpin Running Clearance
- New ..... 0.043/0.068 mm (0.0016/0.0026 in.)
- Max. Wear Limit ..... 0.083 mm (0.0032 in.)

Connecting Rod-to-Crankpin Side Clearance ..... 0.26/0.63 mm (0.0102/0.0248 in.)

Connecting Rod-to-Piston Pin Running Clearance ..... 0.015/0.028 mm (0.0006/0.0011 in.)

Piston Pin End I.D.
- New ..... 17.015/17.023 mm (0.6699/0.6702 in.)
- Max. Wear Limit ..... 17.036 mm (0.6707 in.)

[1]Values are in Metric units. Values in parentheses are English equivalents. Lubricate threads with engine oil prior to assembly.

Crankcase

Governor Cross Shaft Bore I.D.
- New ..... 8.025/8.075 mm (0.3159/0.3179 in.)
- Max. Wear Limit ..... 8.088 mm (0.3184 in.)

Breather Cover Fastener Torque ..... 10.7 N·m (95 in. lb.) into new hole
7.3 N·m (65 in. lb.) into used hole

Oil Drain Plug Torque ..... 13.6 N·m (10 ft. lb.)

Closure Plate

Closure Plate Fastener Torque ..... 24.4 N·m (216 in. lb.)

Crankshaft

End Play (free) ..... 0.070/0.590 mm (0.0028/0.0230 in.)

Crankshaft Sleeve Bearing I.D. (crankcase)
- New ..... 40.974/40.987 mm (1.6131/1.6136 in.)
- Max. Wear Limit ..... 41.000 mm (1.6141 in.)

Crankshaft Bore (in closure plate)
- New ..... 40.974/41.000 mm (1.6131/1.6141 in.)
- Max. Wear Limit ..... 41.038 mm (1.6156 in.)

Crankshaft Bore (in closure plate)-to-Crankshaft
- Running Clearance - New ..... 0.039/0.087 mm (0.0015/0.0034 in.)

Main Bearing Journals
- O.D. - New ..... 40.913/40.935 mm (1.6107/1.6116 in.)
- O.D. - Max. Wear Limit ..... 40.84 mm (1.608 in.)
- Max. Taper ..... 0.022 mm (0.0009 in.)
- Max. Out-of-Round ..... 0.025 mm (0.0010 in.)

Crankshaft to Sleeve Bearing (crankcase)
- Running Clearance - New ..... 0.039/0.074 mm (0.0015/0.0029 in.)

Connecting Rod Journal
- O.D. - New ..... 35.955/35.973 mm (1.4156/1.4163 in.)
- O.D. - Max. Wear Limit ..... 35.94 mm (1.415 in.)
- Max. Taper ..... 0.018 mm (0.0007 in.)
- Max. Out-of-Round ..... 0.025 mm (0.0010 in.)

Crankshaft T.I.R.
- PTO End, Crank in Engine ..... 0.15 mm (0.0059 in.)
- Entire Crank, in V-Blocks ..... 0.10 mm (0.0039 in.)

Cylinder Bore

Cylinder Bore I.D.
- New
  - LH630,LH640 ..... 77.000/77.025 mm (3.0315/3.0325 in.)
  - LH685,LH690 ..... 80.000/80.025 mm (3.1496/3.1506 in.)
  - LH750,LH755,LH760,LH775 ..... 83.006/83.031 mm (3.2679/3.2689 in.)

Cylinder Bore cont.

Max. Wear Limit
- LH630,LH640 ..... 77.063 mm (3.0340 in.)
- LH685,LH690 ..... 80.065 mm (3.1522 in.)
- LH750,LH755,LH760,LH775 ..... 83.069 mm (3.2704 in.)

Max. Out-of-Round ..... 0.12 mm (0.0047 in.)

Max. Taper ..... 0.05 mm (0.0020 in.)

Cylinder Head

Cylinder Head Fastener Torque (torque in 2 increments) ..... first to 16.9 N·m (150 in. lb.)
finally to 33.9 N·m (300 in. lb.)

Max. Out-of-Flatness ..... 0.076 mm (0.003 in.)

Rocker Pivot Fastener Torque ..... 11.3 N·m (100 in. lb.)

Electric Starter

Starter Thru Bolt Torque ..... 5.6-9.0 N·m (49-79 in. lb.)

Starter Mounting Screw Torque ..... 15.3 N·m (135 in. lb.)

Starter Brush Holder Fastener Torque ..... 2.5-3.3 N·m (22-29 in. lb.)

Starter Solenoid Fastener Torque ..... 4.0-6.0 N·m (35-53 in. lb.)

Starter Solenoid Positive (+) Brush Lead Retaining Nut Torque ..... 8.0-11.0 N·m (71-97 in. lb.)

Fan/Flywheel

Rear Fan Shaft to Mounting Bracket Nut Torque ..... 15.8 N·m (140 in. lb.)

Front Fan Assembly to Fan Shaft Nut Toque ..... 15.8 N·m (140 in. lb.)

Fan/Pulley/Hub Assembly Fastener Torque ..... 6.8 N·m (60 in. lb.)

Flywheel Retaining Screw Torque ..... 66.4 N·m (49 ft. lb.)

Lower Flywheel Cover Mounting Screw Torque ..... into hex or weld nuts 9.9 N·m (88 in. lb.)
into Timmerman clips/nuts 2.2-2.8 N·m (20-25 in. lb.)

Lower Pulley Mounting Screw Torque ..... 24.3 N·m (215 in. lb.)

Governor

Governor Cross Shaft to Crankcase Running Clearance ..... 0.025/0.126 mm (0.0009/0.0049 in.)

Governor Cross Shaft O.D.
- New ..... 7.949/8.000 mm (0.3129/0.3149 in.)
- Max. Wear Limit ..... 7.936 mm (0.3124 in.)

Governor Gear Shaft O.D.
- New ..... 5.990/6.000 mm (0.2358/0.2362 in.)
- Max. Wear Limit ..... 5.977 mm (0.2353 in.)

Governor Gear Shaft-to-Governor Gear Running Clearance ..... 0.090/0.160 mm (0.0035/0.0063 in.)

Governor Lever Nut Torque ..... 6.8 N·m (60 in. lb.)

Ignition

Spark Plug Type (Champion® or equivalent)	RC14YC
Spark Plug Gap	0.76 mm (0.030 in.)
Spark Plug Torque	24.4-29.8 N·m (18-22 ft. lb.)
Ignition Module Air Gap	0.203/0.305 mm (0.008/0.012 in.)
Ignition Module Fastener Torque	6.2 N·m (55 in. lb.) into new hole 4.0 N·m (35 in. lb.) into used hole
Rectifier-Regulator Fastener Torque	4.0 N·m (35 in. lb.)

Muffler

Muffler Retaining Nuts Torque	24.4 N·m (216 in. lb.)

Oil Filter

Oil Filter Torque	3/4-1 turn after gasket contact

Piston, Piston Rings, and Piston Pin

Piston-to-Piston Pin	0.006/0.018 mm (0.0002/0.0007 in.)
Piston Pin Bore I.D.	
New	17.006/17.013 mm (0.6695/0.6698 in.)
Max. Wear Limit	17.025 mm (0.6703 in.)
Piston Pin O.D.	
New	16.995/17.000 mm (0.6691/0.6693 in.)
Max. Wear Limit	16.994 mm (0.6691 in.)
Top Compression Ring-to-Groove Side Clearance	
LH630,LH640	0.040/0.086 mm (0.0016/0.0034 in.)
LH685,LH690	0.050/0.096 mm (0.0020/0.0038 in.)
LH750,LH755,LH760,LH775	0.014/0.041 mm (0.0005/0.0016 in.)
Middle Compression Ring-to-Groove Side Clearance	
LH630,LH640	0.040/0.086 mm (0.0016/0.0034 in.)
LH685,LH690	0.030/0.076 mm (0.0012/0.0030 in.)
LH750,LH755,LH760,LH775	0.012/0.039 mm (0.0004/0.0015 in.)
Oil Control Ring-to-Groove Side Clearance	
LH630,LH640	0.046/0.196 mm (0.0018/0.0077 in.)
LH685,LH690	0.046/0.196 mm (0.0018/0.0077 in.)
LH750,LH755,LH760,LH775	0.026/0.176 mm (0.0010/0.0070 in.)
Top and Middle Compression Ring End Gap	
LH630,LH640	
New Bore	
Top Ring	0.180/0.380 mm (0.0071/0.0150 in.)
Middle Ring	0.250/0.450 mm (0.0098/0.0177 in.)
Used Bore (Max.)	0.77 mm (0.030 in.)

[2]Measure 6 mm (0.236 in.) above the bottom of the piston skirt at right angles to the piston pin.

Piston, Piston Rings, and Piston Pin cont.

Top and Middle Compression Ring End Gap cont.
- LH685,LH690
  - New Bore
    - Top Ring ..... 0.180/0.430 mm (0.0071/0.0169 in.)
    - Middle Ring ..... 0.250/0.460 mm (0.0098/0.0181 in.)
  - Used Bore (Max.) ..... 0.80 mm (0.0315 in.)
- LH750,LH755,LH760 LH775
  - New Bore ..... 0.250/0.56 mm (0.0098/0.022 in.)
  - Used Bore ..... 0.94 mm (0.037 in.)

Piston Thrust Face O.D.[2]
- LH630,LH640
  - New ..... 76.968/76.986 mm (3.0302/3.0309 in.)
  - Max. Wear Limit ..... 76.840 mm (3.0252 in.)
- LH685,LH690
  - New ..... 79.963/79.981 mm (3.1481/3.1488 in.)
  - Max. Wear Limit ..... 79.831 mm (3.1430 in.)
- LH750,LH755,LH760 LH775
  - New ..... 82.973/82.991 mm (3.2666/3.2673 in.)
  - Max. Wear Limit ..... 82.841 mm (3.3136 in.)

Piston Thrust Face-to-Cylinder Bore[2] Running Clearance
- LH630,LH640 ..... 0.014/0.057 mm (0.0005/0.0022 in.)
- LH685,LH690 ..... 0.019/0.062 mm (0.0007/0.0024 in.)
- LH750,LH755,LH760 LH775 ..... 0.015/0.058 mm (0.005/0.0022 in.)

Speed Control

Speed Control Bracket Assembly Fastener Torque ..... 10.7 N·m (95 in. lb.) into new holes
7.3 N·m (65 in. lb.) into used holes

Stator

Stator Mounting Screw Torque ..... 6.2 N·m (55 in. lb.)

Valve Cover/Rocker Arms

Valve Cover Fastener Torque ..... 6.2 N·m (55 in. lb.)

Valves and Valve Lifters

Hydraulic Valve Lifter to Crankcase Running Clearance ..... 0.0124/0.0501 mm (0.0005/0.0020 in.)

Intake Valve Stem-to-Valve Guide Running Clearance ..... 0.038/0.076 mm (0.0015/0.0030 in.)

Exhaust Valve Stem-to-Valve Guide Running Clearance ..... 0.050/0.088 mm (0.0020/0.0035 in.)

Intake Valve Guide I.D.
- New ..... 7.038/7.058 mm (0.2771/0.2779 in.)
- Max. Wear Limit ..... 7.134 mm (0.2809 in.)

Intake Valve Stem Diameter
- New ..... 6.982/7.000 mm (0.2749/0.2756 in.)

Exhaust Valve Guide I.D.
- New ..... 7.038/7.058 mm (0.2771/0.2779 in.)
- Max. Wear Limit ..... 7.159 mm (0.2819 in.)

[2]Measure 6 mm (0.236 in.) above the bottom of the piston skirt at right angles to the piston pin.

Valves and Valve Lifters cont.

Exhaust Valve Stem Diameter
- New ..... 6.970/6.988 mm (0.2744/0.2751 in.)

Valve Guide Reamer Size
- Standard ..... 7.048 mm (0.2775 in.)
- 0.25 mm O.S. ..... 7.298 mm (0.2873 in.)

Intake Valve Lift ..... 8.88 mm (0.3496 in.)

Exhaust Valve Lift ..... 8.88 mm (0.3496 in.)

Nominal Valve Seat Angle ..... 45°

Water Pump

Mounting Screw Torque ..... 9.9 N·m (88 in. lb.)
Pulley Mounting Screw Torque ..... 9.9 N·m (88 in. lb.)

General Torque Values

Metric Fastener Torque Recommendations for Standard Applications

Tightening Torque: N·m (in. lb.) + or - 20%

	Property Class					
	4.8	5.8	8.8	10.9	12.9	Noncritical Fasteners Into Aluminum
Size						
M4	1.2 (11)	1.7 (15)	2.9 (26)	4.1 (36)	5.0 (44)	2.0 (18)
M5	2.5 (22)	3.2 (28)	5.8 (51)	8.1 (72)	9.7 (86)	4.0 (35)
M6	4.3 (38)	5.7 (50)	9.9 (88)	14.0 (124)	16.5 (146)	6.8 (60)
M8	10.5 (93)	13.6 (120)	24.4 (216)	33.9 (300)	40.7 (360)	17.0 (150)

Tightening Torque: N·m (ft. lb.) + or - 20%

	Property Class					
	4.8	5.8	8.8	10.9	12.9	Noncritical Fasteners Into Aluminum
M10	21.7 (16)	27.1 (20)	47.5 (35)	66.4 (49)	81.4 (60)	33.9 (25)
M12	36.6 (27)	47.5 (35)	82.7 (61)	116.6 (86)	139.7 (103)	61.0 (45)
M14	58.3 (43)	76.4 (55)	131.5 (97)	184.4 (136)	219.7 (162)	94.9 (70)

Torque Conversions

N·m = in. lb. x 0.113
N·m = ft. lb. x 1.356
in. lb. = N·m x 8.85
ft. lb. = N·m x 0.737

English Fastener Torque Recommendations for Standard Applications

Tightening Torque: N·m (in. lb.) + or - 20%				
Bolts, Screws, Nuts and Fasteners Assembled Into Cast Iron or Steel				**Grade 2 or 5 Fasteners Into Aluminum**
	 **Grade 2**	 **Grade 5**	 **Grade 8**	
Size				
8-32	2.3 (20)	2.8 (25)	---------	2.3 (20)
10-24	3.6 (32)	4.5 (40)	---------	3.6 (32)
10-32	3.6 (32)	4.5 (40)	---------	---------
1/4-20	7.9 (70)	13.0 (115)	18.7 (165)	7.9 (70)
1/4-28	9.6 (85)	15.8 (140)	22.6 (200)	---------
5/16-18	17.0 (150)	28.3 (250)	39.6 (350)	17.0 (150)
5/16-24	18.7 (165)	30.5 (270)	---------	---------
3/8-16	29.4 (260)	---------	---------	---------
3/8-24	33.9 (300)	---------	---------	---------
Tightening Torque: N·m (ft. lb.) + or - 20%				
Size				
5/16-24	---------	----------	40.7 (30)	---------
3/8-16	---------	47.5 (35)	67.8 (50)	---------
3/8-24	---------	54.2 (40)	81.4 (60)	---------
7/16-14	47.5 (35)	74.6 (55)	108.5 (80)	---------
7/16-20	61.0 (45)	101.7 (75)	142.4 (105)	---------
1/2-13	67.8 (50)	108.5 (80)	155.9 (115)	---------
1/2-20	94.9 (70)	142.4 (105)	223.7 (165)	---------
9/16-12	101.7 (75)	169.5 (125)	237.3 (175)	---------
9/16-18	135.6 (100)	223.7 (165)	311.9 (230)	---------
5/8-11	149.2 (110)	244.1 (180)	352.6 (260)	---------
5/8-18	189.8 (140)	311.9 (230)	447.5 (330)	---------
3/4-10	199.3 (150)	332.2 (245)	474.6 (350)	---------
3/4-16	271.2 (200)	440.7 (325)	637.3 (470)	---------

Section 2
Tools & Aids

Certain quality tools are designed to help you perform specific disassembly, repair, and reassembly procedures. By using tools designed for the job, you can properly service engines easier, faster, and safer! In addition, you'll increase your service capabilities and customer satisfaction by decreasing engine downtime.

Here is the list of tools and their source.

Separate Tool Suppliers:

Kohler Tools
Contact your source
of supply.

SE Tools
415 Howard St.
Lapeer, MI 48446
Phone 810-664-2981
Toll Free 800-664-2981
Fax 810-664-8181

Design Technology Inc.
768 Burr Oak Drive
Westmont, IL 60559
Phone 630-920-1300

Tools

Description	Source/Part No.
Balance Gear Timing Tool (K & M Series) To hold balance gears in timed position when assembling engine.	Kohler 25 455 06-S (Formerly Y-357)
Camshaft Endplay Plate For checking camshaft endplay.	SE Tools KLR-82405
Cylinder Leakdown Tester For checking combustion retention and if cylinder, piston, rings, or valves are worn.	Kohler 25 761 05-S
Electronic Fuel Injection (EFI) Diagnostic Software Use with Laptop or Desktop PC.	Kohler 25 761 23-S
EFI Service Kit For troubleshooting and setting up an EFI engine.	Kohler 24 761 01-S
Individual Components Available	Design Technology Inc.
Pressure Tester	DTI-019
Noid Light	DTI-021
90° Adapter	DTI-023
Oetiker Clamp Pliers	DTI-025
Code Plug, Red Wire	DTI-027
Code Plug, Blue Wire	DTI-029
Flywheel Holding Tool (CS Series)	SE Tools KLR-82407
Flywheel Puller To remove flywheel from engine.	SE Tools KLR-82408

Tools (cont.)	
Description	**Source/Part No.**
Flywheel Strap Wrench To hold flywheel during removal.	SE Tools KLR-82409
Hydraulic Valve Lifter Tool To remove and install hydraulic lifters.	Kohler 25 761 38-S
Ignition System Tester For testing output on all systems, except CD. For testing output on capacitive discharge (CD) ignition system.	Kohler 25 455 01-S Kohler 24 455 02-S
Offset Wrench (K & M Series) To remove and reinstall cylinder barrel retaining nuts.	SE Tools KLR-82410
Oil Pressure Test Kit To test and verify oil pressure.	Kohler 25 761 06-S
Rectifier-Regulator Tester (120 volt current) **Rectifier-Regulator Tester (240 volt current)** Used to test rectifier-regulators.	Kohler 25 761 20-S Kohler 25 761 41-S
Individual Components Available CS-PRO Regulator Test Harness Special Regulator Test Harness with Diode	Design Technology Inc. DTI-031 DTI-033
Spark Advance Module (SAM) Tester To test the SAM (ASAM and DSAM) on engines with SMART-SPARK™.	Kohler 25 761 40-S
Starter Brush Holding Tool (Solenoid Shift) To hold brushes during servicing.	SE Tools KLR-82416
Starter Retaining Ring Tool (Inertia Drive) To remove and reinstall drive retaining rings (excluding FASCO starters).	Kohler 25 761 18-S
Starter Servicing Kit (All Starters) To remove and reinstall drive retaining rings and brushes.	SE Tools KLR-82411
Individual Component Available Starter Brush Holding Tool (Solenoid Shift)	SE Tools KLR-82416
Tachometer (Digital Inductive) For checking operating speed (RPM) of an engine.	Design Technology Inc. DTI-110
Vacuum/Pressure Tester Alternative to a water manometer.	Kohler 25 761 22-S
Valve Guide Reamer (K & M Series) For sizing valve guides after installation.	SE Tools KLR-82413
Valve Guide Service Kit (Courage, Aegis, Command, OHC) For servicing worn value guides.	SE Tools KLR-82415

Aids	
Description	**Source/Part No.**
Camshaft Lubricant (Valspar ZZ613)	Kohler 25 357 14-S
Dielectric Grease (GE/Novaguard G661)	Kohler 25 357 11-S
Dielectric Grease (Fel-Pro)	Lubri-Sel
Electric Starter Drive Lubricant (Inertia Drive)	Kohler 52 357 01-S
Electric Starter Drive Lubricant (Solenoid Shift)	Kohler 52 357 02-S
RTV Silicone Sealant Loctite® 5900 Heavy Body in 4 oz aerosol dispenser. Only oxime-based, oil resistant RTV sealants, such as those listed, are approved for use. Loctite® Nos. 5900 or 5910 are recommended for best sealing characteristics. Loctite® 5910 Loctite® Ultra Black 598 Loctite® Ultra Blue 587 Loctite® Ultra Copper	Kohler 25 597 07-S
Spline Drive Lubricant	Kohler 25 357 12-S

Special Tools You Can Make

Flywheel Holding Tool

A flywheel holding tool can be made out of an old junk flywheel ring gear as shown in Figure 2-1, and used in place of a strap wrench.

1. Using an abrasive cut-off wheel, cut out a six tooth segment of the ring gear as shown.

2. Grind off any burrs or sharp edges.

3. Invert the segment and place it between the ignition bosses on the crankcase so that the tool teeth engage the flywheel ring gear teeth. The bosses will lock the tool and flywheel in position for loosening, tightening or removing with a puller.

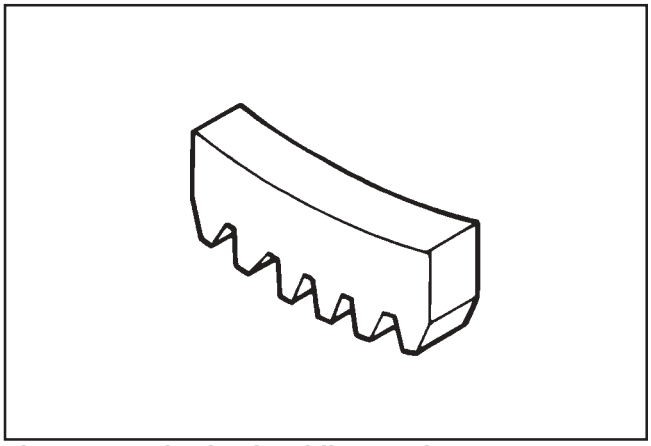


Figure 2-1. Flywheel Holding Tool.

Rocker Arm/Crankshaft Tool

A spanner wrench to lift the rocker arms or turn the crankshaft may be made out of an old junk connecting rod.

1. Find a used connecting rod from a 10 HP or larger engine. Remove and discard the rod cap.

2. Remove the studs of a Posi-Lock rod or grind off the aligning steps of a Command rod, so the joint surface is flat.

3. Find a 1 in. long capscrew with the correct thread size to match the threads in the connecting rod.

4. Use a flat washer with the correct I.D. to slip on the capscrew and approximately 1" O.D. (Kohler Part No. 12 468 05-S). Assemble the capscrew and washer to the joint surface of the rod, as shown in **Figure 2-2**.

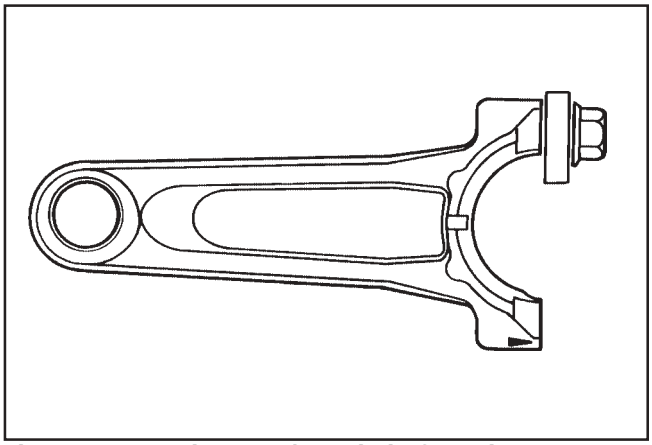


Figure 2-2. Rocker Arm/Crankshaft Tool.

Section 3
Troubleshooting

Troubleshooting Guide

When troubles occur, be sure to check the simple causes which, at first, may seem too obvious to be considered. For example, a starting problem could be caused by an empty fuel tank.

Some common causes of engine troubles are listed below. Use these to locate the causing factors.

Engine Cranks But Will Not Start

1. Empty fuel tank.
2. Fuel shut-off valve closed.
3. Dirt or water in the fuel system.
4. Clogged fuel line.
5. Spark plug lead(s) disconnected.
6. Key switch or kill switch in “off” position.
7. Faulty spark plugs.
8. Faulty ignition module(s).
9. Carburetor solenoid malfunction.
10. Diode in wiring harness failed in open circuit mode.
11. Vacuum fuel pump malfunction, or oil in vacuum hose.
12. Vacuum hose to fuel pump leaking/cracked.
13. Battery connected backwards.
14. Safety interlock system engaged.

Engine Starts But Does Not Keep Running

1. Restricted fuel tank cap vent.
2. Poor fuel, dirt or water in the fuel system.
3. Faulty/misadjusted choke or throttle controls.
4. Loose wires or connections that short the kill terminal of ignition module to ground.
5. Faulty cylinder head gasket.
6. Faulty carburetor.
7. Vacuum fuel pump malfunction, or oil in vacuum hose.
8. Leaking/cracked vacuum hose to fuel pump.
9. Intake system leak.
10. Diode in wiring harness failed in open circuit mode.

Engines Starts Hard

1. PTO drive is engaged.
2. Dirt or water in the fuel system.
3. Clogged fuel line.
4. Loose or faulty wires or connections.
5. Faulty or misadjusted choke or throttle controls.
6. Faulty spark plugs.
7. Low compression.
8. Weak spark.
9. Fuel pump malfunction causing lack of fuel.
10. Engine overheated-cooling system problem.
11. Quality of fuel.
12. Flywheel key sheared.
13. Intake system leak.

Engine Will Not Crank

1. PTO drive is engaged.
2. Battery is discharged.
3. Safety interlock switch is engaged.
4. Loose or faulty wires or connections.
5. Faulty key switch or ignition switch.
6. Faulty electric starter or solenoid.
7. Seized internal engine components.

Engine Runs But Misses

1. Dirt or water in the fuel system.
2. Spark plug lead disconnected.
3. Loose wires or connections that intermittently short the kill circuit of ignition system to ground.
4. Engine overheated-cooling system problem.
5. Faulty ignition module.
6. Faulty spark plugs.
7. Carburetor adjusted incorrectly.
8. Faulty interlock switch.

Engine Will Not Idle

1. Restricted fuel tank cap vent.
2. Dirt or water in the fuel system.
3. Faulty spark plugs.
4. Idle speed (RPM) adjusting screw improperly set.
5. Low compression.
6. Stale fuel and/or gum in carburetor.
7. Fuel supply inadequate.
8. Engine overheated-cooling system problem.

Engine Overheats

1. Radiator, and/or cooling system components clogged, restricted, or leaking.
2. Excessive engine load.
3. Low crankcase oil level.
4. Low cooling system fluid level.
5. High crankcase oil level.
6. Lean fuel mixture.
7. Fan belt failed/off.
8. Cooling fan broken.
9. Water pump belt failed/broken.
10. Water pump malfunction.
11. Faulty carburetor.

Engine Knocks

1. Excessive engine load.
2. Low crankcase oil level.
3. Old or improper fuel.
4. Internal wear or damage.
5. Hydraulic lifter malfunction.
6. Quality of fuel.
7. Incorrect grade of oil.

Engine Loses Power

1. Low crankcase oil level.
2. High crankcase oil level.
3. Dirty air cleaner element.
4. Dirt or water in the fuel system.
5. Excessive engine load.
6. Engine overheated. (See "Engine Overheats")
7. Faulty spark plugs.
8. Low compression.
9. Exhaust restriction.
10. Low battery.
11. Incorrect governor setting.

Engine Uses Excessive Amount Of Oil

1. Incorrect oil viscosity/type.
2. Clogged or improperly assembled breather.
3. Breather reed broken.
4. Worn or broken piston rings.
5. Worn cylinder bore.
6. Worn valve stems or valve guides.
7. Crankcase overfilled.
8. Blow head gasket/overtightened.

Oil Leaks from Oil Seals, Gaskets

1. Crankcase breather is clogged or inoperative.
2. Breather read broken.
3. Loose or improperly torqued fasteners.
4. Piston blowby or leaky valves.
5. Restricted exhaust.

Engine Loses or Uses Coolant

1. Overheating-See "Engine Overheats".
2. External leakage-from a joint connection, or a component of the cooling system.
3. Internal leakage-from a head gasket, or cooling system water jacket (passage) leak.

External Engine Inspection

Before cleaning or disassembling the engine, make a thorough inspection of its external appearance and condition. This inspection can give clues to what might be found inside the engine (and the cause) when it is disassembled.

- Check for buildup of dirt and debris on the radiator, crankcase, cooling system components, and other external surfaces. Dirt or debris on these areas are causes of higher operating temperatures and overheating.

- Check for obvious fuel, oil, and coolant leaks, or damaged components. Excessive oil leakage can indicate a clogged or improperly assembled breather, worn or damaged seals and gaskets, or loose or improperly torqued fasteners. Coolant leaks can cause higher operating temperatures and overheating.

- Check the air cleaner assembly/components for damage or indications of leakage.

- Check the air cleaner element and inner element. Look for holes, tears, cracked/damaged sealing surfaces, or other damage that could allow unfiltered air into the engine. Also note if the elements are dirty or clogged. These could indicate that the engine has been underserviced.

- Check the carburetor throat for dirt. Dirt in the throat is further indication that the air cleaner is not functioning properly.

- Check the oil level. Note if the oil level is within the operating range on the dipstick, or if it is low or overfilled.

- Check the coolant level within the reservoir and in the radiator. A low or improperly filled cooling system can cause overheating, excessive fuel consumption, and a lack of power.

- Check the condition of the oil. Drain the oil into a container - the oil should flow freely. Check the appearance (color) of the oil, and for metal chips or foreign particles. A milky, opaque color denotes the presence of engine coolant in the crankcase oil.

  Sludge is a natural by-product of combustion; a small accumulation is normal. Excessive sludge formation could indicate overrich carburetion, weak ignition, overextended oil change intervals or wrong weight or type of oil was used, to name a few.

  NOTE: It is good practice to drain oil at a location away from the workbench. Be sure to allow ample time for complete drainage.

Cleaning The Engine

After inspecting the external condition of the engine, clean the engine thoroughly before disassembling it. Also clean individual components as the engine is disassembled. Only clean parts can be accurately inspected and gauged for wear or damage. There are many commercially available cleaners that will quickly remove grease, oil, and grime from engine parts. When such a cleaner is used, *follow the manufacturer's instructions and safety precautions carefully*.

Make sure all traces of the cleaner are removed before the engine is reassembled and placed into operation. Even small amounts of these cleaners can quickly break down the lubricating properties of engine oil.

Basic Engine Tests

Crankcase Vacuum Test

A partial vacuum should be present in the crankcase when the engine is operating. Pressure in the crankcase (normally caused by a clogged or improperly assembled breather) can cause oil to be forced out at oil seals, gaskets, or other available spots.

Crankcase vacuum is best measured with either a water manometer or a vacuum gauge (see Section 2). Complete instructions are provided in the kits.

Test the crankcase vacuum with the manometer as follows:

1. Insert the stopper/hose into the oil fill hole. Leave the other tube of manometer open to atmosphere. Make sure the shut-off clamp is closed.

2. Start the engine and run at no-load full throttle speed (3200 to 3750 RPM).

3. Open the clamp and note the water level in the tube.

   The level in the engine side should be a minimum of **10.2 cm (4 in.)** above the level in the open side.

   If the level in the engine side is less than specified (low/no vacuum), or the level in the engine side is lower than the level in the open side (pressure), check for the conditions in the table below.

4. Close the shut-off clamp **before** stopping the engine.

No Crankcase Vacuum/Pressure in Crankcase

Possible Cause	Solution
1. Crankcase breather clogged or inoperative.	1. Replace breather assembly (valve cover).
2. Seals and/or gaskets leaking. Loose or improperly torqued fasteners.	2. Replace all worn or damaged seals and gaskets. Make sure all fasteners are tightened securely. Use appropriate torque values and sequences when necessary.
3. Piston blowby or leaky valves. (Confirm by inspecting components.)	3. Recondition piston, rings, cylinder bore, valves, and valve guides.
4. Restricted exhaust.	4. Repair/replace restricted muffler/exhaust system.

Compression Test

A compression test is best performed on a warm engine. Clean any dirt or debris away from the base of the spark plugs before removing them. Be sure the choke is off, and the throttle is wide open during the test. Compression should be at least 160 psi and should not vary more than 15% between cylinders.

Cylinder Leakdown Test

A cylinder leakdown test can be a valuable alternative to a compression test. By pressurizing the combustion chamber from an external air source you can determine if the valves or rings are leaking, and how badly.

Cylinder Leakdown Tester (see Section 2) is a relatively simple, inexpensive leakdown tester for small engines. The tester includes a quick disconnect for attaching the adapter hose and a holding tool.

Leakdown Test Instructions

1. Run engine 3-5 minutes to warm it up.

2. Remove spark plugs, dipstick, and air filter from engine.

3. Rotate crankshaft until piston (of cylinder being tested) is at top dead center (TDC) of compression stroke. You will need to hold the engine in this position while testing. The holding tool supplied with the tester can be used if the PTO end of the crankshaft is accessible. Slide the holding tool onto the crankshaft and adjust the set screw to fit in the key slot. Install a 3/8" breaker bar into the square hole of the holding tool, so it is perpendicular to both the holding tool and crankshaft PTO. If the flywheel end is more accessible, you can use a breaker bar and socket on the flywheel nut/screw to hold it in position. You may need an assistant to hold the breaker bar during testing.

   If the engine is mounted in a piece of equipment, you may be able to hold it by clamping or wedging a driven component. Just be certain that the engine cannot rotate off of TDC in either direction.

4. Install the adapter hose into the spark plug hole, but do not attach it to the tester at this time.

5. Connect an adequate air source to the tester.

6. Turn the regulator knob in the increase (clockwise) direction until the gauge needle is in the yellow “set” area at the low end of the scale.

7. Connect tester quick-disconnect to the adapter. Note the gauge reading and listen for escaping air at the carburetor intake, exhaust outlet, and oil fill/dipstick tube.

8. Check your test results against the table below:

Leakdown Test Results

Air escaping at oil fill tube	Defective rings, worn cylinder walls, or blown head gasket.
Air escaping from exhaust outlet	Defective exhaust valve/improper seating.
Air escaping from carburetor inlet	Defective intake valve/improper seating.
Gauge reading in ‘‘low’’ (green) zone	Piston rings and cylinder in good condition.
Gauge reading in ‘‘moderate’’ (yellow) zone	Engine is still usable, but there is some wear present. Customer should start planning for overhaul or replacement.
Gauge reading in ‘‘high’’ (red) zone	Rings and/or cylinder have considerable wear. Engine should be reconditioned or replaced.

Cooling Leakage Test

A pressure test can be performed as a simple means of determining whether the cooling system may have a problem. The test procedure, possible results, and recommended corrective action are covered in Section 7.

Section 4
Air Cleaner System

Air Cleaners

General

These engines are equipped with Kohler's heavy-duty, cyclonic air cleaner system. See Figure 4-1. The air cleaner includes a high-density, pleated paper main element (see Figure 4-2), and inner safety element (see Figure 4-3).

Figure 4-1. Heavy-duty Air Cleaner Assembly.

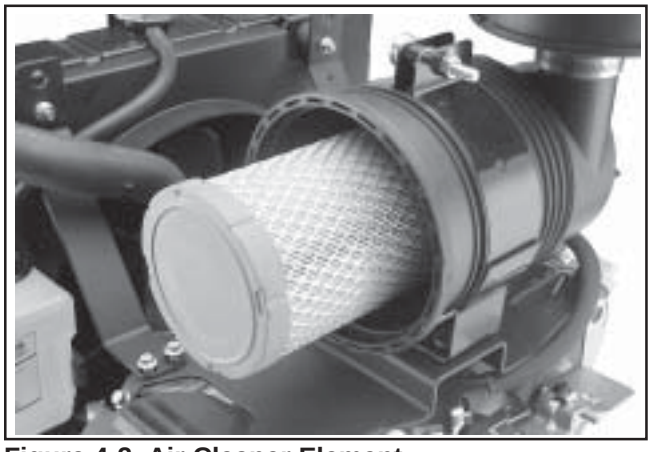


Figure 4-2. Air Cleaner Element.

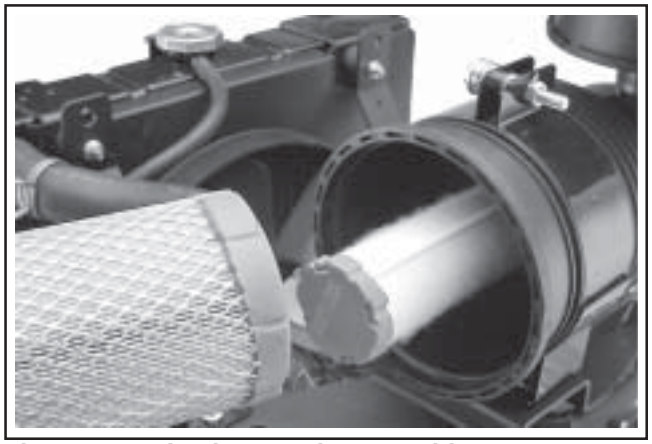


Figure 4-3. Air Cleaner Element with Inner Element.

Air Cleaner Element Service

Every **250 hours** of operation (more often under extremely dusty or dirty conditions), replace the paper element and cylindrical inner element. Follow these steps:

1. Unhook the two retaining clips and remove the end cap from the air cleaner housing. See Figure 4-4.

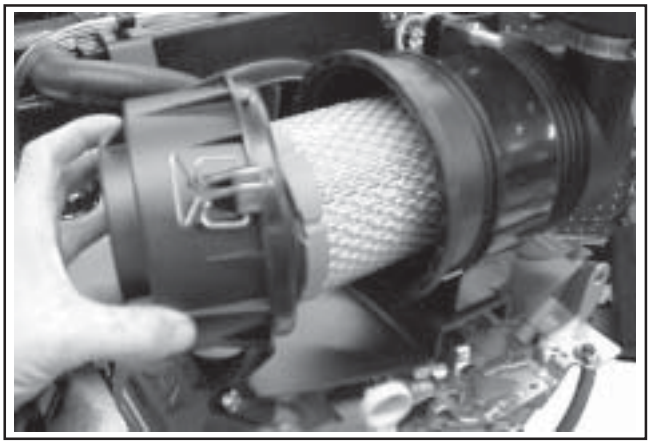


Figure 4-4. Removing End Cap.

2. Pull the air cleaner element out of the housing. See Figure 4-5.

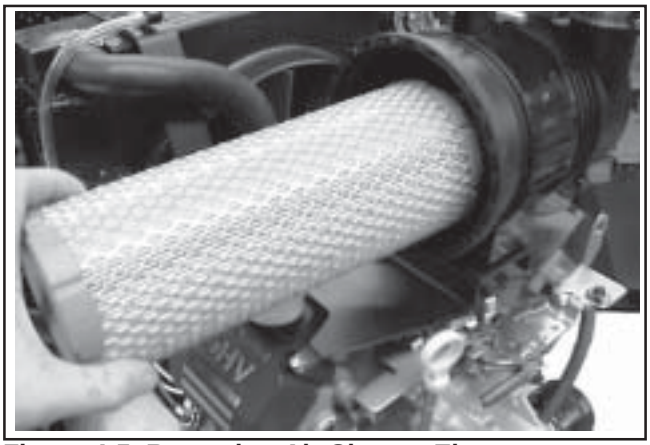


Figure 4-5. Removing Air Cleaner Element.

3. Check the condition of the inner safety element. It should be replaced whenever it appears dirty, typically every other time the main element is replaced. Before removing it from the housing, clean the area around the base of the inner element, so dirt does not get into the engine. See Figure 4-6.

Figure 4-6. Removing Cylindrical Inner Element.

4. The elements must be replaced when dirty. **Do not** attempt to clean the elements with pressurized air, or other means, as the elements will be ruined. Handle new elements carefully; do not use if the sealing surfaces are bent or damaged. Replace any damaged or questionable components.

5. If it is being replaced, install the new inner element, Kohler Part No. **25 083 04-S**, followed by the canister outer element; Kohler Part No. **25 083 01-S**. Slide each fully into place in the housing.

6. Reinstall the end cap, so the dust ejector valve faces down, and secure with the two retaining clips.

Air Cleaner Components

Air Cleaner Housing/End Cap Assembly

Make sure air cleaner housing including the dust ejector valve and the end cap is in good condition and not cracked. The two retainer clips should positively lock when the cap is installed.

Air Cleaner Hose

Inspect the air cleaner hose to make sure it is not cracked, split or damaged. Check that the air cleaner hose is securely clamped to both the air cleaner outlet and the inlet elbow on the carburetor.

Air Cleaner Mounting Base

Make sure the base is securely fastened to the upper valve cover screw locations and the screws securing the clamp bracket for the air cleaner housing are properly installed and tight.

Breather Hose

Make sure the hose is in good condition, not cracked, and properly secured to the breather cover and adapter fitting.

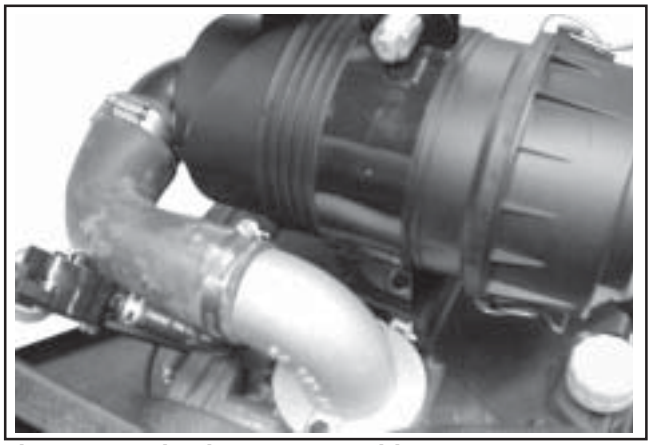


Figure 4-7. Air Cleaner Assembly.

Section 5
Fuel System and Governor

Description

The Aegis horizontal twins use two different types of fuel systems; carbureted or electronic fuel injection (EFI).

This section covers the standard carbureted fuel systems. The EFI systems are covered in subsection 5B. The governor system, covered at the end of this section, is the same for both fuel systems.

WARNING: Explosive Fuel!

Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Do not fill the fuel tank while the engine is hot or running, since spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Do not start the engine near spilled fuel. Never use gasoline as a cleaning agent.

Fuel System Components

The typical carbureted fuel system and related components include the following:

- Fuel Tank
- In-line Fuel Filter
- Fuel Pump
- Carburetor
- Fuel Lines

Operation

The fuel from the tank is moved through the in-line filter and fuel lines by the fuel pump. On engines not equipped with a fuel pump, the fuel tank outlet is located above the carburetor inlet, allowing gravity to feed fuel to the carburetor.

Fuel then enters the carburetor float bowl and is moved into the carburetor body. There, the fuel is mixed with air. This fuel-air mixture is then burned in the engine combustion chamber.

Fuel Recommendations

General Recommendations

Purchase gasoline in small quantities and store in clean, approved containers. A container with a capacity of 2 gallons or less with a pouring spout is recommended. Such a container is easier to handle and helps eliminate spillage during refueling.

- Do not use gasoline left over from the previous season, to minimize gum deposits in your fuel system and to ensure easy starting.
- Do not add oil to the gasoline.
- Do not overfill the fuel tank. Leave room for the fuel to expand.

Fuel Type

For best results, use only clean, fresh, unleaded gasoline with a pump sticker octane rating of 87 or higher. In countries using the Research fuel rating method, it should be 90 octane minimum.

Unleaded gasoline is recommended as it leaves less combustion chamber deposits and reduces harmful exhaust emissions. Leaded gasoline is not recommended and **must not** be used on EFI engines, or on other models where exhaust emissions are regulated.

Gasoline/Alcohol blends

Gasohol (up to 10% ethyl alcohol, 90% unleaded gasoline by volume) is approved as a fuel for Kohler engines. Other gasoline/alcohol blends are not approved.

Gasoline/Ether blends

Methyl Tertiary Butyl Ether (MTBE) and unleaded gasoline blends (up to a maximum of 15% MTBE by volume) are approved as a fuel for Kohler engines. Other gasoline/ether blends are not approved.

Fuel Filter

Most engines are equipped with an in-line fuel filter. Periodically inspect the filter and replace with a genuine Kohler filter every **200 operating hours**.

Fuel System Tests

When the engine starts hard, or turns over but will not start, it is possible that the problem is in the fuel system. To find out if the fuel system is causing the problem, perform the following tests.

Troubleshooting – Fuel System Related Causes

Test	Conclusion
1. Check the following: a. Make sure the fuel tank contains clean, fresh, proper fuel. b. Make sure the vent in fuel tank cap is open. c. Make sure the fuel valve is open. d. Make sure vacuum and fuel lines to fuel pump are secured and in good condition.	
2. Check for fuel in the combustion chamber. a. Disconnect and ground the spark plug leads. b. Close the choke on the carburetor. c. Crank the engine several revolutions. d. Remove a spark plug and check for fuel at the tip.	2. If there **is** fuel at the tip of the spark plug, fuel is reaching the combustion chamber. If there is **no** fuel at the tip of the spark plug, check for fuel flow from the fuel tank (Test 3).
3. Check for fuel flow from the tank to the fuel pump. a. Remove the fuel line from the inlet fitting of fuel pump. b. Hold the line below the bottom of the tank. Open the shut-off valve (if so equipped) and observe flow.	3. If fuel **does** flow from the line, check for faulty fuel pump (Test 4). If fuel **does not** flow from the line, check the fuel tank vent, fuel pickup screen, in-line filter, shut-off valve, and fuel line. Correct any observed problem and reconnect the line.
4. Check the operation of fuel pump. a. Remove the fuel line from the inlet fitting of carburetor. b. Crank the engine several times and observe flow.	4. If fuel **does** flow from the line, check for faulty carburetor. (Refer to the "Carburetor" portions of this section.) If fuel **does not** flow from the line, check for a clogged fuel line. If the fuel line is unobstructed, check for overfilled crankcase and/or oil in pulse line. If none of the checks reveal the cause of the problem, replace the pump.

Fuel Pump

General

These engines are equipped with either a mechanical, or pulse style fuel pump. See Figure 5-1.

Operation

Pulse Fuel Pump

Operation and pumping action is created by alternating positive and negative pressures within the crankcase. This pressure is transmitted to the pulse pump through a rubber hose connected between the pump and the crankcase. The pumping action causes the diaphragm on the inside of the pump to pull fuel in on its own downward stroke and to push it into the carburetor on its upward stroke. Two check valves prevent fuel from going backward through the pump.

Mechanical Fuel Pump

The mechanical fuel pump is built into the #2 valve cover. The actuating arm of the pump extends down inside the cover and contacts one of the rocker arms. Downward movement of the rocker arm allows the pump diaphragm to flex down, drawing in fuel. As the rocker arm comes up, the fuel is forced out toward the carburetor.

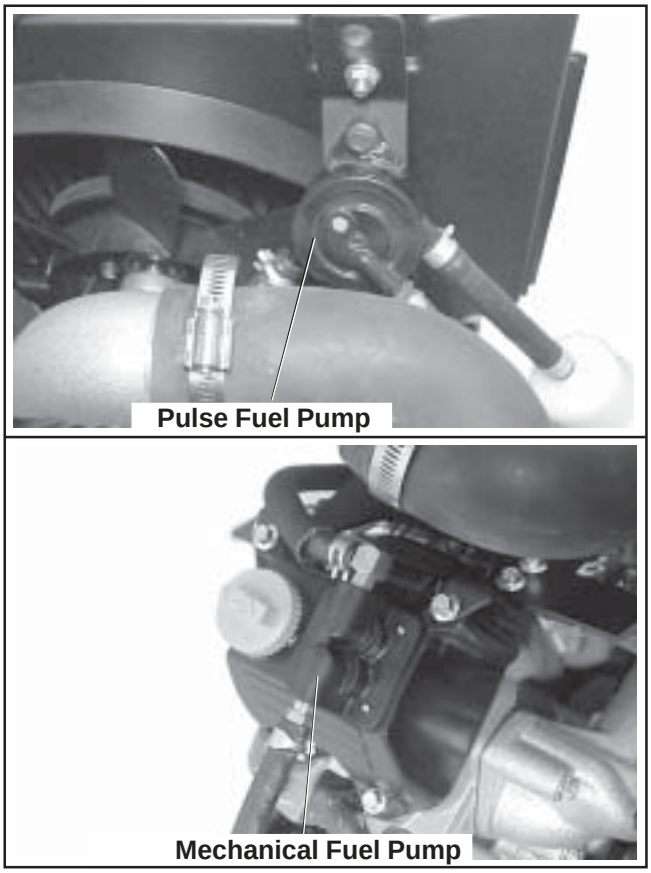


Figure 5-1. Fuel Pump Styles.

Replacing The Fuel Pump

Replacement pumps are available through your source of supply. To replace the pulse pump follow these steps. Note the orientation of pump before removing.

Pulse Fuel Pump

1. Disconnect the fuel lines from the inlet and outlet fittings.

2. Remove the hex flange screws mounting fuel pump to support.

3. Remove the vacuum line that connects the pump to the crankcase.

4. Install a new pump using the hex flange screws.

   NOTE: Make sure the orientation of the new pump is consistent with the removed pump. Internal damage may occur if installed incorrectly.

5. Connect vacuum line between the pump and crankcase.

6. Tighten the hex flange screws to **2.3 N·m (20 in. lb.)**.

7. Connect the fuel lines to the inlet and outlet fittings.

Mechanical Fuel Pump

1. Disconnect the fuel lines from the inlet and outlet fittings.

2. Clean the area and remove the four screws securing the valve cover/pump assembly to the cylinder head. Loosen (but **do not** remove) the four valve cover screws on the opposite side.

3. Lift the air cleaner mounting bracket up slightly and remove the valve cover/pump assembly. Remove and discard the old gasket.

4. Rotate the engine by hand while observing the actuating rocker arm. Stop rotating when end of the rocker arm is at the lowest point (spring is at maximum compression, and valve is open).

5. Position the new gasket onto the new cover/fuel pump assembly and install onto cylinder head. Align the air cleaner mounting bracket holes with the upper two valve cover screw holes.

6. Install the longer screws in the upper holes and the shorter screws in the lower holes. Finger tighten all eight valve cover mounting screws (four each side), then torque the screws to **6.2 N·m (55 in. lb.)** in the sequence shown in Figure 5-2.

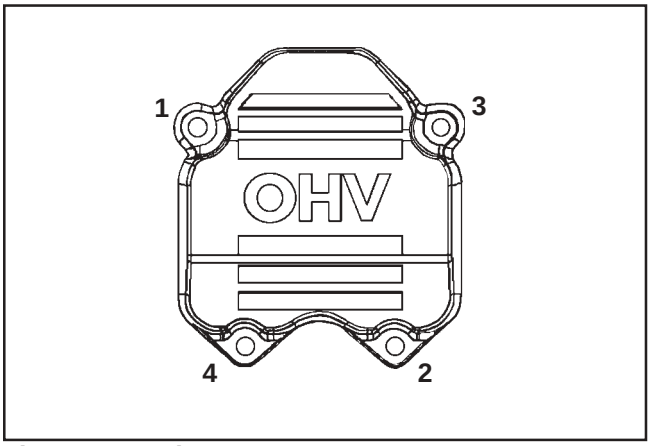


Figure 5-2. Valve Cover Torque Sequence.

Carburetor

General

Engines in this series are equipped with emission compliant fixed main jet carburetors, manufactured by Keihin. All have self-relieving chokes for efficient operation. Depending on the specifications and application involved, most will also contain a fuel shut-off solenoid and an accelerator pump. An exploded view of the carburetor is shown in Figure 5-6, with the accelerator pump components shown in the inset.

Float Circuit: Fuel level in the bowl is maintained by the float and fuel inlet needle. The buoyant force of the float stops fuel flow when the engine is at rest. When fuel is being consumed, the float will drop and fuel pressure will push the inlet needle away from the seat, allowing more fuel to enter the bowl. When demand ceases, the buoyant force of the float will again overcome the fuel pressure and stop the flow.

High Altitude Operation

When operating the engine at altitudes of 1500 m (5000 ft.) and above, the fuel mixture tends to get overrich. This can cause conditions such as black, sooty exhaust smoke, misfiring, loss of speed and power, poor fuel economy, and poor or slow governor response.

To compensate for the effects of high altitude, a special high altitude main jet can be installed. High altitude jets are sold in kits which include the jet and necessary gaskets. Refer to the Parts Manual for the correct kit number.

Fuel Shut-Off Solenoid

Most carburetors are equipped with a fuel shut-off solenoid. The solenoid has a spring loaded pin that retracts when 12 volts is applied to the lead. When power ceases, the spring loaded pin extends and blocks the main jet.

Below is a simple test made with the engine **off** that can determine if the solenoid is functioning properly. Use a separate, switched 12 volt power supply to test.

1. Shut off the fuel and remove the solenoid from the carburetor. When the solenoid is loosened and removed, gas will leak out of the carburetor. Have a container ready to catch the fuel.

2. Wipe the tip of the solenoid with a shop towel or blow it off with compressed air, to remove any remaining fuel. Take the solenoid to a location with good ventilation and no fuel vapors present. You will also need a 12 volt power source that can be switched on and off.

3. Be sure the power source is switched “off”. Connect the positive power source lead to the red lead of the solenoid. Connect the negative power source lead to the solenoid bracket.

4. Turn the power source “on” and observe the pin in the center of the solenoid. The pin should retract with the power “on” and return to its original position with the power off. Test several times to verify operation.

Carburetor Adjustments

General

In compliance with government emission standards, the carburetor is calibrated to deliver the correct air-to-fuel mixture to the engine under all operating conditions. Both the low and the high speed mixture circuits are preestablished and cannot be adjusted. The low idle speed (RPM) is the only adjustment available.

NOTE: Low idle speed (RPM) adjustment should be made only after the engine has warmed up.

Adjusting Low Idle Speed (RPM) Setting

1. Start the engine and run at half throttle for 5 to 10 minutes to warm up. The engine must be warm before making final low idle speed (RPM) adjustment. Check that the throttle and choke plates can fully open.

2. Place the throttle control into the ''**idle**'' or ''**slow**'' position.

3. Set the low idle speed to **1200 RPM* (±75 RPM)** by turning the low idle speed adjusting screw** **in or out**. Check the speed using a tachometer.

   *NOTE: The actual low idle speed depends on the application. Refer to the equipment manufacturer's recommendations. The low idle speed for basic engines is 1200 RPM.

   ** Some early models contained an adjusting cable and knob attached to the adjusting screw. See Figure 5-3.

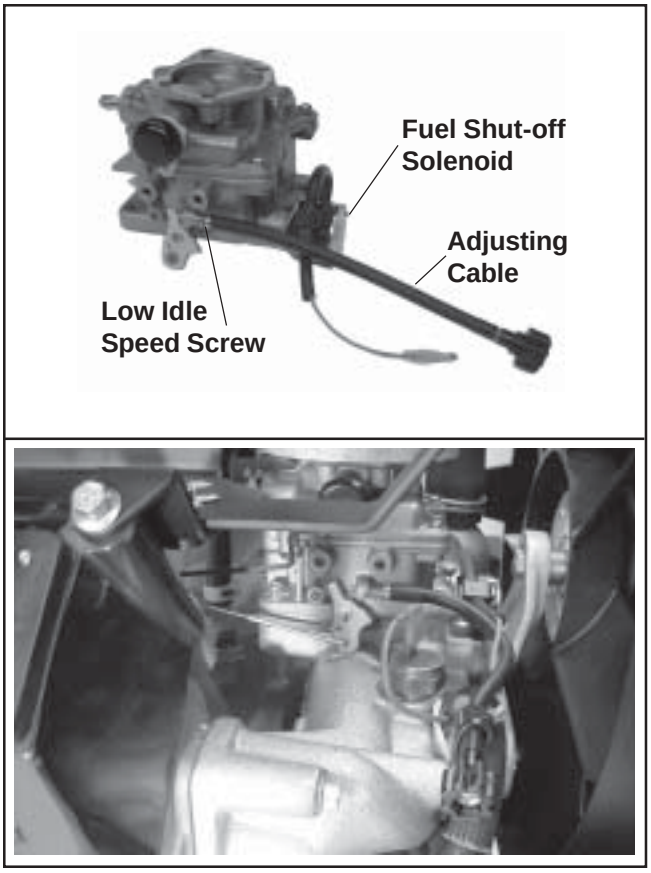


Figure 5-3. Carburetor with Adjusting Cable on the Low Idle Speed Adjustment Screw (Early Models).

Troubleshooting – Carburetor Related Causes

Condition	Possible Cause/Probable Remedy
1. Engine starts hard, runs roughly or stalls at idle speed.	1a. Low idle fuel mixture/speed improperly adjusted. Adjust the low idle speed screw. b. Low idle fuel mixture circuit blocked/restricted. Clean carburetor as required.
2. Engine runs rich (indicated by black, sooty exhaust smoke, misfiring, loss of speed and power, governor hunting, or excessive throttle opening).	2a. Clogged air cleaner. Clean or replace. b. Choke partially closed during operation. Check the choke lever/linkage to ensure choke is operating properly. c. Float level too high. Separate fuel bowl from carburetor body. Free (if stuck), or replace float. d. Dirt under the fuel inlet needle. Remove needle; clean needle and seat and blow with compressed air. e. Bowl vent or air bleeds plugged. Clean vent, ports, and air bleeds. Blow out all passages with compressed air. f. Leaky, cracked, or damaged float. Submerge float to check for leaks.
3. Engine runs lean (indicated by misfiring, loss of speed and power, governor hunting, or excessive throttle opening).	3a. Float level too low. Separate fuel bowl from carburetor body. Free (if stuck), or replace float. b. Idle holes plugged; dirt in fuel delivery channels. Clean main fuel jet and all passages; blow out with compressed air.
4. Fuel leaks from carburetor.	4a. Float stuck. See Remedy 2d. b. Dirt under fuel inlet needle. See Remedy 2e. c. Bowl vents plugged. Blow out with compressed air. d. Carburetor bowl gasket leaks. Replace gasket.

Troubleshooting Checklist

When the engine starts hard, runs roughly or stalls at low idle speed, check the following areas before adjusting or disassembling the carburetor.

- Make sure the fuel tank is filled with clean, fresh gasoline.
- Make sure the fuel tank cap vent is not blocked and that it is operating properly.
- Make sure fuel is reaching the carburetor. This includes checking the fuel shut-off valve, fuel tank filter screen, in-line fuel filter, fuel lines and fuel pump for restrictions or faulty components as necessary.
- Make sure the air cleaner base and carburetor are securely fastened to the engine using gaskets in good condition.
- Make sure the air cleaner element is clean and all air cleaner components are fastened securely.
- Make sure the ignition system, governor system, exhaust system, and throttle and choke controls are operating properly.

If the engine is hard-starting or runs roughly, or stalls at low idle speed, it may be necessary to service the carburetor.

Disassembly

Disassemble the carburetor using the following steps. See Figure 5-6.

1. Remove the intake elbow and hose (if attached), breather hose, and carburetor. Refer to Section 9 - "Disassembly".

2. Remove the four screws and carefully separate the air horn assembly from the carburetor body.

3. Loosen the screw securing the float assembly to the air horn and remove the float, float shaft and fuel inlet needle.

4. Remove the slow jet from the carburetor body.

   NOTE: The main jet is a fixed jet and can be removed if required. Fixed jets for high altitude are available.

5. Remove the black cap on the end of the choke shaft only if it is necessary to inspect and clean the shaft spring.

6. Remove the low idle speed adjusting screw and spring from the carburetor body.

7. In order to clean the "off-idle" vent ports and bowl vent thoroughly, use a good carburetor solvent (like Gumout™). Blow clean compressed air through the idle adjusting needle hole. Be careful to use a suitable shop rag to prevent debris from hitting someone.

8. Remove the formed rubber gasket only if it is to be replaced. If it is removed for any reason, replace it.

Inspection/Repair

Carefully inspect all components and replace those that are worn or damaged.

- Inspect the carburetor body for cracks, holes and other wear or damage.

- Inspect the float for cracks, holes, and missing or damaged float tab. Check the float hinge and pin for wear or damage.

- Inspect the fuel inlet needle and seat for wear or damage.

- The choke plate is spring loaded. Check to make sure it moves freely on the shaft.

Always use new gaskets when servicing or reinstalling carburetors. Repair kits are available which include new gaskets and other components. These kits are described on page 5.10.

Float

If symptoms described in the carburetor troubleshooting guide indicate possible float level problems, a check of the existing float level may be performed as follows. It is not necessary to remove the carburetor from the engine to check or adjust the float level.

1. Remove the air cleaner and breather hose. Refer to Section 9 - "Disassembly".

2. Disconnect the fuel line from the carburetor.

3. Clean dirt and debris from exterior of carburetor.

4. Remove the four screws holding the two carburetor halves together. Carefully lift the carburetor air horn assembly off the carburetor body and disconnect the choke linkage.

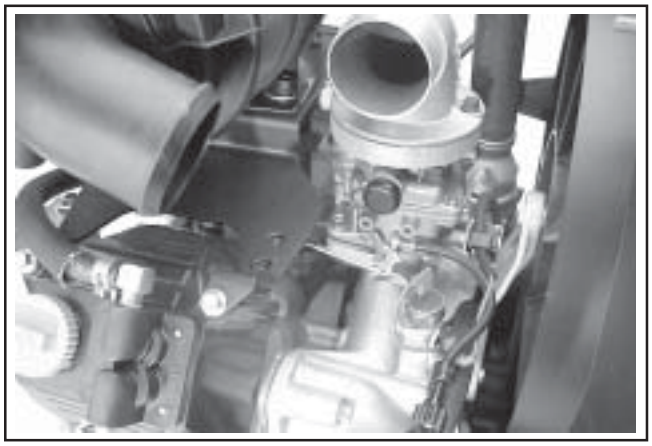


Figure 5-4. Carburetor Mounting Detail.

5. Hold the carburetor air horn so that the float assembly hangs vertically and rests lightly against the fuel inlet needle. The fuel inlet needle should be fully seated but the needle tip should not be depressed. See Figure 5-5.

NOTE: The fuel inlet needle tip is spring loaded. Make sure float assembly rests against the fuel inlet needle without depressing the tip.

6. The correct float height adjustment is **22 mm (0.86 in.)** measured from the float bottom to the air horn casting. Adjust the float height by carefully bending the tab.

   NOTE: Be sure to measure from the casting surface, not the rubber gasket surface.

7. If proper float height adjustment cannot be achieved, check to see if the fuel inlet needle is dirty, obstructed or worn. Remove the brass screw and float assembly to remove the fuel inlet needle.

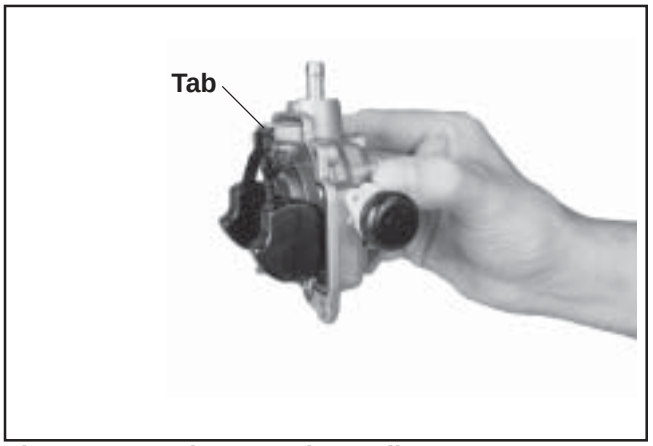
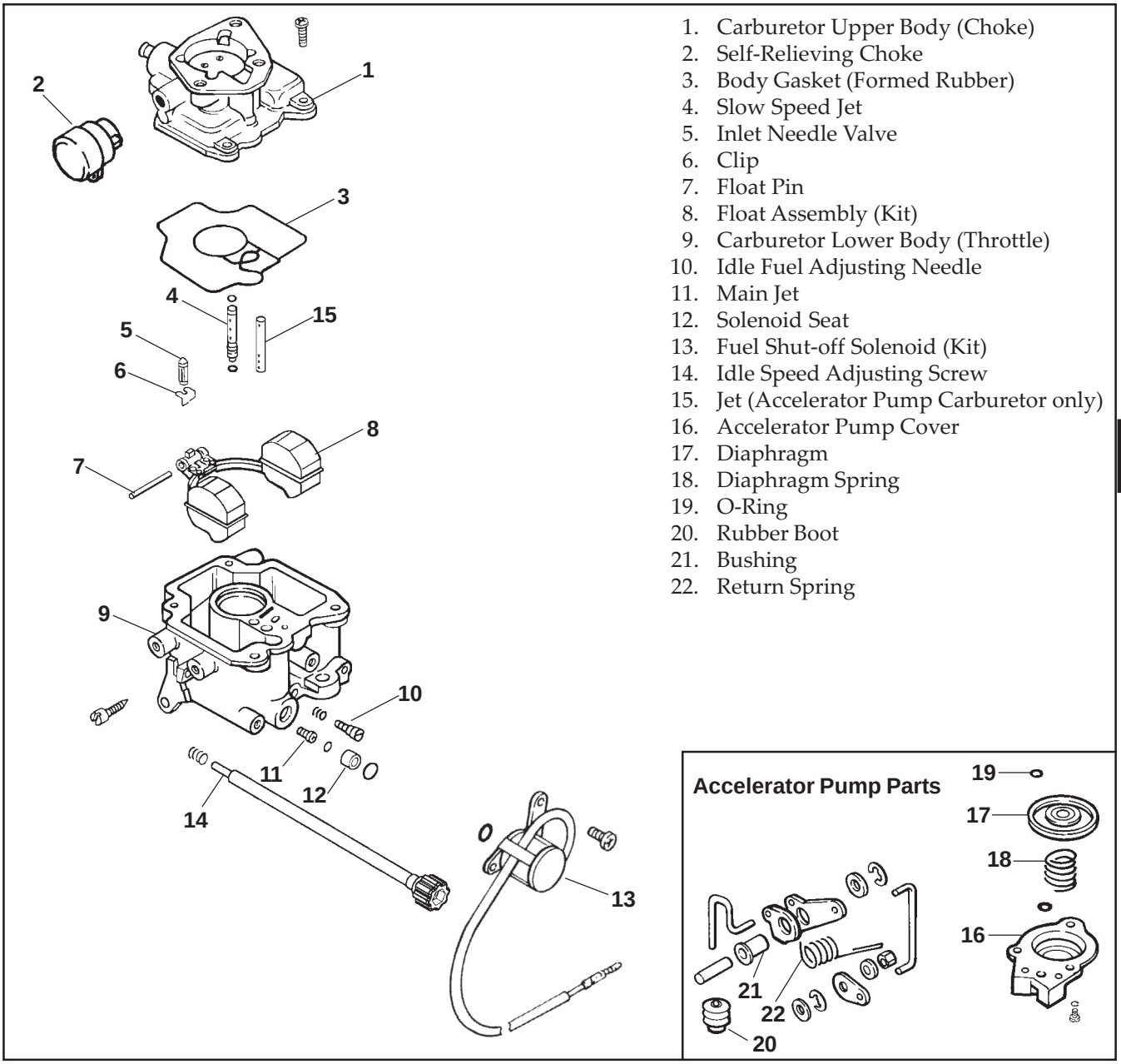


Figure 5-5. Carburetor Float Adjustment.

8. Once proper float height is obtained, carefully lower the carburetor upper body onto the carburetor lower body, connecting the choke linkage. Install the four screws. Torque screws to **1.7 N·m (15 in. lb.)**. See Figure 5-4.

9. Connect the fuel line.

10. Install the breather hose and air cleaner assembly following the steps in Section 11 - "Reassembly".



1. Carburetor Upper Body (Choke)
2. Self-Relieving Choke
3. Body Gasket (Formed Rubber)
4. Slow Speed Jet
5. Inlet Needle Valve
6. Clip
7. Float Pin
8. Float Assembly (Kit)
9. Carburetor Lower Body (Throttle)
10. Idle Fuel Adjusting Needle
11. Main Jet
12. Solenoid Seat
13. Fuel Shut-off Solenoid (Kit)
14. Idle Speed Adjusting Screw
15. Jet (Accelerator Pump Carburetor only)
16. Accelerator Pump Cover
17. Diaphragm
18. Diaphragm Spring
19. O-Ring
20. Rubber Boot
21. Bushing
22. Return Spring

Figure 5-6. Carburetor - Exploded View.

Carburetor Service/Repair Kits

Always refer to the Parts Manual for the engine being serviced to ensure the correct repair kits and replacement parts are ordered.

Carburetor Repair Kit Contains:

Qty.	Description
1	Carburetor Body Gasket
4	Carburetor Body Screw
1	Idle Needle Spring
2	Slow Jet O-Ring
1	Main Jet O-Ring
1	Solenoid O-Ring
1	Solenoid O-Ring
1	Solenoid O-Ring
1	Inlet Needle Clip
1	Inlet Fuel
1	Inlet Needle Valve
1	O-Ring

Float Kit Contains:

Qty.	Description
1	Carburetor Body Gasket
1	Float Screw
1	Float Assembly
1	Float Shaft

High Altitude (1500 Meter) Kit Contains:

Qty.	Description
1	Carburetor Gasket
1	Carburetor Gasket (plastic intake manifold)
1	Air Cleaner Base Gasket
1	Main Jet O-Ring
1	Solenoid O-Ring
1	Solenoid O-Ring
1	Solenoid O-Ring
1	Main Jet

Solenoid Kit Contains:

Qty.	Description
2	Solenoid Screw
1	O-Ring
1	O-Ring
1	O-Ring
1	Solenoid Assembly
1	Solenoid Seat

Accelerator Pump Diaphragm Kit Contains:

Qty.	Description
3	Screw
1	Diaphragm
1	Spring
2	O-Ring

Accelerator Pump Seal & Bushing Kit Contains:

Qty.	Description
2	E-Clip Retainer
1	Seal
1	Hex Nut
1	Boot
1	Collar
1	Spring Washer
1	Washer
1	Washer
1	Washer

Choke Repair Kit Contains:

Qty.	Description
2	Choke Plate Screw
1	Choke Spring
1	Choke Lever
1	Choke Shaft
1	Choke Plate
1	Choke Bushing
1	Choke Lever Cap
1	Sealant

Reassembly Procedure

Reassemble the carburetor using the following steps. See Figure 5-6.

1. Assemble fuel inlet needle to the float tab. Install the float, float shaft and inlet needle to the carburetor upper body. Tighten the screw. Check float height using the procedure found previously in the "Adjustments" subsection.

2. Install the slow jet so the stepped end will be toward the bottom of the carburetor. Make sure jet is fully seated.

3. Install the low idle adjusting needle and spring.

4. Assemble the carburetor upper body and carburetor lower body using the four screws. Torque screws to **1.7 N·m (15 in. lb.)**.

5. Install the carburetor on the engine following the procedures in Section 11 - "Reassembly".

Governor

General

The engine is equipped with a centrifugal flyweight mechanical governor. It is designed to hold the engine speed constant under changing load conditions. The governor gear/flyweight mechanism is mounted inside the closure plate and is driven off the gear on the camshaft. The governor works as follow:

- Centrifugal force acting on the rotating governor gear assembly causes the flyweights to move outward as speed increases. Governor spring tension moves them inward as speed decreases.

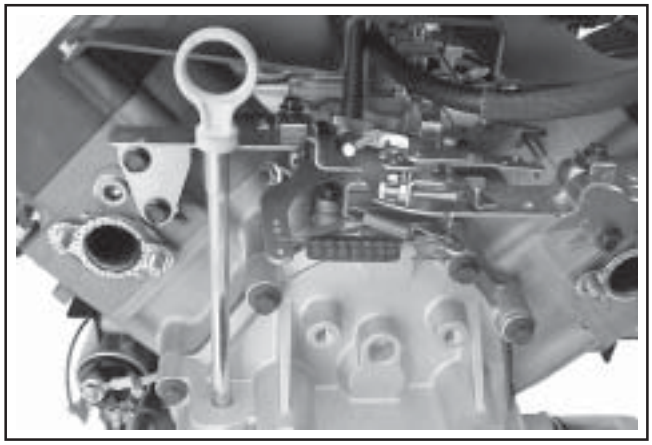


Figure 5-7. Governor Linkage.

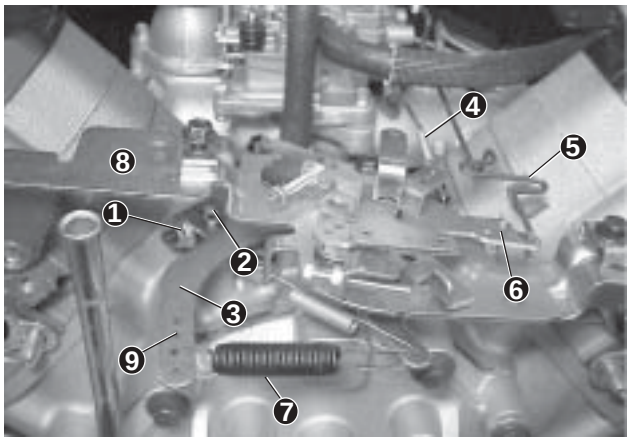
- As the flyweights move outward, they cause the regulating pin to move outward.

- The regulating pin contacts the tab on the cross shaft causing the shaft to rotate.

- One end of the cross shaft protrudes through the crankcase. The rotating action of the cross shaft is transmitted to the throttle lever of the carburetor through the external linkage. See Figure 5-7.

- When the engine is at rest, and the throttle is in the “fast” position, the tension of the governor spring holds the throttle plate open. When the engine is operating, the governor gear assembly is rotating. The force applied by the regulating pin, against the cross shaft, tends to close the throttle plate. The governor spring tension and the force applied by the regulating pin balance each other during operation, to maintain engine speed.

- When load is applied and the engine speed and governor gear speed decreases, the governor spring tension moves the governor arm to open the throttle plate wider. This allows more fuel into the engine, increasing engine speed. As speed reaches the governed setting, the governor spring tension and the force applied by the regulating pin will again offset each other to hold a steady engine speed.



1. Governor Lever Hex Nut
2. Governor Cross Shaft
3. Governor Lever
4. Throttle Lever Linkage
5. Choke Linkage
6. Choke Actuating Lever
7. Governor Spring
8. Speed Control Bracket
9. Governor Lever (Holes for Sensitivity Adjustment)

Figure 5-8. Governor Controls and Linkage (External) (Air Cleaner Removed for Clarity).

Adjustments

General

The governed speed setting is determined by the position of the throttle control. It can be variable or constant, depending on the engine application.

Initial Adjustment

NOTE: The LH760 and LH775 (EFI) engines require a special initial adjustment procedure, which is covered in subsection 5B. Refer to pages 5B.21-5B.22.

Make this adjustment whenever the governor lever is loosened or removed from the cross shaft. See Figure 5-8 and adjust as follows:

1. Make sure the throttle linkage is connected to the governor lever and the throttle lever on the carburetor.

2. Loosen the hex nut holding the governor lever to the cross shaft.

3. Move the governor lever **towards** the carburetor as far as it will move (wide open throttle) and hold in position.

4. Insert a nail into the hole on the cross shaft and rotate the shaft **counterclockwise** as far as it will turn, then torque hex nut to **6.8 N·m (60 in. lb.)**.

Sensitivity Adjustment

Governor sensitivity is adjusted by repositioning the governor spring in the holes on the governor lever. If speed surging occurs with a change in engine load, the governor is set too sensitive. If a big drop in speed occurs when normal load is applied, the governor should be set for greater sensitivity. See Figure 5-8 and adjust as follows:

1. To increase the sensitivity, move the spring closer to the governor cross shaft.

2. To decrease the sensitivity, move the spring away from the governor cross shaft.

High Speed RPM Adjustment (See Figure 5-9.)

1. With the engine running, move the throttle control to **fast**. Use a tachometer to check the RPM speed.

2. Loosen the lock nut on the high speed adjusting screw. Turn screw outward to decrease, or inward to increase RPM speed. Check RPM with a tachometer.

3. When the desired RPM speed is obtained, retighten the lock nut.

NOTE: When the throttle and choke control cables are routed side-by-side, especially under a single clamp, there must be a small gap between the cables to prevent internal binding. After the high-speed setting has been complete, check that there is gap of at least 0.5 mm (0.020 in.) between the control cables.

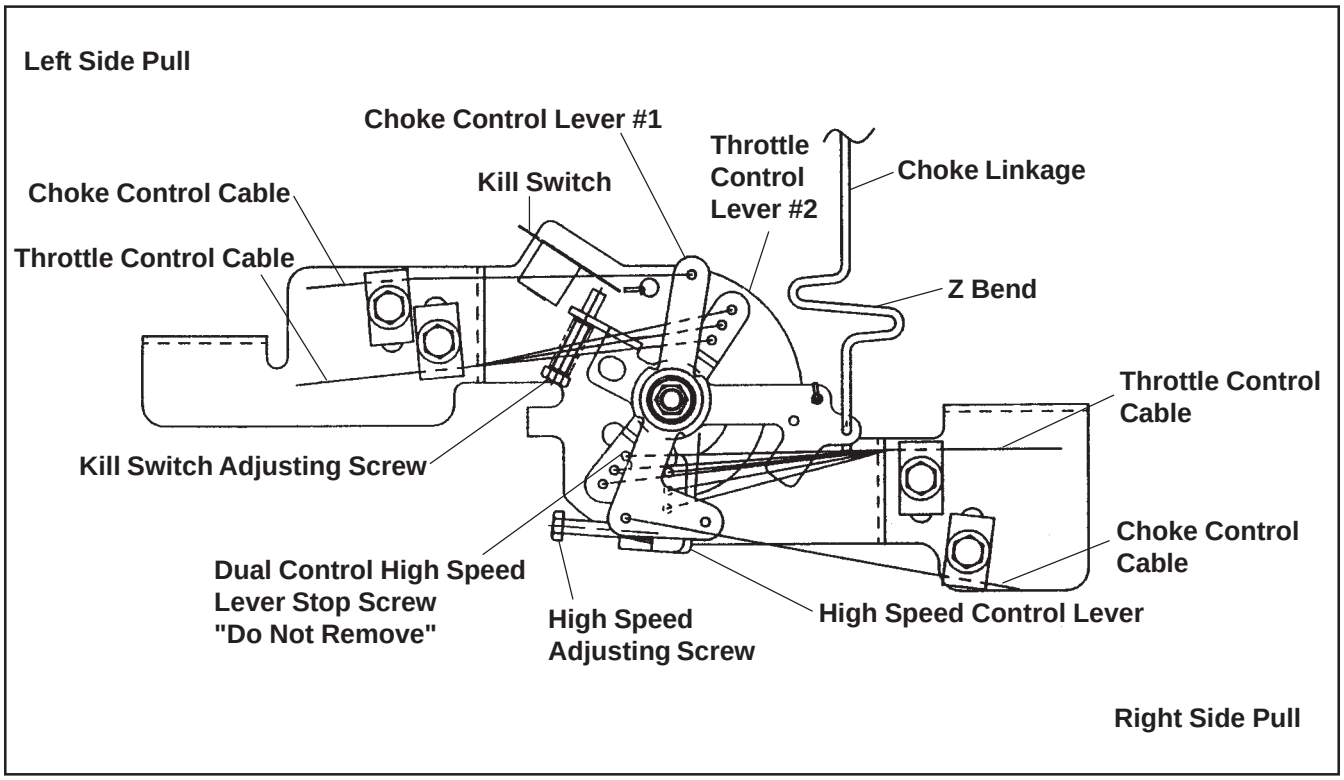


Figure 5-9. Governor Control Connections.

5

Section 5B
Electronic Fuel Injection (EFI) Fuel System

Contents

Description

WARNING

Explosive Fuel can cause fires and severe burns.

Fuel system ALWAYS remains under HIGH PRESSURE.

WARNING: Explosive Fuel!

Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Do not fill the fuel tank while the engine is hot or running, since spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Do not start the engine near spilled fuel. Never use gasoline as a cleaning agent.

The EFI fuel system remains under high pressure, even when the engine is stopped. Before attempting to service any part of the fuel system, the pressure must be relieved. Pressure tester, (part of EFI Service Kit, see Section 2) has an integral relief valve. Connect the black tester hose to the test valve in the fuel rail. Route the clear hose into a portable gasoline container. Depress the button on the tester relief valve.

Initial Starting/Priming Procedure

Important: The EFI fuel system must be purged of air (primed) prior to the initial start up, and/or any time the system has been disassembled or the fuel tank run dry.

1. Turn the key switch to the “on/run” position. You will hear the fuel pump cycle on and off. When the fuel pump stops cycling approximately one minute), the system is primed; start the engine.

Fuel Recommendations

General Recommendations

Purchase gasoline in small quantities and store in clean, approved containers. An approved container with a capacity of 2 gallons or less with a pouring spout is recommended. Such a container is easier to handle and helps prevent spillage during refueling.

- Do not use gasoline left over from the previous season, to minimize gum deposits in your fuel system, and to ensure easy starting.
- Do not add oil to the gasoline.
- Do not overfill the fuel tank. Leave room for the fuel to expand.

Fuel Type

Do not use leaded gasoline, as component damage will result. Any costs/damages incurred as a result of using leaded fuel will not be warranted. Use only clean, fresh, **unleaded** gasoline with a pump sticker octane rating of 87 or higher. In countries using the Research method, it should be 90 octane minimum.

Gasoline/Alcohol blends

Gasohol (up to 10% ethyl alcohol, 90% unleaded gasoline by volume) is approved as a fuel for Kohler EFI engines. Other gasoline/alcohol blends are not approved.

Gasoline/Ether blends

Methyl Tertiary Butyl Ether (MTBE) and unleaded gasoline blends (up to a maximum of 15% MTBE by volume) are approved as a fuel for Kohler EFI engines. Other gasoline/ether blends are not approved.

EFI Fuel System Components

General

The Electronic Fuel Injection (EFI) system is a complete engine fuel and ignition management design. The system includes the following principal components:

- Fuel Pump
- Fuel Filter
- Fuel Rail
- Fuel Line(s)
- Fuel Pressure Regulator
- Fuel Injectors
- Throttle Body/Intake Manifold
- Engine Control Unit (ECU)
- Ignition Coils
- Engine (Coolant) Temperature Sensor
- Throttle Position Sensor (TPS)
- Speed Sensor
- Oxygen Sensor
- Wire Harness Assembly & Affiliated Wiring,
- Malfunction Indicator Light (MIL)

Operation

The EFI system is designed to provide peak engine performance with optimum fuel efficiency and lowest possible emissions. The ignition and injection functions are electronically controlled, monitored and continually corrected during operation to maintain the theoretical ideal or "stoichiometric" air/fuel ratio of 14.7:1.

The central component of the system is the Motronic™ Engine Control Unit (ECU) which manages system operation, determining the best combination of fuel mixture and ignition timing for the current operating conditions.

An electric fuel pump is used to move fuel from the tank through the fuel line and in-line fuel filter. A fuel pressure regulator maintains a system operating pressure of 39 psi and returns any excess fuel to the tank. At the engine, fuel is fed through the fuel rail and into the injectors, which inject it into the intake ports. The ECU controls the amount of fuel by varying the length of time that the injectors are "on." This can range from 1.5-8.0 milliseconds depending on fuel requirements. The controlled injection of the fuel occurs each crankshaft revolution, or twice for each 4-stroke cycle. One-half the total amount of fuel needed for one firing of a cylinder is injected during each injection. When the intake valve opens, the fuel/air mixture is drawn into the combustion chamber, ignited, and burned.

The ECU controls the amount of fuel injected and the ignition timing by monitoring the primary sensor signals for engine temperature, speed (RPM), and throttle position (load). These primary signals are compared to preprogrammed "maps" in the ECU computer chip, and the ECU adjusts the fuel delivery to match the mapped values. An oxygen sensor provides continual feedback to the ECU based upon the amount of unused oxygen in the exhaust, indicating whether the fuel mixture being delivered is rich or lean. Based upon this feedback, the ECU further adjusts fuel input to re-establish the ideal air/fuel ratio. This operating mode is referred to as "closed loop" operation. The EFI system operates "closed loop" when all three of the following conditions are met:

a. The engine (coolant) temperature is greater than 35°C (95°F).

b. The oxygen sensor has warmed sufficiently to provide a signal (minimum 375°C, 709°F).

c. Engine operation is at a steady state (not starting, warming up, accelerating, etc.).

During "closed loop" operation the ECU has the ability to readjust temporary and learned adaptive controls, providing compensation for changes in overall engine condition and operating environment, so it will be able to maintain the ideal air/fuel ratio of 14.7:1. The system requires a minimum engine coolant temperature greater than 55°C (130°F) to properly adapt. These adaptive values are maintained as long as the ECU is "powered up" by the battery.

During certain operating periods such as cold starts, warm up, acceleration, etc., an air/fuel ratio richer than 14.7:1 is required, and the system operates in an "open loop" mode. In "open loop" operation the monitoring of exhaust gases (output) is not used, and the controlling adjustments are based on the primary sensor signals and programmed maps only. The system operates "open loop" whenever the three conditions for closed loop operation (above) are not being met.

Important Service Notes!

- Cleanliness is essential and must be maintained at all times when servicing or working on the EFI system. Dirt, even in small quantities, can cause significant problems.
- Clean any joint or fitting with parts cleaning solvent before opening to prevent dirt from entering the system.
- Always depressurize the fuel system through the test valve in fuel rail before disconnecting or servicing any fuel system components. See fuel warning on page 5B.2.
- Never attempt to service any fuel system component while engine is running or ignition switch is **"on."**
- Do not use compressed air if the system is open. Cover any parts removed and wrap any open joints with plastic if they will remain open for any length of time. New parts should be removed from their protective packaging just prior to installation.
- Avoid direct water or spray contact with system components.
- Do not disconnect or reconnect the wiring harness connector to the control unit or any individual components with the ignition ''on.'' This can send a damaging voltage spike through the ECU.
- Do not allow the battery cables to touch opposing terminals. When connecting battery cables attach the positive (+) cable to positive (+) battery terminal first, followed by negative (-) cable to negative (-) battery terminal.
- Never start the engine when the cables are loose or poorly connected to the battery terminals.
- Never disconnect battery while engine is running.
- Never use a quick battery charger to start the engine.
- Do not charge battery with key switch ''on.''
- Always disconnect negative (-) battery cable lead before charging battery, and also unplug harness from ECU before performing any welding on equipment.

Electrical Components

Electronic Control Unit (ECU)

Figure 5B-1. "32 Pin" (MSE 1.1) Plastic-Cased ECU.

General

A "32 Pin" (MSE 1.1) plastic-cased ECU is used on these engines. See Figure 5B-1. The ECU is the brain or central processing computer of the entire EFI fuel/ignition management system. During operation, sensors continuously gather data which is relayed through the wiring harness to input circuits within the ECU. Signals to the ECU include: ignition (on/off), crankshaft position and speed (RPM), throttle position, coolant temperature, exhaust oxygen levels, and battery voltage. The ECU compares the input signals to the programmed maps in its memory to determine the appropriate fuel and spark requirements for the immediate operating conditions. The ECU then sends output signals to set the injector duration and ignition timing.

The ECU continually performs a diagnostic check of itself, each of the sensors, and the system performance. If a fault is detected, the ECU turns on the Malfunction Indicator Light (MIL) on the equipment control panel, stores the fault code in its fault memory, and goes into a default operating mode. Depending on the significance or severity of the fault, normal operation may continue, or "limp home" operation (slowed speed, richer running) may be initiated. A technician can access the stored fault code using a "blink code" diagnosis flashed out through the MIL. An optional computer software diagnostic program is also available, see Section 2.

The ECU requires a minimum of 7.0 volts to operate. The adaptive memory in the ECU is operational the moment the battery cables are connected, however the adapted values are lost if the battery becomes disconnected for any reason. The ECU will "relearn" the adapted values if the engine is operated for 10-15 minutes at varying speeds and loads after the coolant temperature exceeds 55°C (130°F).

To prevent engine over-speed and possible failure, a "rev-limiting" feature is programmed into the ECU. If the maximum RPM limit (4500) is exceeded, the ECU suppresses the injection signals, cutting off the fuel flow. This process repeats itself in rapid succession, limiting operation to the preset maximum.

Service

Never attempt to disassemble the ECU. It is sealed to prevent damage to internal components. Warranty is void if the case is opened or tampered with in any way.

All operating and control functions within the ECU are preset. No internal servicing or readjustment may be performed. If a problem is encountered, and you determine the ECU to be faulty, contact your source of supply. Do not replace the ECU without authorization.

The relationship between the ECU and the throttle position sensor (TPS) is very critical to proper system operation. If the TPS or ECU is changed, or the mounting position of the TPS is altered, the "TPS Initialization Procedure" (see pages 5B.7 and 5B.8) must be performed to restore the synchronization.

Engine Speed Sensor

General

The engine speed sensor is essential to engine operation; constantly monitoring the rotational speed (RPM) of the crankshaft. A ferromagnetic 60-tooth ring gear with two consecutive teeth missing is mounted on the flywheel. The inductive speed sensor is mounted **1.5 ± 0.25 mm (0.059 ± 0.010 in.)** away from the ring gear. During rotation, an AC voltage pulse is created within the sensor for each passing tooth. The ECU calculates engine speed from the time interval between the consecutive pulses. The two-tooth gap creates an interrupted input signal, corresponding to specific crankshaft position (84° BTDC) for cylinder #1. This signal serves as a reference for the control of ignition timing by the ECU. Synchronization of the inductive speed pickup and crankshaft position takes place during the first two revolutions each time the engine is started. The sensor must be properly connected at all times. If the sensor becomes disconnected for any reason, the engine will quit running.

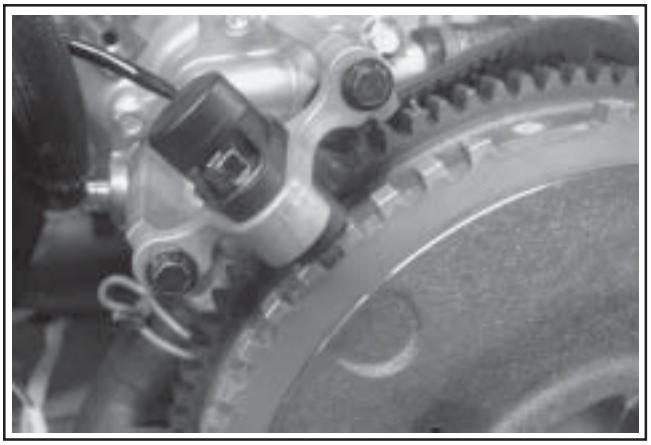


Figure 5B-2. Engine Speed Sensor.

Service

The engine speed sensor is a sealed, non-serviceable assembly. If diagnosis indicates a problem within this area, check and test as follows.

1. Check the mounting and air gap of sensor. It must be **1.5 mm ± 0.25 mm (0.059 ± 0.010 in.)**.

2. Inspect the wiring and connections for damage or problems.

3. Make sure the engine has resistor type spark plugs.

4. Disconnect main harness connector from ECU.

5. Connect an ohmmeter between pin terminals #9 and #10 in the plug. See chart on page 5B.24. A resistance value of **750-1000 Ω** at room temperature (20°C, 68°F) should be obtained. If resistance is correct, check the mounting, air gap, toothed ring gear (damage, runout, etc.), and flywheel key.

6. Disconnect the speed sensor connector from wiring harness. It is the connector with one heavy black lead (see Figure 5B-3). Viewing the connector as shown (dual aligning rails on top), test the resistance between the terminals indicated. A reading of **750-1000 Ω** should again be obtained.

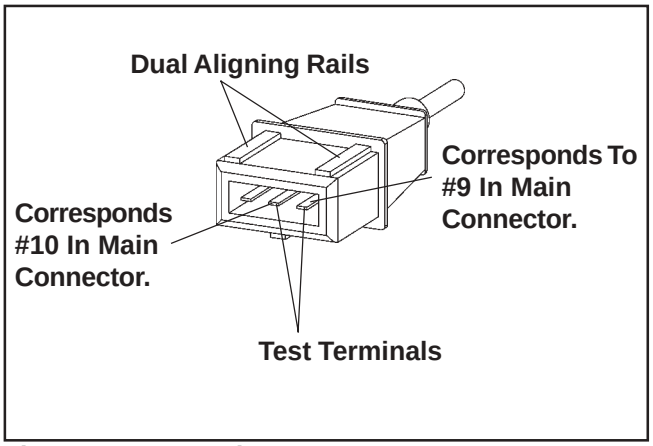


Figure 5B-3. Speed Sensor Connector.

7. a. If the resistance is incorrect, remove the screw securing the sensor to the mounting bracket and replace the sensor.

   b. If the resistance in step 2 was incorrect, but the resistance of the sensor alone was correct, test the main harness circuits between the sensor connector terminals and the corresponding pin terminals in the main connector. Correct any observed problem, reconnect the sensor, and perform step 5 again.

Throttle Position Sensor (TPS)

General

The throttle position sensor (TPS) is used to indicate throttle plate angle to the ECU. Since the throttle (by way of the governor) reacts to engine load, the angle of the throttle plate is directly proportional to the load on the engine.

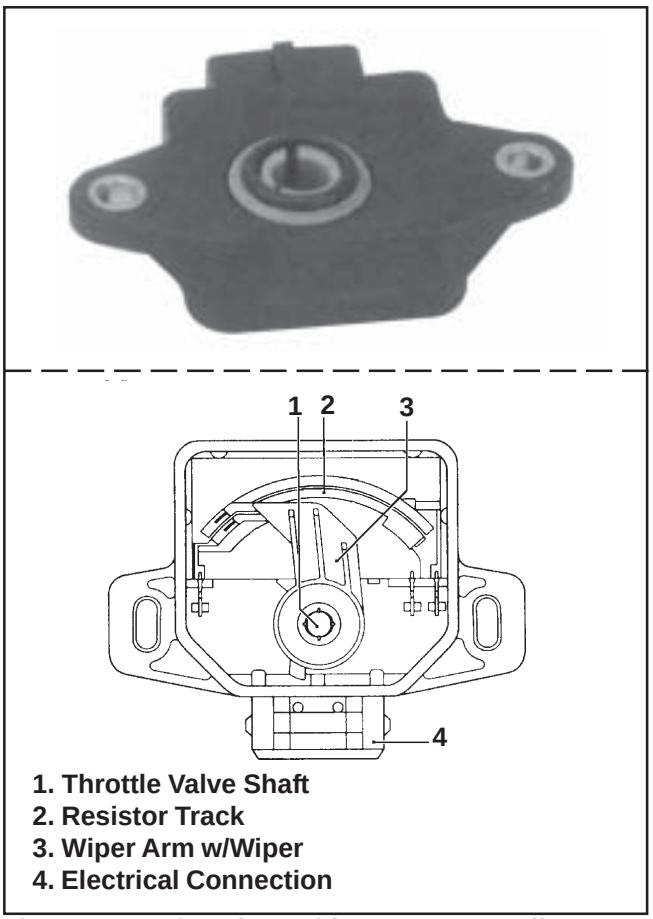


Figure 5B-4. Throttle Position Sensor Details.

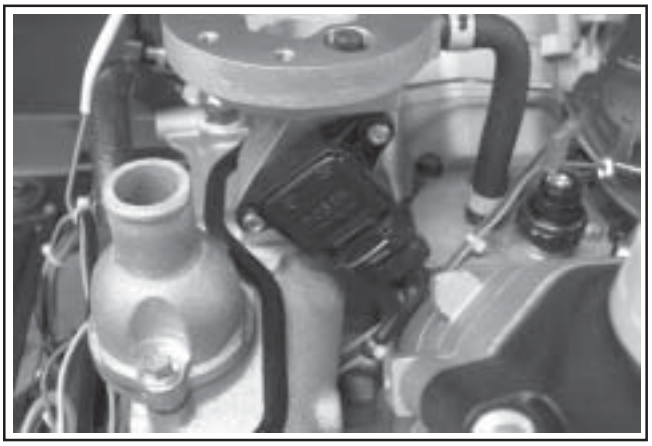


Figure 5B-5. TPS Location.

Mounted on the throttle body/intake manifold and operated directly off the end of the throttle shaft, the TPS works like a rheostat, varying the voltage signal to the ECU in direct correlation to the angle of the throttle plate. This signal, along with the other sensor signals, is processed by the ECU and compared to the internal pre-programmed maps to determine the required fuel and ignition settings for the amount of load.

The correct position of the TPS is established and set at the factory. Do not loosen the TPS or alter the mounting position unless absolutely required by fault code diagnosis or throttle shaft service. If the TPS is loosened or repositioned the "TPS Initialization Procedure" (see pages 5B.7 and 5B.8) must be performed to re-establish the baseline relationship between the ECU and the TPS.

Service

The TPS is a sealed, non-serviceable assembly. If diagnosis indicates a bad sensor, complete replacement is necessary. If a blink code indicates a problem with the TPS, it can be tested as follows.

1. Counting the number of turns, back out the idle speed adjusting screw (counterclockwise) until the throttle plate can be closed completely.

2. Disconnect the main harness connector from the ECU, but leave the TPS mounted to the throttle body/manifold.

3. Connect the ohmmeter leads as follows: (See chart on page 5B.24.) Connect the Red (positive) ohmmeter lead to #8 pin terminal, and the Black (negative) ohmmeter lead to #4 pin terminal. Hold the throttle closed and check the resistance. It should be **800-1200 Ω**.

4. Leave the leads connected to the pin terminals as described in step 3. Rotate the throttle shaft slowly counterclockwise to the full throttle position. Monitor the dial during rotation for indication of any momentary short or open circuits. Note the resistance at the full throttle position. It should be **1800-3000 Ω**.

5. Disconnect the main wiring harness connector from the TPS, leaving the TPS assembled to the manifold. Refer to the following chart and perform the resistance checks indicated between the terminals in the TPS socket, with the throttle in the positions specified.

Throttle Position	Between Terminals	Resistance Value (Ω)	Continuity
Closed	2 & 3	800-1200	Yes
Closed	1 & 3	1800-3000	Yes
Full	2 & 3	1800-3000	Yes
Full	1 & 3	800-1200	Yes
Any	1 & 2	1600-2500	Yes

   If the resistance values in steps 3, 4, and 5 are within specifications, go to step 6.

   If the resistance values are not within specifications, or a momentary short or open circuit was detected during rotation (step 4), the TPS needs to be replaced, go to step 7.

6. Check the TPS circuits (input, ground) between the TPS plug and the main harness connector for continuity, damage, etc., Pin Circuits #8 and #4. See chart on page 5B.24.

   a. Repair or replace as required.

   b. Turn the idle speed screw back in to its original setting.

   c. Reconnect connector plugs, start engine and retest system operation.

7. Remove the two mounting screws from the TPS. Save the screws for reuse. Remove and discard the faulty TPS. Install the replacement TPS and secure with the original mounting screws.

   a. Reconnect both connector plugs.

   b. Perform the "TPS Initialization Procedure" integrating the new sensor to the ECU.

TPS Initialization Procedure

"32 Pin" (MSE 1.1) Plastic-Cased ECU (Auto-Learn Initialization)

1. Check that the basic engine, all sensors, fuel, fuel pressure, and battery are good and functionally within specifications.

Important!

2. Remove/disconnect ALL external loads from the engine (belts, pumps, electric PTO clutch, alternator, rectifier-regulator, etc.).

3. Locate the service connector plug in the wiring harness. To initiate the TPS auto-learn function, connect a jumper wire from the TPS initialization pin #24 (violet wire) to the battery voltage pin (red wire), or use a jumper connector plug with the blue jumper wire. See Figure 5B-6. If using the PC-based diagnostic tool and software (see Section 2), go to "Special Tests" and follow the prompts to complete.

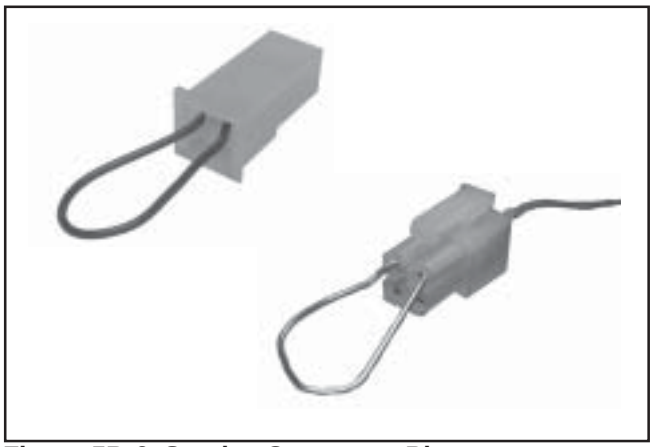


Figure 5B-6. Service Connector Plug.

4. Start the engine and immediately observe the Malfunction indicator Light (MIL). The light should start blinking 4 consecutive times every 2 seconds.

5. Remove the jumper wire or plug from the service connector plug in wiring harness.

6. Run the engine at full throttle (above 3000 RPM), to warm up the engine and initiate O_2 sensor function in "closed-loop" operation.

7. Watch the "MIL." When the light starts blinking rapidly, (5 blinks per second), move the throttle lever to the low idle speed position. Check and adjust the idle speed to **1500 RPM**, using a tachometer. The lamp should continue to blink rapidly for another 30 seconds before switching over to a slow blink.

8. When the "MIL" blinks slowly, do not do anything but wait until the "MIL" shuts off. This indicates that this procedure has been completed successfully.

9. Shut off the engine.

If the learn procedure was successfully completed, the external loads removed/disconnected in Step 2 may be reconnected.

If the procedure was unsuccessful see Steps a. and b. following.

a. If during this procedure, the "MIL" goes back into blinking 4 consecutive blinks every 2 seconds, the engine and Oxygen sensor have cooled down and out of "closed-loop" operation, prohibiting the learning from occurring. Repeat Steps 5-8.

b. If during the procedure with the engine running, the "MIL" stays "On" continuously, for more than 15 seconds, turn off the ignition. Then initiate the fault code sequence by doing three consecutive key-on/key-off cycles leaving the key "on" in the last sequence, (each key-on/key-off sequence must be less than 2.5 seconds long). The fault detected must be corrected before the "auto-learn" function of the ECU can be re-initiated. The PC-based diagnostic tool and software may be used to read out the fault code and assist with the troubleshooting and repair.

Engine (Coolant) Temperature Sensor

Figure 5B-7. Engine (Coolant) Temperature Sensor.

General
The engine (coolant) temperature sensor (Figure 5B-7) is used by the system to help determine fuel requirements for starting (a cold engine needs more fuel than one at or near operating temperature). Mounted in the throttle body/intake manifold, it has a temperature-sensitive resistor that extends into the coolant flow. The resistance changes with coolant temperature, altering the voltage sent to the ECU. Using a table stored in its memory, the ECU correlates the voltage drop to a specific temperature. Using the fuel delivery "maps", the ECU then knows how much fuel is required for starting at that temperature.

Service
The coolant temperature sensor is a sealed, non-serviceable assembly. A faulty sensor must be replaced. If a blink code indicates a problem with the temperature sensor, it can be tested as follows.

1. Drain coolant from system so level is lower than the coolant temperature sensor (approximately 1-1/2 qt.), then remove the sensor from the throttle body/intake manifold assembly.

2. Wipe sensor clean and allow it to reach room temperature (20°C, 68°F).

3. Unplug the main harness connector from the ECU.

4. With the sensor connected, check the coolant temperature sensor circuit resistance. Check between the #6 and #4 pin terminals. The resistance value should be **2375-2625 Ω**. See chart on page 5B.24.

5. Unplug the sensor connector and check the sensor resistance separately. Resistance value should again be **2375-2625 Ω**.

   a. If the resistance is out of specifications, replace the temperature sensor and refill the cooling system.

   b. If it is within specifications, proceed to Step 6.

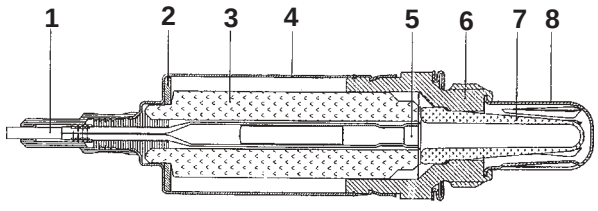
6. Check the temperature sensor circuits (input, ground) from the main harness connector to the corresponding terminal in the sensor plug for continuity, damage, etc. Pin circuits #6 and #4.

Oxygen Sensor

Figure 5B-8. Oxygen Sensor.

General
The oxygen sensor functions like a small battery, generating a voltage signal to the ECU, based upon the difference in oxygen content between the exhaust gas and the ambient air.

The tip of the sensor, protruding into the exhaust gas, is hollow (see cutaway Figure 5B-9). The outer portion of the tip is surrounded by the exhaust gas, with the inner portion exposed to the ambient air. When the oxygen concentration on one side of the tip is different than that of the other side, a voltage signal typically cycling between 0.2 and 1.0 volt is generated between the electrodes and sent to the ECU. The voltage signal tells the ECU if the engine is straying from the ideal 14.7:1 fuel mixture, and the ECU then adjusts the injector pulse accordingly.



1. Connection Cable
2. Disc Spring
3. Ceramic Support Tube
4. Protective Sleeve
5. Contact Element
6. Sensor Housing
7. Active Ceramic Sensor
8. Protective Tube

Figure 5B-9. Cutaway of Oxygen Sensor.

The oxygen sensor can function only after being heated by exhaust temperatures to a minimum of 375°C (709°F). A cold oxygen sensor will require approximately 1-2 minutes at moderate engine load to warm sufficiently to generate a voltage signal. Proper grounding is also critical. The oxygen sensor grounds through the metal shell, so a good, solid, unbroken ground path back through the exhaust system components, engine, and wiring harness is required. Any disruption or break in the ground circuit can affect the output signal and trigger misleading fault codes. Keep that in mind when doing any troubleshooting associated with the oxygen sensor. The oxygen sensor can also be contaminated by leaded fuel, certain RTV and/or other silicone compounds, carburetor cleaners, etc. Use only those products indicated as "O_2 Sensor Safe."

Service

Like the other sensors already discussed, the oxygen sensor is a non-serviceable component. Complete replacement is required if it is faulty. The sensor and wiring harness can be checked as follows.

NOTE: All tests should be conducted with a good quality, high-impedance, digital VOA meter for accurate results.

1. Oxygen sensor must be hot (minimum of 400°C, 725°F). Run engine for about 5 minutes. With the engine running, disconnect the oxygen sensor lead from the wiring harness. Set VOA meter for DC volts and connect the **red** lead to the disconnected sensor lead, and the **black** lead to the sensor shell. Check for a cycling voltage reading between **0.2 and 1.0 volt**.

   a. If voltage is in the specified range, go to step 2.

   b. If the voltage is not in the specified range, reconnect the oxygen sensor lead. With the lead connected, probe or connect the sensor connection with the red VOA meter lead. Attach the black VOA meter lead to a known good ground location. Start and run the engine at 3/4 throttle and note the voltage output.

      The reading should cycle between **0.2 and 1.0** volt, which indicates the oxygen sensor is functioning normally and also the fuel delivery controlled by the ECU is within prescribed parameters. If the voltage readings show a steady decline, bump the governor lever to make the engine accelerate very quickly and check the reading again. If voltage momentarily increases and then again declines, without cycling, engine may be running lean due to incorrect TPS initialization. Shut off the engine, perform TPS initialization, and then repeat the test. If TPS initialization cannot be achieved, perform step c.

   c. Replace the oxygen sensor (see next page). Run the engine long enough to bring the new sensor up to temperature and repeat the output test from step 1. The cycling voltage from **0.2 to 1.0** volt should be indicated.

2. Move the **black** voltmeter lead to the engine ground location and repeat the output test. The same voltage (**0.2 v-1.0 v**) should be indicated.

   a. If the same voltage reading exists, go on to step 3.

   b. If the voltage output is no longer correct, a bad ground path exists between the sensor and the engine ground. Touch the black lead at various points, backtracking from the engine ground back toward the sensor, watching for a voltage change at each location. If the correct voltage reading reappears at some point, check for a problem (rust, corrosion, loose joint or connection) between that point and the previous checkpoint. For example, if the reading is too low at points on the crankcase, but correct voltage is indicated when the black lead is touched to the skin of the muffler, the flange joints at the exhaust ports become suspect.

3. With sensor still **hot** (minimum of 400°C, 752°F), switch meter to the Rx1K or Rx2K scale and check the resistance between the sensor lead and sensor case. It should be less than **2.0 KΩ**.

   a. If the resistance is less than **2.0 KΩ**, go to step 4.

   b. If the resistance is greater than **2.0 KΩ**, the oxygen sensor is bad, replace it.

4. Allow the sensor to cool (less than 60°C, 140°F) and retest the resistance with the meter set on the Rx1M scale. With the sensor cool, the resistance should be greater than **1.0 MΩ**.

a. If the resistance is greater than **1.0 MΩ**, go to step 5.

b. If the resistance is less than **1.0 MΩ**, the sensor is bad, replace it.

5. With the oxygen sensor disconnected and engine not running, disconnect the main harness connector from the ECU and set the meter to the Rx1 scale. Check for circuit continuity from pin #19 of the ECU connector (see page 5B.24) to the shell of the oxygen sensor, and from pin #20 to the sensor terminal of the main harness. Both tests should indicate continuity.

   a. If there is no continuity displayed in either of the tests, check the harness circuit for breaks or damage, and the connections for poor contact, moisture, or corrosion. If no continuity was found in the first test, also check for a poor/broken ground path back through the exhaust system, engine, and mounting (sensor is grounded through its shell).

   b. If continuity is indicated, go to step 6.

6. With the key switch in the ''on/run'' position, using a high impedance voltmeter, check the voltage from the wiring harness oxygen sensor connector to the engine ground location. Look for a steady voltage from **350-550 mv (0.35 - 0.55 v)**.

   a. If the voltage reading is not as specified, move the black voltmeter lead to the negative post of the battery, to be certain of a good ground. If the voltage is still not correct, the ECU is probably bad.

   b. If the voltage readings are correct, clear the fault codes and run the engine to check if any fault codes reappear.

To Replace Oxygen Sensor:

1. Disconnect the oxygen sensor connector from wiring harness.

2. Loosen and remove the oxygen sensor from the exhaust manifold/muffler assembly.

3. Apply anti-seize compound sparingly to threads of new oxygen sensor, if none already exists. **DO NOT** get any on the tip as it will contaminate the sensor. Install sensor and torque to **50-60 N·m (37-44 ft. lb.)**.

4. Reconnect the lead to wiring harness connector. Make sure it can not contact hot surfaces, moving parts, etc.

5. Test run the engine.

Electrical Relay

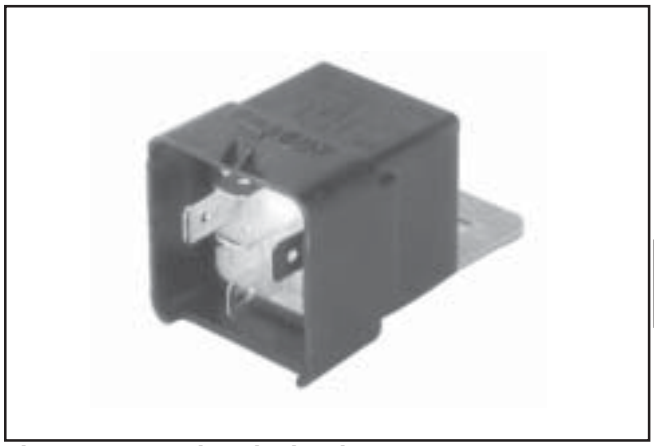


Figure 5B-10. Electrical Relay.

General

The electrical relay is used to supply power to the injectors, coils, and fuel pump. When the key switch is turned "on" and all safety switch requirements met, the relay provides 12 volts to the fuel pump circuit, injectors, and ignition coils. The fuel pump circuit is continuously grounded, so the pump is immediately activated and pressurizes the system. Activation of the ignition coils and injectors is controlled by the ECU, which grounds their respective circuits at the proper times.

Service

A malfunctioning relay can result in starting or operating difficulties. The relay and related wiring can be tested as follows.

1. Disconnect the relay connector plug from the relay.

2. Connect the black lead of a VOA meter to a chassis ground location. Connect the red lead to the #86 terminal in relay connector (see Figure 5B-11). Set meter to test resistance (Rx1). Turn the key switch from **"off"** to **"on."** Meter should indicate continuity (ground circuit is completed) for 1 to 3 seconds. Turn key switch back off.

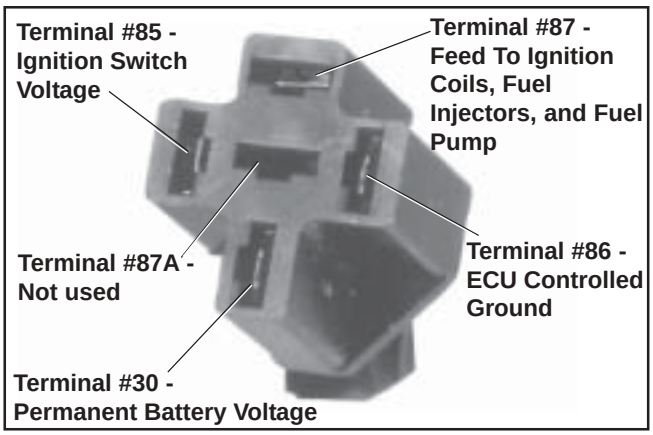


Figure 5B-11. Relay Connector.

a. Clean the connection and check wiring if circuit was not completed.

3. Set the meter for DC voltage. Touch the red tester lead to the #30 terminal in relay connector. A reading of **12 volts** should be indicated at all times.

4. Connect the red lead of meter to the #85 terminal in the relay connector. Turn the key switch to the "on" position. Battery voltage should be present.

   a. No voltage present indicates a problem in the wiring or at the connector.

   b. If voltage is present, the wiring to the connector is good. Turn ignition switch ''off'' and proceed to test 5 to test the relay.

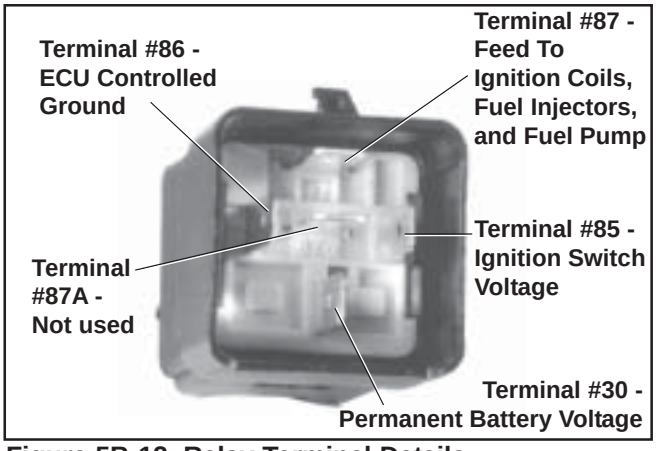


Figure 5B-12. Relay Terminal Details.

5. Connect an ohmmeter (Rx1 scale) between the #85 and #86 terminals in the relay. There should be continuity.

6. Attach ohmmeter leads to the #30 and #87 terminals in relay. Initially, there should be no continuity. Using a 12 volt power supply, connect the positive (+) lead to the #85 terminal and touch the negative (-) lead to the #86 terminal. When 12 volts is applied, the relay should activate and continuity should exist (circuit made) between the #30 and #87 terminals. Repeat the test several times. If, at any time the relay fails to activate the circuit, replace the relay.

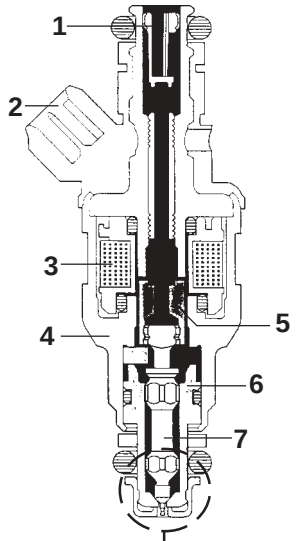
Fuel Injectors

Figure 5B-13. Fuel Injector.

General

The fuel injectors mount into the intake manifold, and the fuel rail attaches to them at the top end. Replaceable O-Rings on both ends of the injector prevent external fuel leakage and also insulate it from heat and vibration. A special clip connects each injector to the fuel rail, retaining it in place.

When the key switch is on and the relay is closed, the fuel rail is pressurized, and voltage is present at the injector. At the proper instant, the ECU completes the ground circuit, energizing the injector. The valve needle in the injector is opened electromagnetically, and the pressure in the fuel rail forces fuel down through the inside. The "director plate" at the tip of the injector (see inset) contains a series of calibrated openings which directs the fuel into the manifold in a cone-shaped spray pattern.



1. Filter strainer in fuel supply
2. Electrical connection
3. Solenoid winding
4. Valve housing
5. Armature
6. Valve body
7. Valve needle

Figure 5B-14. Fuel Injector Details.

The injector is opened and closed once for each crankshaft revolution, however only one-half the total amount of fuel needed for one firing is injected during each opening. The amount of fuel injected is controlled by the ECU and determined by the length of time the valve needle is held open, also referred to as the "injection duration" or "pulse width". It may vary in length from 1.5-8 milliseconds depending on the speed and load requirements of the engine.

Service

Injector problems typically fall into three general categories: electrical, dirty/clogged, or leakage. An electrical problem usually causes one or both of the injectors to stop functioning. Several methods may be used to check if the injectors are operating.

1. With the engine running at idle, feel for operational vibration, indicating that they are opening and closing.

2. When temperatures prohibit touching, listen for a buzzing or clicking sound with a screwdriver or mechanic's stethoscope (see Figure 5B-15).

Figure 5B-15. Checking Injectors.

3. Disconnect the electrical connector from an injector and listen for a change in idle performance (only running on one cylinder) or a change in injector noise or vibration.

If an injector is not operating, it can indicate either a bad injector, or a wiring/electrical connection problem. Check as follows:

NOTE: **Do not** apply voltage to the fuel injector(s). Excessive voltage will burn out the injector(s). **Do not** ground the injector(s) with the ignition **"on."** Injector(s) will open/turn on if the relay is energized.

1. Disconnect the electrical connector from both injectors. Plug a 12 volt noid light (part of EFI Service Kit, see Section 2) in one connector.

Figure 5B-16. Volt Noid Light.

2. Make sure all safety switch requirements are met. Crank the engine and check for flashing of noid light. Repeat test at other connector.

   a. If flashing occurs, use an ohmmeter (Rx1 scale) and check the resistance of each injector across the two terminals. Proper resistance is **12-20 Ω**. If injector resistance is correct, check whether the connector and injector terminals are making a good connection. If the resistance is not correct, replace the injector following steps 1-8 and 13-16 below.

   b. If no flashing occurs, reattach connectors to both injectors. Disconnect the main harness connector from the ECU and the connector from the relay. Set the ohmmeter to the Rx1 scale and check the injector circuit resistance as follows: Check the resistance between relay terminal #87 and pin #14 in the main connector. Then check the resistance between relay terminal #87 and pin #15. Resistance should be **4-15 Ω** for each circuit.

      Check all electrical connections, connectors, and wiring harness leads if resistance is incorrect.

Injector leakage is very unlikely, but in those rare instances it can be internal (past the tip of the valve needle), or external (weeping around the injector body). See Figure 5B-17. The loss of system pressure from the leakage can cause hot restart problems and longer cranking times. To check for leakage it will be necessary to remove the blower housing, which may involve removing the engine from the unit.

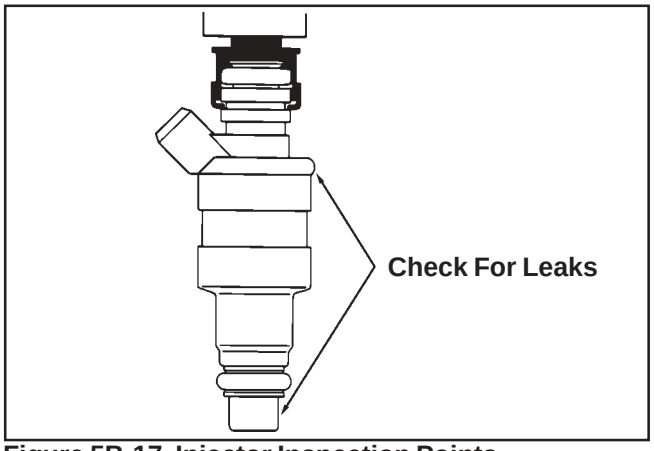


Figure 5B-17. Injector Inspection Points.

1. Engine must be cool. Depressurize fuel system through the test valve in fuel rail.

2. Disconnect the spark plug leads from spark plugs.

3. Remove the air cleaner outer cover, inner wing nut, element cover and air cleaner element/ precleaner. Service the air cleaner components as required.

4. Remove the two screws securing the air cleaner base to throttle body manifold. Remove the air cleaner base to permit access to the injectors. Check condition of air cleaner base gasket, replace if necessary.

5. Remove the flywheel screen if it overlaps the blower housing.

6. If the engine has a radiator-type oil cooler mounted to the blower housing, remove the two oil cooler mounting screws.

7. Remove the blower housing mounting screws. Note the location of the plated (silver) screw attaching the rectifier/regulator ground lead. Remove the blower housing.

8. Thoroughly clean the area around and including the throttle body/manifold and the injectors.

9. Disconnect the throttle linkage and damper spring from the throttle lever. Disconnect the TPS lead from the harness.

10. Remove the manifold mounting bolts and separate the throttle body/manifold from the engine leaving the TPS, fuel rail, air baffle, injectors and line connections intact. Discard the old gaskets.

11. Position the manifold assembly over an appropriate container and turn the key switch **"on"** to activate the fuel pump and pressurize the system. **Do not** turn switch to **"start"** position.

12. If either injector exhibits leakage of more than two to four drops per minute from the tip, or shows any sign of leakage around the outer shell, turn the ignition switch off and replace injector as follows.

13. Depressurize the fuel system following the procedure in the fuel warning on page 5B.2. Remove the two fuel rail mounting screws.

14. Clean any dirt accumulation from the sealing/ mounting area of the faulty injector(s) and disconnect the electrical connector(s).

15. Pull the retaining clip off the top of the injector(s) and remove from manifold.

16. Reverse the appropriate procedures to install the new injector(s) and reassemble the engine. Use new O-Rings any time an injector is removed (new replacement injectors include new O-Rings). Lubricate O-Rings lightly with oil. Torque fuel rail and blower housing mounting screws to **3.9 N·m (35 in. lb.)**, and the intake manifold and air cleaner mounting screws to **9.9 N·m (88 in. lb.)**.

Injector problems due to dirt or clogging are generally unlikely, due to the design of the injectors, the high fuel pressure, and the detergent additives in the gasoline. Symptoms that could be caused by dirty/ clogged injectors include rough idle, hesitation/ stumble during acceleration, or triggering of fault codes related to fuel delivery. Injector clogging is usually caused by a buildup of deposits on the director plate, restricting the flow of fuel, resulting in a poor spray pattern. Some contributing factors to injector clogging include higher than normal operating temperatures, short operating intervals, and dirty, incorrect, or poor quality fuel. Cleaning of clogged injectors is not recommended; they should be replaced. Additives and higher grades of fuel can be used as a preventative measure if clogging has been a problem.

Ignition System

General

A high voltage, solid state, battery ignition system is used with the EFI system. The ECU controls the ignition output and timing through transistorized control of the primary current delivered to the coils. Based on input from the speed sensor, the ECU determines the correct firing point for the speed at which the engine is running. At the proper instant, it releases the flow of primary current to the coil. The primary current induces high voltage in the coil secondary, which is then delivered to the spark plug. Each coil fires every revolution, but every other spark is "wasted."

Service

Except for removing the spark plug lead by unscrewing it from the secondary tower (see Figure 5B-18), no coil servicing is possible. If a coil is determined to be faulty, replacement is necessary. An ohmmeter may be used to test the wiring and coil windings.

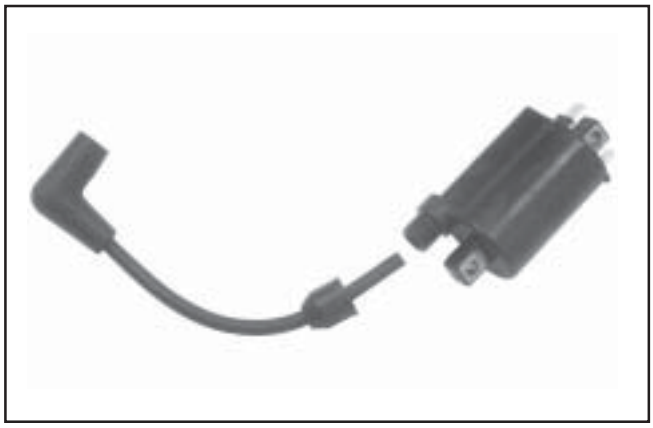


Figure 5B-18. Ignition Coil.

NOTE: **Do not** ground the coils with the ignition **"on,"** as they may overheat or spark.

1. Disconnect the main harness connector from ECU. Locate pins #30 and #31 in the 32 pin connector. See page 5B.24.

2. Disconnect the connector from the relay and locate terminal #87 in connector.

3. Using an ohmmeter set on the Rx1 scale, check the resistance in circuits as follows: Check between terminal #87 and pin #30 for coil #1. Repeat the test between terminal #87 and pin #31 for coil #2.

   A reading of **1.8-4.0 Ω** in each test indicates that the wiring and coil primary circuits are OK.

   a. If the reading(s) are not within specified range, check and clean connections and retest.

   b. If the reading(s) are still not within the specified range, test the coils separately from the main harness as follows:

      1. Disconnect the red and black primary leads from the coil terminals.

      2. Connect an ohmmeter set on the Rx1 scale to the primary terminals. Primary resistance should be **1.8-2.5 Ω**.

3. Disconnect the secondary lead from the spark plug. Connect an ohmmeter set on the Rx10K scale between the spark plug boot terminal and the red primary terminal. Secondary resistance should be **13,000-17,500 Ω**.

4. If the secondary resistance is not within the specified range, unscrew the spark plug lead nut from the coil secondary tower and remove the plug lead. Repeat step b3, testing from the secondary tower terminal to the red primary terminal. If resistance is now correct, the coil is good, but the spark plug lead is faulty, replace the lead. If step b2 resistance was incorrect and/or the secondary resistance is still incorrect, the coil is faulty and needs to be replaced.

Spark Plugs
EFI engines require resistor spark plugs. **Do not** try to substitute non-resistor plugs.

Wiring Harness
The wiring harness used in the EFI system connects the electrical components, providing current and ground paths for the system to operate. All input and output signaling occurs through a special all weather connector that attaches and locks to the ECU (see Figure 5B-19).

Figure 5B-19. "32 Pin" (MSE 1.1) Plastic-Cased ECU Connector.

The condition of the wiring, connectors, and terminal connections is essential to system function and performance. Corrosion, moisture, and poor connections are more likely the cause of operating problems and system errors than an actual component. Refer to the ''Troubleshooting – Electrical'' section for additional information.

Battery Charging System
EFI engines are equipped with either a 15 or 25 amp charging system to accommodate the combined electrical demands of the ignition system and the specific application. Charging system troubleshooting information is provided in Section 8.

Fuel Components

Fuel Pump

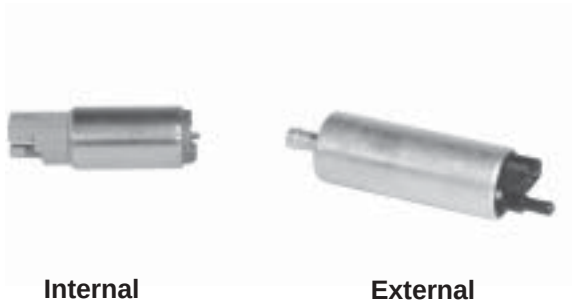


Figure 5B-20. Fuel Pump Styles.

General
An electric fuel pump is used to transfer fuel in the EFI system. Depending on the application, the pump may be inside the fuel tank, or in the fuel line near the tank. The pumps are rated for a minimum output of 25 liters per hour at 39 psi. The pumps have an internal 60-micron filter. In addition, the in-tank style pumps will have a pre-filter attached to the inlet. In-line pump systems may also have a filter ahead of the pump on the pick-up/low pressure side. The final filter is covered separately on pages 5B.18 and 5B.19.

When the key switch is turned **"on"** and all safety switch requirements are met, the ECU, through the relay, activates the fuel pump, which pressurizes the system for start-up. If the key switch is not promptly turned to the "start" position, the engine fails to start, or the engine is stopped with the key switch "on" (as in the case of an accident), the ECU switches off the pump preventing the continued delivery of fuel. In this situation, the MIL will go on, but it will go back off after 4 cranking revolutions if system function is OK. Once the engine is running, the fuel pump remains on.

Service

The fuel pumps are non-serviceable and must be replaced if determined to be faulty. If a fuel delivery problem is suspected, make certain the pump is being activated through the relay, all electrical connections are properly secured, the fuses are good, and a minimum of 7.0 volts is being supplied. If during cranking, voltage drops below 7.0 volts, a reduction of fuel pressure may occur resulting in a lean starting condition. If required, testing of the fuel pump and relay may be conducted.

1. Connect the black hose of Pressure tester (part of EFI Service Kit, see Section 2) to the test valve in the fuel rail. Route the clear hose into a portable gasoline container or the equipment fuel tank.

2. Turn on the key switch to activate the pump and check the system pressure on the gauge. If a system pressure of **39 psi ±3** is observed, the relay, fuel pump, and regulator are working properly. Turn the key switch off and depress the valve button on the tester to relieve the system pressure.

   a. If the pressure is too high, and the regulator is outside the tank (just down line from the pump), check that the return line from the regulator to the tank is not kinked or blocked. If the return line is good, replace the regulator (see ''Regulator Service'' on page 5B.18).

   b. If the pressure is too low, install in-line ''T'' between the pump and regulator and retest the pressure at that point. If it is too low there also, replace the fuel pump.

3. If the pump did not activate (step 2), disconnect the plug from the fuel pump. Connect a DC voltmeter across the terminals in the plug, turn on the key switch and observe if a minimum of 7 volts is present. If voltage is between 7 and 14, turn key switch off and connect an ohmmeter between the terminals on the pump to check for continuity.

   a. If there was no continuity between the pump terminals, replace the fuel pump.

   b. If the voltage was below 7, test the wiring harness and relay as covered in the ''Electrical Relay'' section.

4. If voltage at the plug was good, and there was continuity across the pump terminals, reconnect the plug to the pump, making sure you have a good connection. Turn on the key switch and listen for the pump to activate.

   a. If the pump starts, repeat steps 1 and 2 to verify correct pressure.

   b. If the pump still does not operate, replace it.

Fuel Pressure Regulator

Figure 5B-21. External Fuel Pressure Regulator with Base.

General

The fuel pressure regulator assembly maintains the required operating system pressure of **39 psi ± 3**. A rubber-fiber diaphragm (see Figure 5B-22) divides the regulator into two separate sections; the fuel chamber and the pressure regulating chamber. The pressure regulating spring presses against the valve holder (part of the diaphragm), pressing the valve against the valve seat. The combination of atmospheric pressure and regulating spring tension equals the desired operating pressure. Any time the fuel pressure against the bottom of the diaphragm exceeds the desired (top) pressure, the valve opens, relieving the excess pressure, returning the excess fuel back to the tank.

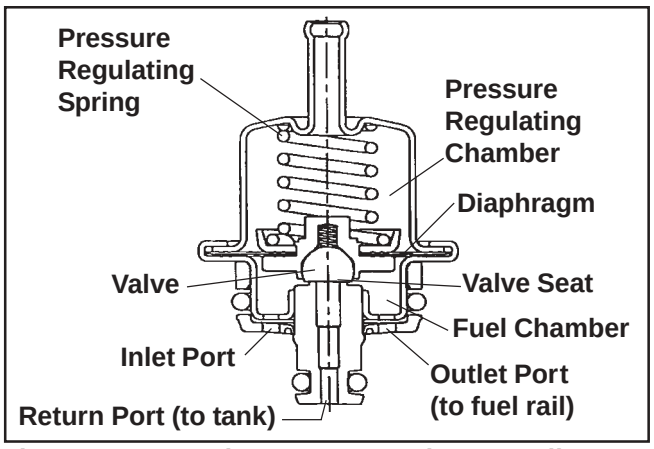


Figure 5B-22. Fuel Pressure Regulator Details.

Service

Depending on the application, the regulator may be located in the fuel tank along with the fuel pump, or outside the tank just down line from the pump. The regulator is a sealed, non-serviceable assembly. If it is faulty, it must be separated from the base/holder assembly and replaced as follows.

1. Shut engine off, make sure engine is cool, and disconnect the negative (-) battery cable.

2. Depressurize fuel system through test valve in fuel rail (see fuel warning on page 5B.2).

3. Access the regulator assembly as required and clean any dirt or foreign material away from the area.

4. **External Regulator**
   Remove the retaining ring securing the regulator in the regulator housing. Pull the regulator out of the housing. See Figure 5B-23.

   Internal (In-Tank) Regulator
   Remove the three screws securing the retaining ring and regulator in the base/holder assembly. Grasp and pull the regulator out of the base/holder. See Figure 5B-24.

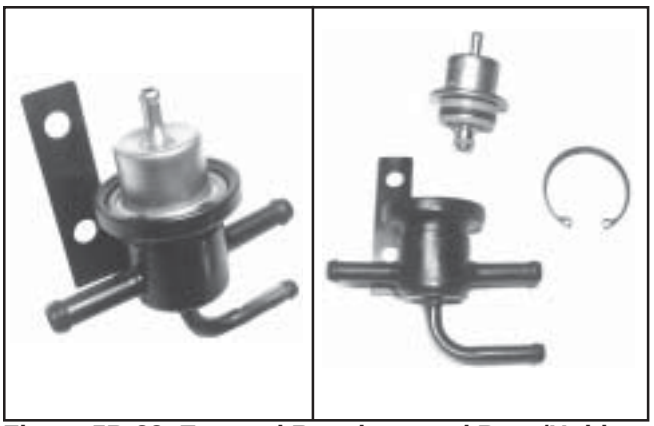


Figure 5B-23. External Regulator and Base/Holder.

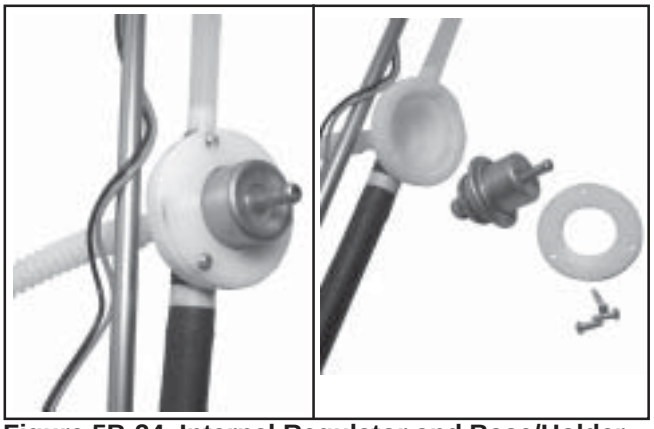


Figure 5B-24. Internal Regulator and Base/Holder.

5. Always use new O-Rings and hose clamps when installing a regulator. A new replacement regulator will have new O-Rings already installed. Lubricate the O-Rings with light grease or oil.

6. Install the new regulator by carefully pushing and rotating it slightly into the base or housing.

7. Secure with the retaining ring. Be careful not to dent or damage the body of the regulator as operating performance can be affected.

8. Reassemble any parts removed in step 3.

9. Reconnect the negative (-) battery cable.

10. Recheck the regulated system pressure at the fuel rail test valve.

Fuel Filter

EFI engines use a high-volume, high-pressure, 10-15 micron, in-line fuel filter.

Figure 5B-25. In-Line Fuel Filter.

Service

Fuel filter replacement is recommended every **1500 hours** of operation or more frequently under extremely dusty or dirty conditions. Use only the specified filter, and install it according to the directional arrows. **DO NOT** use a substitute filter as operating performance and safety can be affected. Relieve system pressure through the safety valve in the fuel rail before servicing.

Fuel Rail

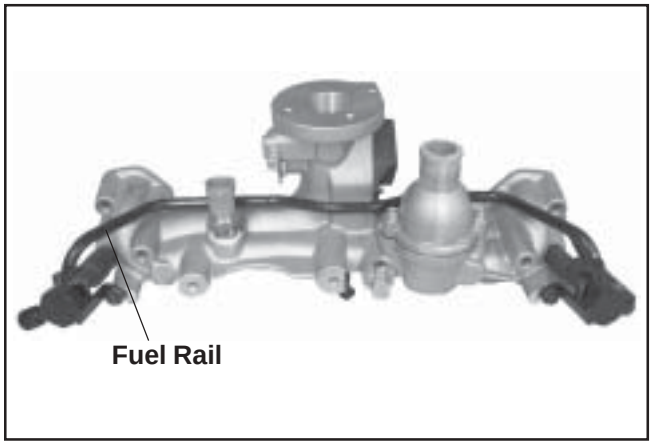


Figure 5B-26. Manifold Assembly.

General

The fuel rail is a formed tube assembly that feeds fuel to the top of the injectors. The tops of the injectors fit into formed cups in the fuel rail. When the rail is fastened to the manifold, the injectors are locked into place. A small retaining clip provides a secondary lock. Incorporated into the fuel rail is a pressure relief/test valve for testing operating pressure or relieving fuel system pressure for servicing. The fuel supply line is attached to the barbed end of the fuel rail with an Oetiker hose clamp.

Service

The fuel rail is mounted to the throttle body/intake manifold. It can be detached by removing the two mounting screws and the injector retaining clips. Thoroughly clean the area around all joints prior to any disassembly. No specific servicing is required unless operating conditions indicate that it needs internal cleaning or replacement.

Fuel Line

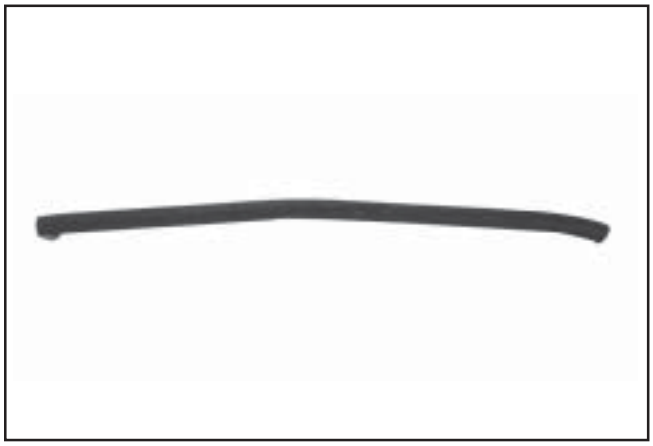


Figure 5B-27. High Pressure Fuel Line.

General

Special low permeation high-pressure fuel line with an SAE30 R9 rating is required for safe and reliable operation, due to the higher operating pressure of the EFI system. If hose replacement is necessary, order Fuel Line Service Kit, Part No. **25 111 37-S** (containing 60" of high-pressure hose and 10 Oetiker clamps), or use only the type specified. Special Oetiker clamps (Kohler Part No. **24 237 05-S**) are used on all fuel line connections to prevent tampering and safety hazards with the high fuel pressure. The old clamp must be cut to open a connection, so replacement is necessary each time. Oetiker Clamps Pliers (part of EFI Service Kit, see Section 2) is used to crimp the replacement clamps.

CAUTION: *Fuel lines between the fuel pump and fuel rail must be made from SAE 30 R9 fuel line. Standard fuel line (SAE 30 R7) may* ***only*** *be used between the fuel tank and pump (5/16" ID) and for the return line from the pressure regulator to the tank (1/4" ID). All high-pressure fuel line connections must be secured with Oetiker clamps (Kohler Part No. 24 237 05-S), installed/crimped with the corresponding pliers.*

Throttle Body/Intake Manifold Assembly

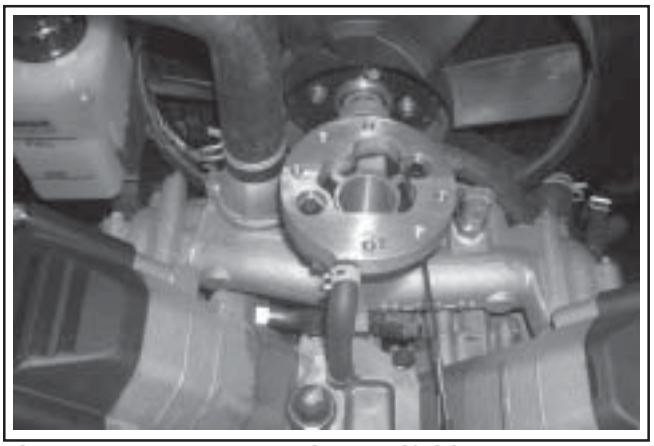


Figure 5B-28. Upper Intake Manifold.

General

The EFI engines have no carburetor, so the throttle function (regulate incoming combustion airflow) is incorporated in the intake manifold assembly. The manifold consists of a one-piece aluminum casting which also provides mounting for the fuel injectors, throttle position sensor, fuel rail, air baffle, idle speed screw, and air cleaner assembly.

Service

The throttle body/intake manifold is serviced as an assembly, with the throttle shaft, throttle plate, and idle speed adjusting screw installed. The throttle shaft rotates on needle bearings (non-serviceable), capped with rubber seals to prevent air leaks.

Idle Speed Adjustment (RPM)

General

The idle speed is the only adjustment that may be performed on the EFI system. The standard idle speed setting for EFI engines is **1500 RPM**, but certain applications might require a different setting. Check the equipment manufacturer's recommendation.

For starting and warm up, the ECU will adjust the fuel and ignition timing, based upon ambient temperature, engine temperature, and loads present. In cold conditions, the idle speed will probably be higher than normal for a few moments. Under other conditions, the idle speed may actually start lower than normal, but gradually increase to the established setting as operation continues. Do not attempt to circumvent this warm up period, or readjust the idle speed during this time. The engine must be completely warmed up for accurate idle speed adjustment.

Adjustment Procedure

1. Make sure there are no fault codes present in the ECU memory.

2. Start the engine and allow it to **fully warm up** and establish closed looped operation (approximately 5-10 min.).

3. Place the throttle control in the ''idle/slow'' position and check the idle speed with a tachometer. Turn the idle speed screw in or out as required to obtain **1500 RPM**, or the idle speed specified by the equipment manufacturer.

4. The low idle speed adjustment can affect the high speed setting. Move the throttle control to the full throttle position and check the high speed. Adjust as necessary to **3750 RPM** (no load), or the speed specified by the equipment manufacturer.

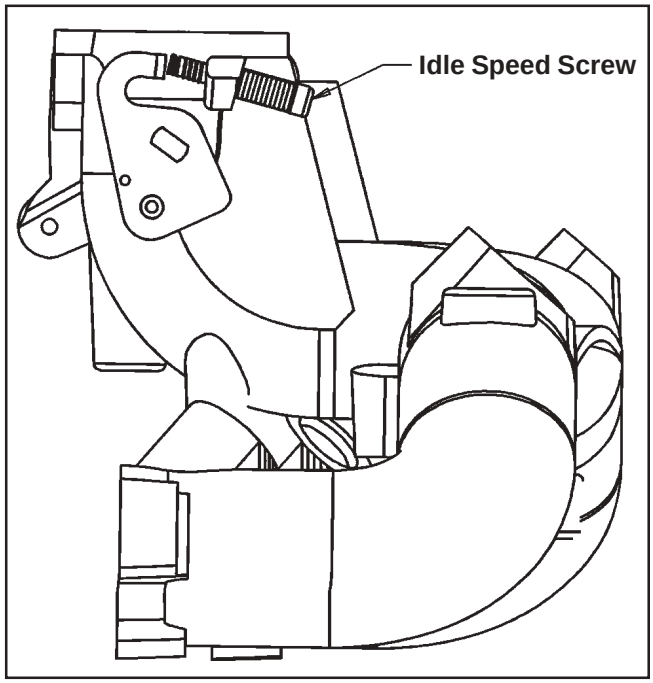


Figure 5B-29. Idle Speed Screw Details.

Initial Governor Adjustment

The initial governor adjustment is especially critical on EFI engines because of the accuracy and sensitivity of the electronic control system. Incorrect adjustment can result in overspeed, loss of power, lack of response, or inadequate load compensation. If you encounter any of these symptoms and suspect them to be related to the governor setting, the following should be used to check and/or adjust the governor and throttle linkage.

If the governor/throttle components are all intact, but you think there may be a problem with the adjustment, follow Procedure A to check the setting. If the governor lever was loosened or removed, go immediately to Procedure B to perform the initial adjustment.

A. Checking the Initial Adjustment

1. Unsnap the plastic linkage bushing attaching the throttle linkage to the governor lever. See Figure 5B-30 Unhook the damper spring from the lever, separate the linkage from the bushing, and remove the bushing from the lever. Mark the hole position and unhook the governor spring from the governor lever.

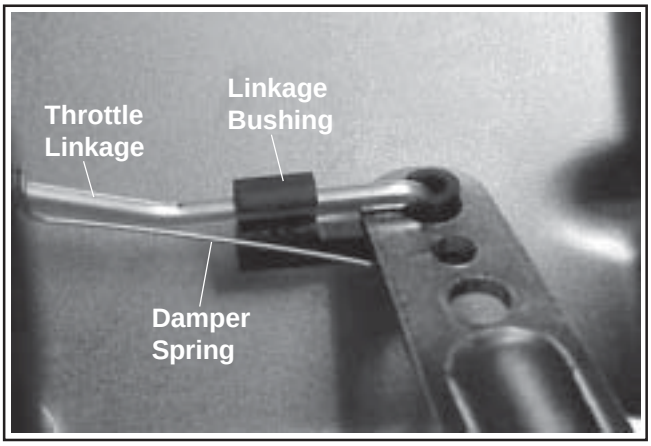


Figure 5B-30. Throttle Linkage/Governor Lever Connection.

2. Pivot the throttle shaft and plate into the "Full Throttle" position, so the tang of the throttle shaft plate is against the manifold casting. See Figure 5B-31. Temporarily clamp in this position.

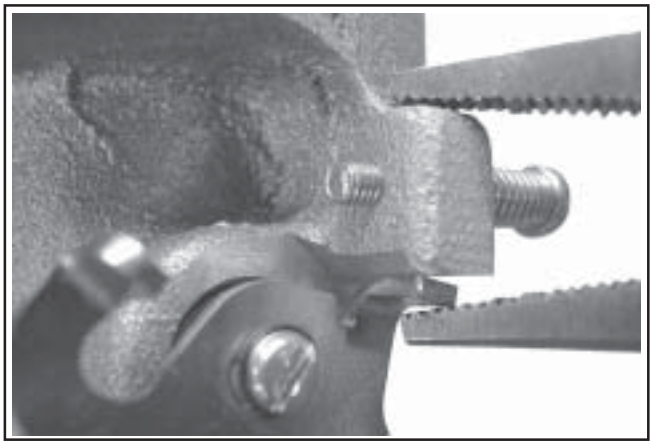


Figure 5B-31. Clamping Throttle Against Stop.

3. Rotate the governor lever and shaft counterclockwise until it stops. Use only enough pressure to hold it in that position.

4. Check how the end of the throttle linkage aligns with the bushing hole in the governor lever. See Figure 5B-32. It should fall in the center of the hole. If it doesn't, perform the adjustment procedure as follows.

Figure 5B-32. Throttle Link in Center of Hole.

B. Setting The Initial Adjustment

1. Check the split where the clamping screw goes through the governor lever. See Figure 5B-33. There should be a gap of at least 1/32". If the tips are touching and there is no gap present, the lever should be replaced. If not already installed, position the governor lever on the cross shaft, but leave the clamping screw loose.

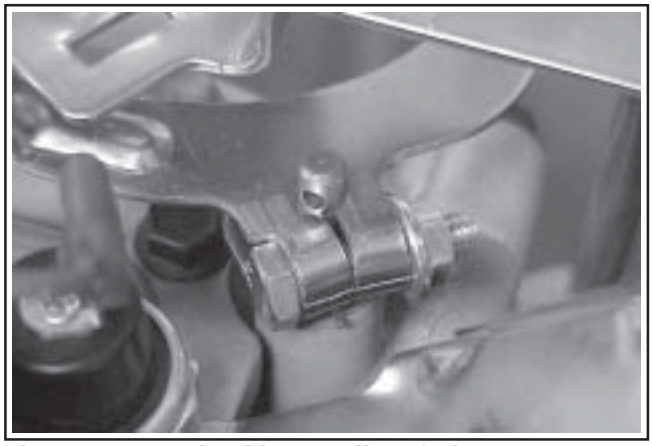


Figure 5B-33. Checking ''Split'' of Clamp.

2. Follow the instructions in Step 2 of ''Checking the Initial Adjustment,'' then reattach the throttle linkage to the governor lever with the bushing clip. It is not necessary to reattach the damper or governor springs at this time.

3. Insert a nail into the hole in the top of the cross shaft. Using light pressure, rotate the governor shaft **counterclockwise** as far as it will turn, then torque the hex nut on the clamping screw to **6.8 N·m (60 in. lb.**). See Figure 5B-34. Make sure that the governor arm has not twisted up or down after the nut has been tightened.

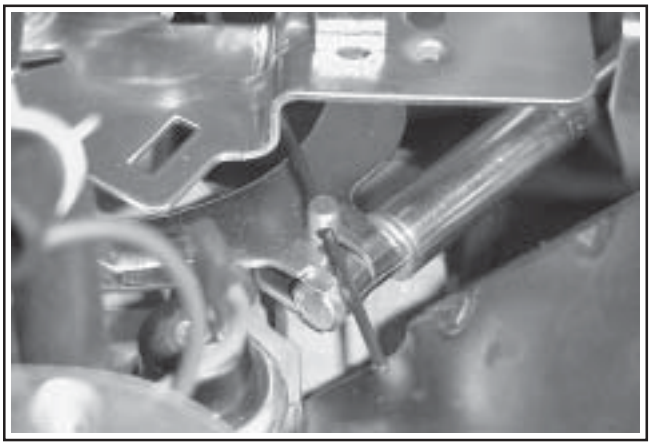


Figure 5B-34. Adjusting Governor Shaft.

4. Verify that the governor has been set correctly. With the linkage still retained in the "Full Throttle" position (Step 2), unsnap the bushing clip, separate the linkage from the bushing, and remove the bushing from the lever. Follow Steps 3 and 4 in ''Checking the Initial Adjustment''.

5. Reconnect the dampening spring into its governor lever hole from the bottom. Reinstall the bushing and reattach the throttle linkage. See Figure 5B-30. Reattach the governor spring in the marked hole.

6. Start the engine and allow it to fully warm up and establish closed loop operation (approximately 5-10 min.). Check the speed settings and adjust as necessary, first the low idle speed, and then the high speed setting.

Troubleshooting

General

When troubleshooting a problem on an engine with EFI, basic engine operating problems must be eliminated first before faulting the EFI system components. What appears to be an EFI problem could be something as simple as a fuel tank with debris in the bottom or a plugged vent. Be sure the engine is in good mechanical operating condition and all other systems are functional before attempting to troubleshoot the EFI system.

Troubleshooting Guide

Engine starts hard or fails to start when cold

1. Fuel pump not running
2. Engine temp sensor faulty
3. Incorrect fuel pressure
4. TPS faulty
5. TPS offset incorrect
6. Old/stale fuel
7. Low system voltage
8. Speed sensor loose or faulty
9. Faulty injectors
10. Faulty coils
11. Faulty spark plugs

Engine starts hard or fails to start when hot

1. Fuel pressure low
2. Fuel pump not running
3. Engine temp sensor faulty
4. Insufficient fuel delivery
5. TPS faulty
6. TPS offset incorrect
7. Speed sensor loose or faulty
8. Faulty injectors
9. Faulty spark plugs

Engine misses, hesitates, or stalls under load

1. Fuel injector(s), fuel filter, fuel line, or fuel pick-up dirty/restricted
2. Dirty air cleaner
3. Insufficient fuel pressure or fuel delivery
4. Vacuum (intake air) leak
5. Improper governor setting, adjustment or operation
6. Speed sensor malfunction
7. TPS faulty, mounting problem or "TPS Initialization Procedure" incorrect
8. Bad coil(s), spark plug(s), or wires

Low Power

1. Faulty/malfunctioning ignition system
2. Dirty air filter
3. Insufficient fuel delivery
4. Improper governor adjustment
5. Plugged/restricted exhaust
6. One injector not working
7. Basic engine problem exists
8. TPS faulty or mounting exists
9. Throttle plates in throttle body/intake manifold not fully opening to WOT stop (if so equipped)

Electrical System

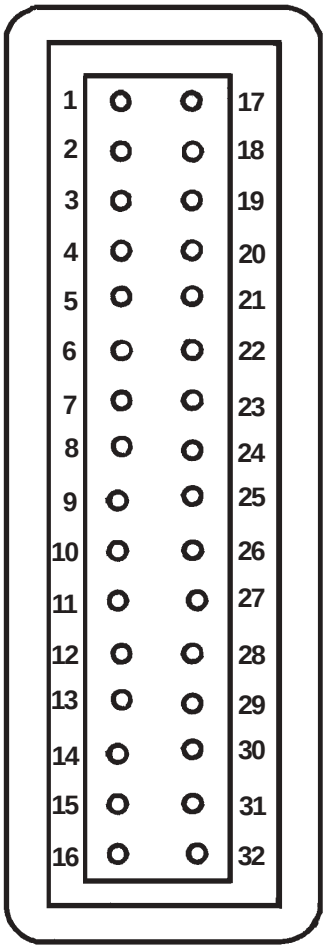
The EFI system is a 12 VDC negative ground system, designed to operate down to a minimum of 7.0 volts. If system voltage drops below this level, the operation of voltage sensitive components such as the ECU, fuel pump, and injectors will be intermittent or disrupted, causing erratic operation or hard starting. A fully charged, 12 volt battery with a minimum of 350 cold cranking amps is important in maintaining steady and reliable system operation. Battery condition and state of charge should always be checked first when troubleshooting an operational problem.

Keep in mind that EFI-related problems are more often caused by the wiring harness or connections than by the EFI components. Even small amounts of corrosion or oxidation on the terminals can interfere with the milliamp currents used in system operation. Cleaning the connectors and grounds will solve problems in many cases. In an emergency situation, simply disconnecting and reconnecting the connectors may clean up the contacts enough to restore operation, at least temporarily.

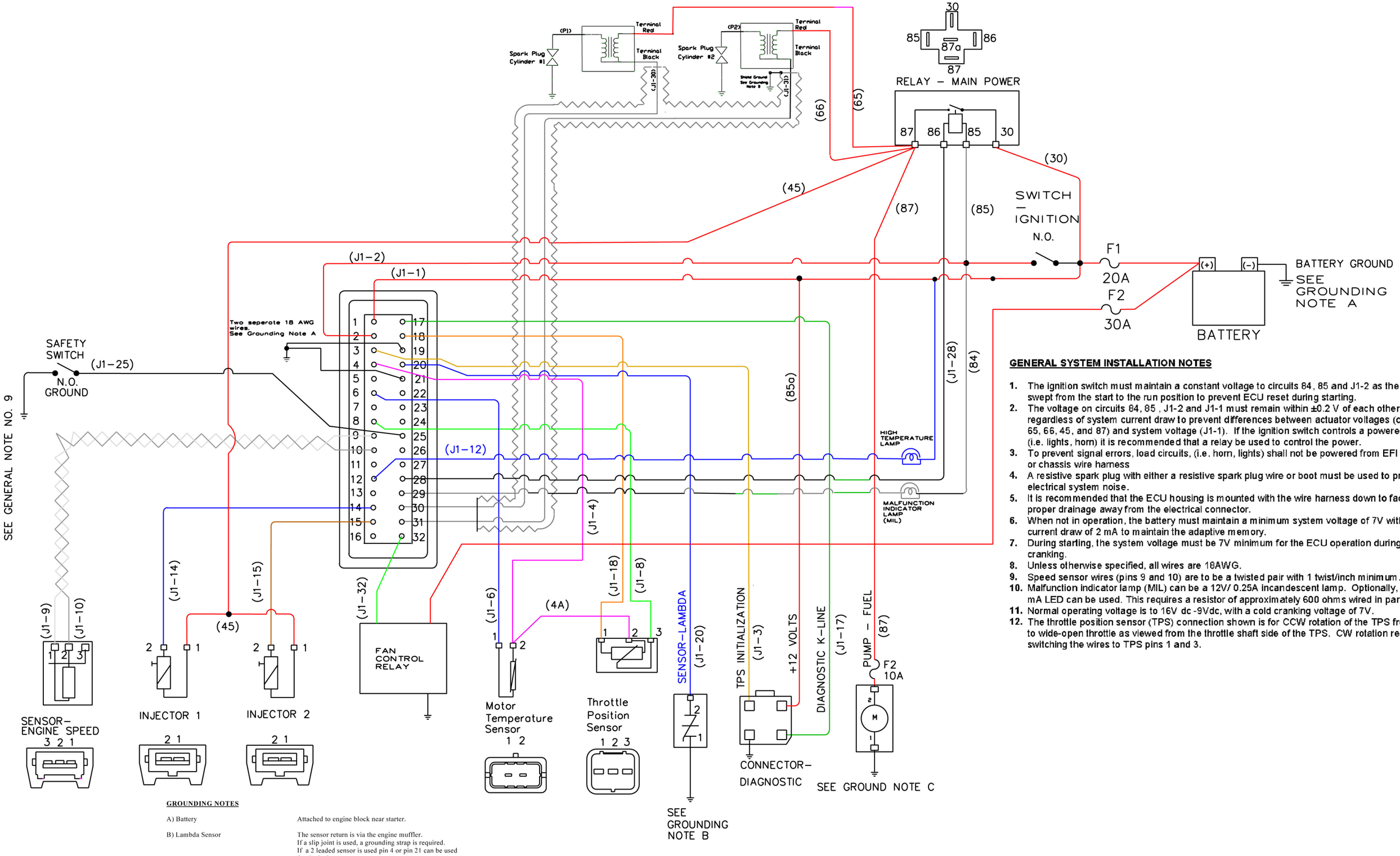
If a fault code indicates a problem with an electrical component, disconnect the ECU connector and test for continuity between the component connector terminals and the corresponding terminals in the ECU connector using an ohmmeter. Little or no resistance should be measured, indicating that the wiring of that particular circuit is OK. An illustrated listing of numerical terminal locations is provided below.

NOTE: When performing voltage or continuity tests, avoid putting excessive pressure on or against the connector pins. Flat pin probes are recommended for testing to avoid spreading or bending the terminals.

Pin #	Function
1	Permanent Battery Voltage
2	Switched Battery Voltage
3	TPS Set; “Auto-Learn” Initialization Terminal
4	Throttle Position Sensor (TPS) and Temperature Sensor Ground
5	Not Used
6	Oil Temperature Sensor Input
7	Not Used
8	Throttle Position Sensor (TPS) Input
9	Speed Sensor Input (+)
10	Speed Sensor Ground (-)
11	Not Used
12	High Temperature Warning Output*
13	Not Used
14	Injector 1 Output
15	Injector 2 Output
16	Not Used
17	Diagnostic Line
18	Throttle Position/Temperature Sensor Supply Voltage
19	Battery Ground
20	Oxygen Sensor Input
21	Battery Ground (Secondary)
22	Not Used
23	Not Used
24	Not Used
25	Safety Switch Input
26	Not Used
27	Not Used
28	Main Relay Output
29	Malfunction Indicator Light (MIL)
30	Ignition Coil #1 Output
31	Ignition Coil #2 Output
32	Fan Control Output*



*On LH775 Kohler liquid-cooled engines, the ECU and corresponding wiring harness provide two additional circuits. Pin circuit 32 provides ability to control an optional OEM electric cooling fan, switching it on and off at the appropriate coolant temperatures using a relay. Pin circuit 12 switches on when the coolant temperature is too high to operate an optional engine temperature warning light.



GENERAL SYSTEM INSTALLATION NOTES

1. The ignition switch must maintain a constant voltage to circuits 84, 85 and J1-2 as the key is swept from the start to the run position to prevent ECU reset during starting.
2. The voltage on circuits 84, 85 , J1-2 and J1-1 must remain within ±0.2 V of each other regardless of system current draw to prevent differences between actuator voltages (circuits 65, 66, 45, and 87) and system voltage (J1-1). If the ignition switch controls a powered circuit (i.e. lights, horn) it is recommended that a relay be used to control the power.
3. To prevent signal errors, load circuits, (i.e. horn, lights) shall not be powered from EFI engine or chassis wire harness
4. A resistive spark plug with either a resistive spark plug wire or boot must be used to prevent electrical system noise.
5. It is recommended that the ECU housing is mounted with the wire harness down to facilitate proper drainage away from the electrical connector.
6. When not in operation, the battery must maintain a minimum system voltage of 7V with a current draw of 2 mA to maintain the adaptive memory.
7. During starting, the system voltage must be 7V minimum for the ECU operation during cranking.
8. Unless otherwise specified, all wires are 18AWG.
9. Speed sensor wires (pins 9 and 10) are to be a twisted pair with 1 twist/inch minimum.
10. Malfunction indicator lamp (MIL) can be a 12V/ 0.25A incandescent lamp. Optionally, a 20 mA LED can be used. This requires a resistor of approximately 600 ohms wired in parallel.
11. Normal operating voltage is to 16V dc -9Vdc, with a cold cranking voltage of 7V.
12. The throttle position sensor (TPS) connection shown is for CCW rotation of the TPS from idle to wide-open throttle as viewed from the throttle shaft side of the TPS. CW rotation requires switching the wires to TPS pins 1 and 3.

GROUNDING NOTES

A) Battery	Attached to engine block near starter.
B) Lambda Sensor	The sensor return is via the engine muffler. If a slip joint is used, a grounding strap is required. If a 2 leaded sensor is used pin 4 or pin 21 can be used for the is the return.
C) Fuel Pump	Attached to the chassis
D) Shield	Attached to the engine block close to the coils.

Fuel System

WARNING: Fuel System Under Pressure!

The fuel system operates under high pressure. System pressure must be relieved through the test valve in the fuel rail prior to servicing or removing any fuel system components. Do not smoke or work near heaters or other fire hazards. Have a fire extinguisher handy and work only in a well-ventilated area.

The function of the fuel system is to provide sufficient delivery of fuel at the system operating pressure of 39 psi ± 3. If an engine starts hard, or turns over but will not start, it may indicate a problem with the EFI fuel system. A quick test will verify if the system is operating.

1. Disconnect and ground the spark plug leads.

2. Complete all safety interlock requirements and crank the engine for approximately 3 seconds.

3. Remove the spark plugs and check for fuel at the tips.

    a. If there is fuel at the tips of the spark plugs, the fuel pump and injectors are operating.

    b. If there is no fuel at the tips of the spark plugs, check the following:

        1. Make sure the fuel tank contains clean, fresh, proper fuel.

        2. Make sure that vent in fuel tank is open.

        3. Make sure fuel tank valve (if so equipped) is fully opened.

        4. Make sure battery is supplying proper voltage.

        5. Check that the fuses are good, and that all electrical and fuel line connections are good.

        6. Test fuel pump and relay operation as described earlier under ''Fuel Pump – Service.''

Fault Codes

The ECU continuously monitors engine operation against preset performance limits. If the operation is outside the limits, the ECU activates the MIL and stores a diagnostic code in its fault memory. If the component or system returns to proper function, the ECU will eventually self-clear the fault code and turn off the MIL. If the MIL stays illuminated, it warns the customer that dealer service is required. Upon receipt, the dealer technician can access the fault code(s) to help determine what portion of the system is malfunctioning. The 2-digit blink codes available are listed on page 5B.28.

The codes are accessed through the key switch and displayed as blinks or flashes of the MIL. Access the codes as follows.

1. Start with the key switch off.

2. Turn the key switch on-off-on-off-on, leaving it on in the third sequence. The time between sequences must be less than 2.5 seconds.

3. Any stored fault codes will then be displayed as a series of MIL blinks (from 2 to 6) representing the first digit, followed by a pause, and another series of blinks (from 1 to 6) for the second digit. See Figure 5B-35.

    a. It's a good idea to write down the codes as they appear, as they may not be in numerical sequence.

    b. Code 61 will always be the last code displayed, indicating the end of code transmission. If code 61 appears immediately, no other fault codes are present.

Example of Diagnostic Display

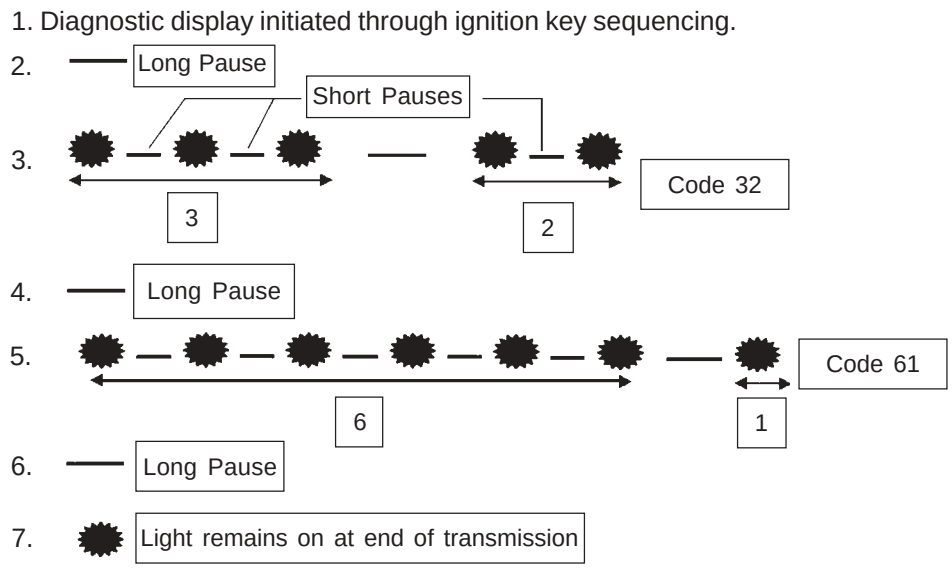


Figure 5B-35. Diagnostic Display.

After the problem has been corrected, the fault codes may be cleared as follows.

1. Disconnect the negative (-) battery cable from battery terminal, or remove the main fuse for the ECU for approximately 1 minute.

2. Reconnect the cable and tighten securely, or reinstall the main fuse. Start the engine and allow it to run for several minutes. The MIL should remain off if the problem was corrected, and the fault codes should not reappear (codes 31, 32, 33, and 34 may require 10-15 minutes of running to reappear).

The following chart lists the fault codes, what they correspond to, and what the visual indications will be. Following the chart is a list of the individual codes with an explanation of what triggers them, what symptoms might be expected, and the probable causes.

Diagnostic Code Summary

Blink Code	OBD2 P-Code	Condition or Failure Description	MIL Illuminated	Note
–	–	No RPM Signal	Y	
21	P0335	Loss of Synchronization	Y	
22	P0122	TPS - Open or Short Circuit to Ground	Y	
22	P0123	TPS - Short Circuit to Battery	Y	
23	P0601	Defective ECU	Y	
24	-	Engine Speed Sensor	Y	4
31	P0174	System too Lean	Y	2
31	P0132	O_2 Sensor Circuit: Shorted to Battery	Y	1
32	P0134	O_2 Sensor Circuit: No Activity Detected	Y	
33	P0175	System too Rich	Y	3
33	P0020	O_2 Sensor Control at Upper Limit	Y	
34	P0171	Maximum Adaption Limit Reached	Y	
34	P0172	Minimum Adaption Limit Reached	Y	
42	P0117	Temperature Sensor Circuit: Shorted to Ground	Y	
42	P0118	Temperature Sensor Circuit: Open Circuit or Short to Battery	Y	
43	P1670	Failure Completing Autolearn - TPS Offset below minimum allowable limit	Y	
44	P1671	Failure Completing Autolearn - TPS Offset above maximum allowable limit	Y	
51	P1260	Injector 1 - Open Circuit	Y	
51	P0261	Injector 1 - Short Circuit to Ground	Y	
51	P0262	Injector 1 - Short Circuit to Battery	Y	
52	P1263	Injector 2 - Open Circuit	Y	
52	P0264	Injector 2 - Short Circuit to Ground	Y	
52	P0265	Injector 2 - Short Circuit to Battery	Y	
54	P0655	High Temperature Warning Lamp Circuit Open	N	4
54	P1657	High Temperature Warning Lamp Circuit Shortened to Ground	N	4
54	P1658	High Temperature Warning Lamp Circuit Shorted to Voltage	N	4
55	P1651	MIL Lamp - Open Circuit	N	
55	P1652	MIL Lamp - Short Circuit to Ground	Y	
55	P1653	MIL Lamp - Short Circuit to Battery	Y	
56	P1231	Pump Relay - Open Circuit	Y	
56	P1232	Pump Relay - Short Circuit to Ground	Y	
56	P1233	Pump Relay - Short Circuit to Battery	Y	
58	P1480	Cooling Fan Driver Circuit Open	N	
58	P1481	Cooling Fan Driver Circuit Shorten to Ground	N	
58	P1482	Cooling Fan Driver Circuit Shorten to Voltage	N	
61	–	End of Code Transmission	N	

NOTE: 1. "O_2 Sensor Short to Battery" diagnostic detection is disabled with SAS fuel-cutoff calibrated out.
2. "System too Lean" used to be "O_2 Sensor - Short to Ground (P0131)."
3. "System too Rich" used to be "O_2 Sensor Control at Lower Limit (P0019)."
4. Will not blink out.

MIL Lamp is always switched OFF when failure is SPORADIC.

Diagnostic Code Summary

Code: **21**
Source: Engine Speed Sensor
Explanation: ECU receiving inconsistent tooth count signals from speed sensor.
Expected Engine Response: Possible misfire as ECU attempts to resynchronize, during which time fuel and spark calculations are not made.

Possible Causes:

1. Engine Speed Sensor Related
   a. Sensor connector or wiring.
   b. Sensor loose or incorrect air gap.
   c. Flywheel key sheared.

2. Speed Sensor Ring Gear Related
   a. Damaged teeth.
   b. Varying gap (gear loose/out of alignment).

3. Engine Wire Harness Related
   a. Pin circuits 9 and/or 10 wiring or connectors.
   b. Shielding for pin circuits 9 and/or 10 damaged or not properly grounded.
   c. Poor or improper grounds in system (battery, ECU, oxygen sensor, shielding, fuel pump, ignition output).
   d. Pin circuits 9 and/or 10 routed near noisy electrical signals (coils, spark plug lead, plug connector).

4. ECU/Harness Related
   a. ECU-to-harness connection problem.

5. Ignition System Related
   a. Non-resistor spark plug(s) used.

Code: **22**
Source: Throttle Position Sensor (TPS)
Explanation: Unrecognizable signal is being sent from sensor (too high, too low, inconsistent).
Expected Engine Response: A "limp-home" operating mode occurs, with an overall decrease in operating performance and efficiency. Fuel delivery is based upon the oxygen sensor and five mapped values only. Rich running (black smoke) will occur until "closed loop" operation is initiated. A stumble or misfire on hard acceleration and/or erratic operation may be exhibited.

Possible Causes:

1. TPS Sensor Related
   a. Sensor connector or wiring.
   b. Sensor output affected or disrupted by dirt, grease, oil, wear, or breather tube position (must be to side opposite the TPS).
   c. Sensor loose on throttle body manifold.

2. Throttle Body Related
   a. Throttle shaft or bearings worn/damaged.

3. Engine Wire Harness Related
   a. Pin circuits 4, 8, and/or 18 damaged (wiring, connectors).
   b. Pin circuits 4, 8, and/or 18 routed near noisy electrical signal (coils, alternator).
   c. Intermittent 5 volt source from ECU (pin circuit 18).

4. ECU/Harness Related
   a. ECU-to-harness connection problem.

Code: **23**
Source: ECU
Explanation: ECU is unable to recognize or process signals from its memory.
Expected Engine Response: Engine will not run.

Possible Causes:
1. ECU (internal memory problem).
   a. Diagnosable only through the elimination of all other system/component faults.

Code: **24** (will not blink out)
Source: Engine Speed Sensor
Explanation: No tooth signal from speed sensor. MIL light will not go out when cranking.
Expected Engine Response: None-engine will not start or run as ECU is unable to estimate speed.

Possible Causes:
1. Engine Speed Sensor Related
   a. Sensor connector or wiring.
   b. Sensor loose or air gap incorrect.

2. Speed Sensor Wheel Related
   a. Damaged teeth.
   b. Gap section not registering.

3. Engine Wire Harness Related
   a. Pin circuit #9 and/or #10 wiring or connectors.

4. ECU/Harness Related
   a. ECU-to-harness connection problem.

Code: **31**
Source: Fuel Mixture or Oxygen Sensor
Explanation: "System to Lean" Oxygen sensor not sending expected voltage to ECU.
Expected Engine Response: System operates under "open loop" control only. Until fault is detected and registered by ECU, engine will run rich if oxygen sensor is shorted to ground or lean if it is shorted to battery voltage. After fault is detected, performance can vary, depending on cause. If performance is pretty good, the problem is probably with the oxygen sensor, wiring, or connectors. If the engine is still running rich (laboring, short on power) or lean (popping or misfiring), the fuel mixture is suspect, probably incorrect TPS initialization or low fuel pressure.

Possible Causes:
1. TPS Initialization Incorrect
   a. Lean condition (check oxygen sensor signal with VOA and see Oxygen Sensor section).

2. Engine Wire Harness Related
   a. Pin circuit #20 wiring or connectors.

3. Oxygen Sensor Related
   a. Sensor connector or wiring problem.
   b. Exhaust leak.
   c. Poor ground path to engine (sensor is case grounded).

Code: **32**
Source: Oxygen Sensor
Explanation: No change in the sensor output signal.
Expected Engine Response: "Open loop" operation only, may cause a drop in system performance and fuel efficiency.

Possible Causes:
1. Engine Wiring Harness Related
   a. Pin circuit #20 wiring or connectors.

2. Oxygen Sensor Related
   a. Sensor connector or wiring problem.
   b. Sensor contaminated or damaged.
   c. Sensor below the minimum operating temperature (375°C, 709°F).
   d. Poor ground path to engine (sensor grounds through shell, see Oxygen Sensor section).

Code: **33**
Source: Oxygen Sensor/Fuel System
Explanation: "System to Rich" Temporary fuel adaptation control is at the upper limit.
Expected Engine Response: Erratic performance. Will run rich (smoke).

Possible Causes:
1. Fuel Supply Related (nothing lean – only rich)
   a. Restricted return line causing excessive fuel pressure.
   b. Fuel inlet screen plugged (in-tank fuel pump only).
   c. Incorrect fuel pressure at fuel rail.

2. Oxygen Sensor Related
   a. Sensor connector or wiring problem.
   b. Sensor contaminated or damaged.
   c. Exhaust leak.
   d. Poor ground path.
   e. Pin circuit #20 wiring or connectors.

3. TPS Sensor Related
   a. Throttle plate position incorrectly set or registered during "Initialization.''
   b. TPS problem or malfunction.

4. Engine Wiring Harness Related
   a. Difference in voltage between sensed voltage (pin circuit 2) and actual injector voltage (circuit 45).

5. Systems Related
   a. Ignition (spark plug, plug wire, ignition coil.
   b. Fuel (fuel type/quality, injector, fuel pump, fuel pressure.
   c. Combustion air (air cleaner dirty/restricted, intake leak, throttle bores).
   d. Base engine problem (rings, valves).
   e. Exhaust system leak.
   f. Fuel in the crankcase oil.
   g. Blocked or restricted fuel return circuit to tank.

6. ECU Related
   a. ECU-to-harness connection problem.

Code: **34**
Source: Oxygen Sensor/Fuel System Components
Explanation: Long term fuel adaptation control is at the upper or lower limit.
Expected Engine Response: System operates "closed loop." No appreciable performance loss as long as the temporary adaptation can provide sufficient compensation.

Possible Causes:
1. Oxygen Sensor Related
   a. Sensor connector or wiring.
   b. Sensor contaminated or damaged.
   c. Exhaust leak.
   d. Poor ground path.
   e. Pin circuit #20 wiring or connectors.

2. TPS Sensor Related
   a. Throttle plate position incorrect during "Initialization" procedure.
   b. TPS problem or malfunction.

3. Engine Wiring Harness Related
   a. Difference in voltage between sensed voltage (pin circuit 2) and actual injector voltage (circuit 45).
   b. Problem in wiring harness.
   c. ECU-to-harness connection problem.

4. Systems Related
   a. Ignition (spark plug, plug wire, ignition coil.
   b. Fuel (fuel type/quality, injector, fuel pressure, fuel pump).
   c. Combustion air (air cleaner dirty/restricted, intake leak, throttle bore).
   d. Base engine problem (rings, valves).
   e. Exhaust system leak (muffler, flange, oxygen sensor mounting boss, etc.).
   f. Fuel in the crankcase oil.
   g. Altitude.
   h. Blocked or restricted fuel return circuit to tank.

Code: **42**
Source: Engine (Coolant) Temperature Sensor
Explanation: Not sending proper signal to ECU.
Expected Engine Response: Engine may be hard to start because ECU can't determine correct fuel mixture.

Possible Causes:
1. Temperature Sensor Related
   a. Sensor wiring or connection.

2. Engine Wiring Harness Related
   a. Pin circuits 4, 6 and/or 4A damaged (wires, connectors) or routed near noisy signal (coils, alternator, etc.).
   b. ECU-to-harness connection problem.

3. System Related
   a. Engine is operating above the 176°C (350°F) coolant temperature sensor limit.
   b. ECU-to-harness connection problem.

Code: **43 and 44**
Source: TPS "Auto-Learn" initialization function failed, throttle angle out of learning range.
Explanation: While performing the TPS "Auto-Learn" function the measured throttle angle was not within acceptable limits.
Expected Engine Response: MIL illuminated. Engine will continue to run but not properly. Upon restart TPS Auto-Learn function will run again unless voltage to ECU disconnected to clear memory.

Possible Causes:

1. TPS related
   a. TPS rotated on throttle shaft assembly out of allowable range.
   b. TPS bad.

2. Engine wiring harness related
   a. Broken or shorted wire in harness. ECU pin 18 to TPS pin 1. ECU pin 4 to TPS pin 2. ECU pin 8 to TPS pin 3.

3. Throttle body related
   a. Throttle shaft inside TPS worn, broken, or damaged.
   b. Throttle plate loose or misaligned.
   c. Throttle plate bent or damaged allowing extra airflow past or restricting movement.

4. ECU related
   a. Circuit providing voltage or ground to TPS damaged.
   b. TPS signal input circuit damaged.

Code: **51**
Source: Injector #1 circuit open, shorted to ground, or shorted to battery.
Explanation: Injector #1 is not functioning because the circuit is open, shorted to ground, or shorted to battery.
Expected Engine Response: Engine will run very poorly with only one cylinder functioning.

Possible Causes:

1. Injector related
   a. Injector coil shorted or opened.

2. Engine wiring harness related
   a. Broken or shorted wire in harness. ECU pin 14 to injector pin 2. ECU pin 28 to fuel pump relay pin 86. Note: After key-off then key-on, code 56 would be set also. Fuel pump relay pin 87 to injector pin 1.
   b. Open main fuse F1.

3. Fuel pump relay related
   a. Bad fuel pump relay. Primary side functional, but pin 30 to pin 87 remains open. Primary side pin 85 to pin 86 is either open, or shorted during engine operation. Note: After key-off then key-on, code 56 would be set also.

4. ECU related
   a. Circuit controlling injector #1 damaged.
   b. Circuit controlling fuel pump relay damaged.

Code: **52**
Source: Injector #2 circuit open, shorted to ground, or shorted to battery.
Explanation: Injector #2 is not functioning because the circuit is open, shorted to ground, or shorted to battery.
Expected Engine Response: Engine will run very poorly with only one cylinder functioning.

Possible Causes:

1. Injector related
   a. Injector coil shorted or opened.

2. Engine wiring harness related
   a. Broken or shorted wire in harness. ECU pin 15 to injector pin 2. ECU pin 28 to fuel pump relay pin 86. Note: After key-off then key-on code 56 would be set also. Fuel pump relay pin 87 to injector pin 1.
   b. Opened main fuse F1.

3. Fuel pump relay related
   a. Bad fuel pump relay. Primary side functional, but pin 30 to pin 87 remains open. Primary side pin 85 to pin 86 is open or shorted during engine operation. Note: After key-off then key- on code 56 would be set also.

4. ECU related
   a. Circuit controlling injector #2 damaged.
   b. Circuit controlling fuel pump relay damaged.

Code: 55
Source: MIL (Diagnostic lamp) circuit open, shorted to ground, or shorted to battery.
Explanation: MIL is not functioning because the circuit is open, shorted to ground, or shorted to battery.
Expected Engine Response: Engine will run normally if no other errors are present.

Possible Causes:

1. MIL (diagnostic lamp) related
   a. MIL element opened or element shorted to ground.
   b. Lamp missing.

2. Engine wiring harness related
   a. Broken or shorted wire in harness. ECU pin 29 to lamp open or shorted.

3. Vehicle wiring harness related
   a. Broken or shorted wire in harness. Power lead to MIL open or shorted.

4. ECU related
   a. Circuit controlling lamp damaged.

Code: 56
Source: Fuel pump relay circuit open, shorted to ground, or shorted to battery
Explanation: Fuel pump, ignition coils, and fuel injectors will not function because the fuel pump relay circuit is either open, shorted to ground, or may be "on" continuously if shorted to battery.
Expected Engine Response: Engine will not run, or fuel pump will continue to run when switch is off.

Possible Causes:

1. Fuel pump relay related
   a. Bad fuel pump relay. Primary side open or shorted.

2. Fuel pump related
   a. Fuel pump open or shorted internally.

3. Engine wiring harness related
   a. Fuel pump fuse F1 open.
   b. Broken or shorted wire in harness. ECU pin 28 to fuel pump relay pin 86. Ignition switch to fuel pump relay pin 85.

4. ECU related
   a. Circuit controlling fuel pump relay damaged.

Code: 61
Source:
Explanation: Denotes the end of fault codes. If signaled first, no other fault codes are present.

Troubleshooting Flow Chart

The following flow chart provides an alternative method of troubleshooting the EFI system. The chart will enable you to review the entire system in about 10-15 minutes. Using the chart, the accompanying diagnostic aids (listed after the chart), and any signaled fault codes, you should be able to quickly locate any problems within the system.

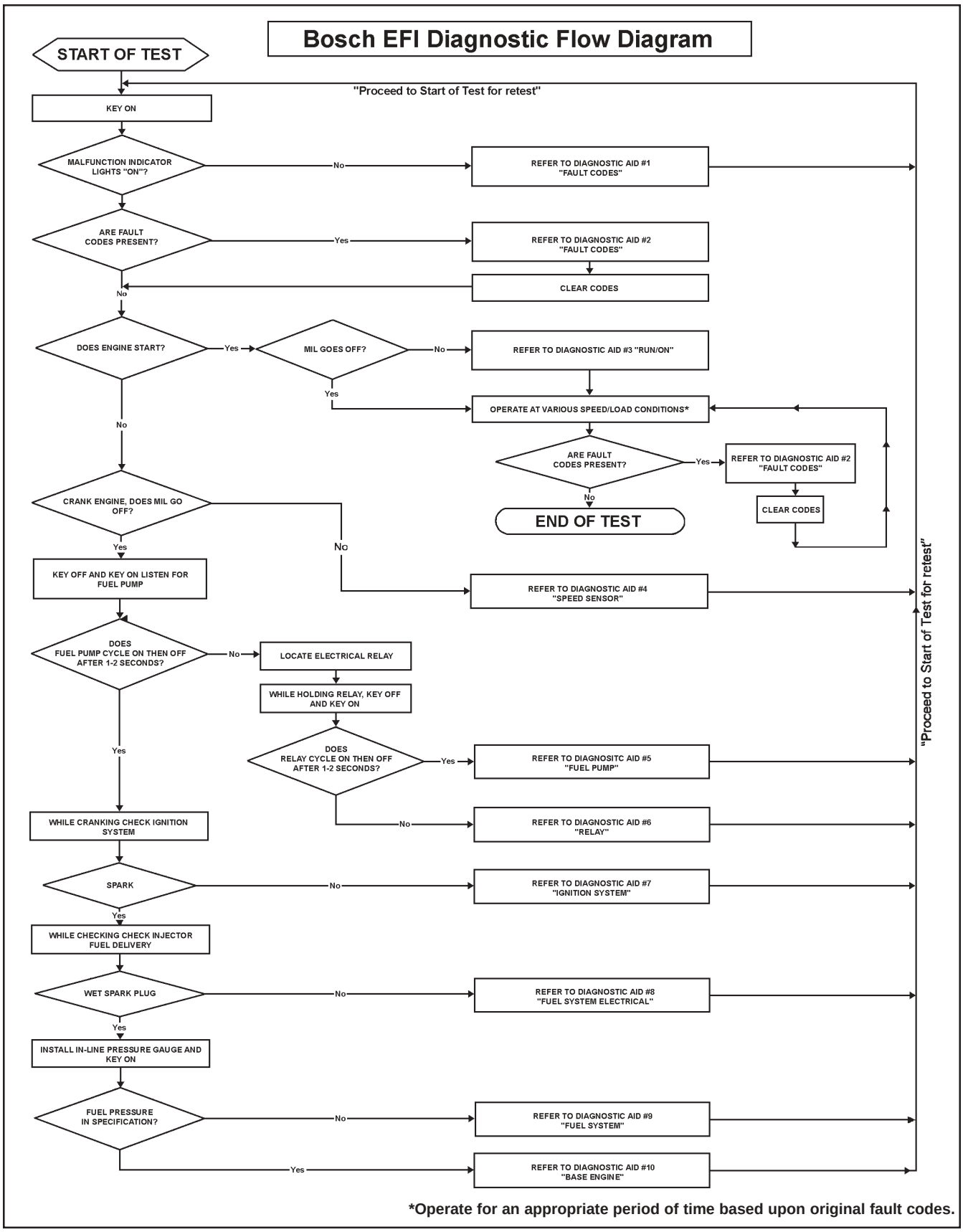

Bosch EFI Diagnostic Flow Diagram
START OF TEST
"Proceed to Start of Test for retest"
KEY ON
MALFUNCTION INDICATOR LIGHTS "ON"?
No
REFER TO DIAGNOSTIC AID #1 "FAULT CODES"
ARE FAULT CODES PRESENT?
Yes
REFER TO DIAGNOSTIC AID #2 "FAULT CODES"
CLEAR CODES
No
DOES ENGINE START?
Yes
MIL GOES OFF?
No
REFER TO DIAGNOSTIC AID #3 "RUN/ON"
Yes
OPERATE AT VARIOUS SPEED/LOAD CONDITIONS*
ARE FAULT CODES PRESENT?
Yes
REFER TO DIAGNOSTIC AID #2 "FAULT CODES"
CLEAR CODES
No
END OF TEST
No
CRANK ENGINE, DOES MIL GO OFF?
Yes
No
KEY OFF AND KEY ON LISTEN FOR FUEL PUMP
REFER TO DIAGNOSTIC AID #4 "SPEED SENSOR"
DOES FUEL PUMP CYCLE ON THEN OFF AFTER 1-2 SECONDS?
No
LOCATE ELECTRICAL RELAY
WHILE HOLDING RELAY, KEY OFF AND KEY ON
DOES RELAY CYCLE ON THEN OFF AFTER 1-2 SECONDS?
Yes
REFER TO DIAGNOSITC AID #5 "FUEL PUMP"
No
REFER TO DIAGNOSTIC AID #6 "RELAY"
Yes
WHILE CRANKING CHECK IGNITION SYSTEM
SPARK
No
REFER TO DIAGNOSTIC AID #7 "IGNITION SYSTEM"
Yes
WHILE CHECKING CHECK INJECTOR FUEL DELIVERY
WET SPARK PLUG
No
REFER TO DIAGNOSTIC AID #8 "FUEL SYSTEM ELECTRICAL"
Yes
INSTALL IN-LINE PRESSURE GAUGE AND KEY ON
FUEL PRESSURE IN SPECIFICATION?
No
REFER TO DIAGNOSTIC AID #9 "FUEL SYSTEM"
Yes
REFER TO DIAGNOSTIC AID #10 "BASE ENGINE"
"Proceed to Start of Test for retest"
*Operate for an appropriate period of time based upon original fault codes.

Figure 5B-36.

Flow Chart Diagnostic Aids

Diagnostic Aid #1 "SYSTEM POWER" (MIL does not illuminate when key is turned **"on"**)

Possible causes:

1. Battery
2. Main system fuse
3. MIL light bulb burned out
4. MIL electrical circuit problem. Pin circuits 29 and 84.
5. Ignition switch
6. Permanent ECU power circuit problem. Pin circuit 1.
7. Switched ECU power circuit problem. Pin circuit 2.
8 ECU grounds
9. ECU

Diagnostic Aid #2 "FAULT CODES" (Refer to detailed fault code listing before flow chart and "servicing" information for the respective components)

1. Code 21 - Engine Speed Synchronization
2. Code 22 - Throttle Position Sensor (TPS)
3. Code 23 - Engine Control Unit (ECU)
4. Code 31 - Oxygen Sensor
5. Code 32 - Oxygen Sensor
6. Code 33 - Fuel System (temporary adaptation factor)
7. Code 34 - Fuel System (permanent adaptation factor)
8. Code 42 - Engine (Coolant) Temperature Sensor
9. Code 43 - TPS "Auto-Learn" Initialization Function. (Below Min. Limit)
10. Code 44 - TPS "Auto-Learn" Initialization Function. (Above Max. Limit)
11. Code 51 - Injector 1
12. Code 52 - Injector 2
13. Code 55 - MIL (Diagnostic Light)
14. Code 56 - Pump Relay
15. Code 61 - End of Fault/Blink Code Transmission.

Diagnostic Aid #3 "RUN/ON" (MIL remains **"on"** while engine is running)*

Possible causes:

1. Fault codes which turn on MIL when engine is running.
   a. Code 21 - Engine Speed Synchronization
   b. Code 22 - Throttle Position Sensor (TPS)
   c. Code 23 - Engine Control Unit (ECU)
   d. Code 31 - Oxygen Sensor (shorted)
   e. Code 34 - Fuel System (permanent adaptation at limit)
   f. Code 42 - Engine (Coolant) Temperature Sensor
   g. Code 43 - TPS "Auto-Learn" Initialization Function (Below Min. Limit)
   h. Code 44 - TPS "Auto-Learn" Initialization Function (Above Max. Limit)
   i. Code 51 - Injector 1
   j. Code 52 - Injector 2
   k. Code 55 - MIL (Diagnostic Light)
   l. Code 56 - Pump Relay
2. MIL circuit grounded between light and ECU. Pin circuit 29.
3. ECU

*NOTE: The MIL (diagnostic light) used must be a 1/4 watt incandescent lamp. An LED style light will stay on continuously (dim) and should not be used.

Diagnostic Aid #4 "SPEED SENSOR" (MIL does not turn off during cranking) Indicates the ECU is not receiving a signal from the speed sensor.

Possible causes:

1. Speed sensor
2. Speed sensor circuit problem. Pin circuits 9 and 10.
3. Speed sensor/toothed wheel air gap
4. Toothed wheel
5. Flywheel key sheared
6. ECU

Diagnostic Aid #5 "FUEL PUMP" (fuel pump not turning on)

Possible causes:
1. Fuel pump fuse
2. Fuel pump circuit problem. Circuits 30, 87, and relay.
3. Fuel pump

Diagnostic Aid #6 "RELAY" (relay not operating)

Possible causes:
1. Safety switches/circuit(s) problem. Circuit 25.
2. Relay circuit(s) problem. Circuits 28, 85, 30, and 87.
3. Relay
4. ECU grounds
5. ECU

Diagnostic Aid #7 "IGNITION SYSTEM" (no spark)

Possible causes:
1. Spark plug
2. Plug wire
3. Coil
4. Coil circuit(s). Circuits 30, 31, 65, 66, relay and relay circuit 30.
5. ECU grounds
6. ECU

Diagnostic Aid #8 "FUEL SYSTEM-ELECTRICAL" (no fuel delivery)

Possible causes:
1. No fuel
2. Air in fuel rail
3. Fuel valve shut off
4. Fuel filter/line plugged
5. Injector circuit(s). Circuits 14, 15, 45 and 4A.
6. Injector
7. ECU grounds
8. ECU

Diagnostic Aid #9 "FUEL SYSTEM" (fuel pressure)

Possible causes for low fuel system pressure:
1. Low fuel
2. Fuel filter plugged
3. Fuel supply line plugged
4. Pressure regulator
5. Fuel pump

Possible causes for high fuel system pressure:
1. Pressure regulator
2. Fuel return line plugged or restricted.

Diagnostic Aid #10 "BASIC ENGINE" (cranks but will not run)

Possible causes:
1. Refer to basic engine troubleshooting charts within service manual sections 3, 5, and 8.

Common Complaints/Problems

Following are some of the most common complaints or problems reported by customers. For each problem, you will find a list of the most likely causes or areas to be investigated. Always start by checking if there are any stored fault codes to guide you in the right direction.

Engine starts hard or fails to start when cold. (Code 31, 42, 51, 52, 56)
1. Fuel pump or relay, not activating/operational.
2. Engine (Coolant) Temperature sensor faulty.
3. Fuel pressure insufficient/incorrect.
4. Fuel injector(s) leaking.
5. Fuel injector(s), fuel filter, fuel line, or fuel pick-up dirty, clogged, or restricted.
6. Speed sensor malfunction.
7. Stale fuel.
8. Low system voltage.
9. Bad spark plug(s) or coil(s).
10. Base ignition timing incorrect.

Engine starts hard or fails to start when warm. (Code 42, 51, 52)
1. Insufficient fuel system pressure.
2. Engine (Coolant) Temperature sensor faulty.
3. Fuel injector(s) leaking.
4. Fuel injector(s), fuel filter, fuel line, or fuel pick-up dirty/restricted.
5. Low fuel pressure.
6. Wrong grade of fuel.
7. Bad spark plug(s) or coil(s).
8. Low system voltage.
9. Speed sensor problem.
10. Base ignition timing problem.

Engine stalls or idles roughly. (Code 22, 31, 34, 42, 43, 51, 52)
1. Vacuum (intake air) leak.
2. Fuel injector(s), fuel filter, fuel line, or fuel pick-up dirty/clogged/restricted.
3. Insufficient fuel pressure/delivery.
4. Engine (Coolant) Temperature sensor faulty.
5. TPS faulty or "TPS Initialization Procedure" incorrect.
6. Leaking fuel injector O-Rings.
7. Bad spark plug(s) or coil(s).

Engine idles too fast (after full warm-up).
1. Throttle linkage binding or not returning to idle position.
2. Idle speed adjustment incorrect.
3. Vacuum (intake air) leak.
4. Leaking fuel injector O-Rings (injector to manifold).
5. Engine (Coolant) Temperature sensor faulty.
6. TPS faulty or "TPS Initialization Procedure." incorrect.
7. Base ignition timing incorrect.

Engine misses, hesitates, or stalls under load. (Code 22, 31, 34, 43, 44, 51, 52)
1. Fuel injector(s), fuel filter, fuel line, or fuel pick-up dirty/restricted.
2. Dirty air cleaner.
3. Insufficient fuel pressure or fuel delivery.
4. Vacuum (intake air) leak.
5. Improper governor setting, adjustment or operation.
6. Speed sensor malfunction.
7. TPS faulty, mounting problem or "TPS Initialization Procedure" incorrect.
8. Bad coil(s), spark plug(s), or wires.
9. Base ignition timing incorrect.

Low Power. (51, 52)
1. Throttle plates in throttle body/intake manifold not fully opening to WOT stop (if so equipped).
2. Insufficient fuel delivery.
3. Dirty air filter.
4. Faulty/malfunctioning ignition system.
5. TPS faulty or mounting problem.
6. Basic engine problem exists.
7. Improper governor adjustment.
8. Plugged/restricted exhaust.
9. One injector not working.
10. One spark plug, coil, or wire not working.

Section 6
Lubrication System

General

This engine uses a full pressure lubrication system. This system delivers oil under pressure to the crankshaft, camshaft and connecting rod bearing surfaces. In addition to lubricating the bearing surfaces, the lubrication system supplies oil to the hydraulic valve lifters.

A high-efficiency gerotor pump is located in the closure plate. The oil pump maintains high oil flow and oil pressure, even at low speeds and high operating temperatures. A pressure relief valve in the closure plate limits the maximum pressure of the system.

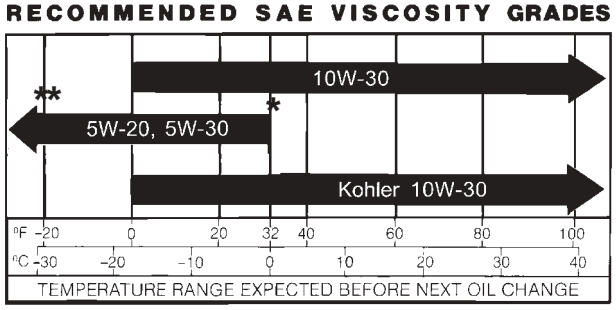
Service

The closure plate must be removed to service the oil pickup, the pressure relief valve, and the oil pump. Refer to the appropriate procedures in Sections 9 and 10.

Oil Recommendations

Using the proper type and weight of oil in the crankcase is extremely important; so is checking oil daily and changing the oil and filter regularly.

Use high-quality detergent oil of **API (American Petroleum Institute) service class SG, SH, SJ, or higher**. Select the viscosity based on the air temperature at the time of operation as shown in the following table.



*Use of synthetic oil having 5W-20 or 5W-30 rating is acceptable, up to 4°C (40°F).

**Synthetic oils will provide better starting in extreme cold below -23°C (-10°F).

NOTE: Using other than service class SG, SH, SJ or higher oil, or extending oil change intervals longer than recommended can cause engine damage.

NOTE: Synthetic oils meeting the listed classifications may be used with oil changes performed at the recommended intervals. However, to allow piston rings to properly seat, a new or rebuilt engine should be operated for at least 50 hours using standard petroleum based oil before switching to synthetic oil.

A logo or symbol on oil containers identifies the API service class and SAE viscosity grade. See Figure 6-1.

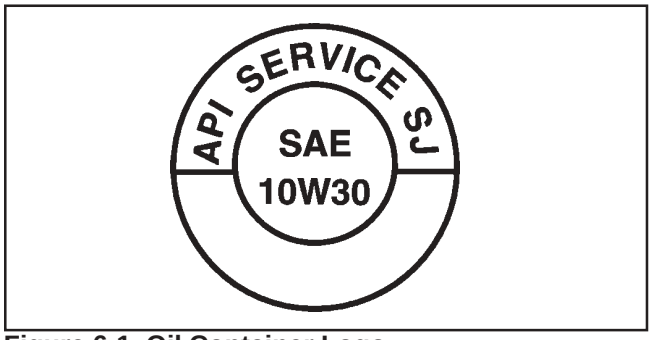


Figure 6-1. Oil Container Logo.

The top portion of the symbol shows service class such as **API SERVICE CLASS SJ**. The symbol may show additional categories such as **CC or CD**. The center portion shows the viscosity grade such as SAE 10W-30. If the bottom portion shows ''Energy Conserving,'' it means that oil is intended to improve fuel economy in passenger car engines.

Checking Oil Level

The importance of checking and maintaining the proper oil level in the crankcase cannot be overemphasized. Check oil **BEFORE EACH USE** as follows:

1. Make sure the engine is stopped, level, and cool so the oil has had time to drain into the sump.

2. Clean the area around the dipstick before removing it. This will help to keep dirt, grass clippings, etc., out of the engine.

3. Pull out the dipstick and wipe off the oil. Reinstall the dipstick into the tube and push it all the way in. See Figure 6-2.

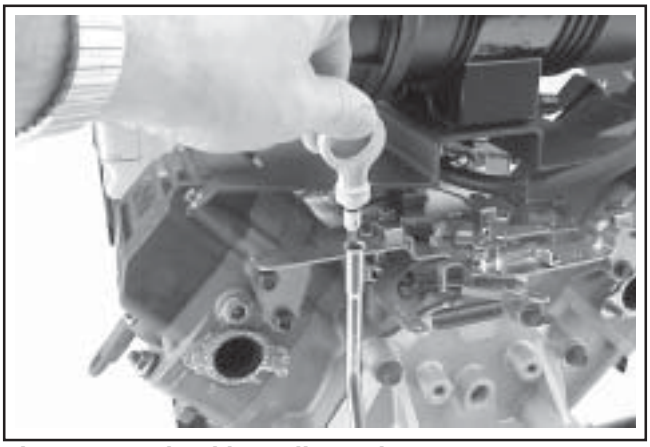


Figure 6-2. Checking Oil Level.

4. Remove the dipstick and check the oil level. The level should be between the "F" and "L" marks. If low, add oil of the proper type to bring the level up to the "F" mark. Reinstall the oil fill cap and dipstick.

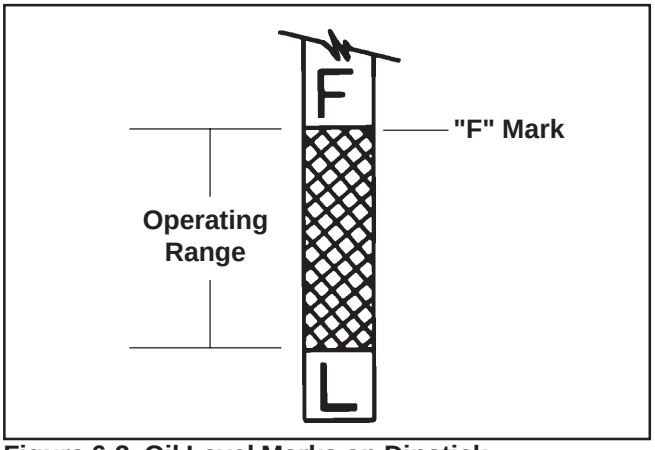


Figure 6-3. Oil Level Marks on Dipstick.

NOTE: To prevent extensive engine wear or damage, always maintain the proper oil level in the crankcase. Never operate the engine with the oil level below the "L" mark or above the "F" mark on the dipstick.

Changing Oil and Oil Filter

Change oil and oil filter after **every 200 hours or annually, whichever comes first** (more often under severe conditions). Refill with service class SG, SH, SJ or higher oil, as specified in the ''Viscosity Grades'' table on previous page. Always use a genuine Kohler oil filter. Use chart below to determine part number to order.

Oil Filter Part No.	Length
12 050 01-S	2-1/2"
52 050 02-S	3-3/8"

Change the oil while the engine is still warm. The oil will flow freely and carry away more impurities. Make sure the engine is level when filling or checking oil.

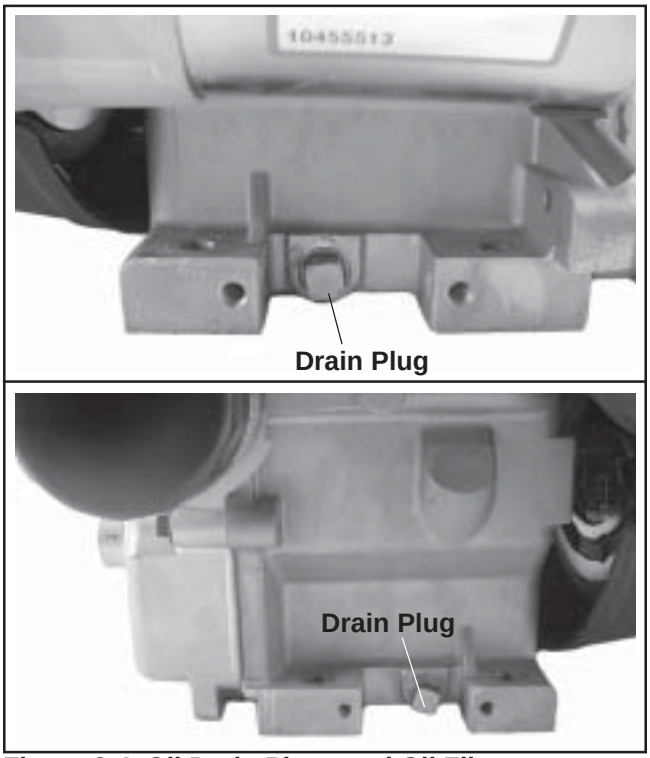


Figure 6-4. Oil Drain Plugs and Oil Filter.

Change the oil and oil filter as follows (See Figure 6-4.):

1. To keep dirt, debris, etc. out of the engine, clean the area around the oil fill cap and the dipstick before removal.

2. Remove one of the oil drain plugs and the dipstick. Be sure to allow ample time for complete drainage.

3. Before removing the oil filter, clean the surrounding area to keep dirt and debris out of the engine. Remove the old filter and wipe/clean the surface where the filter mounts.

4. Reinstall the drain plug. Make sure it is tightened to **13.6 N·m (10 ft. lb.)**.

5. Place a new oil filter in a shallow pan with the open end up. Pour new oil, of the proper type, in through the threaded center hole. Stop pouring when the oil reaches the bottom of the threads. Allow a minute or two for the oil to be absorbed by the filter material.

6. Apply a thin film of oil to the rubber gasket on the new filter.

7. Install the new oil filter to the filter adapter. Turn the oil filter clockwise until the rubber gasket contacts the surface, then tighten the filter an additional 3/4-1 turn.

8. Remove the oil fill cap from the valve cover. Fill the crankcase with new oil, of the proper type, to the "F" mark on the dipstick. Refer to "Oil Type" and "Check Oil Level" on pages 6.1 and 6.2. Always check the level with the dipstick before adding more oil. Push dipstick in completely.

9. Reinstall the oil fill cap and tighten securely by turning to the right.

   NOTE: To prevent extensive engine wear or damage, always maintain the proper oil level in the crankcase. Never operate the engine with the oil level below the ''L'' mark or above the ''F'' mark on the dipstick.

Angle of Operation

This engine will operate continuously at angles up to 20°. Check oil level to assure crankcase oil level is at the ''F'' mark on the dipstick.

Refer to the operating instructions of the equipment this engine powers. Because of equipment design or application, there may be more stringent restrictions regarding the angle of operation.

NOTE: Do not operate this engine continuously at angles exceeding 20° in any direction. Engine damage could result from insufficient lubrication.

Oil Sentry™

Some engines are equipped with an optional Oil Sentry™ oil pressure monitor. If the oil pressure decreases below an acceptable level, the Oil Sentry™ will either shut off the engine or activate a warning signal, depending on the application.

Operation

The pressure switch is designed to break contact as the oil pressure increases, and make contact as the oil pressure decreases. At oil pressure above approximately 3.0/5.0 psi, the switch contacts open. Below this pressure, the switch contacts close.

On stationary or unattended applications (pumps, generators, etc.), the pressure switch can be used to ground the ignition module to stop the engine. On vehicular applications (lawn tractors, mowers, etc.) the pressure switch can only be used to activate a warning light or signal.

NOTE: Make sure the oil level is checked BEFORE EACH USE and is maintained up to the ''F'' mark on the dipstick. This includes engines equipped with Oil Sentry™.

Installation

The Oil Sentry™ pressure switch is installed in the breather cover. See Figure 6-5.

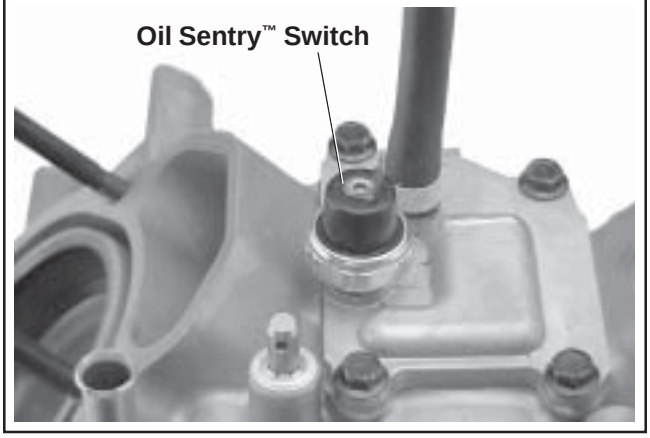


Figure 6-5. Oil Sentry™ Location.

On engines not equipped with Oil Sentry™ the installation hole is sealed with a 1/8-27 N.P.T.F. pipe plug.

To install the switch, follow these steps:

1. Apply **pipe sealant with Teflon®** (Loctite® No. 59241 or equivalent) to the threads of the switch.

2. Install the switch into the tapped hole in the breather cover. See Figure 6-5.

3. Torque the switch to **4.5 N·m (40 in. lb.)**.

Testing

Compressed air, a pressure regulator, pressure gauge and a continuity tester are required to test the switch.

1. Connect the continuity tester to the blade terminal and the metal case of the switch. With **0 psi** pressure applied to the switch, the tester should indicate **continuity (switch closed)**.

2. Gradually increase the pressure to the switch. As pressure increases through the range of **3.0/5.0 psi,** the tester should indicate a change to **no continuity (switch open)**. The switch should remain open as the pressure is increased to **90 psi maximum**.

3. Gradually decrease the pressure through the range of **3.0/5.0 psi**. The tester should indicate a change to **continuity (switch closed) down to 0 psi**.

4. Replace the switch if it does not operate as specified.

Crankcase Breather System

The crankcase breather system is a necessary complement to the lubrication system. To help prevent the engine oil from weeping out past shafts, seals, and gaskets during operation, it is desirable to have a low vacuum inside the crankcase. A typical crankcase breather system incorporates a simple one-way valve to provide the desired vacuum.

Breather Design and Function

The breather system on these engines is designed to control and maintain the vacuum in the engine crankcase. When the pistons move downward, a controlled amount of crankcase air is pushed past the reed, which in turn closes when the pistons travel upward. The hole for the breather (reed) is positioned high in the crankcase, so that most of the oil mist has already been purged from the air before it enters the breather chamber. Remaining oil is separated through a baffle and filter, as the air moves through the chamber. A hose connects the breather outlet to an adapter on top of the carburetor, where the vented breather air is mixed proportionately with the incoming combustion air on its way to the combustion chamber. A drain hole at the bottom of the chamber returns the separated oil to the crankcase.

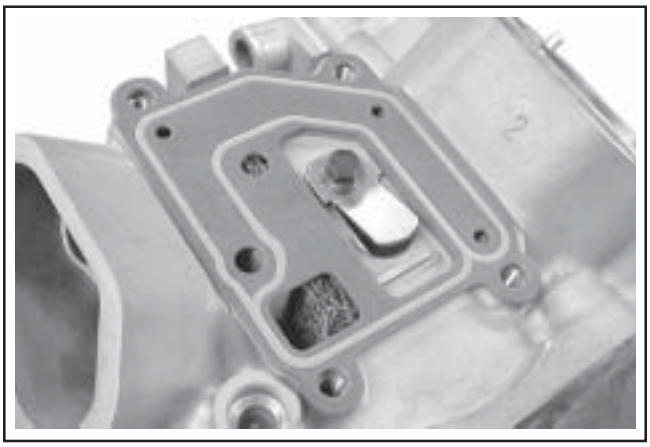


Figure 6-6. Reed/Breather Assembly in Crankcase.

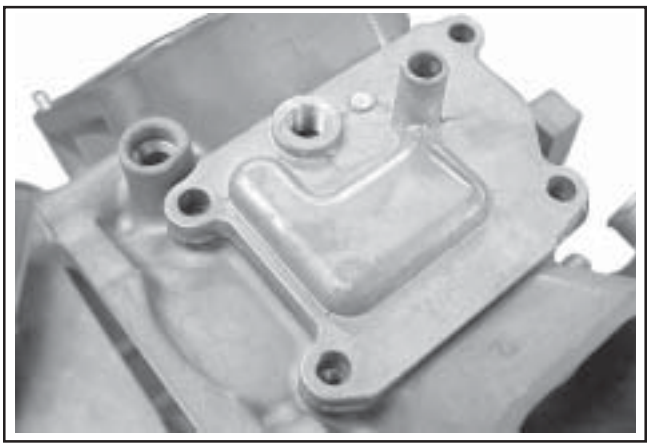


Figure 6-7. Breather Cover.

Section 7
Cooling System

WARNING: Explosive release of fluids from pressurized cooling system can cause serious burns!
When it is necessary to open cooling system at radiator cap, shut off engine and remove filler cap ***only when cool enough to touch with bare hands.*** *Slowly loosen cap to first stop to relieve pressure before removing completely.*

This section covers the operation and servicing of the liquid cooling system.

Cooling System Components

The cooling system consists of the following components:

- Radiator with removable screen
- Hoses
- Coolant Pump and Belt
- Thermostat
- Intake Manifold with Thermostat Housing
- Radiator Cap
- Cooling Fan, Belt, and Drive Pulleys
- Overflow Reservoir
- Crankcase and Heads with Integral Cooling Passages

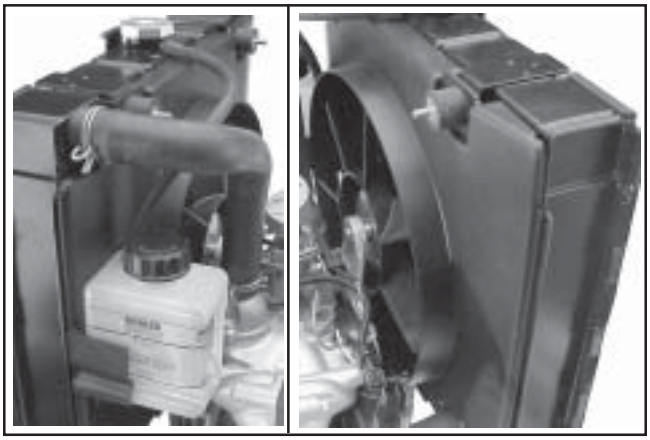


Figure 7-1. Cooling System Components (Air Cleaner Removed For Clarity).

Operation

The engine coolant is pumped through the cooling system by a pump, belt-driven off the camshaft. The coolant coming out of the pump is divided, and moves simultaneously through separate circuits within each head and the corresponding sides of the crankcase. As the coolant moves through these passages, it absorbs heat from the engine parts. After traveling through the engine, the coolant from the two separate circuits merges and moves through the intake manifold to the lower side of the thermostat. During warm-up, the thermostat is closed, preventing circulation through the radiator. The coolant circulates through the engine only and is returned to the pump via the bypass hose. When engine heat brings the coolant up to a temperature of 79.4°C (175°F), the thermostat will begin to open, allowing coolant to circulate through the upper hose to the radiator. The thermostat is completely open at 90.5°C (195°F) allowing full coolant flow through the radiator, where it is cooled. After getting "cooled" in the radiator, the coolant is drawn into the pump through the lower radiator hose and circulation starts all over again. A cooling fan, driven off the flywheel by a belt, draws ambient air through the radiator, to maintain the cooling process.

Coolant Recommendations

Use equal parts of ethylene glycol (antifreeze) and water only. Distilled or deionized water is recommended, especially in areas where the water contains a high mineral content. Propylene glycol based antifreeze is not recommended.

This mixture will provide protection from -37°C (-34°F) to 108°C (226°F). For protection and use outside the indicated temperature limits, follow the antifreeze manufacturer's instructions on the container, but do not exceed 70% antifreeze.

DO NOT use antifreeze with stop-leak additive(s), or put any other additives in the cooling system.

Cooling System Maintenance and Service

Maintenance

Maintaining the correct coolant level, cleaning any debris accumulation from the radiator surfaces, and insuring all parts are in proper operating condition, is critical to ensuring long life, proper system performance and preventing overheating. To ensure proper air circulation, make sure the radiator, cooling fan, drive belt, pulleys, cooling fins, and external surfaces of the engine are kept clean and in good condition **at all times**. Check the coolant level and clean away any debris accumulation daily or before each use. At the same time inspect the hoses and all system connections for signs of leakage. Make sure the cooling fan is not cracked or missing any blades. Check that the fan belt and the two drive pulleys, are in good condition and the proper belt tension is present. See Figure 7-2.

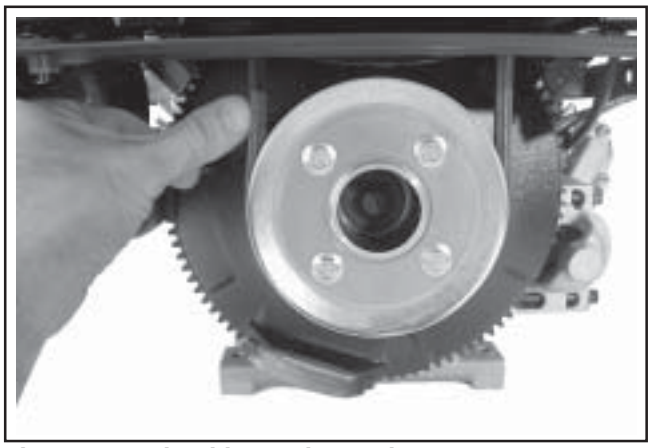


Figure 7-2. Checking Belt Tension.

Servicing

Every **100 hours** of operation (more often under extremely dusty, dirty conditions), clean the removable screen, cooling fins of the radiator, all shrouding and external surfaces of the engine as necessary. Check the condition of fan assembly and v-belt tension. Do not operate the engine without all shrouds and protective guards installed.

Lift the screen vertically to remove for cleaning/servicing. Clean the screen and cooling fins of the radiator with a soft brush or blow out using clean compressed air. See Figure 7-3. To avoid damage to the screen and cooling fins, do not use a high pressure washer to clean.

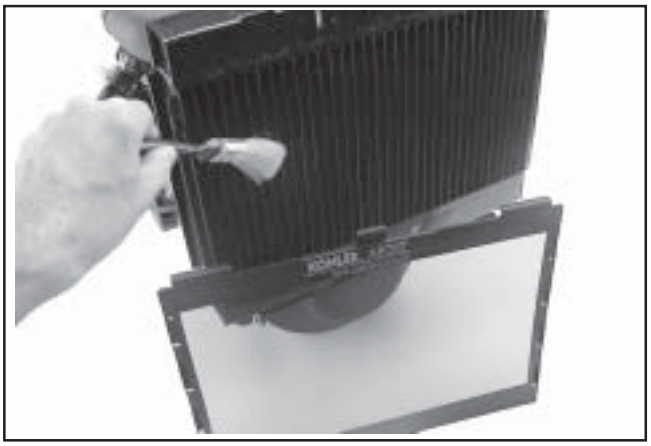


Figure 7-3. Cleaning Radiator and Screen.

Engine coolant should be changed every **two years or 1000 hours, whichever comes first**. When changing the engine coolant, the system should also be flushed to remove any contaminants left behind during draining. Following are general recommended procedures for checking, draining, flushing, and filling the cooling system.

Checking Coolant Level

The coolant level should be checked at the overflow reservoir, located behind the radiator on the fan shroud. See Figure 7-4.

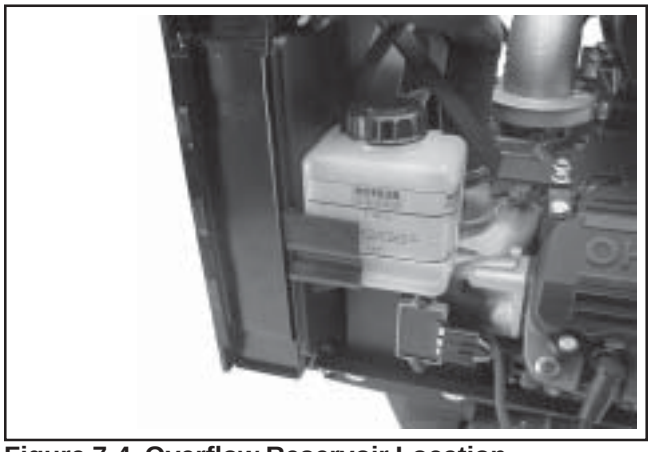


Figure 7-4. Overflow Reservoir Location.

1. Check the coolant level within the overflow reservoir. Coolant level should be between the "FULL" and "ADD" marks on the reservoir. See Figure 7-5. **Do not** operate the engine with the coolant level below the "ADD" mark.

   Add coolant to the overflow reservoir as required, which is a 50/50 mixture of ethylene glycol and water (distilled or deionized water is recommended).

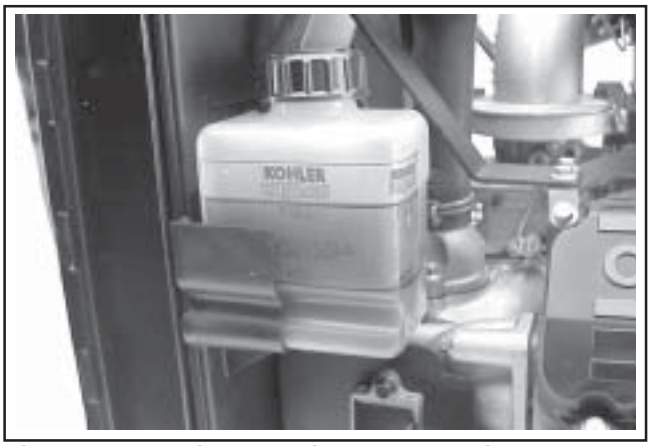


Figure 7-5. Coolant Levels on Reservoir.

NOTE: **Do not** operate the engine without coolant in the system. **Do not** remove the radiator cap when hot. Engine coolant is hot and under pressure and can cause severe burns. To prevent engine overheating and damage, **do not** exceed more than 70% antifreeze in the cooling system.

Draining Cooling System

1. Stop the engine and let the engine cool sufficiently.

2. Slowly remove the radiator cap.

3. Loosen/remove the radiator drain plug in the lower left rear corner or the bottom of the radiator. See Figure 7-6.

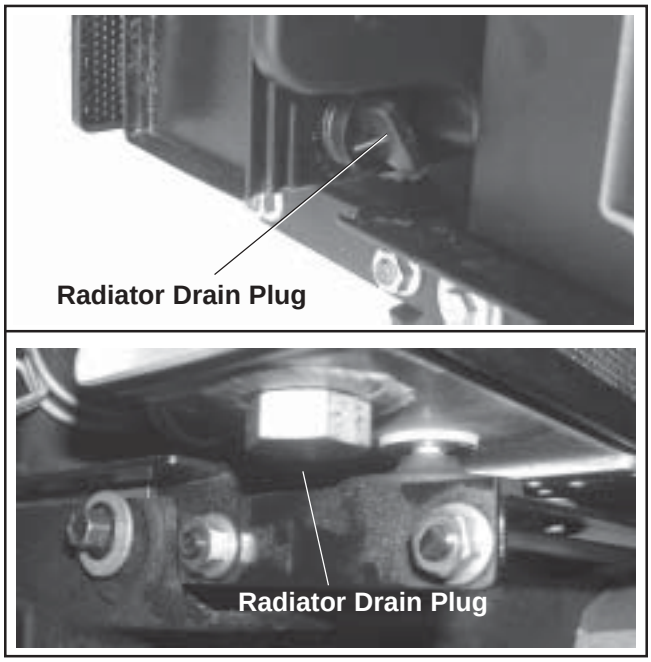


Figure 7-6. Radiator Drain Plug.

Drain the coolant into a suitable container. Then remove the coolant drain plugs if equipped from the sides of the block and allow the remaining coolant to drain. See Figure 7-7.

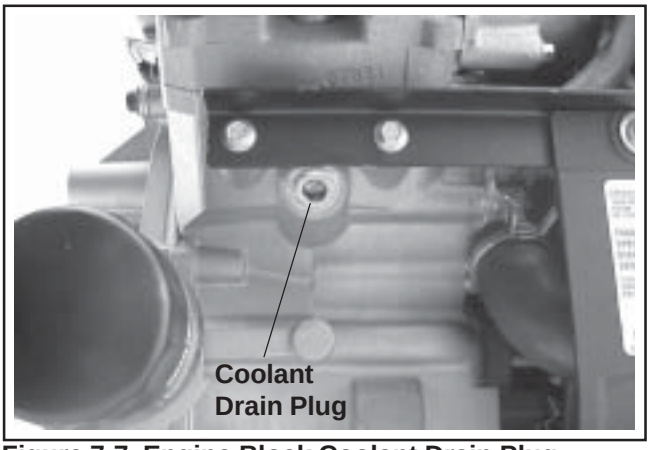


Figure 7-7. Engine Block Coolant Drain Plug (Some Models).

On the starter side it may be preferable to first remove the starter, or use a piece of cardboard formed in a "V" to drain the coolant out over the starter. After the coolant has drained, apply **pipe sealant with Teflon®** (Loctite® 59241 or equivalent) to the threads of the plugs and reinstall the plugs. Torque the plugs to **13.5 N·m (120 in. lb.)**. Always use brass plugs when service is performed.

4. Unhook inboard catch and remove the overflow reservoir from its mounting location. See Figure 7-8. Remove the cap and pour out the contents of the reservoir. Wash or clean as required. Dispose of all the old coolant properly, according to local regulations.

Figure 7-8. Removing Reservoir.

5. Reinstall the reservoir into the mounting bracket, and install the cap. Do not kink/pinch the hose.

6. Flush the cooling system.

Flushing Cooling System

NOTE: To prevent engine damage, **do not** pour water into a hot engine. **Do not** operate engine without coolant.

With system properly drained:

1. Fill the cooling system with clean water and a cooling system cleaner recommended for aluminum engines. Follow the directions on the container.

2. Reinstall and tighten the radiator cap.

3. Start and run the engine five minutes, or until it reaches operating temperature.

4. Drain the cooling system immediately, before contaminants settle (refer to "Draining Cooling System").

5. Fill the cooling system.

Filling Cooling System

NOTE: To prevent engine damage, **do not** use antifreeze mixture greater than 70% ethylene glycol in the cooling system. **Do not** use antifreeze with stop-leak additive(s) or mix/add other additives to the cooling system. Use only ethylene glycol antifreeze.

Cooling system capacity is approximately 2 liters (2.18 qt.)

1. Check the condition of cooling system hoses, clamps, and associated components. Replace as required.

2. Mix 50% ethylene glycol with 50% distilled or deionized water (See Coolant Recommendation). For extremely cold temperature applications or protection outside the limits listed in the Coolant Recommendation Section, refer to the antifreeze manufacturer's instructions on the container.

3. Fill the cooling system through the radiator neck. Allow coolant to drain into the lower areas. Fill the overflow reservoir midway between the ''ADD'' and ''FULL'' marks, then install the radiator and reservoir caps.

4. Start engine, run for five minutes and let cool.

5. Check coolant level in reservoir. Coolant level should be between the "FULL'' and ''ADD'' marks. See Figure 7-5. Add coolant if required.

Inspection

Cooling Fan Assembly, Belt, and Drive Pulleys

The cooling fan assembly, used to draw the air through the radiator, is attached to a hub and pulley assembly with sealed ball bearings. This assembly is belt driven off the flywheel, via a lower split pulley, and requires very little service or maintenance. **DO NOT operate the engine without the fan and properly functioning cooling system or engine damage will occur.** See Figure 7-9.

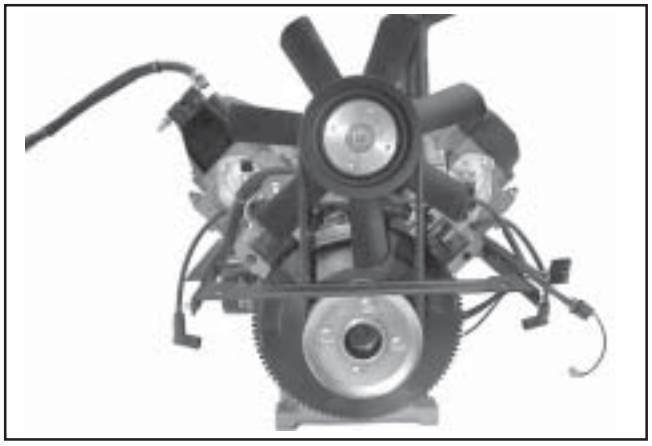


Figure 7-9. Cooling System (Front View).

1. Inspect the fan for any cracks, damaged/missing fan blades, and secure mounting.

2. The bearings in the hub of the pulley should rotate smoothly, without roughness, binding, or play/wobble.

3. The v-groove of each pulley (upper and lower) should not be bent, nicked, or damaged. Pulley mounting areas and lower pulley shims should be free of any cracks or elongation.

4. The drive belt is designed and constructed for this system. **Do not use a substitute belt.** Check the overall condition and replace the belt if cracked, damaged, or proper tension cannot be established by repositioning of the lower pulley shims. Use only Kohler Part No. **66 203 02-S** belt if replacement is necessary.

   See an authorized Kohler Service Dealer for any necessary service.

Checking Fan Belt and Tension

The fan belt and belt tension should be checked daily or before each use. The fan belt should not be cracked, damaged, or exhibit excessive wear. Proper tension is **3/8" - 1/2" (12.7 mm)** belt deflection per side under **10 lbs**. applied tension. See Figure 7-10.

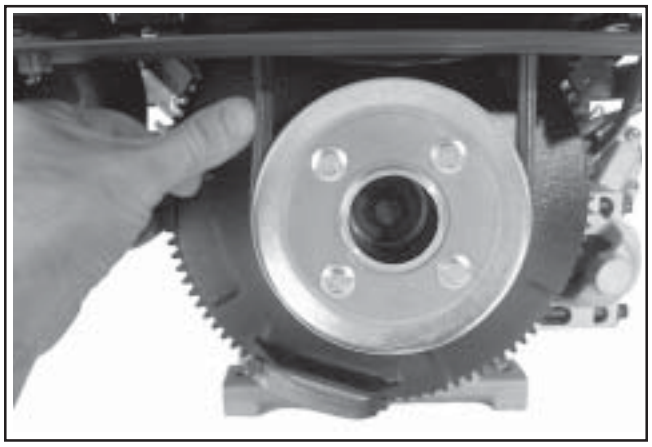


Figure 7-10. Checking Belt Tension.

If the belt is cracked, damaged, or is worn to the extent that relocation of pulley shims cannot establish proper belt tension, the belt should be replaced. Use only Kohler Part No. **66 203 02-S** belt. **DO NOT** use a substitute belt.

For a **new** belt, assemble the lower pulley with all three shims between the pulley halves. For a **used/original** belt being reinstalled, assemble with two or one shim(s) between the pulley halves and remaining shim(s) on the outside (front) of the outer pulley half. Check the belt tension as described above.

When proper tension is obtained, individually remove, each capscrew of the lower pulley apply Loctite® No. 242 to the threads and reinstall. Torque each of the four capscrews in a criss-cross sequence to **24.5 N·m (215 in. lb.)**. See Figure 7-11.

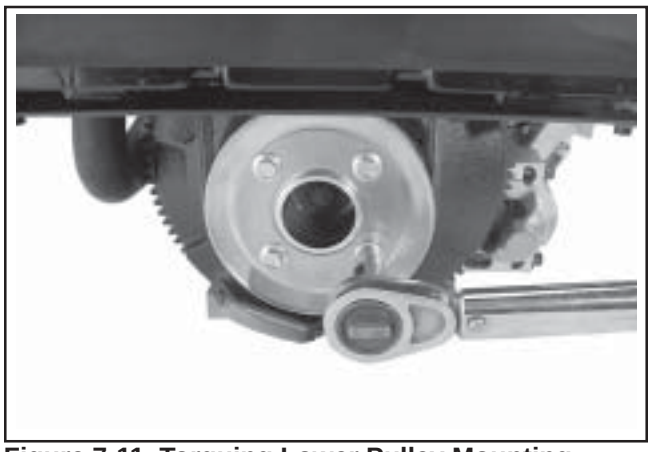


Figure 7-11. Torquing Lower Pulley Mounting Screws.

Hoses and Tubes

Hoses and tubes are used to connect the components within the cooling system. To guard against coolant loss and hose failure, the hoses, tubes and their connections should be checked regularly for leaks or damage. Loss of coolant can result in serious engine damage. Over time, engine vibration can affect hose/joint connections, and the hoses themselves can be affected by heat and the coolant. Swelling, hardening, and/or deterioration can occur depending on the operating environment. Deterioration usually takes place more rapidly from the inside, making outside inspections incomplete and not always dependable. Regular outside inspection and careful inside inspection whenever connections are opened, can minimize a possible ''in-service'' problem.

Use new clamps whenever a hose is replaced or a joint connection is opened. When making hose connections, a light coating of rubber lubricant will make assembly easier.

Thermostat Testing and Servicing

The thermostat is mounted in the intake manifold, beneath the thermostat housing. See Figure 7-12. It controls the rapid warm-up and operating temperature of the engine. If a problem is encountered which is thought to be the fault of the thermostat, it can be checked to determine its operating condition. Before removing and testing the thermostat, make sure all other possible causes such as debris accumulation/obstruction, leaks, belt or fan failure, coolant level, and damaged components are eliminated as possible causes.

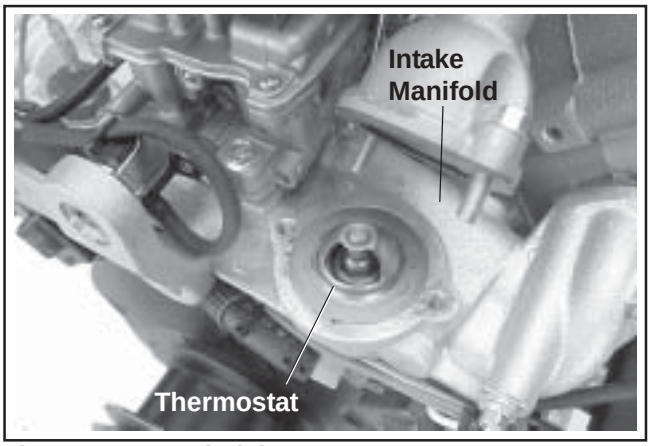


Figure 7-12. Intake/Thermostat.

To Test

Remove the thermostat from the system. Hang or suspend the thermostat by its frame in a container of water, so the thermostat does not touch the bottom of the container. Heat the water and measure the temperature (an oven thermometer can be used). The spring-loaded valve of the thermostat should begin to open at 79.4°C (175°F), and can be completely open at 90°C (195°F). If the valve opens at a temperature more than 10 degrees below the specified opening or fails to open at a temperature 10 to 15 degrees above the specified opening, the thermostat should be replaced. If the valve in the thermostat can be moved or pushed off its seat with a slight effort when the thermostat is cold, the unit may be considered defective and should be replaced. The thermostat should be replaced if operation is found to be questionable or faulty.

Installation

1. Thoroughly clean the sealing surfaces of the intake manifold and thermostat housing with an aerosol gasket remover. Make sure the sealing surfaces are clean and free of nicks or damage. Make sure the notch in the intake manifold is clean.

2. Install a new thermostat into the intake manifold, so the larger spring end is down into the well of the intake manifold. Position a new thermostat gasket on the intake manifold.

3. Install the thermostat housing onto the intake manifold.

4. Install and torque the two hex flange screws to **9.9 N·m (88 in. lb.)**.

5. Reconnect the radiator hose and secure with the hose clamp, if separated previously.

High Temperature Sensor

A high temperature sensor may be mounted in the intake manifold and is used to activate a warning light, audible alarm, or kill the engine (depending on the application), if the safe operating temperature is exceeded. The sensor is a ''normally open'' switch which completes a circuit, when the coolant temperature reaches the rated temperature limit of the switch. For these engines the temperature sensor limit is 123.8°C (255°F).

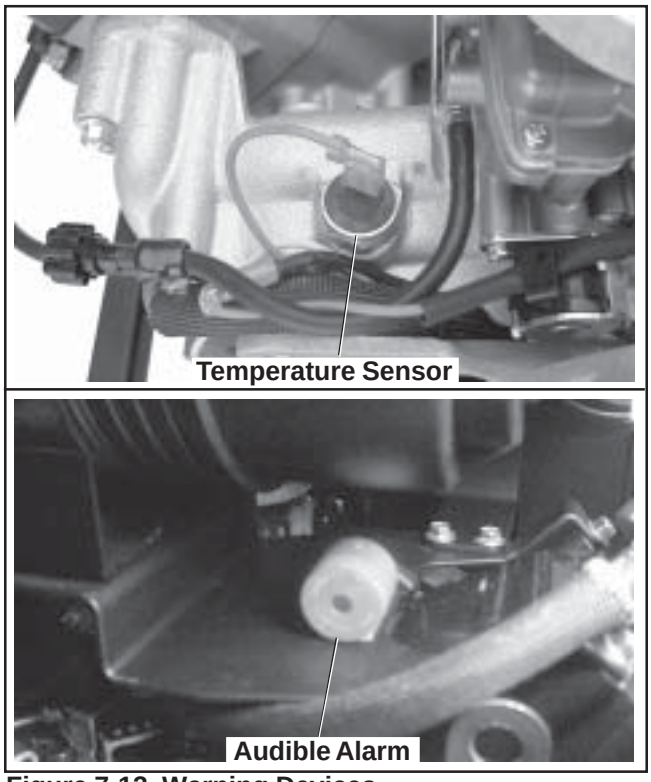


Figure 7-13. Warning Devices.

If the warning device activates, or the engine kills, indicating an excessive operating temperature, check the following:

1. Make sure fan belt is in good condition and properly tensioned.

2. Make sure cooling fan is properly secured, not broken, damaged, or missing blades.

3. Make sure all air intake and cooling surfaces are clean and free of debris accumulation.

4. After the engine has sufficiently cooled, check the coolant level in the system to make sure it is not low, or improperly mixed.

5. Check cooling system for leaks.

6. Check the thermostat, and pressure test the radiator cap.

7. Make sure the water pump and the drive belt are operational.

8. Check and inspect the wiring from the sensor for shorting or damage.

If none of those are found to be the cause do the following:

1. Drain coolant from the system, so the level is lower than the installed position of the temperature sensor.

2. Remove and replace the temperature sensor. Use pipe sealant with Teflon® on the threads.

Cooling System Leakage Test

A pressure test of the cooling system can be performed as a relatively simple means of determining whether the cooling system may contain a leak. A pump/pressure type cooling system tester with the appropriate 45 mm adapter may be used to check the cooling system and the radiator cap. A typical tester and adapter is shown in Figure 7-14.

Figure 7-14. A Typical Tester and Adapter.

Test Instructions

1. With the engine cool, carefully remove the radiator cap (see Pressure Radiator Cap Section). Make sure all parts of the cap and adapter are clean. Install the cap on the corresponding adapter and make sure it is completely seated. Install the adapter onto the tester and lock in place. See Figure 7-15.

Figure 7-15. Adapter Installed onto the Tester.

2. Pressurize the tester to 15 psi.

3. Observe the indicated pressure. It should hold steady and not decrease or leak down.

   If leakage is detected, the cap should be replaced. If the tester pressure is increased to 16 psi, or above, the cap should then ''bleed off'' this excess pressure.

4. Install and lock the system adapter and tester onto the neck of the cooling system. Pressurize the tester to 14-15 psi. See Figure 7-16.

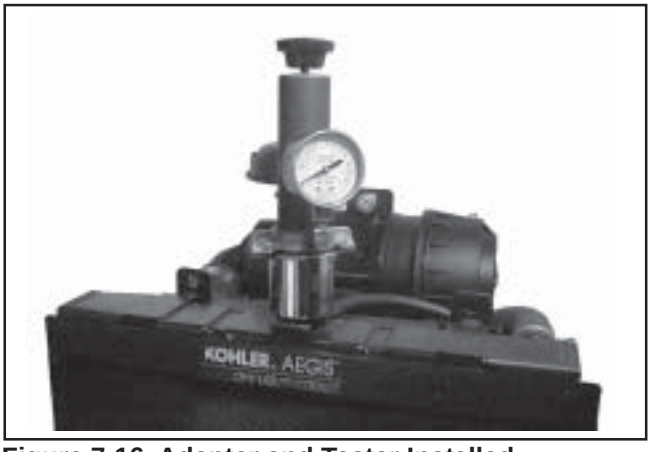


Figure 7-16. Adapter and Tester Installed.

5. Observe the system pressure on the gauge.

Gauge Needle Holds Steady

If the gauge needle holds steady, there should be no serious leaks in the system. It is however, recommended that all connections be checked for overall condition anyway, using a flashlight.

Gauge Needle Drops Slowly

If the gauge needle drops slowly it indicates the presence of a small leak or seepage. Check all components and connections for signs of leakage. Check the condition of the radiator hoses. If they swell excessively while testing the system, they may be weak and should be replaced.

Gauge Needle Drops Quickly

A steady drop or loss of pressure indicates serious leakage is occurring within the system, which must be located and corrected before the engine is returned to service.

If a pressure loss is noted:

1. With pressure on the system, apply a soap/water solution and check all joint connections, hoses, and cooling system components for external leakage. Repair or replace as required.

2. Remove the dipstick and check the appearance of the oil in the crankcase. Another method would be to remove an oil drain plug and drain a small amount of oil for inspection. A milky or an opaque color, similar to chocolate milk, indicates the presence of engine coolant in the oil. Check for a blown head gasket (step 3 below) or a possible crack or internal leakage from the water jacket.

3. Remove the spark plugs. Apply 14-15 lbs. of pressure and listen/inspect for internal coolant leakage into the cylinder/combustion chambers. This can denote a head gasket failure/leak. If required, further test by performing a ‘‘Cylinder Leakdown Test’’ as described in Section 3.

Section 8
Electrical System and Components

This section covers the operation, service, and repair of the electrical system components. Systems and components covered in this section are:

- Spark Plugs
- Battery and Charging System
- Electronic CD Ignition System
- Electric Starter

Spark Plugs

Engine misfire or starting problems are often caused by a spark plug that has improper gap or is in poor condition.

The engine is equipped with the following spark plugs:

Type: The standard spark plug is a Champion® RC14YC (Kohler Part No. 66 132 01-S). Equivalent alternate brand plugs can also be used.
Gap: 0.76 mm (0.030 in.)
Thread Size: 14 mm
Reach: 19.1 mm (3/4 in.)
Hex Size: 16 mm (5/8 in.)

Spark Plug Service

Annually or every **200 hours** of operation (whichever comes first), remove the spark plugs, check condition, and reset the gap or replace with new spark plugs as necessary. Every **500 hours** of operation, replace the spark plugs. To service the spark plugs perform the following steps:

1. Before removing each spark plug, clean the area around the base of the plug to keep dirt and debris out of the engine.
2. Remove the plug and check its condition. See "Inspection" following this procedure. Replace the plug if necessary.

   NOTE: Do not clean spark plug in a machine using abrasive grit. Some grit could remain in the spark plug and enter the engine causing extensive wear and damage.

3. Check the gap using a wire feeler gauge. Adjust the gap to **0.76 mm (0.030 in.)** by carefully bending the ground electrode. See Figure 8-1.

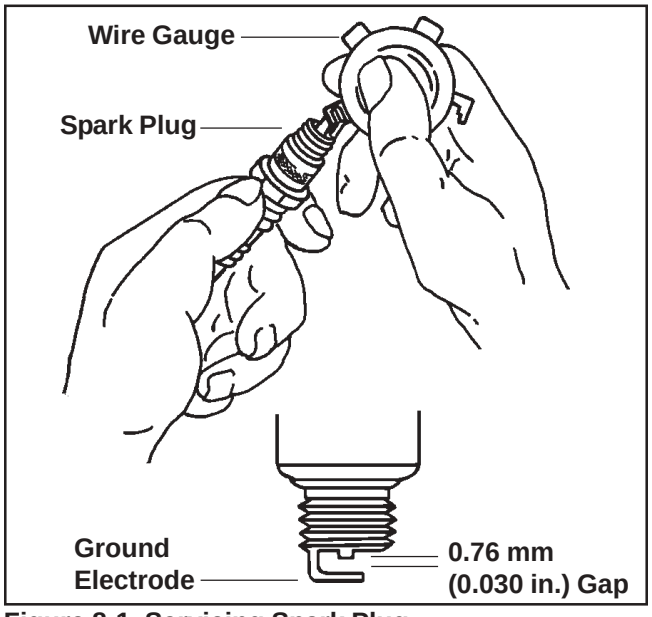


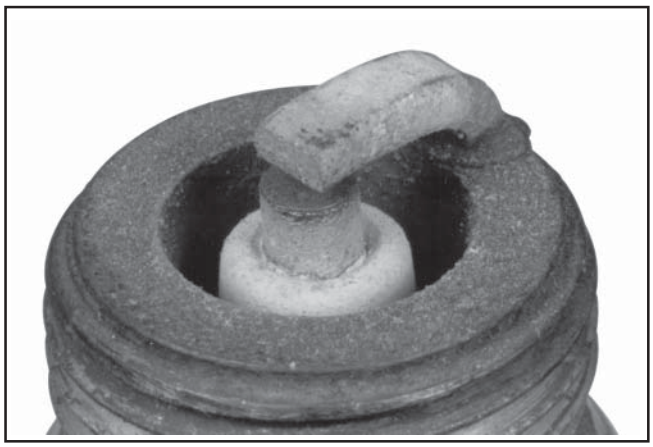
Figure 8-1. Servicing Spark Plug.

4. Reinstall the spark plug into the cylinder head and tighten to **24.4-29.8 N·m (18-22 ft. lb.)**.

Inspection

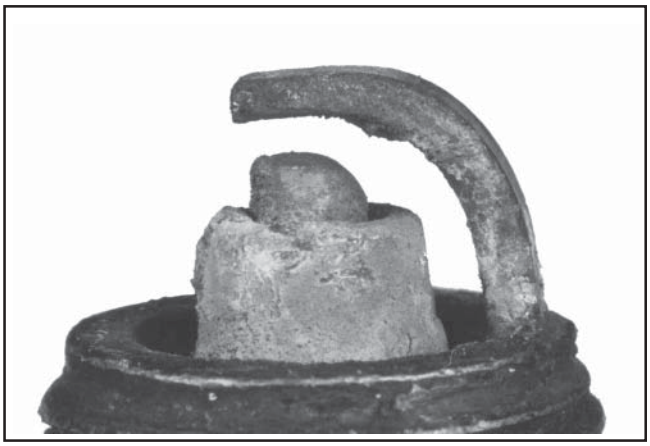
Inspect each spark plug as it is removed from the cylinder head. The deposits on the tip can be an indication of the general condition of the engine and/or adverse operating conditions.

Normal and fouled plugs are shown in the following photos:

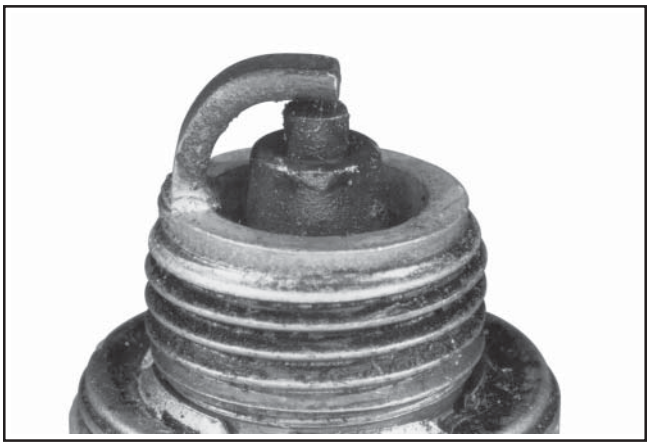


Normal: A plug taken from an engine operating under normal conditions will have light tan or gray colored deposits. If the center electrode is not worn, a plug in this condition could be set to the proper gap and reused.

Carbon Fouled: Soft, sooty, black deposits indicate incomplete combustion caused by a restricted air cleaner, overrich carburetion, weak ignition, or poor compression.



Worn: On a worn plug, the center electrode will be rounded and the gap will be greater than the specified gap. Replace a worn spark plug immediately.



Wet Fouled: A wet plug is caused by excess fuel or oil in the combustion chamber. Excess fuel could be caused by a restricted air cleaner, a carburetor problem, or operating the engine with too much choke. Oil in the combustion chamber is usually caused by a restricted air cleaner, a breather problem, worn piston rings or valve guides.

Overheated: Chalky, white deposits indicate very high combustion temperatures. This condition is usually accompanied by excessive gap erosion. Lean carburetor settings, an intake air leak, or incorrect spark timing are normal causes for high combustion temperatures.

Battery

General

A 12-volt battery with 400 cold cranking amps is generally recommended for starting in all conditions. A smaller capacity battery is often sufficient if an application is started only in warmer temperatures. Refer to the following table for minimum capacities (cca) based on anticipated ambient temperatures. The actual cold cranking requirement depends on engine size, application, and starting temperatures. The cranking requirements increase as temperatures decrease and battery capacity shrinks. Refer also to the operating instructions of the equipment being this engine powers for specific battery requirements.

Battery Size Recommendations

Temperature	Battery Required
Above 32°F (0°C)	200 cca minimum
0°F to 32°F (-18°C to 0°C)	250 cca minimum
-5°F to 0°F (-21°C to -18°C)	300 cca minimum
-10°F (-23°C) or below	400 cca minimum

If the battery charge is not sufficient to turn over the engine, recharge the battery.

Battery Maintenance

Regular maintenance is necessary to prolong battery life.

WARNING: Explosive Gas!

Batteries produce explosive hydrogen gas while being charged. To prevent a fire or explosion, charge batteries only in well ventilated areas. Keep sources of ignition away from the battery at all times. Keep batteries out of the reach of children. Remove all jewelry when servicing batteries.

Before disconnecting the negative (-) ground cable, make sure all switches are OFF. If ON, a spark will occur at the ground cable terminal which could cause an explosion if hydrogen gas or gasoline vapors are present.

1. Regularly check the level of electrolyte. Add distilled water as necessary to maintain the recommended level.

   NOTE: Do not overfill the battery. Poor performance or early failure due to loss of electrolyte will result.

2. Keep the cables, terminals, and external surfaces of the battery clean. A build-up of corrosive acid or grime on the external surfaces can cause the battery to self-discharge. Self-discharge occurs rapidly when moisture is present.

3. Wash the cables, terminals, and external surfaces with a mild baking soda and water solution. Rinse thoroughly with clear water.

   NOTE: Do not allow the baking soda solution to enter the cells as this will destroy the electrolyte.

Battery Test

To test the battery, you will need a DC voltmeter. Perform the following steps. See Figure 8-2:

1. Connect the voltmeter across the battery terminals.

2. Crank the engine. If the battery drops below 9 volts while cranking, the battery is too small, discharged, or faulty.

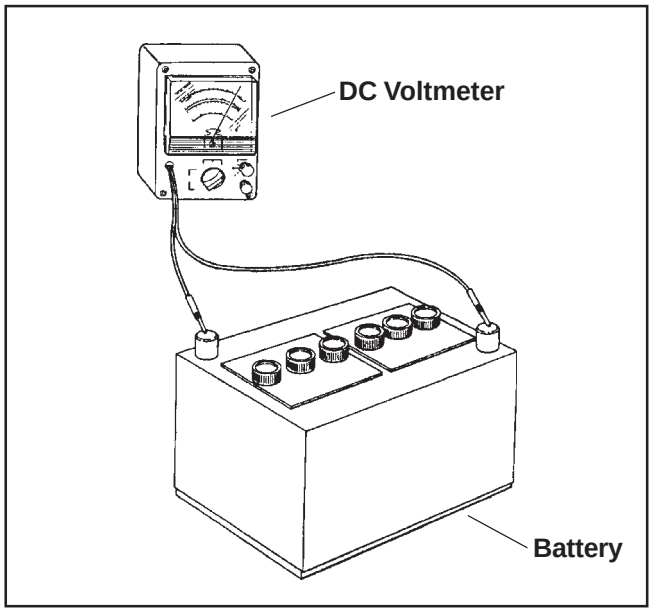


Figure 8-2. Battery Voltage Test.

Electronic CD Ignition Systems

Operation of CD Ignition Systems

Capacitive Discharge with Fixed Timing.

This system consists of the following components. See Figure 8-3.

- A magnet assembly which is permanently affixed to the flywheel.
- Two electronic capacitive discharge ignition modules which mount on the engine crankcase.
- A kill switch (or key switch) which grounds the modules to stop the engine.
- Two spark plugs.

The timing of the spark is controlled directly by the location of the flywheel magnet group as referenced to engine top dead center.

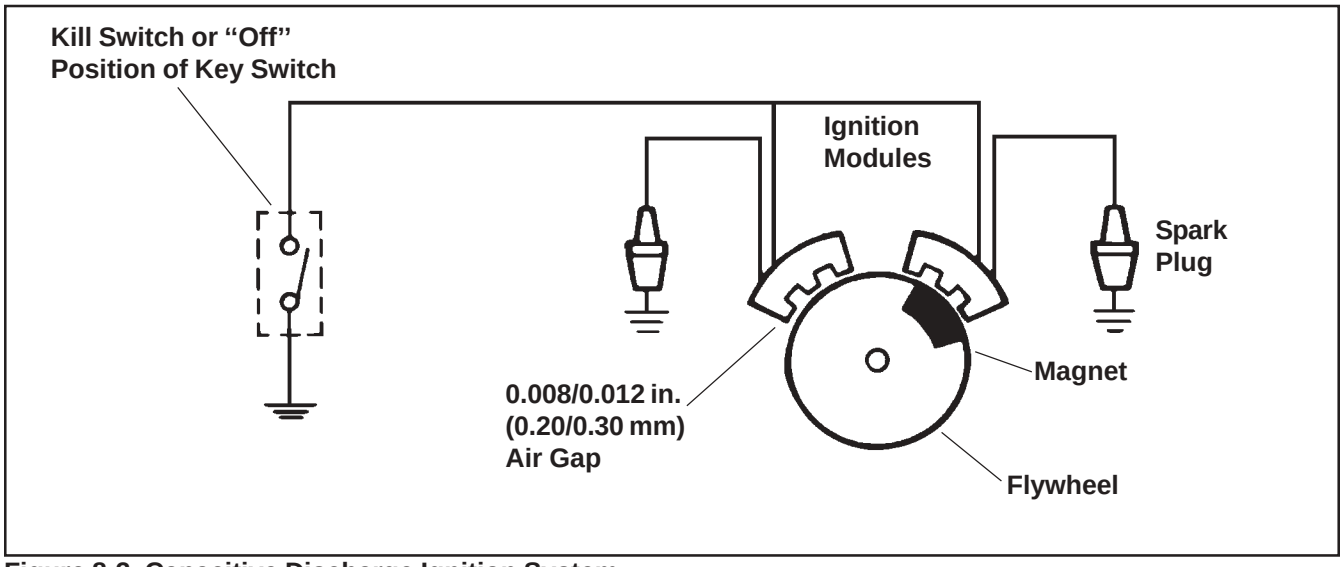


Figure 8-3. Capacitive Discharge Ignition System.

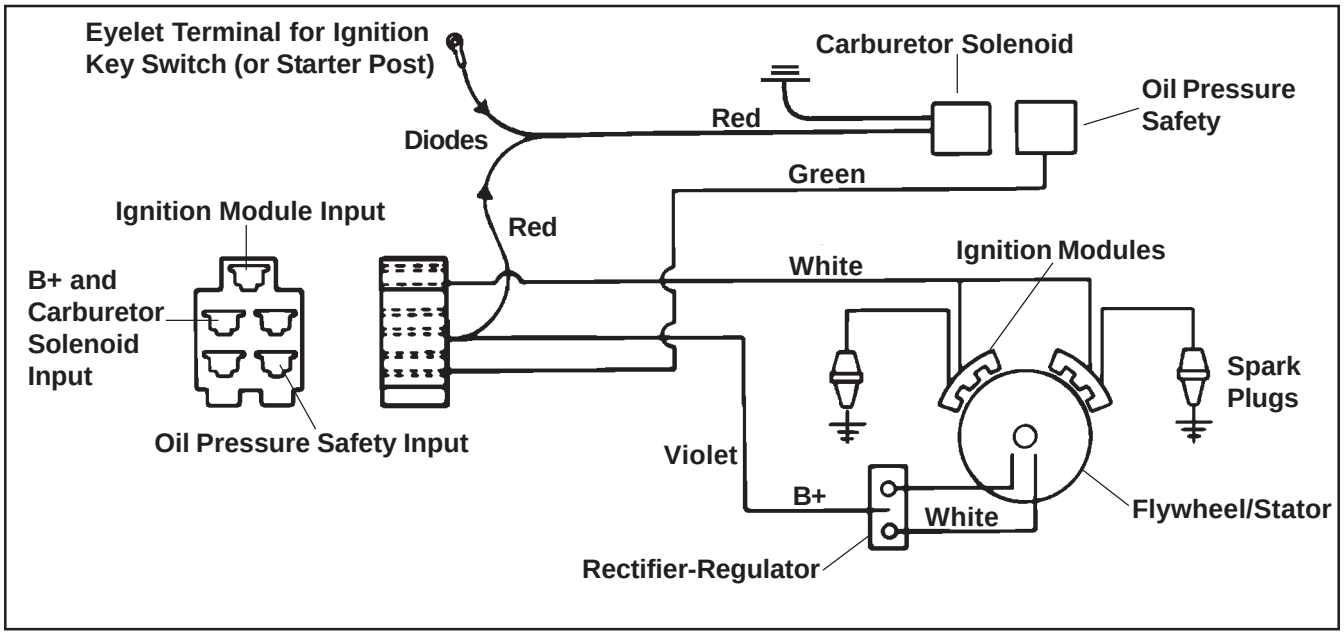


Figure 8-4. Electronic CD Ignition System (For Customer Connected Tractor Applications).

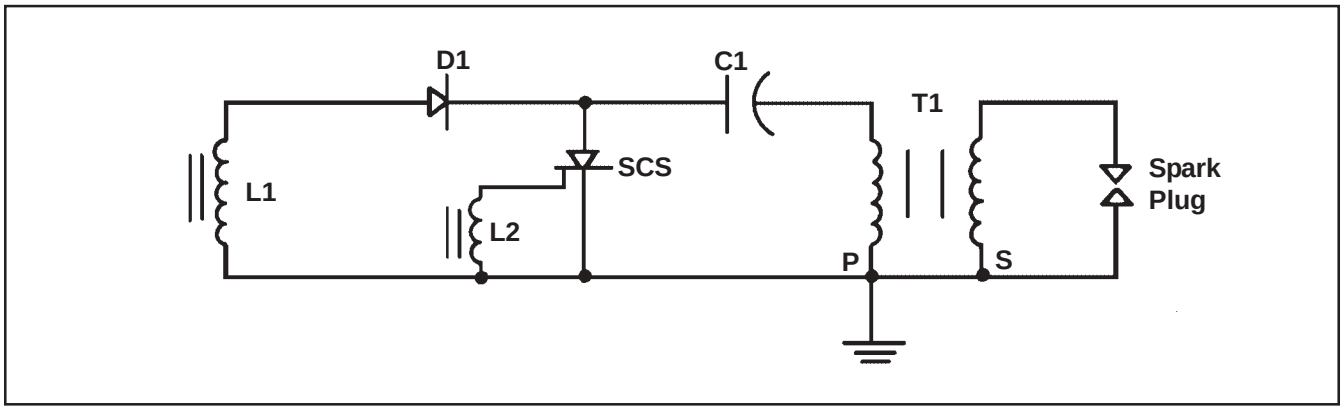


Figure 8-5. Capacitive Discharge Ignition Module.

Operation: As the flywheel rotates, the magnet grouping passes the input coil (L1). The corresponding magnetic field induces energy into the input coil (L1). The resultant pulse is rectified by D1 and charges capacitor C1. As the magnet assembly completes its pass, it activates the triggering device (L2), which causes the semiconductor switch (SCS) to turn on. With the device switch "ON," the charging capacitor (C1) is directly connected across the primary (P) of the output transformer (T1). As the capacitor discharges, the current initiates a fast rising flux field in the transformer core. A high voltage pulse is generated from this action into the secondary winding of the transformer. This pulse is delivered to the spark plug gap. Ionization of the gap occurs, resulting in an arc at the plug electrodes. This spark ignites the fuel-air mixture in the combustion chamber.

Troubleshooting CD Ignition Systems

The CD ignition systems are designed to be trouble free for the life of the engine. Other than periodically checking/replacing the spark plugs, no maintenance or timing adjustments are necessary or possible. Mechanical systems do occasionally fail or break down however, so the following troubleshooting information is provided to help you get to the root of a reported problem.

CAUTION: High Energy Electric Spark!

The CD ignition systems produce a high energy electric spark, but the spark must be discharged, or damage to the system can result. Do not crank or run an engine with a spark plug lead disconnected. Always provide a path for the spark to discharge to ground.

Reported ignition problems are most often due to poor connections. Before beginning the test procedure, check all external wiring. Be certain all ignition-related wires are connected, including the spark plug leads. Be certain all terminal connections fit snugly. Make sure the ignition switch is in the run position.

NOTE: The CD ignition systems are sensitive to excessive load on the kill lead. If a customer complains of hard starting, low power, or misfire under load, it may be due to excessive draw on the kill circuit. Perform the preliminary test which follows.

Preliminary Test

To be certain the reported problem is in the engine ignition system, it should be isolated from the unit.

1. Locate the plug connectors where the wiring harnesses from the engine and unit are joined. Separate the connectors and remove the white ''kill'' lead from the engine connector. Rejoin the connectors and position or insulate the kill lead terminal so it cannot touch ground. Try to start* the engine to verify whether the reported problem is still present.

    a. If the problem is gone, the electrical system on the unit is suspect. Check the key switch, wires, connections, safety interlocks, etc.

    b. If the problem persists, follow the test procedure on the next page. Leave the kill lead isolated until all testing is completed.

*NOTE: If the engine starts or runs during any of the testing, you may need to ground the kill lead to shut it down. As you have interrupted the kill circuit, it may not stop with the switch.

2. Test for spark on both cylinders with Kohler ignition tester (see Section 2). Disconnect one spark plug lead and connect it to the post terminal of the tester. Connect the clip to a good ground, not to the spark plug. Crank the engine and observe the tester spark gap. Repeat the procedure on the other cylinder. Remember to reconnect the first spark plug lead.

    a. If one side is not firing, check all wiring, connections, and terminations on that side. If wiring is okay, replace ignition module and retest for spark.

    b. If the tester shows spark, but the engine misses or won't run on that cylinder, try a new spark plug.

    c. If neither side is firing, recheck position of ignition switch and check for shorted kill lead.

Battery Charging System

General

These engines are equipped with either a 15, 20 or 25 amp regulated charging system. See Figure 8-6 for the 15/20/25 amp system diagram.

NOTE: Observe the following guidelines to avoid damage to the electrical system and components:

- Make sure the battery polarity is correct. A negative (-) ground system is used.
- Disconnect the plug from the rectifier-regulator and the battery cables before doing electric welding on the equipment powered by the engine.
- Prevent the stator (AC) leads from touching or shorting while the engine is running. This could damage the stator.

Wiring Color Codes	
B	Black
L	Blue
R	Red
Y	Yellow
W	White
P	Purple
O	Orange
L/R	Blue/Red

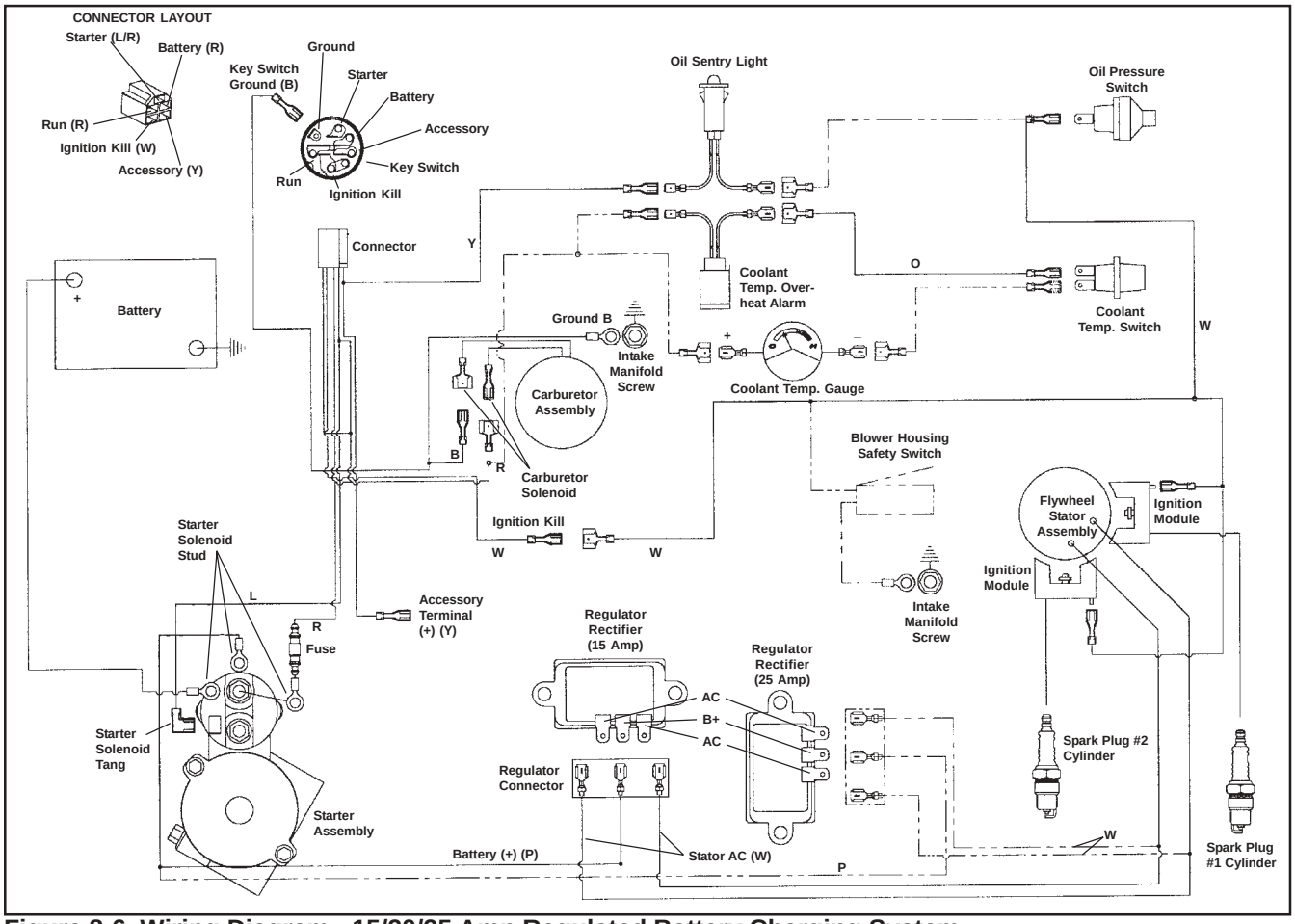


Figure 8-6. Wiring Diagram - 15/20/25 Amp Regulated Battery Charging System.

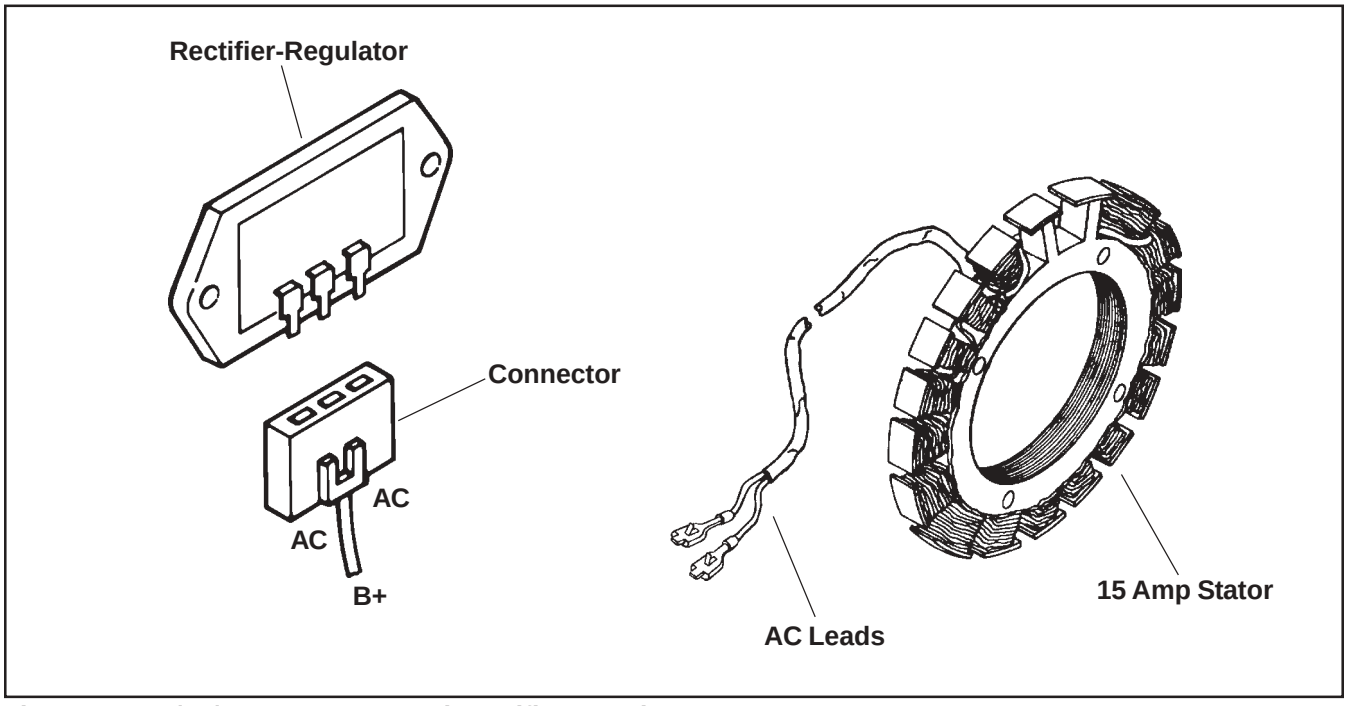


Figure 8-7. 15/20/25 Amp Stator and Rectifier-Regulator.

Stator

The stator is mounted on the crankcase behind the flywheel. If the stator needs to be replaced, follow the procedures in Section 9 - "Disassembly."

Rectifier-Regulator

The rectifier-regulator is mounted on the bracket below the overflow reservoir. See Figure 8-8. To replace it; disconnect the connector plug and remove the two screws. Take off the rectifier-regulator.

NOTE: When installing the rectifier-regulator, make sure the cooling fins are "in", towards the fan.

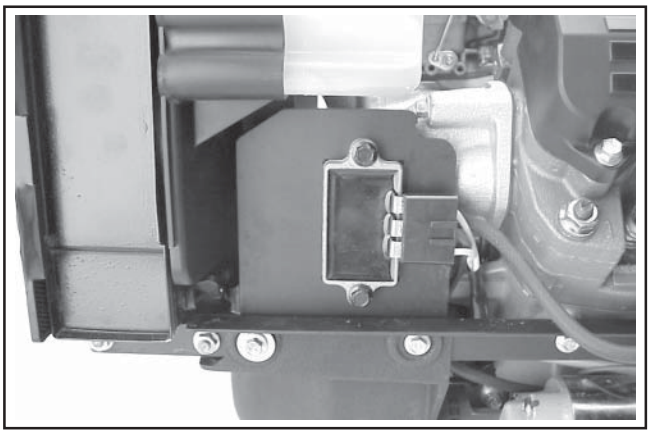


Figure 8-8. Rectifier-Regulator.

Testing of the rectifier-regulator may be performed as follows, using the appropriate Rectifier-Regulator Tester (see Section 2).

To Test –

NOTE: Disconnect all electrical connections attached to the rectifier-regulator. Testing may be performed with the rectifier-regulator mounted or loose. The figures show the part removed from the engine for clarity. Repeat the applicable test procedure **two or three times** to determine the condition of the part.

15 Amp Rectifier-Regulators

1. Connect the tester ground lead (with spring clamp) to the body of the rectifier-regulator being tested.

2. Connect the tester red lead to the B+ terminal of the rectifier-regulator and the two black tester leads to the two AC terminals. See Figure 8-9.

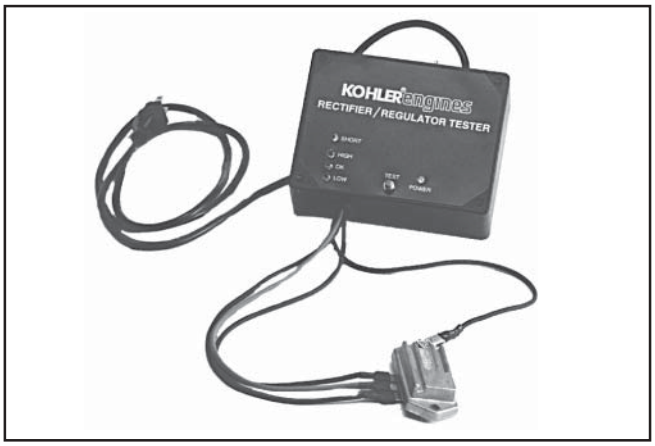


Figure 8-9.

3. Plug the tester into the proper AC outlet/power for tester being used. Turn on the power switch. See Figure 8-10. The ''POWER'' light should be illuminated and one of the four status lights may be on as well. This does not represent the condition of the part.

Figure 8-10.

4. Press the ''TEST'' button until a "click" is heard and then release. See Figure 8-11. Momentarily one of the four lights will illuminate, indicating the condition of the part.

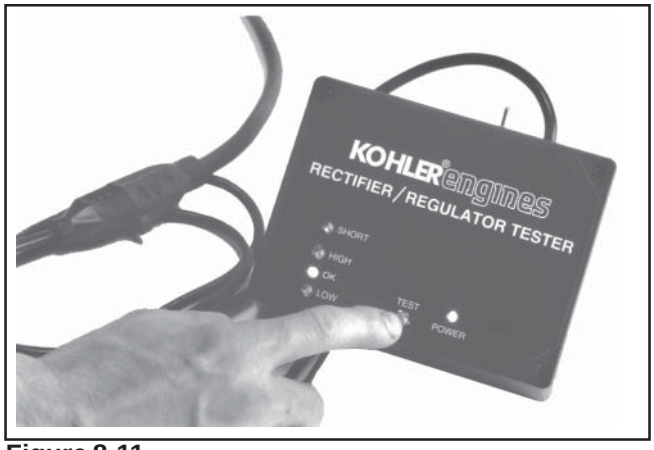


Figure 8-11.

a. If the "OK" (green) light comes on and stays steady, the part is good and may be used.

b. If any other light is displayed,* the rectifier-regulator is faulty and should not be used.

*NOTE: A flashing "LOW" light can also occur as a result of an inadequate ground lead connection. Make certain connection location is clean and clamp is secure.

20/25 Amp Rectifier-Regulators

1. Connect the single lead adapter in between the B+ (center) terminal of rectifier-regulator being tested and the squared single end of the tandem adapter lead. See Figure 8-12.

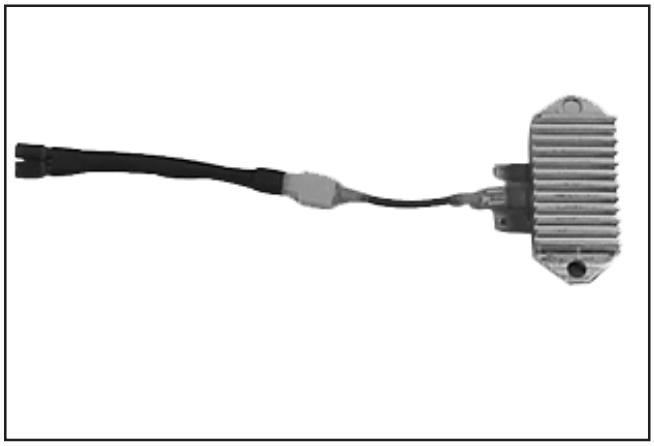


Figure 8-12.

2. Connect the tester ground lead (with spring clamp) to the body of the rectifier-regulator.

3. Connect the red lead and one of the black leads to the pair of terminals on the open end of the tandem adapter lead (connections are not location specific).

4. Connect the remaining black lead from the tester to one of the outer AC terminals on the rectifier-regulator. See Figure 8-13.

Figure 8-13.

5. Plug the tester into the proper AC outlet/power for tester being used. Turn on the power switch. The ''POWER'' light should be illuminated and one of the four status lights may be on as well. See Figure 8-10. This **does not** represent the condition of the part.

6. Press the ''TEST'' button until a ''click'' is heard and then release. See Figure 8-11. Momentarily one of the four lights will illuminate indicating the **partial condition** of the part.

   a. If the ''OK'' (green) light comes on, disconnect the tester black lead attached to one AC terminal and reconnect it to the other AC terminal. Repeat the test. If the ''OK'' (green) light comes on again, the part is good and may be used.

   b. If any other light is displayed* in either of the tests, the rectifier-regulator is faulty and should not be used.

*NOTE: A flashing ''LOW'' light can also occur as a result of an inadequate ground lead connection. Make certain the connection location is clean and the clamp is secure.

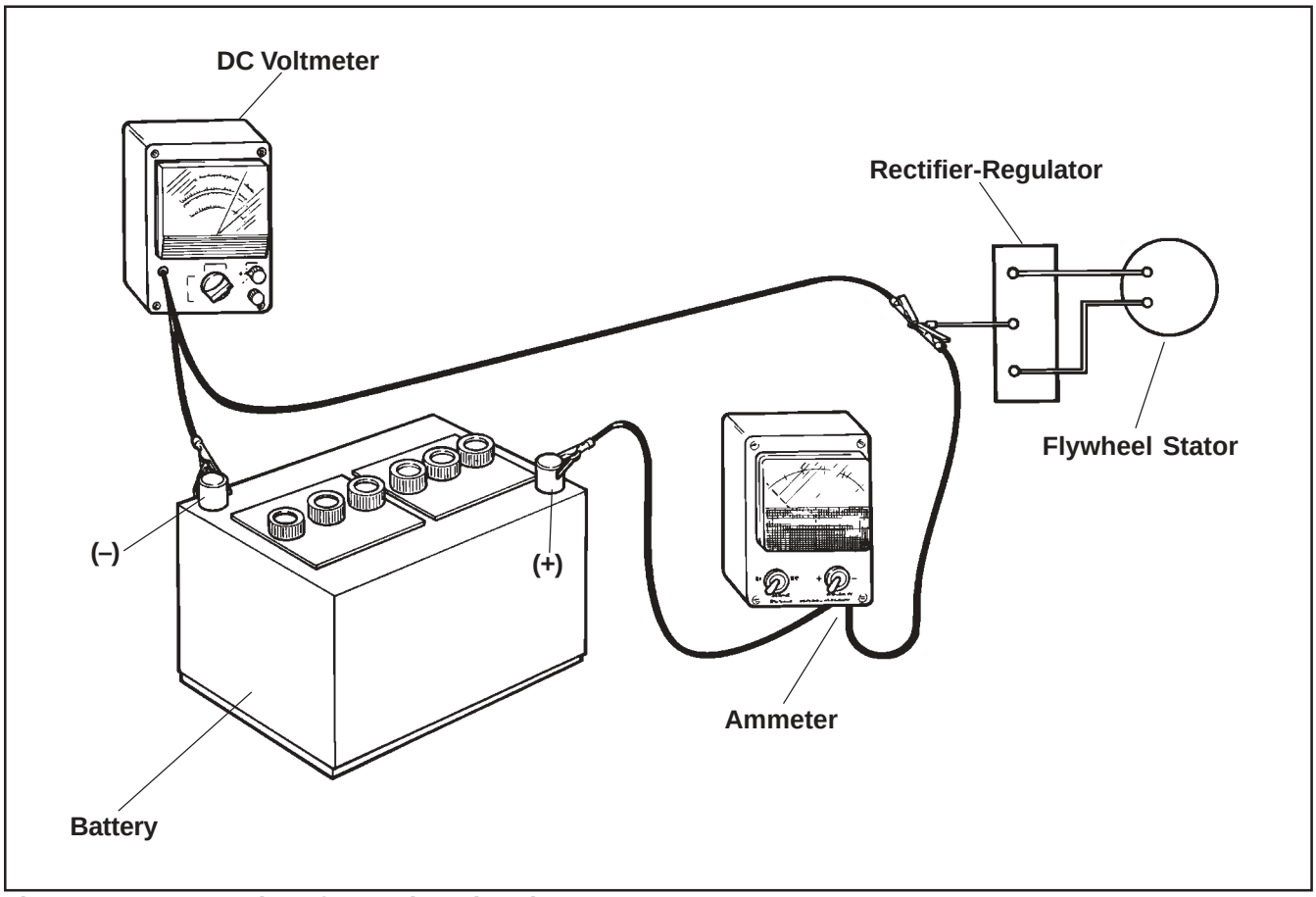


Figure 8-14. Connections for Testing Charging System.

Troubleshooting Guide

15/20/25 Amp Battery Charging Systems

If it is difficult to keep the battery charged, or the battery overcharges, the problem is usually with the charging system or the battery.

NOTE: **Always zero ohmmeter on each scale before testing** to ensure accurate readings. Voltage tests should be made with the engine running at 3600 RPM - no load. The battery must be fully charged.

Problem	Test	Conclusion
No Charge to Battery	1. Trace B+ lead from rectifier-regulator to key switch, or other accessible connection. Disconnect it from switch or connection. Connect an ammeter from loose end of B+ lead to positive terminal of battery. Connect DC voltmeter from loose end of B+ lead to negative terminal of battery. With engine running at 3600 RPM, read voltage on voltmeter. If voltage is 13.8 volts or more, place a minimum load of 5 amps* on battery to reduce voltage. Observe ammeter. *NOTE: Turn on lights (if 60 watts or more) or place a 2.5 ohm, 100 watt resistor across battery terminals.	1. If voltage is 13.8-14.7 and charge rate increases when load is applied, the charging system is OK and battery was fully charged. If voltage is less than 13.8, or charge rate does not increase when load is applied, test stator (Tests 2 and 3).
	2. Remove connector from rectifier-regulator. With engine running at 3600 RPM, measure AC voltage across stator leads using an AC voltmeter.	2. If voltage is **28 volts or more**, stator is OK. Rectifier-regulator is faulty. Replace the rectifier-regulator. If voltage is **less than 28 volts**, stator is probably faulty and should be replaced. Test stator further using an ohmmeter (Test 3).
	3a. With engine stopped, measure the resistance across stator leads using an ohmmeter.	3a. If resistance is **0.064/0.2 ohms**, the stator is OK. If the resistance is **infinity ohms**, stator is open. Replace stator.
	3b. With the engine stopped, measure the resistance from each stator lead to ground using an ohmmeter.	3b. If the resistance is **infinity ohms** (no continuity), the stator is OK (not shorted to ground). If resistance (or continuity) **is measured**, the stator leads are shorted to ground. Replace stator.
Battery Continuously Charges at High Rate	1. Perform same test as step 1 above.	1. If the voltage is **14.7 volts or less** the charging system is OK. The battery is unable to hold a charge. Service battery or replace as necessary. If voltage is **more than 14.7 volts**, the rectifier-regulator is faulty. Replace rectifier-regulator.

Electric Starting Motors

These engines utilize solenoid shift style starter motors for dependable operation. Operation, service and troubleshooting of the starter and starter system follow in this section.

Starting Motor Precautions

NOTE: Do not crank the engine continuously for more than 10 seconds at a time. If the engine does not start, allow a 60 second cool-down period between starting attempts. Failure to follow these guidelines can burn out the starter motor.

NOTE: If the engine develops sufficient speed to disengage the starter pinion but does not keep running (a false start), the engine rotation must be allowed to come to a complete stop before attempting to restart the engine. If the starter is engaged while the flywheel is rotating, the starter pinion and flywheel ring gear may clash, resulting in damage to the starter.

NOTE: If the starter does not crank the engine, shut off the starter immediately. Do not make further attempts to start the engine until the condition is corrected.

NOTE: Do not drop the starter or strike the starter frame. Doing so can damage the starter.

Starter Removal and Installation

Refer to the "Disassembly" and "Reassembly" Sections for starter removal and installation procedures.

Use the exploded view (Figure 8-26) for reference during the disassembly and reassembly procedure.

Troubleshooting Guide – Starting Difficulties

Problem	Possible Fault	Correction
Starter Does Not Energize	Battery	1. Check the specific gravity of battery. If low, recharge or replace battery as necessary.
	Wiring	1. Clean corroded connections and tighten loose connections. 2. Replace wires in poor condition and with frayed or broken insulation.
	Starter Switch or Solenoid	1. Bypass the switch or solenoid with a jumper wire. If starter cranks normally, replace the faulty component. **Solenoid Shift Starters:** Perform individual solenoid test procedure. See pages 8.21 and 8.22.
Starter Energizes But Turns Slowly	Battery	1. Check the specific gravity of battery. If low, recharge or replace battery as necessary. 2. Battery too small, must be at least 400 cold cranking amps .
	Brushes	1. Check for excessively dirty or worn brushes and commutator. Clean using a coarse cloth (not emery cloth). 2. Replace brushes if excessively or unevenly worn.
	Transmission or Engine	1. Make sure the clutch or transmission is disengaged or placed in neutral. This is especially important on equipment with hydrostatic drive. The transmission must be exactly in neutral to prevent resistance which could keep the engine from starting. 2. Check for seized engine components such as the bearings, connecting rod, and piston.

Delco-Remy Starters

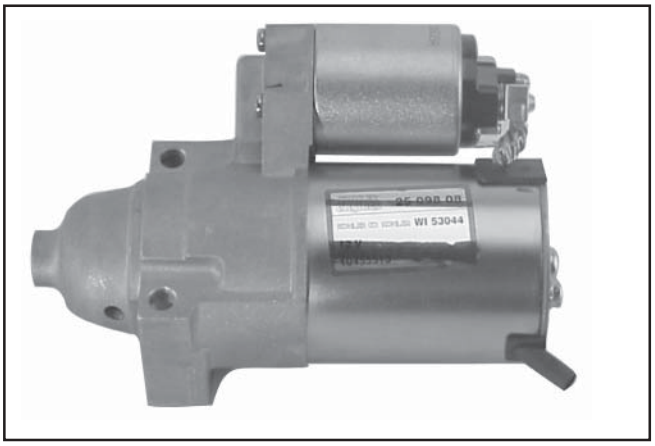


Figure 8-15. Completed Delco-Remy Starter.

Starter Disassembly

1. Remove the hex nut and disconnect the positive (+) brush lead/bracket from the solenoid terminal.

2. Remove the three screws securing the solenoid to the starter. See Figure 8-16.

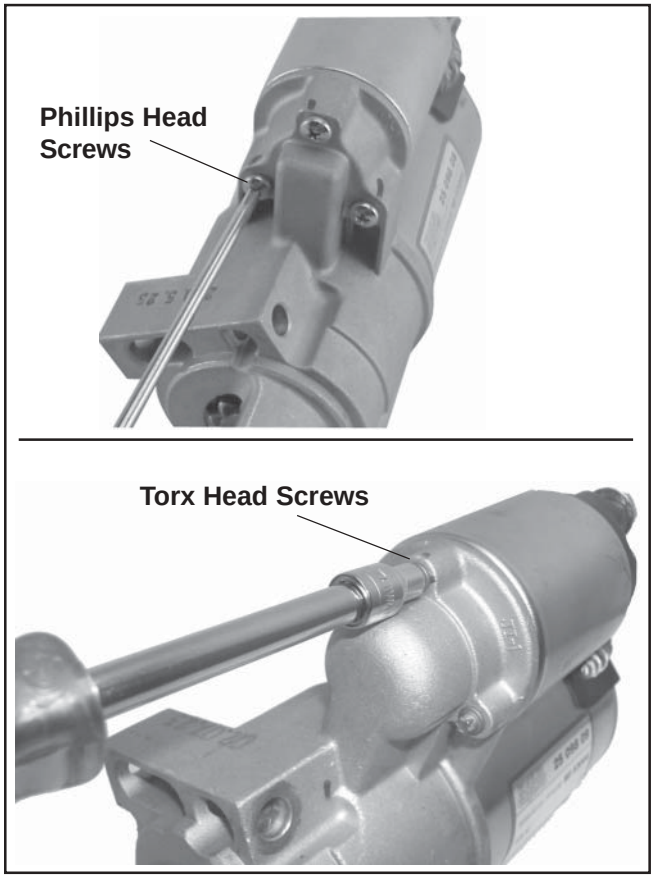


Figure 8-16. Removing Solenoid Screws.

3. If the solenoid was mounted with Phillips head screws, separate the solenoid and plunger spring from the drive end cap. If the solenoid was mounted with external Torx head screws, the plunger is part of the solenoid, unhook the plunger pin from the drive lever. Remove the gasket from the recess in the housing. See Figures 8-17 and 8-18.

NOTE: Test procedure for checking starter solenoid on pages 8.21 and 8.22.

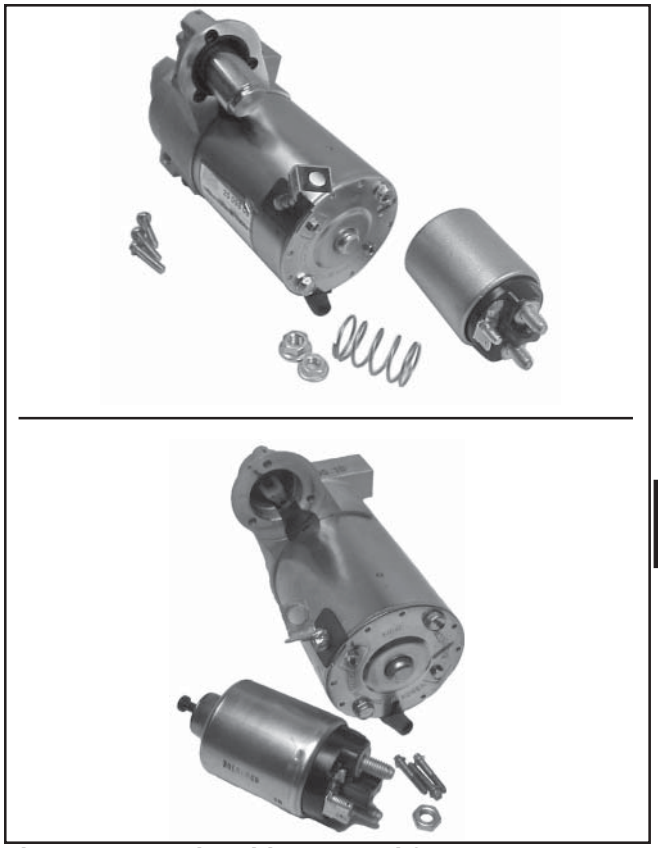


Figure 8-17. Solenoid Removed from Starter.

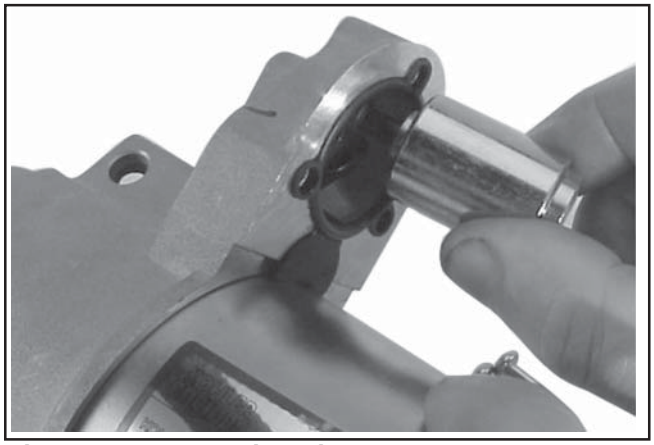


Figure 8-18. Removing Plunger.

4. Remove the two thru (larger) bolts. See Figure 8-19.

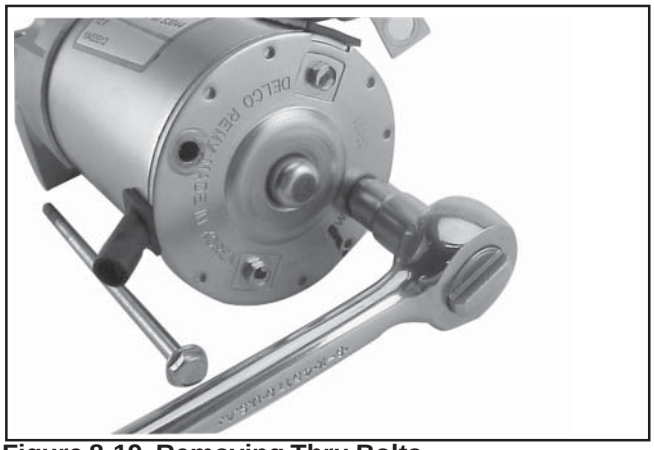


Figure 8-19. Removing Thru Bolts.

5. Remove the commutator end plate assembly, containing the brush holder, brushes, springs, and locking caps. Remove the thrust washer from inside the commutator end. See Figure 8-20.

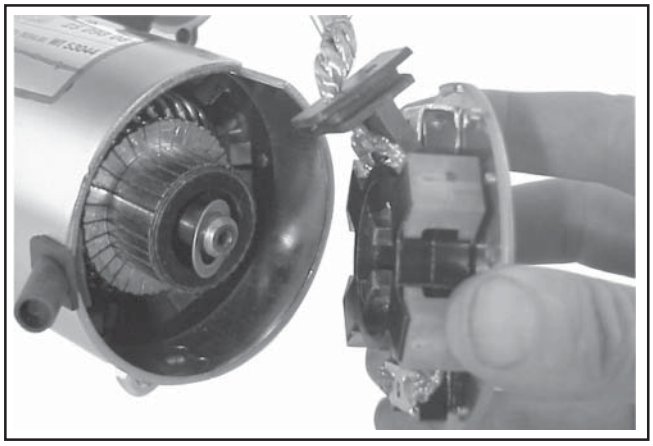


Figure 8-20. Removing Commutator End Plate Assembly.

6. Remove the frame from the armature and drive end cap. See Figure 8-21.

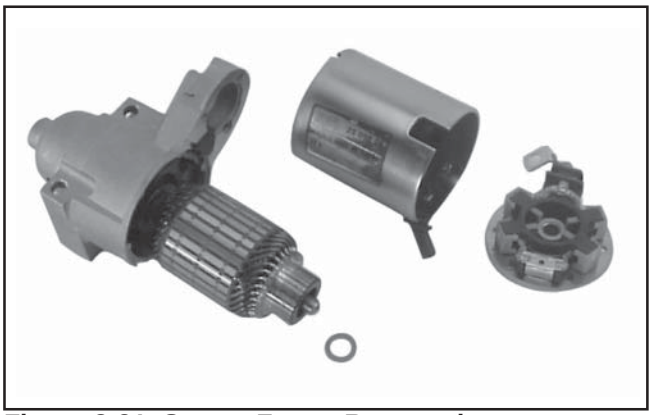


Figure 8-21. Starter Frame Removed.

7. Remove the drive lever pivot bushing and backing plate from the end cap. See Figure 8-22.

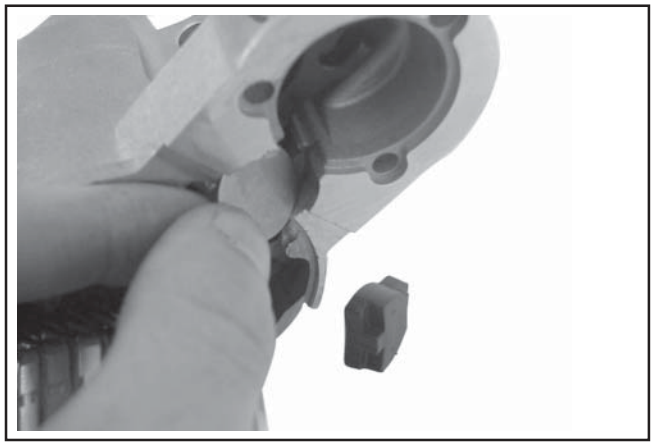


Figure 8-22.

8. Take out the drive lever and pull the armature out of the drive end cap. See Figure 8-23.

9. Remove the thrust washer from the armature shaft. See Figure 8-23.

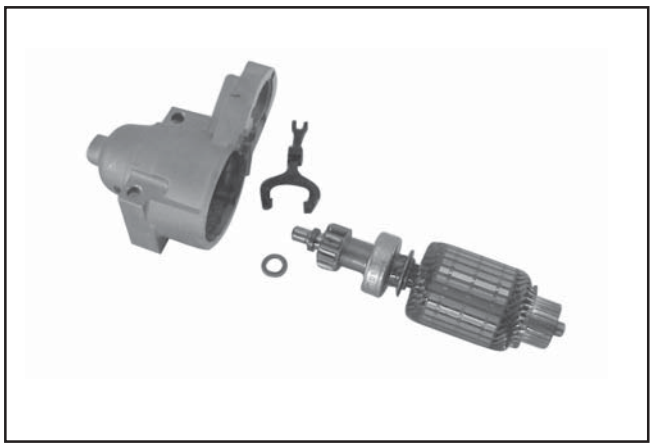


Figure 8-23. Armature and Lever Removed.

10. Push the stop collar down to expose the retaining ring. See Figure 8-24.

Figure 8-24. Retaining Ring Detail.

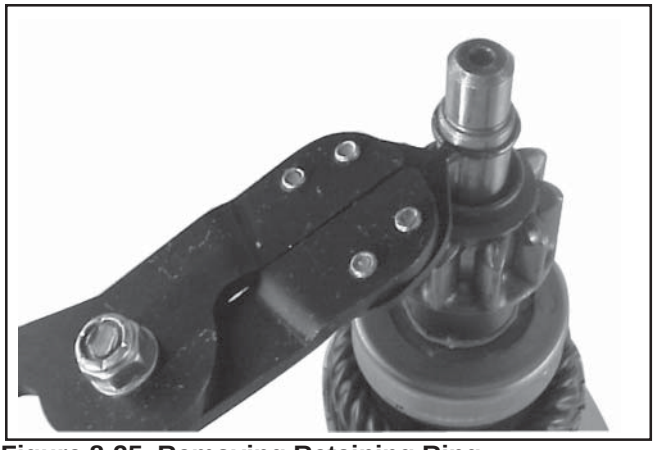


Figure 8-25. Removing Retaining Ring.

11. Remove the retainer from the armature shaft. Save the stop collar.

NOTE: Do not reuse the old retainer.

12. Remove the drive pinion assembly from the armature.

13. Clean the parts as required.

NOTE: **Do not** soak the armature or use solvent when cleaning. Wipe clean using a soft cloth, or use compressed air.

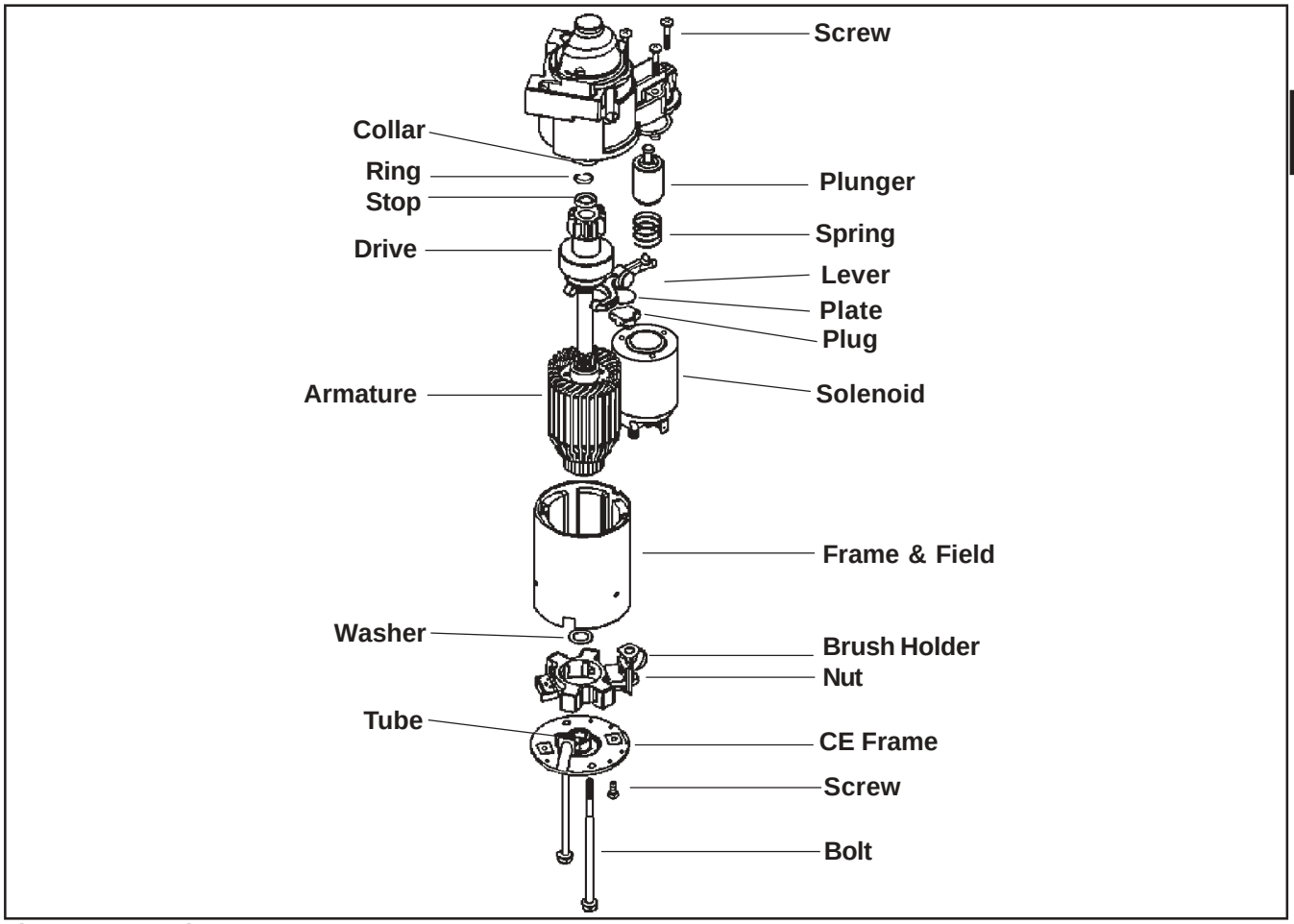


Figure 8-26. Delco-Remy Starter.

Inspection

Drive Pinion

Check and inspect the following areas:

a. The pinion teeth for abnormal wear or damage.

b. The surface between the pinion and the clutch mechanism for nicks, or irregularities which could cause seal damage.

c. Check the drive clutch by holding the clutch housing and rotating the pinion. The pinion should rotate in one direction only.

Brushes and Springs

Inspect both the springs and brushes for wear, fatigue, or damage. Measure the length of each brush. The minimum length for each brush is **7.6 mm (0.300 in.)**. See Figure 8-27. Replace the brushes if they are worn undersize, or their condition is questionable.

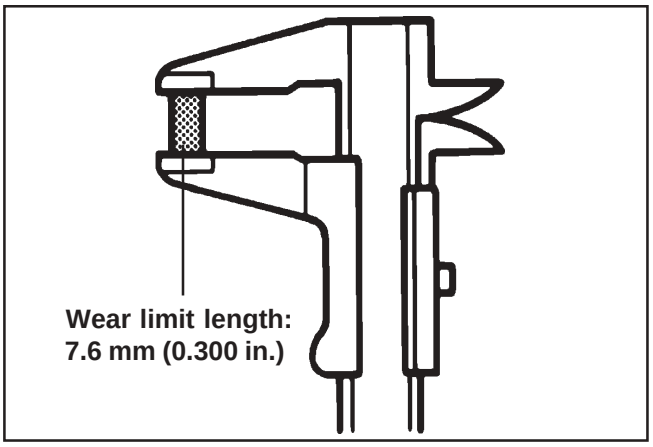


Figure 8-27. Checking Brushes.

Armature

1. Clean and inspect the commutator (outer surface). The mica insulation must be lower than the commutator bars (undercut) to ensure proper operation of the commutator. See Figure 8-28.

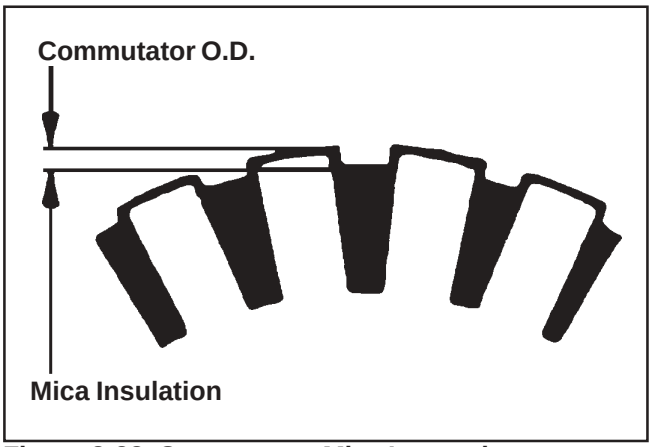


Figure 8-28. Commutator Mica Inspection.

2. Use an ohmmeter set to the Rx1 scale. Touch the probes between two different segments of the commutator, and check for continuity. See Figure 8-29. Test all the segments. Continuity must exist between all or the armature is bad.

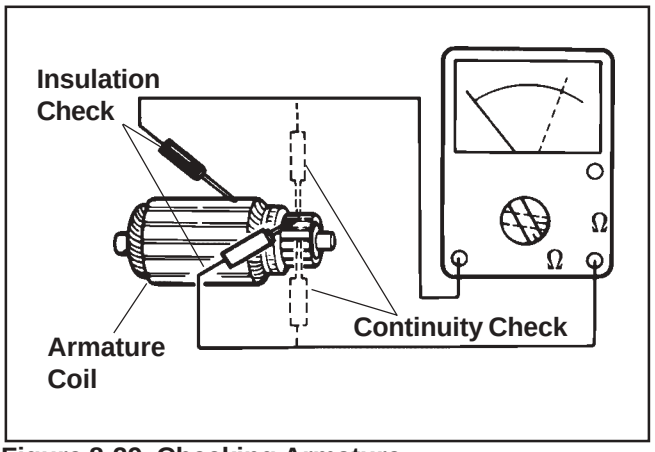


Figure 8-29. Checking Armature.

3. Check for continuity between the armature coil segments and the commutator segments. See Figure 8-29. There should be no continuity. If continuity exists between any two, the armature is bad.

4. Check the armature windings/insulation for shorting.

Shift Fork

Check that the shift fork is complete, and the pivot and contact areas are not excessively worn, cracked or broken.

Brush Replacement

The brushes and springs are serviced as a set (4). Use Brush and Spring Kit, Kohler Part No. **25 221 01-S**, if replacement is necessary.

1. Perform steps 1-5 in "Starter Disassembly."

2. Remove the two screws securing the brush holder assembly to the end cap (plate). Note the orientation for reassembly later. See Figure 8-30. Discard the old brush holder assembly.

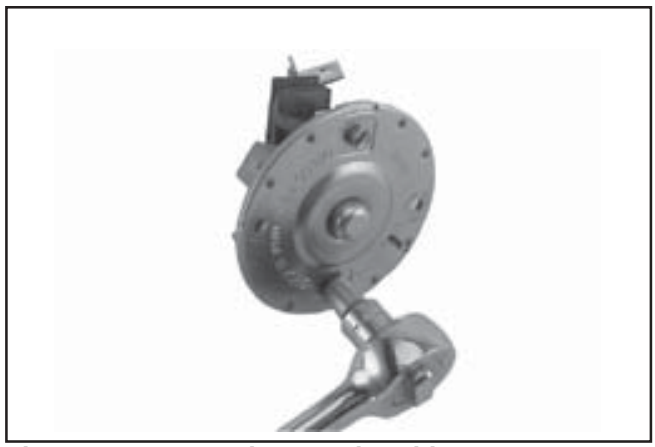


Figure 8-30. Removing Brush Holder.

3. Clean the component parts as required.

4. The new brushes and springs come preassembled in a brush holder with a protective sleeve that will also serve as an installation tool. See Figure 8-31.

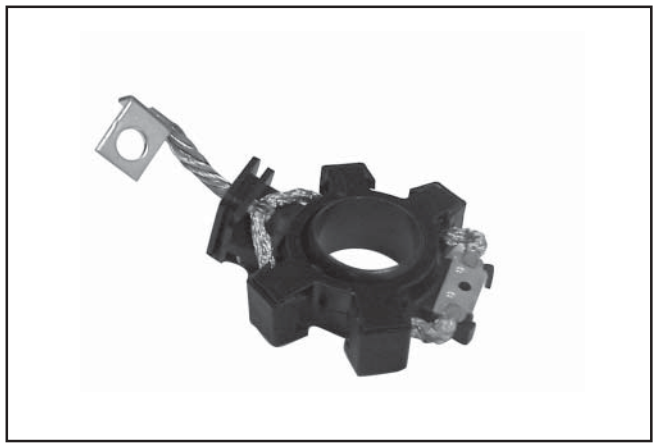


Figure 8-31. Service Brush Kit.

5. Perform Steps 10-13 in the "Starter Reassembly" sequence. Installation must be done after the armature, drive lever, and frame are installed, if the starter has been disassembled.

Starter Service

Clean the drive lever and armature shaft. Apply Kohler electric starter drive lubricant (see Section 2) to the lever and shaft. Clean and check the other starter parts for wear or damage as required.

Starter Reassembly

1. Apply drive lubricant (see Section 2) to the armature shaft splines. Install the drive pinion onto the armature shaft.

2. Install and assemble the stop collar/retainer assembly.

   a. Install the stop collar down onto the armature shaft with the counter bore (recess) up.

   b. Install a new retainer in the larger (rear) groove of the armature shaft. Squeeze with a pliers to compress it in the groove.

   c. Slide the stop collar up and lock it into place, so the recess surrounds the retainer in the groove. If necessary, rotate the pinion outward on the armature splines against the retainer to help seat the collar around the retainer.

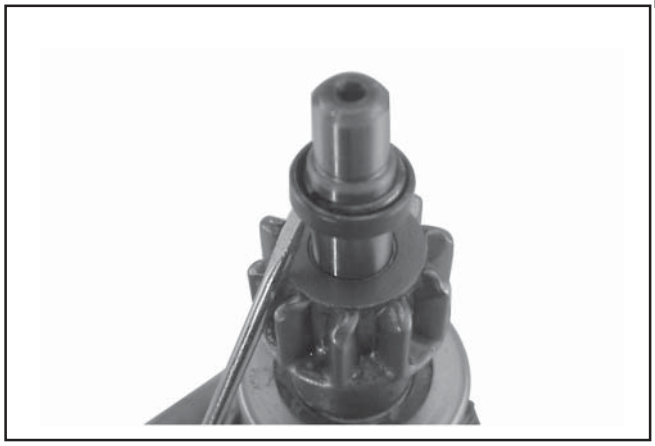


Figure 8-32. Installing Stop Collar and Retainer.

NOTE: Always use a new retainer. Do not reuse old retainers which have been removed.

3. Install the offset thrust (stop) washer so the smaller "offset" of the washer faces the retainer/collar. See Figure 8-33.

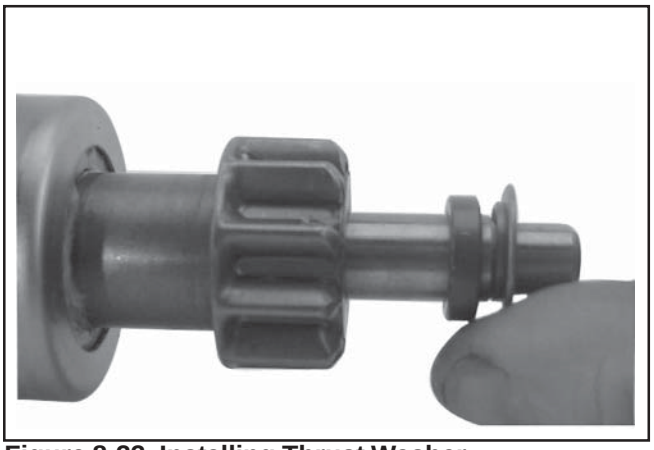


Figure 8-33. Installing Thrust Washer.

4. Apply a small amount of oil to the bearing in the drive end cap, and install the armature with the drive pinion.

5. Lubricate the fork end and center pivot of the drive lever with drive lubricant (see Section 2). Position the fork end into the space between the captured washer and the rear of the pinion.

6. Slide the armature into the drive end cap, and at the same time seat the drive lever into the housing.

NOTE: Correctly installed, the center pivot section of the drive lever will be flush or below the machined surface of the housing which receives the backup washer. See Figure 8-34.

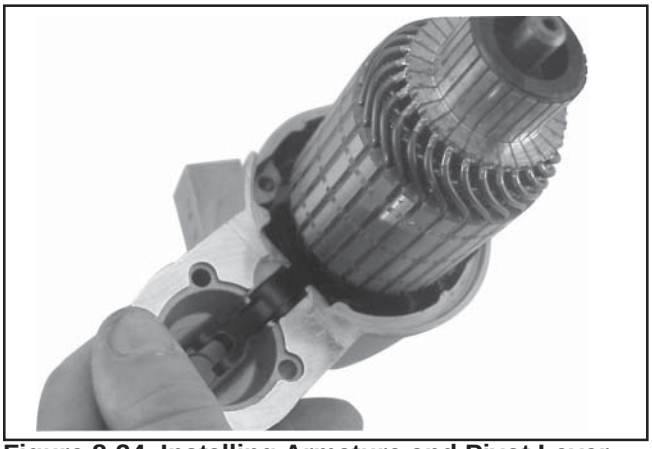


Figure 8-34. Installing Armature and Pivot Lever.

7. Install the backup washer, followed by the rubber grommet, into the matching recess of the drive end cap. The molded recesses in the grommet should be "out", matching and aligned with those in the end cap. See Figure 8-35.

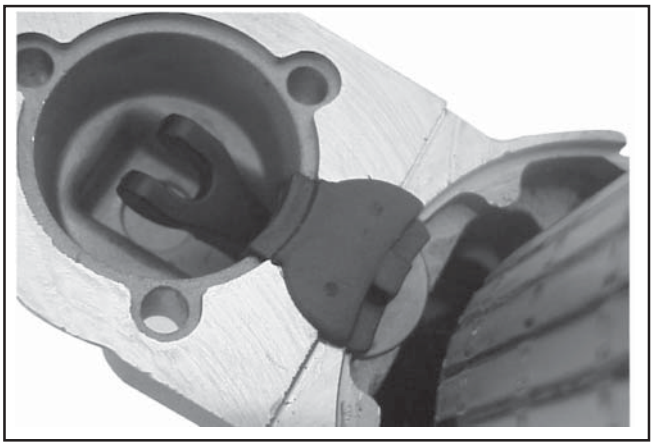


Figure 8-35. Installing Backup Washer and Grommet.

8. Install the frame, with the small notch forward, onto the armature and drive end cap. Align the notch with the corresponding section in the rubber grommet. Install the drain tube in the rear cutout, if it was removed previously. See Figure 8-36.

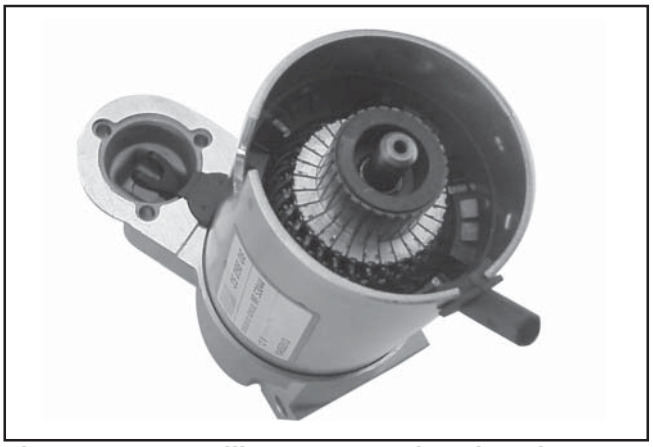


Figure 8-36. Installing Frame and Drain Tube.

9. Install the flat thrust washer onto the commutator end of the armature shaft. See Figure 8-37.

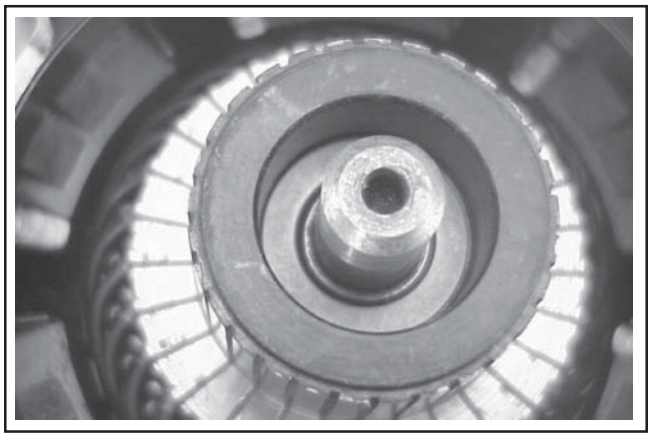


Figure 8-37. Installing Thrust Washer.

10. Starter reassembly when replacing the Brushes/ Brush Holder Assembly:

    a. Hold the starter assembly vertically on the end housing, and carefully position the assembled brush holder assembly, with the supplied protective tube, against the end of the commutator/armature. The mounting screw holes in the metal clips must be "up/ out." Slide the brush holder assembly down into place around the commutator, and install the positive (+) brush lead grommet in the cutout of the frame. See Figure 8-38. The protective tube may be saved and used for future servicing.

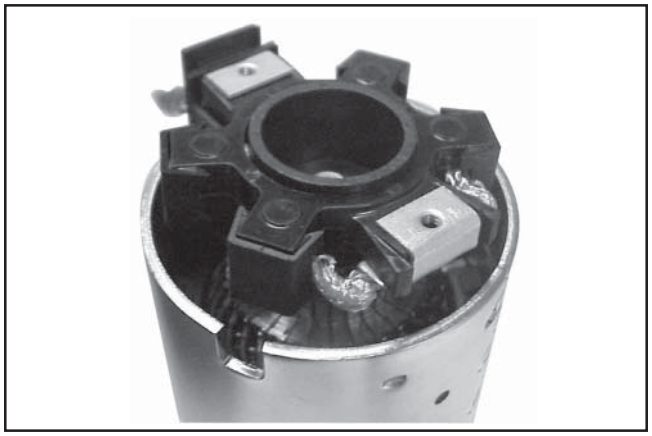


Figure 8-38. Installing Brush Holder Assembly with Supplied Tube.

Starter reassembly when not replacing the Brushes/ Brush Holder Assembly:

a. Carefully unhook the retaining caps from over each of the brush assemblies. Do not lose the springs.

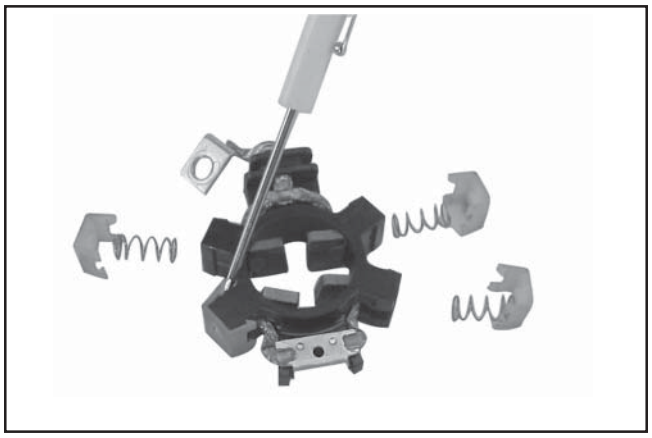


Figure 8-39. Removing Retaining Clips.

b. Position each of the brushes back in their slots so they are flush with the I.D. of the brush holder assembly. Insert the Brush Installation Tool (with extension), or use the tube described above from a prior brush installation, through the brush holder assembly, so the holes in the metal mounting clips are "up/out."

c. Install the brush springs and snap on the four retainer caps. See Figure 8-40.

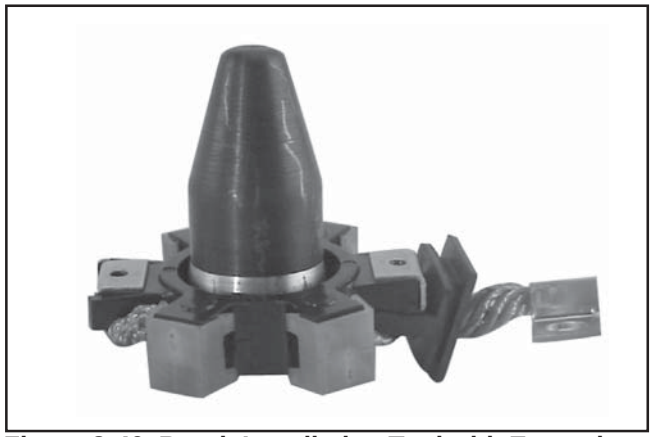


Figure 8-40. Brush Installation Tool with Extension.

d. Hold the starter assembly vertically on the end housing, and carefully place the tool (with extension) and assembled original brush holder assembly onto the end of the armature shaft. Slide the brush holder assembly down into place around the commutator, install the positive (+) brush lead grommet in the cutout of the frame. See Figure 8-41.

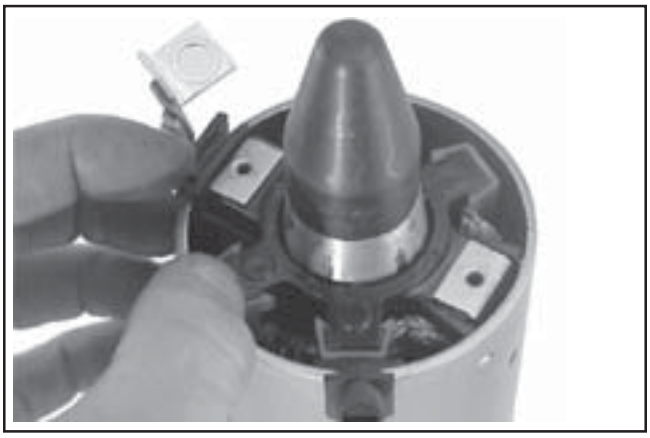


Figure 8-41. Installing Brush Holder Assembly Using Tool with Extension.

11. Install the end cap onto the armature and frame, aligning the thin raised rib in the end cap with the corresponding slot in the grommet of the positive (+) brush lead.

12. Install the two thru bolts, and the two brush holder mounting screws. Torque the thru bolts to **5.6-9.0 N·m (49-79 in. lb.)**. Torque the brush holder mounting screws to **2.5-3.3 N·m (22-29 in. lb.)**. See Figures 8-42 and 8-43.

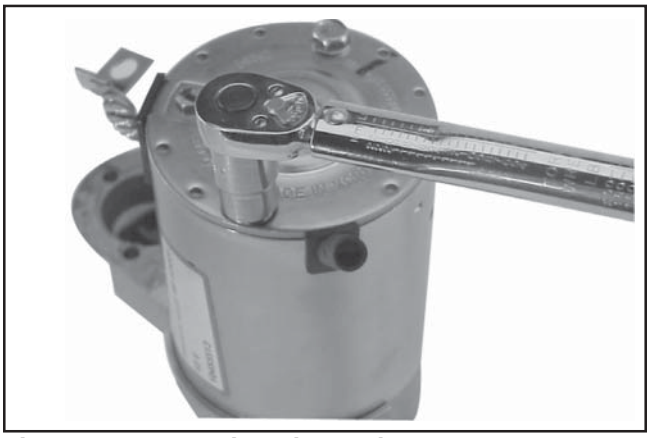


Figure 8-42. Torquing Thru Bolts.

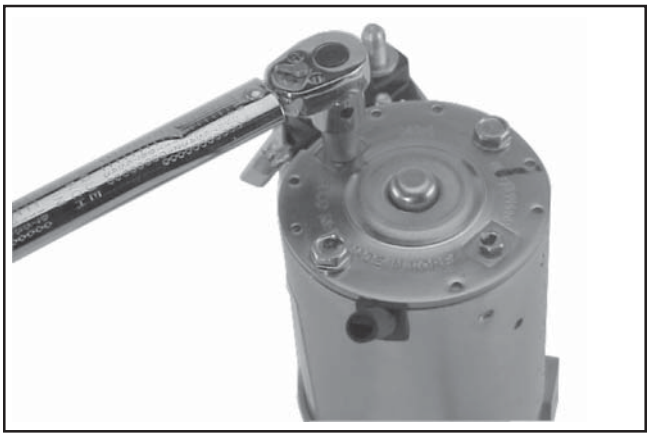


Figure 8-43. Torquing Brush Holder Screws.

13. Hook the plunger behind the upper end of the drive lever, and install the spring into the solenoid. Insert the three mounting screws through the holes in the drive end cap. Use these to hold the solenoid gasket in position, then mount the solenoid. Torque the screws to **4.0-6.0 N·m (35-53 in. lb.)**.

14. Connect the positive (+) brush lead/bracket to the solenoid and secure with the hex nut. Torque the nut to **8-11 N·m (71-97 in. lb.)**. Do not overtighten. See Figure 8-44.

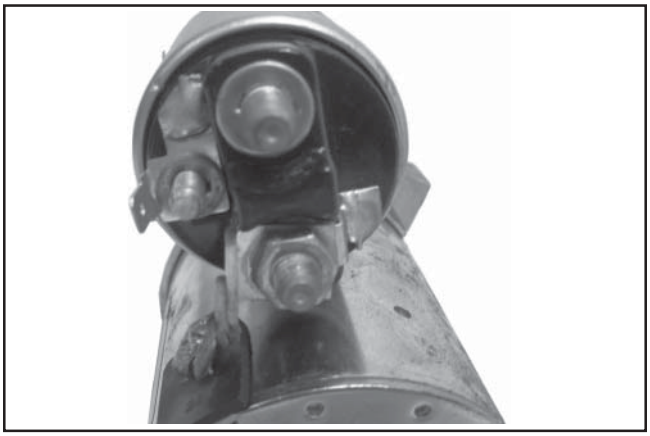


Figure 8-44. Positive (+) Brush Lead Connection.

Solenoid Test Procedure

Solenoid Shift Style Starters

Disconnect all leads from the solenoid including the positive brush lead attached to the lower stud terminal. Remove the mounting hardware and separate the solenoid from the starter for testing.

Test 1. Solenoid Pull-In Coil/Plunger Actuation Test.

Use a 12 volt power supply and two test leads. Connect one lead to the flat spade "S/start" terminal on the solenoid. Momentarily* connect the other lead to the lower large post terminal. See Figure 8-45. When the connection is made the solenoid should energize (audible click), and the plunger retract. Repeat the test several times. If the solenoid fails to activate, it should be replaced.

*NOTE: **DO NOT** leave the 12 volt test leads connected to the solenoid for any time over what is necessary for performing each of the individual tests. Internal damage to the solenoid may otherwise occur.

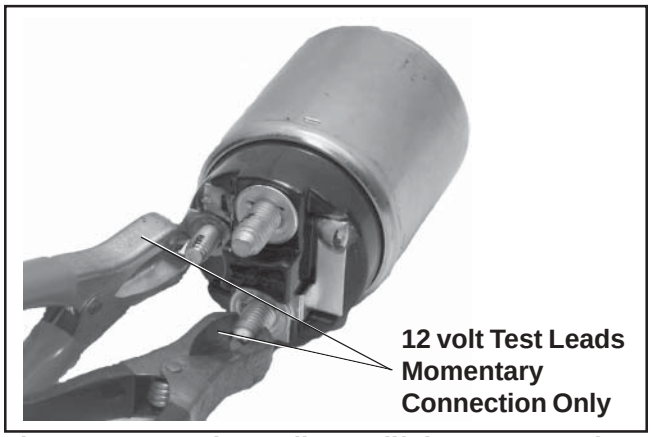


Figure 8-45. Testing Pull-In Coil/Plunger Actuation.

Test 2. Solenoid Pull-In Coil/Contact Continuity Test.

Use an ohmmeter set to the audible or Rx2K scale, and connect the two ohmmeter leads to the two large post terminals. Perform the preceding test (1) and check for continuity. See Figure 8-46. The ohmmeter should indicate continuity, if no continuity is indicated the solenoid should be replaced. Repeat test several times to confirm condition.

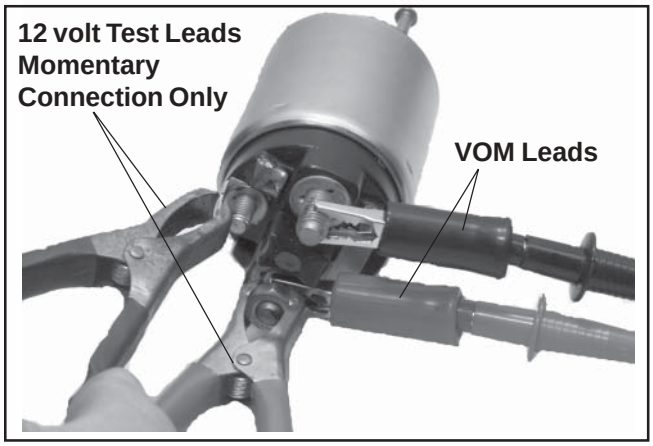


Figure 8-46. Testing Pull-In Coil/Solenoid Contact Continuity.

Test 3. Solenoid Hold-In Coil Function Test.

Connect one 12 volt test lead to the flat spade "S/start" terminal on the solenoid, and the other lead to the body or mounting surface of the solenoid. Then, manually push the plunger "In" and check if the "Hold-In" coil holds the plunger retracted. See Figure 8-47. Do not allow the test leads to remain connected to the solenoid for a prolonged period of time. If the plunger fails to stay retracted, the solenoid should be replaced.

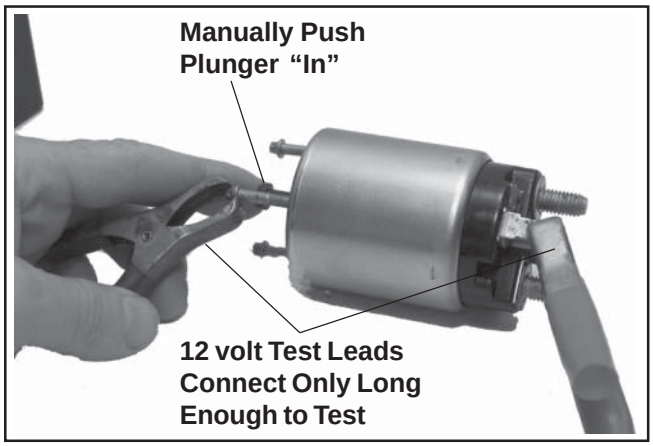


Figure 8-47. Testing Hold-In Coil/Function Test.

Test 4. Solenoid Hold-In Coil/Contact Continuity Test.

Use an ohmmeter set to the audible or Rx2K scale, and connect the two ohmmeter leads to the two large post terminals. Perform the preceding test (3) and check for continuity. See Figure 8-48. The meter should indicate continuity, if no continuity is indicated the solenoid should be replaced. Repeat test several times to confirm condition.

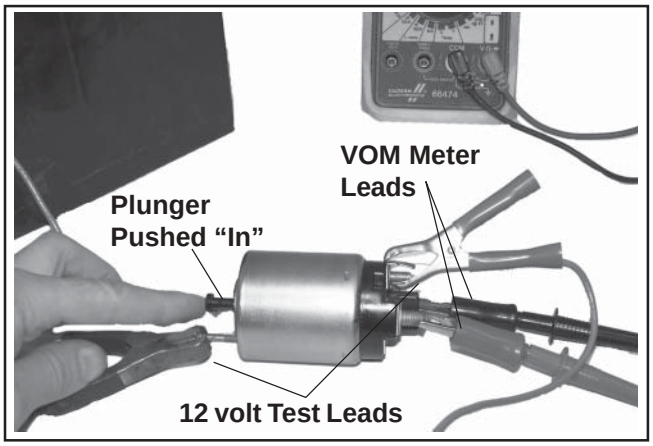


Figure 8-48. Testing Hold-In Coil/Solenoid Contact Continuity.

Section 9
Disassembly

WARNING: Accidental Starts!

Disabling engine. Accidental starting can cause severe injury or death. *Before working on the engine or equipment, disable the engine as follows: 1) Disconnect the spark plug lead(s). 2) Disconnect negative (-) battery cable from battery.*

General

Clean all parts thoroughly as the engine is disassembled. Only clean parts can be accurately inspected and gauged for wear or damage. There are many commercially available cleaners that will quickly remove grease, oil, and grime from engine parts. When such a cleaner is used, follow the manufacturer's instructions and safety precautions carefully.

Make sure all traces of the cleaner are removed before the engine is reassembled and placed into operation. Even small amounts of these cleaners can quickly break down the lubricating properties of engine oil.

Typical Disassembly Sequence

The following sequence is suggested for complete engine disassembly. The sequence can be varied to accommodate options or special equipment.

1. Disconnect spark plug leads.
2. Shut off fuel supply.
3. Remove muffler.
4. Remove starter and adapter plate.
5. Drain coolant from cooling system.
6. Drain oil from crankcase and remove oil filter.
7. Remove flywheel cover, radiator assembly, mounting brackets, and attached components.
8. Remove air cleaner assembly.
9. Remove throttle and choke controls.
10. Remove external governor controls.
11. Remove carburetor and adapter.
12. Remove Oil Sentry™.
13. Remove breather cover.
14. Remove valve covers.
15. Remove lower drive pulley and fan belt.
16. Remove fan assembly, mounting bracket and fan shaft.
17. Remove ignition modules.
18. Remove flywheel.
19. Remove stator assembly.
20. Remove intake manifold, thermostat housing, by-pass hose and wiring harness.
21. Remove cam pulley and water pump belt.
22. Remove water pump and transfer tube.
23. Remove spark plugs.
24. Remove cylinder heads and valve lifters.
25. Remove closure plate.
26. Remove camshaft.
27. Remove connecting rods with pistons and rings.
28. Remove crankshaft.
29. Remove governor cross shaft.
30. Remove flywheel end oil seals.

Disconnect Spark Plug Leads

1. Disconnect the leads from the spark plugs. See Figure 9-1.

   NOTE: Pull on boot only, to prevent damage to spark plug lead.

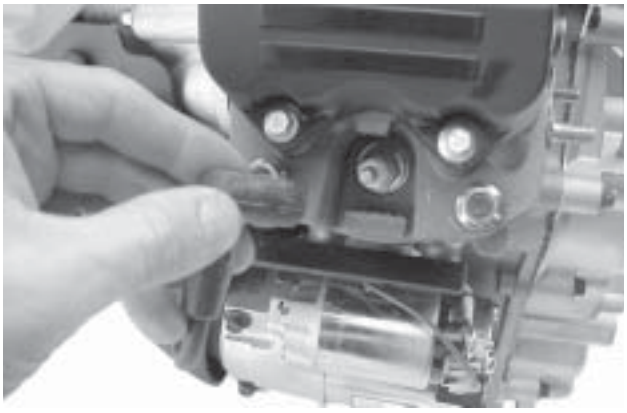


Figure 9-1. Disconnecting Spark Plug Leads.

Shut Off Fuel Supply

Remove Muffler

1. Remove the exhaust system, muffler, and attaching hardware from the engine.

Remove Starter and Adapter Plate

1. Disconnect the leads attached to the starter solenoid terminals.

2. Remove the two hex flange screws securing the starter to the adapter plate. See Figure 9-2.

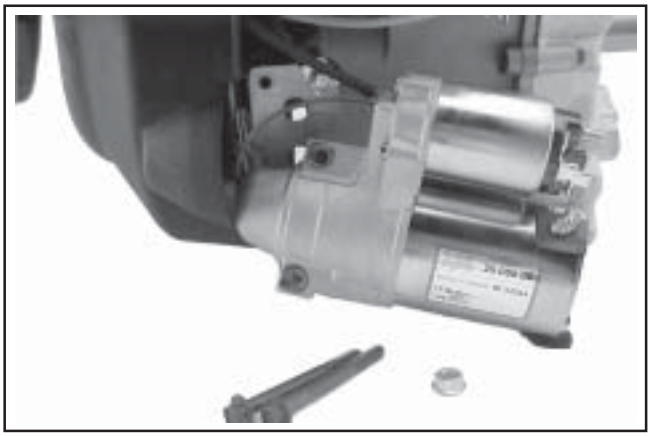


Figure 9-2. Removing Starter Assembly.

3. Remove the two hex flange screws attaching the adapter to the crankcase. Note the orientation of the cutout. The upper screw may also secure a clamp for the stator leads.

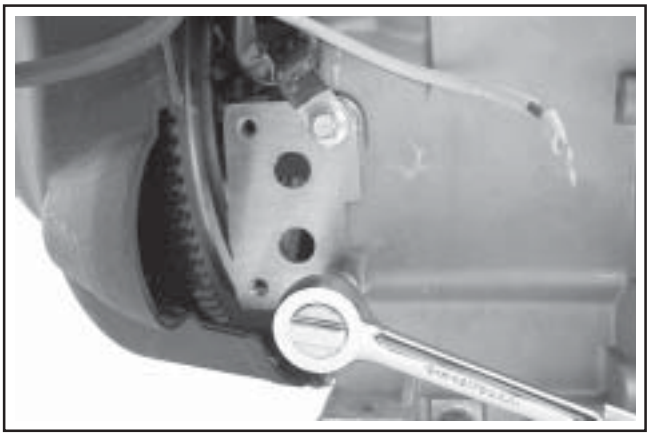


Figure 9-3. Removing the Adapter Plate Screws.

Drain Coolant from Cooling System

1. Loosen the radiator cap, then loosen the radiator drain plug and allow the system to drain. Use a suitable container to catch the coolant. See Figure 9-4.

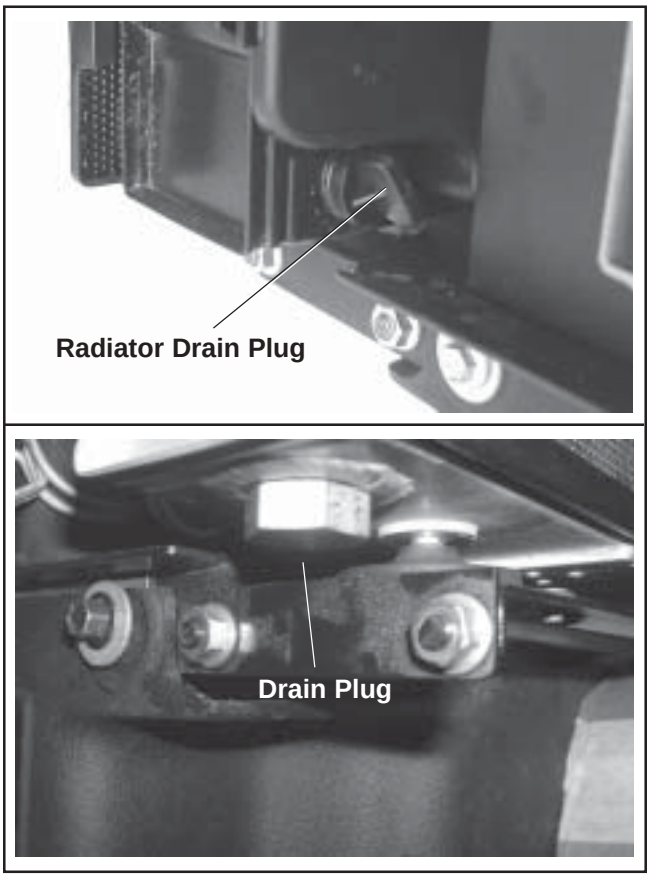


Figure 9-4. Radiator Drain Plug.

2. If equipped, remove the coolant drain plugs on each side of block. Allow any remaining coolant to drain out. See Figure 9-5. Dispose of the coolant properly, according to local regulations.

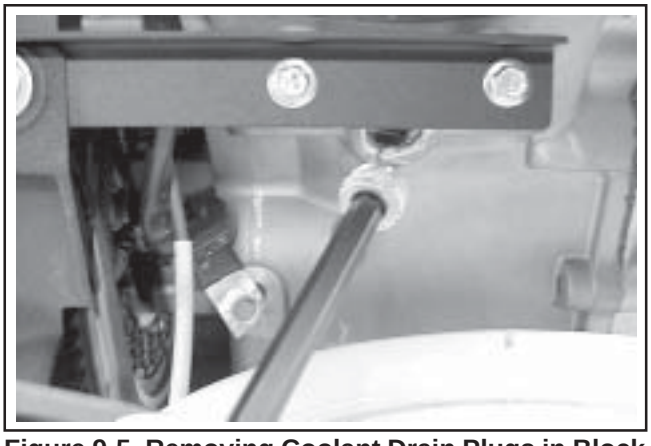


Figure 9-5. Removing Coolant Drain Plugs in Block.

Drain Oil from Crankcase and Remove Oil Filter

1. Remove the oil fill cap and dipstick, and one or both of the drain plugs. See Figures 9-6 and 9-7. Allow sufficient time for the oil to drain out.

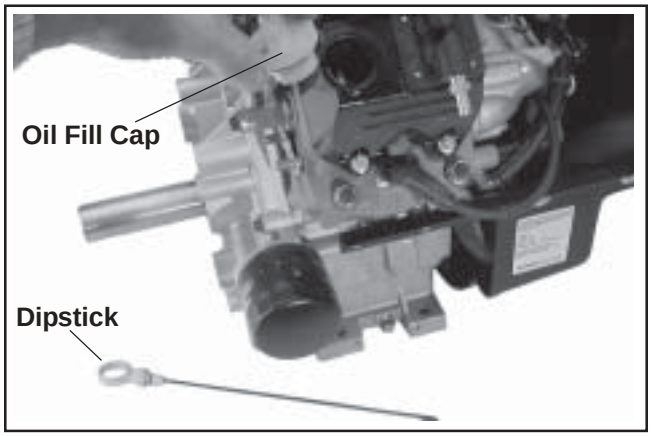


Figure 9-6. Removing Oil Fill Cap and Dipstick.

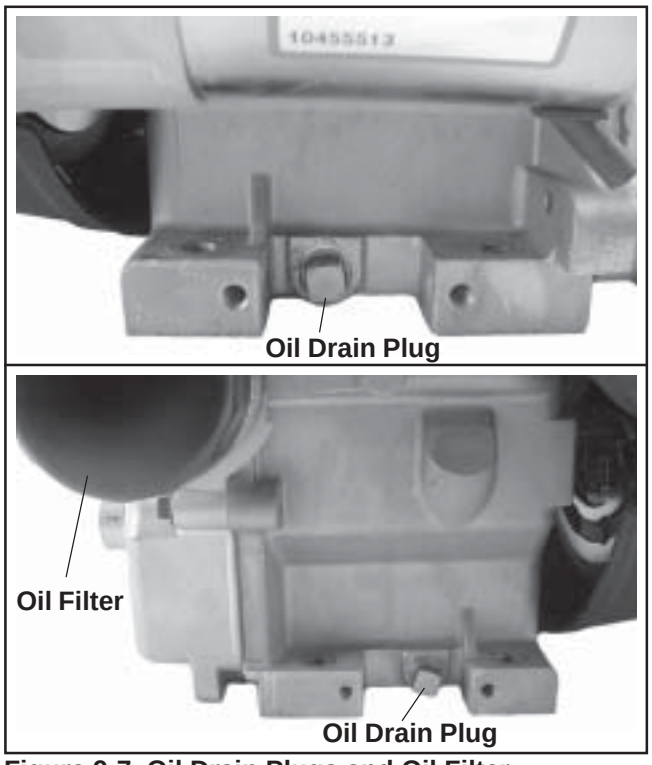


Figure 9-7. Oil Drain Plugs and Oil Filter.

2. Remove and discard the oil filter.

Remove Flywheel Cover, Radiator Assembly, Mounting Brackets and Attached Components

1. Remove the screws or nuts and flat washers (2 on each side) securing the lower flywheel cover to the LH and RH radiator support brackets. See Figure 9-8. The mounting plate for the rectifier-regulator will become detached when the LH screws are removed. Do not lose the small spacers located within the holes of the lower cover. Clips are used on some models instead of hex nuts.

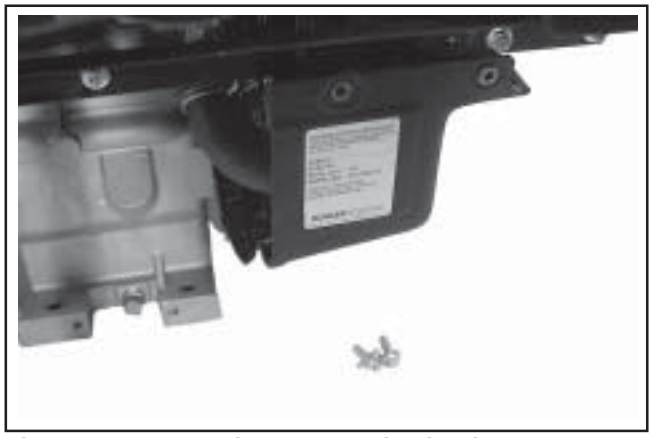


Figure 9-8. Removing Lower Flywheel Cover.

2. If a "pulse" style fuel pump is used, disconnect the fuel line from the pump outlet, and disconnect the pulse line from the fuel pump fitting. See Figure 9-9.

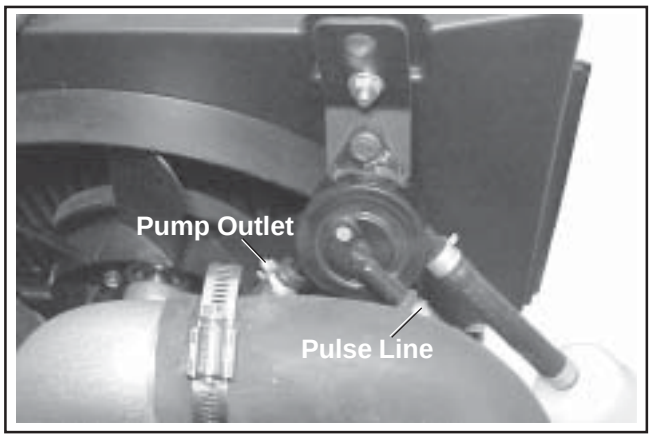


Figure 9-9. Fuel Line and Pump Pulse Line.

3. Disconnect the upper radiator hose from the radiator, and the lower radiator hose from the inlet of the water pump. See Figure 9-10.

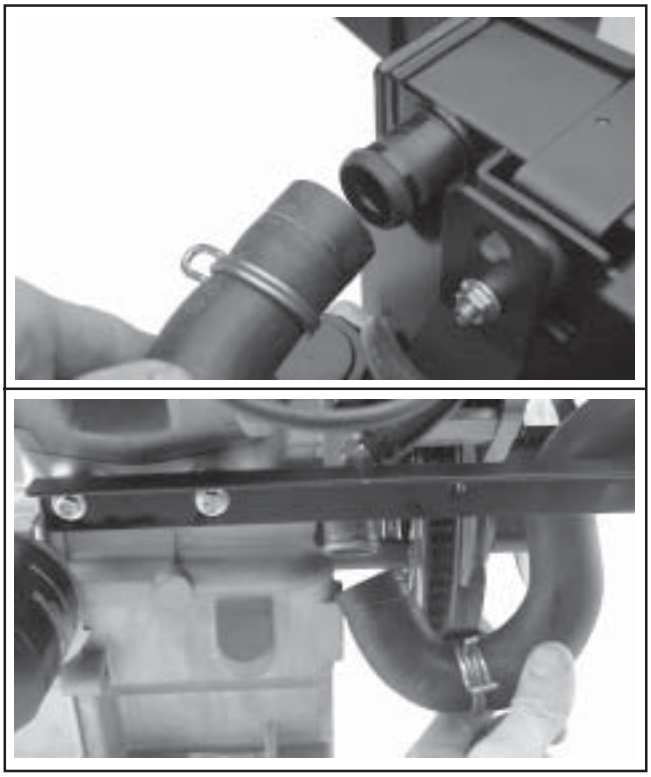


Figure 9-10. Disconnecting Upper and Lower Radiator Hose.

4. Remove the four screws securing the two upper radiator supports to the air cleaner mounting bracket. See Figure 9-11.

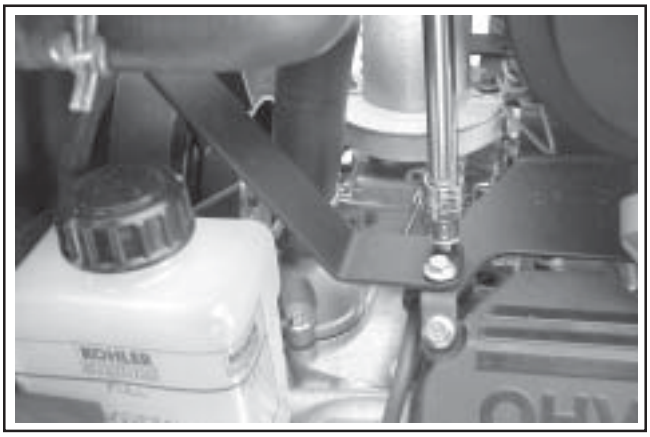


Figure 9-11. Remove Upper Radiator Support Screws.

5. Carefully tilt (pull) the radiator forward slightly to clear the fan and lift the complete assembly out of the lower mounting bracket. See Figure 9-12.

   NOTE: Do not allow the cooling fins of the radiator to contact the fan blades.

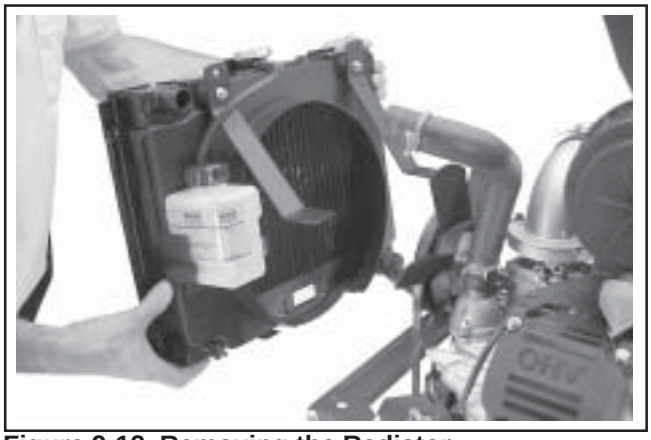


Figure 9-12. Removing the Radiator.

6. Disconnect the connector plug from the rectifier-regulator and remove the mounting plate, with rectifier-regulator attached.

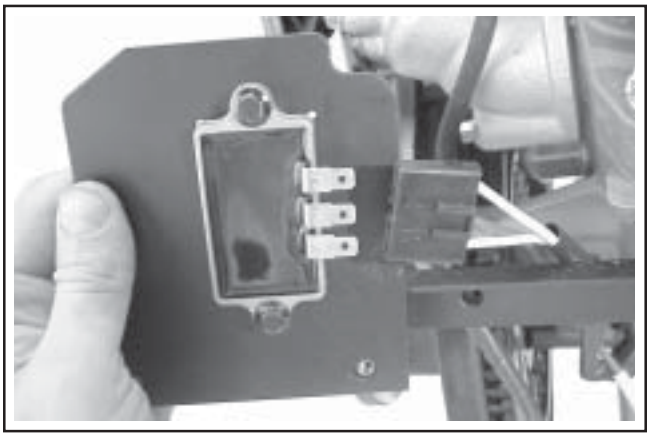


Figure 9-13. Disconnecting the Rectifier-Regulator.

7. Remove the four screws securing the LH and RH side mounting brackets to the crankcase. Pull the complete mount assembly forward to remove. See Figure 9-14.

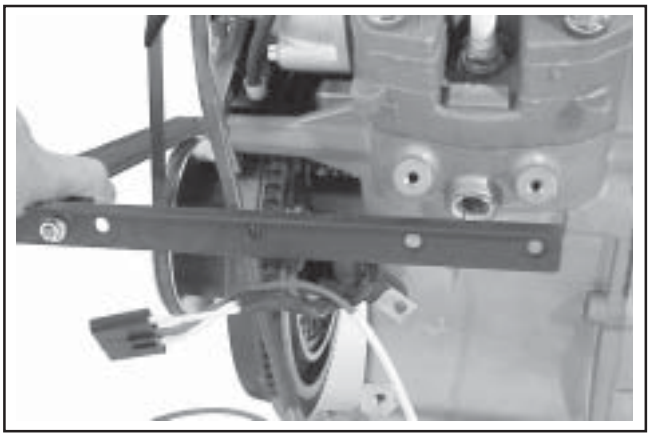


Figure 9-14. Removing LH and RH Mounting Brackets/Screws.

8. Further disassembly for component servicing may be performed as required.

Remove Air Cleaner Assembly

1. Remove the two screws securing the elbow adapter and gasket to the carburetor. See Figure 9-15.

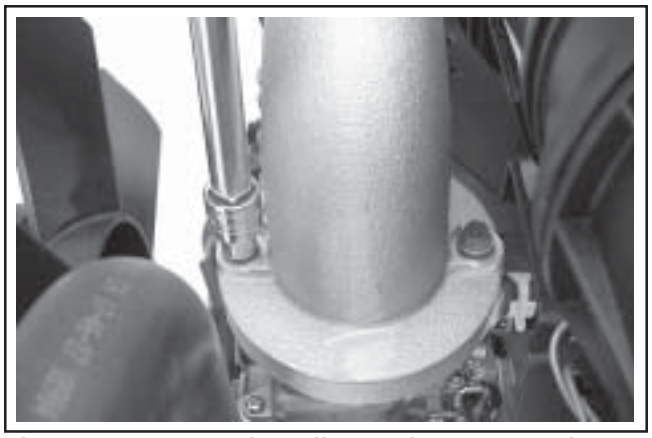


Figure 9-15. Removing Elbow Adapter Mounting Screws.

2. Remove the two upper valve cover mounting screws on each side, which also secure the main mounting bracket for the air cleaner. See Figure 9-16.

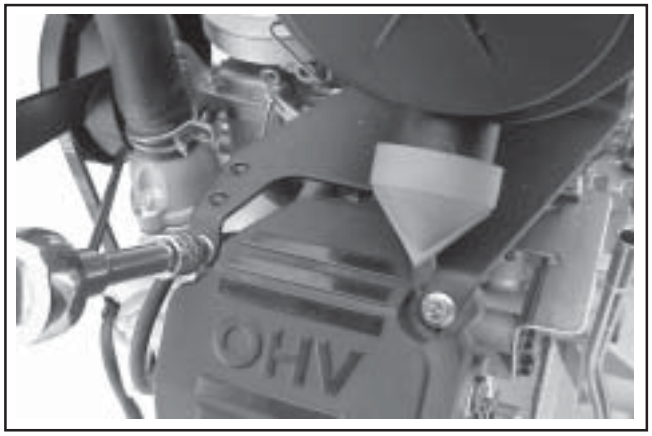


Figure 9-16. Removing Upper Valve Cover Mounting Bracket Screws.

3. Lift the air cleaner/mounting bracket assembly off the engine. See Figure 9-17.

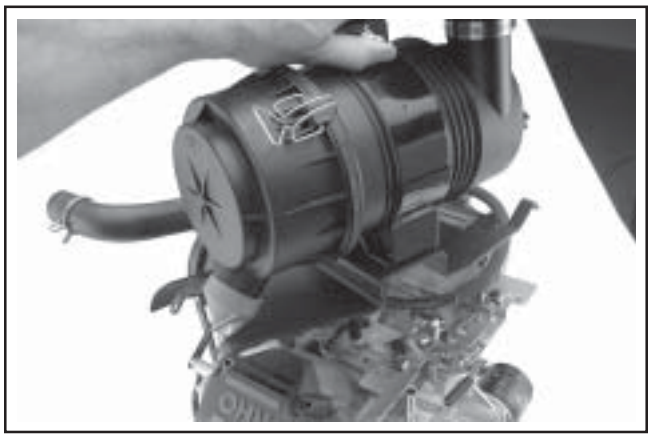


Figure 9-17. Removing Air Cleaner From Engine.

Remove Throttle and Choke Controls

1. Remove the four hex flange screws securing the main control bracket to the cylinder heads. See Figure 9-18.

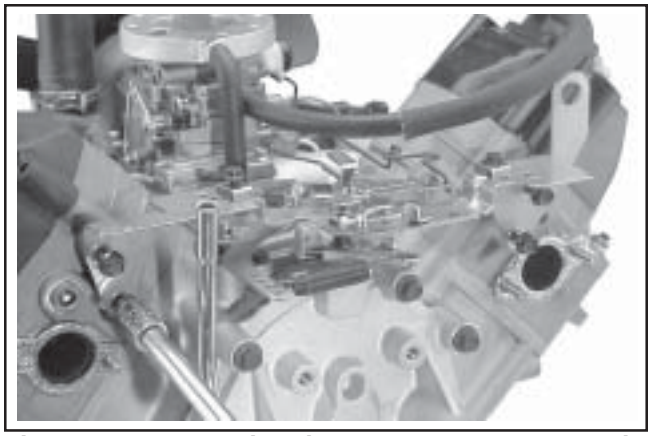


Figure 9-18. Removing the Four Screws From Main Control Bracket.

2. Mark the hole location and disconnect the governor spring from the governor lever.

3. Tilt the main bracket and disconnect the choke linkage from the choke lever. See Figure 9-19. Remove the main control bracket.

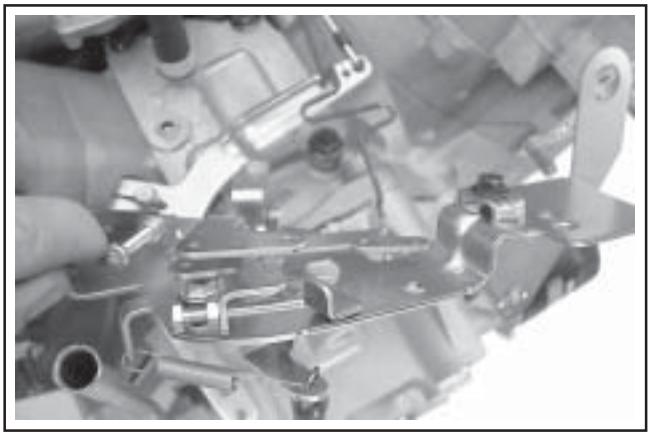


Figure 9-19. Tilting Bracket and Unhooking Choke Link.

4. Unhook the choke linkage from the actuator lever on carburetor. See Figure 9-20.

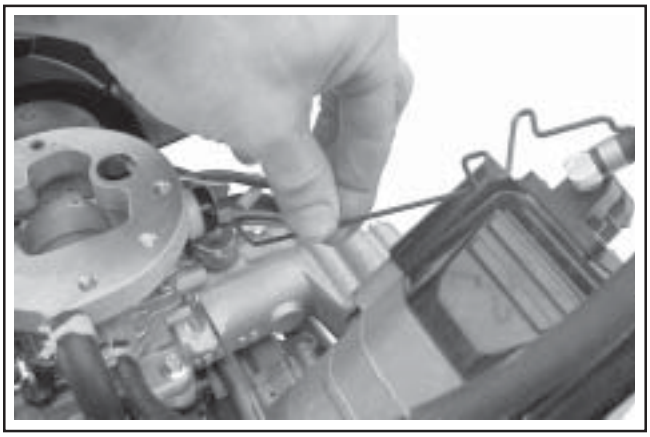


Figure 9-20. Disconnecting Choke Linkage from Carburetor.

Remove External Governor Controls

1. Loosen the hex flange nut of the governor lever mounting screw. See Figure 9-21. Leave the throttle linkage and spring connected to the lever. Lift the governor lever off of the governor shaft and lay the assembly on top of the crankcase, to be removed with the carburetor.

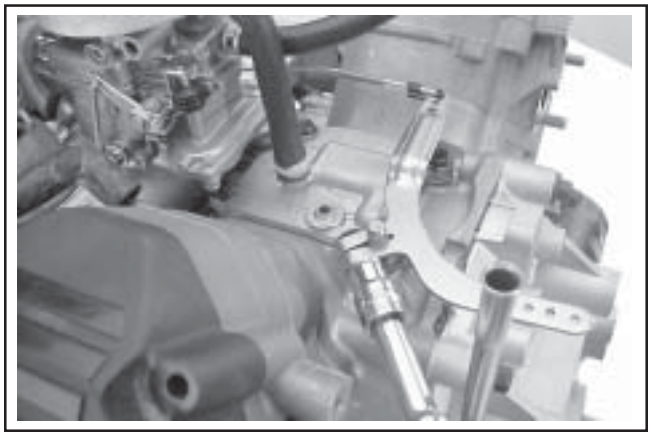


Figure 9-21. Loosening Governor Lever Mounting Nut.

Remove Carburetor and Adapter

WARNING: Explosive Fuel!

Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Do not fill the fuel tank while the engine is hot or running, since spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Do not start the engine near spilled fuel. Never use gasoline as a cleaning agent.

1. Disconnect the lead to the fuel shut-off solenoid (if equipped). If a mechanical fuel pump is used, disconnect the fuel line from the carburetor inlet.

2. Disconnect the breather hose from the adapter fitting on the carburetor.

3. Remove the two carburetor mounting screws. See Figure 9-22. If a flexible tube and knob idle speed adjuster is used, open the retaining clamp and unhook.

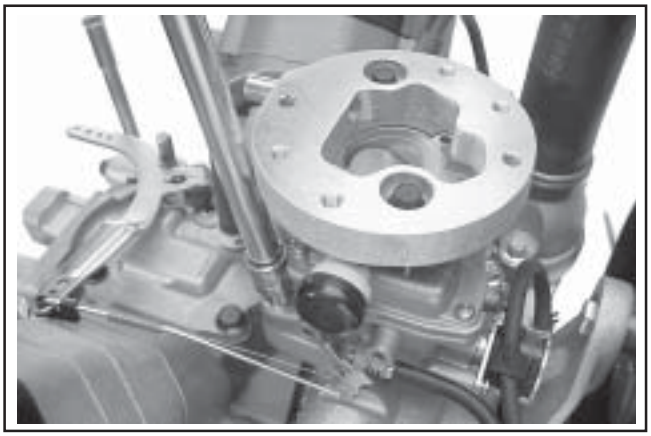


Figure 9-22. Removing the Carburetor Mounting Screws.

4. Remove the carburetor, throttle linkage and governor lever as an assembly. See Figure 9-23.

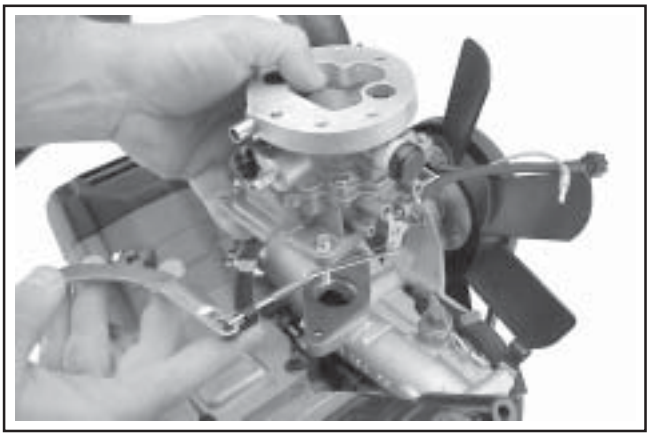


Figure 9-23. Removing Carburetor from Engine.

5. Remove the carburetor gasket.

6. The carburetor, adapter, throttle linkage, and governor lever may be separated for individual component servicing as required. If the linkages are separated, reattach the bushings to the linkages to prevent them from being lost.

Remove Oil Sentry™ (If So Equipped)

1. Disconnect the wire lead from the Oil Sentry™ switch, and remove the switch from the breather cover. See Figure 9-24.

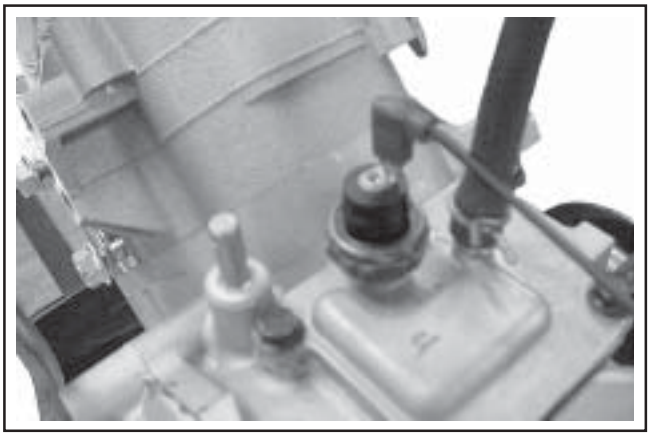


Figure 9-24. Oil Sentry™ Location on Engine.

Remove Breather Cover

1. Remove the four hex flange screws securing the breather cover to the crankcase. See Figure 9-25.

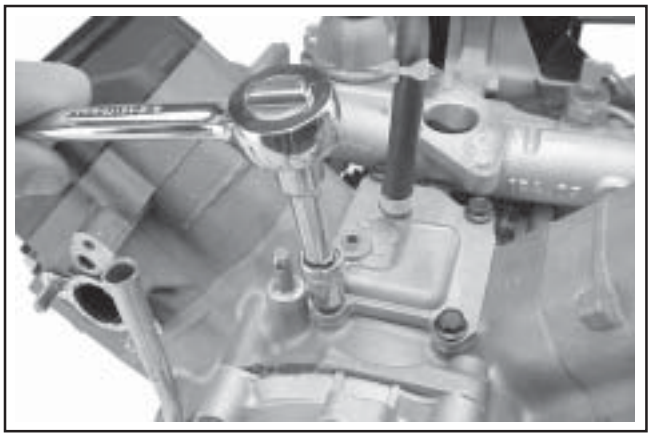


Figure 9-25. Removing the Breather Cover Screws.

2. Carefully pry under the protruding edge of the breather cover to separate and remove the cover from the gasket. See Figure 9-26.

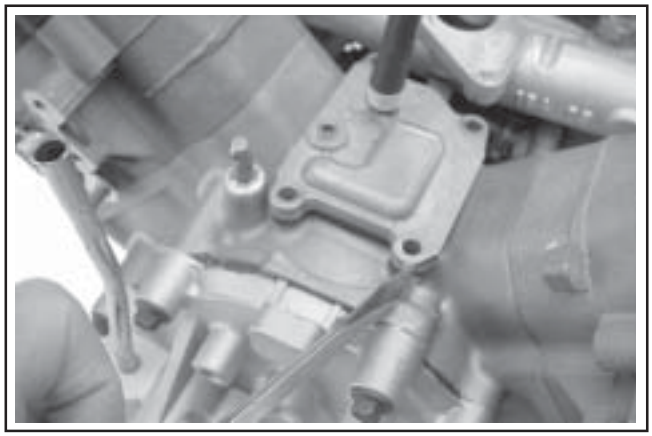


Figure 9-26. Prying Off the Breather Cover.

Do not pry on the sealing surfaces as it could cause damage resulting in leaks.

3. Remove the breather gasket and fiber filter from the breather chamber. See Figure 9-27.

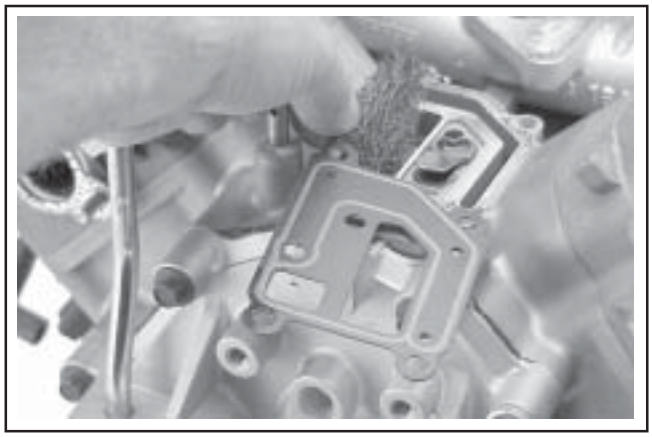


Figure 9-27. Removing the Breather Gasket and Filter.

4. Remove the hex flange screw, breather reed retainer and breather reed from the breather chamber. See Figure 9-28.

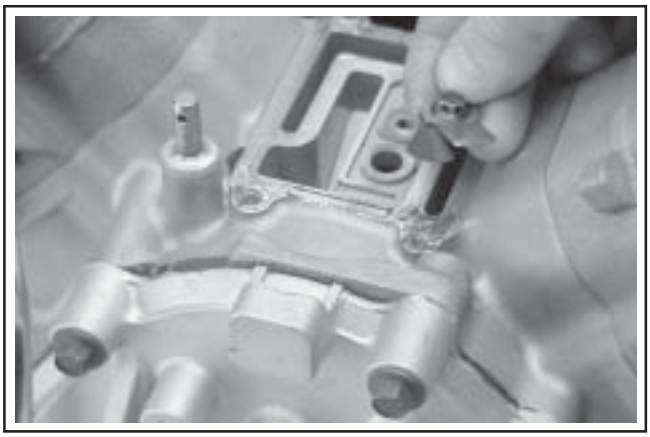


Figure 9-28. Removing the Breather Reed Assembly Parts.

Remove Valve Covers

1. Remove the hex flange screws from the two lower valve cover mounting locations on each side. See Figure 9-29.

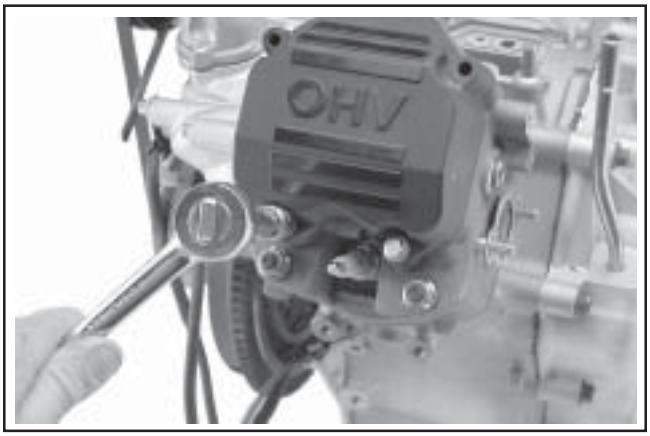


Figure 9-29. Removing Two Lower Valve Cover Screws.

2. Remove the valve covers and valve cover gaskets. Note on which side the oil fill or fuel pump is located, for correct reassembly later. See Figure 9-30.

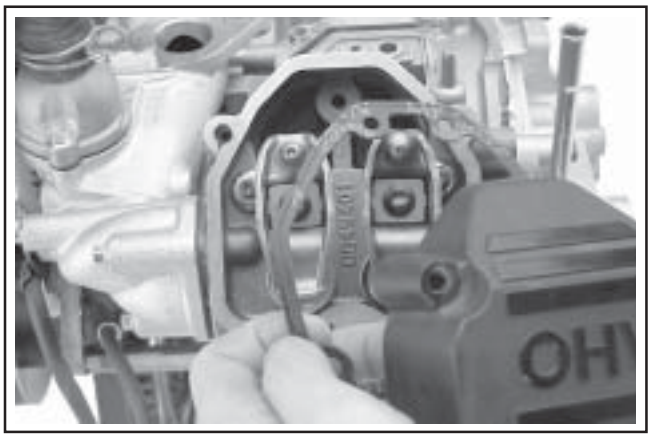


Figure 9-30. Removing Valve Covers and Gaskets.

Remove Lower Drive Pulley and Fan Belt

1. Remove the four screws attaching the lower drive pulley assembly to the pulley adapter and flywheel. See Figure 9-31.

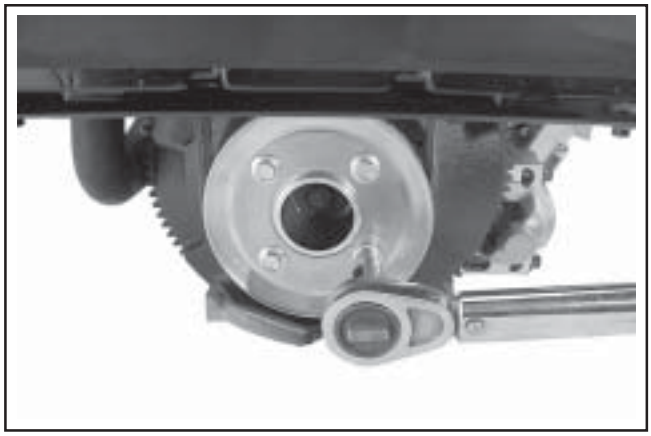


Figure 9-31. Removing Lower Pulley Four Screws.

2. Remove the pulley halves with the spacer shims from the adapter, and take the fan belt off the upper pulley/fan assembly. Note the number of shims between pulley halves, and on the front side of pulley, especially if the same belt will be reinstalled. See Figure 9-32.

Figure 9-32. Disassembled Lower Pulley Assembly.

Remove Fan Assembly, Mounting Bracket, and Fan Shaft

1. Remove the front hex flange nut and washer securing the fan assembly to the fan shaft. Remove the fan and pulley assembly from the upper mounting bracket. See Figure 9-33.

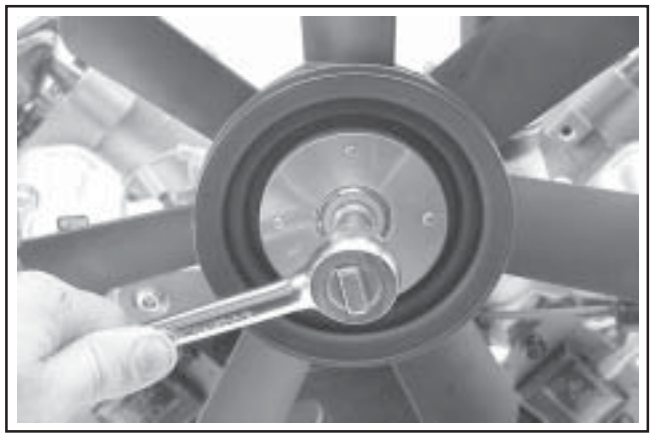


Figure 9-33. Removing Front Flange Nut and Flat Washer.

NOTE: Further disassembly of the fan/hub and pulley assembly is not necessary unless a problem exists; see "Inspection - Cooling Fan Assembly, Belt, and Drive Pulleys" (Section 7). If disassembly is performed, note the assembly order and position of parts. See Figure 9-34.

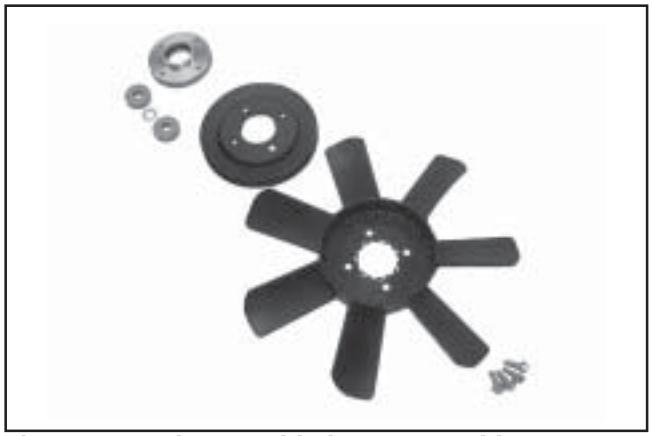


Figure 9-34. Disassembled Fan Assembly Component.

2. Remove the two hex flange screws and take off the mounting bracket, with the fan shaft attached. See Figure 9-35.

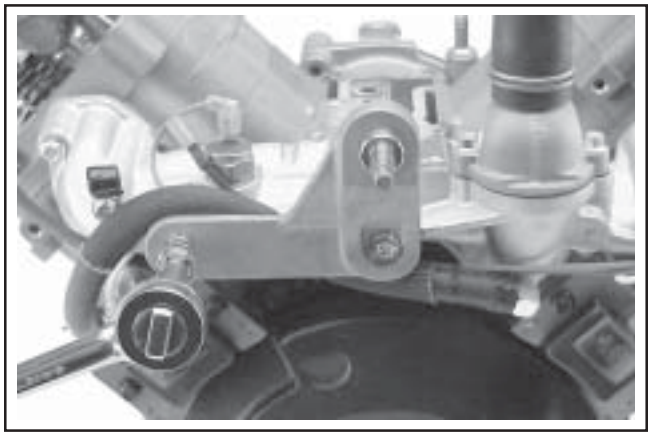


Figure 9-35. Removing Upper Fan Mounting Bracket Screws.

3. The fan shaft may be removed from the mounting bracket, by removing the rear hex flange nut, if individual servicing of either part is required.

Remove Ignition Modules

1. Disconnect the kill leads from the ignition modules. See Figure 9-36.

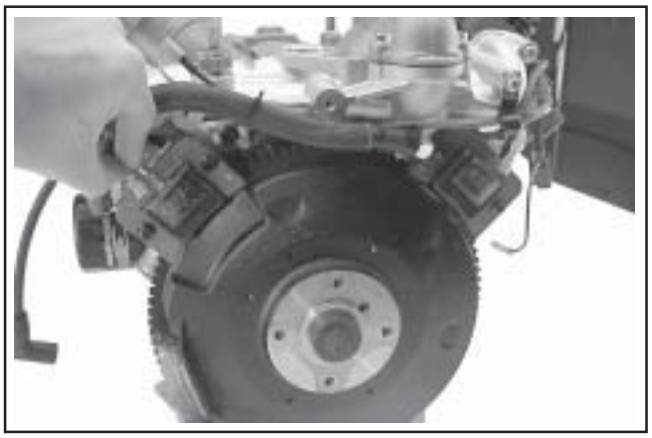


Figure 9-36. Removing Kill Leads from Ignition Modules.

2. Rotate the flywheel, so the magnet is away from the ignition modules.

3. Remove the mounting screws and take off each ignition module. See Figure 9-37.

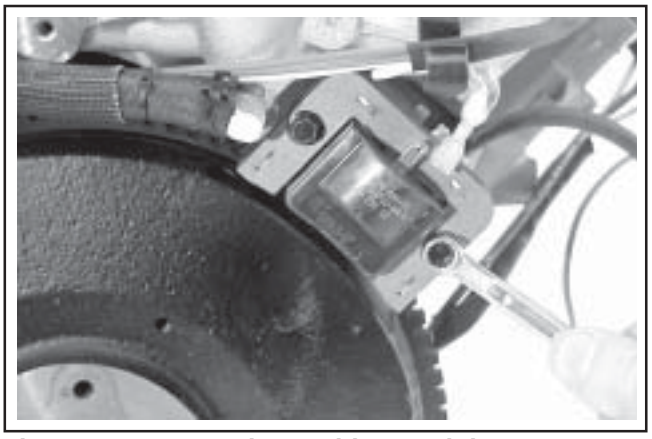


Figure 9-37. Removing Ignition Modules.

Remove Flywheel

1. Use a flywheel strap wrench or holding tool (see Section 2) to hold the flywheel. Remove the hex flange screw and flat washer. See Figure 9-38.

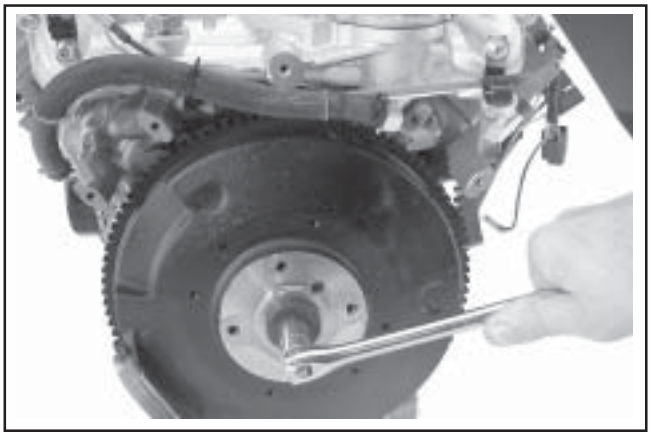


Figure 9-38. Removing Flywheel Screw and Washer.

2. Use a puller to remove the flywheel from the crankshaft. See Figure 9-39.

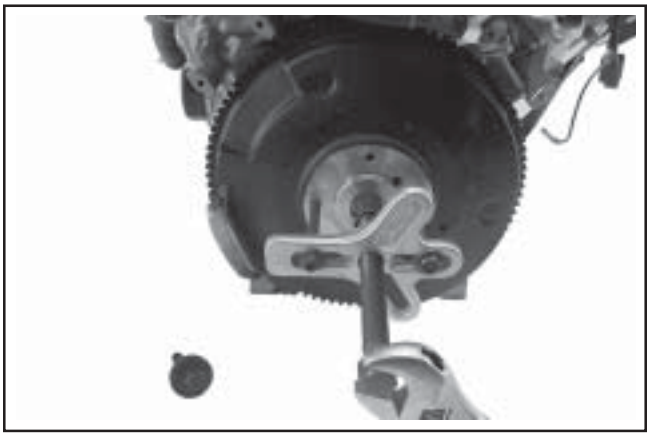


Figure 9-39. Removing Flywheel with Puller.

NOTE: Always use a flywheel puller to remove the flywheel from the crankshaft. Do not strike the crankshaft or flywheel, as these parts could become cracked or damaged.

3. Remove the woodruff key from the crankshaft keyway.

Remove Stator Assembly

1. Remove the two mounting screws, and pull the stator, with the plug-in connector attached, from the engine. See Figure 9-40.

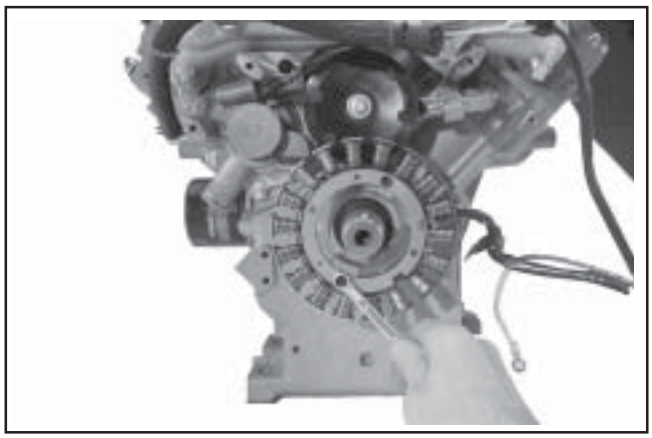


Figure 9-40. Removing Stator Screws.

Remove Intake Manifold, Thermostat Housing, By-pass Hose and Wiring Harness

1. Disconnect the by-pass hose from the fitting on the water pump. See Figure 9-41.

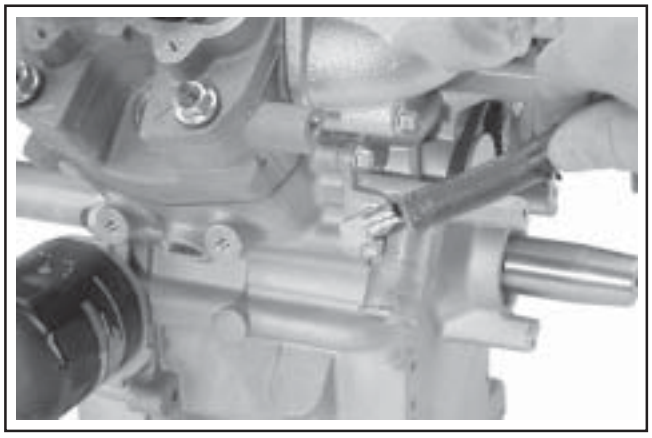


Figure 9-41. Removing By-pass Hose from Water Pump Fitting.

2. Remove the six mounting screws and carefully separate the intake manifold from the cylinder heads, with the by-pass hose and wiring harness attached. See Figures 9-42 and 9-43.

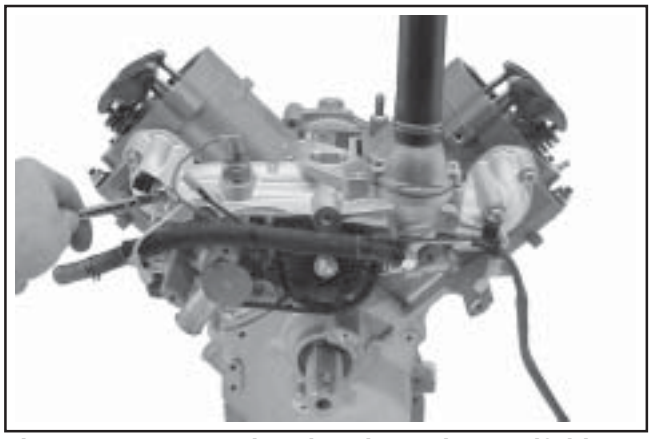


Figure 9-42. Removing the Six Intake Manifold Screws.

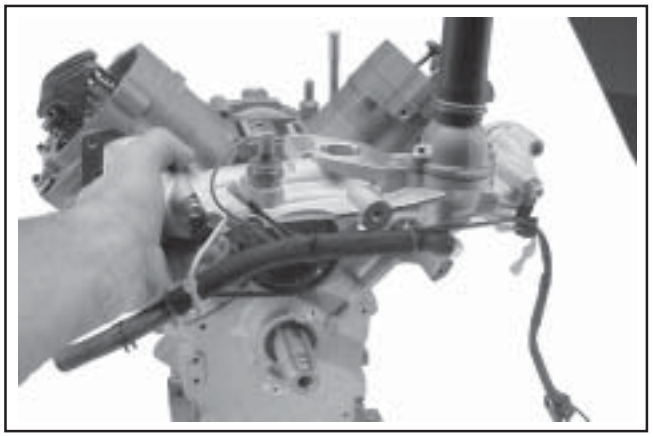


Figure 9-43. Removing the Intake Manifold Assembly from the Engine.

3. Remove the intake manifold gaskets.

4. Further disassembly of the intake manifold components may be performed as necessary. If the thermostat is to be removed, loosen and remove the two hex flange screws securing the thermostat housing to the intake manifold. Separate the housing and remove the thermostat, discard the old gasket. Disassembled components are shown in Figure 9-44.

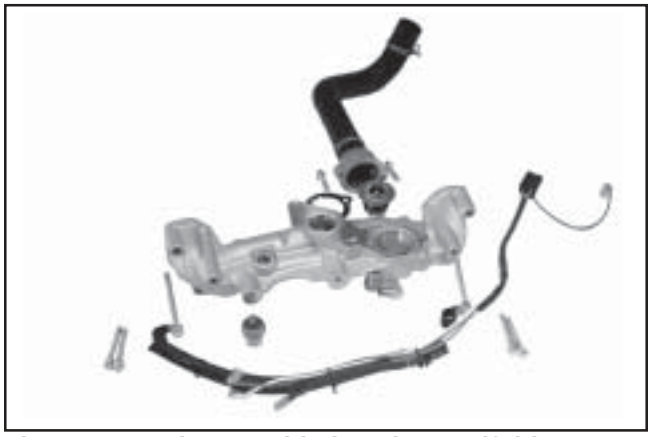


Figure 9-44. Disassembled Intake Manifold Assembly Components.

Remove Camshaft Pulley and Water Pump Belt

1. Remove the hex flange screw and flat washer, securing the cogged drive pulley to the camshaft. See Figure 9-45.

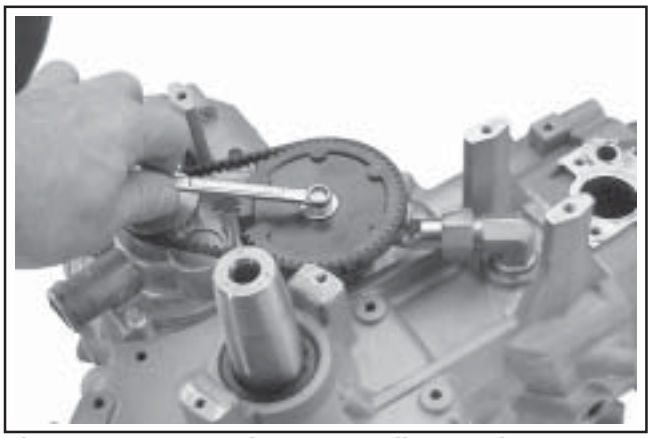


Figure 9-45. Removing Cam Pulley Hardware.

2. Carefully lift the pulley off the camshaft and remove the belt from the water pump pulley. See Figure 9-46.

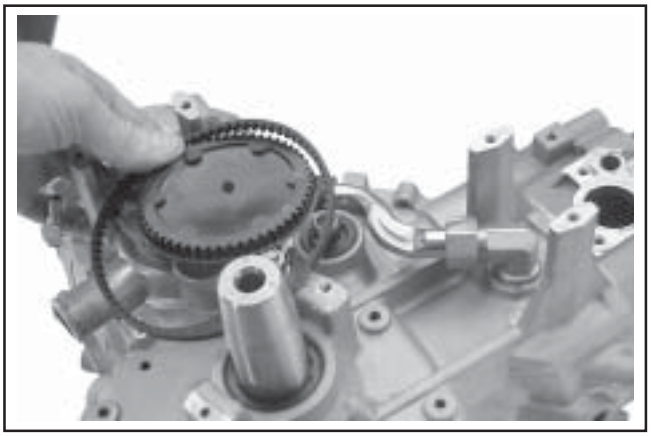


Figure 9-46. Removing Cam Pulley and Belt.

3. Remove the camshaft key from the keyway.

Remove Water Pump and Transfer Tube

1. Loosen and unscrew the hex cap section securing the transfer tube to the 90° fitting in the crankcase. See Figure 9-47. Support the fitting with a wrench, when loosening the hex cap section.

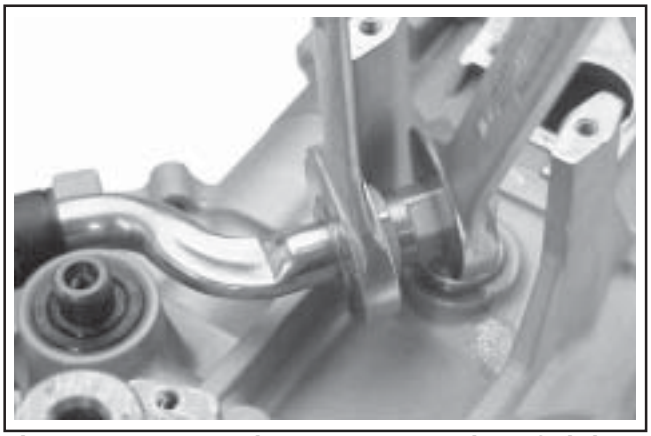


Figure 9-47. Loosening Hex Cap Section of Fitting.

2. Remove the six screws securing the water pump to the crankcase. See Figure 9-48.

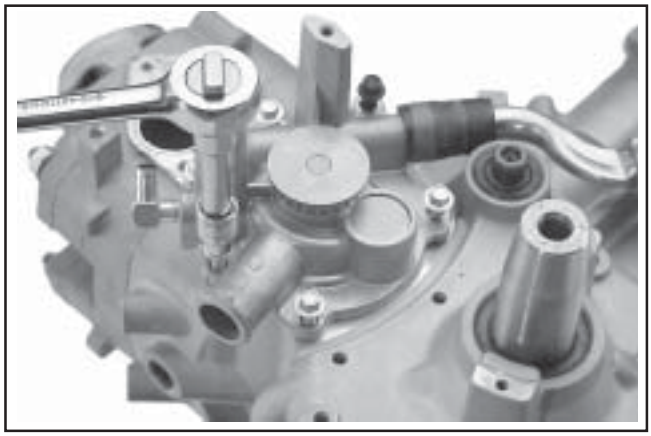


Figure 9-48. Removing Water Pump Screws.

3. Lift the water pump up, and carefully work the ferruled end of the transfer tube out of the fitting. Remove the water pump with the transfer tube and the hose section attached. Remove and discard the O-Ring from within the channel of the pump housing. See Figure 9-49.

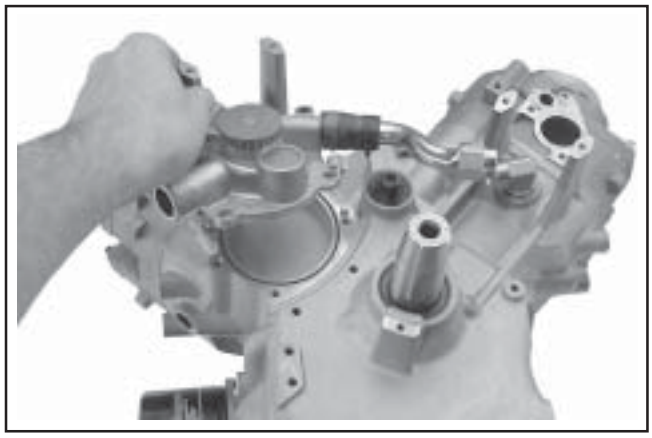


Figure 9-49. Removing the Water Pump Assembly from Block.

4. Inspect and, if necessary, separate the transfer tube and hose section from the water pump. Remove the hose clamps, noting their size differences and position of tangs.

   IMPORTANT: The 90° fitting in the crankcase, which the transfer tube is connected to, is sealed and installed at the factory in a specific position. **Do not** loosen, remove, or alter the mounted position of this fitting at any time. Contact the factory service department for specific instructions if the fitting is damaged, or its mounting is affected in any way.

Remove Spark Plugs

1. Remove the spark plugs from the cylinder heads using a spark plug socket. See Figure 9-50.

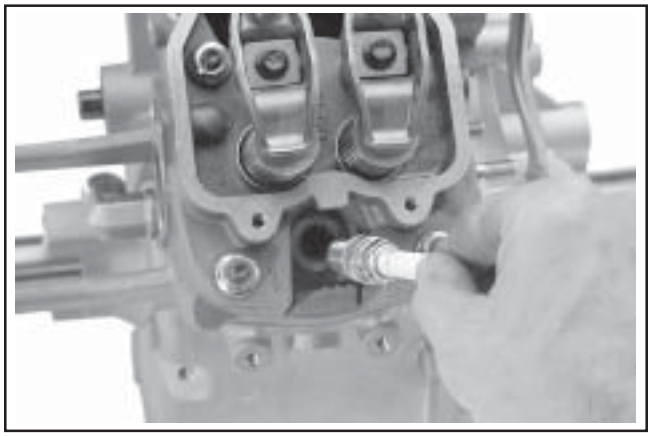


Figure 9-50. Removing Spark Plugs.

Remove Cylinder Heads and Valve Lifters

1. Rotate the crankshaft of the engine until the valves of one cylinder are closed. Loosen the rocker arm screws until the rocker arms can be pivoted to free the push rods. See Figure 9-51.

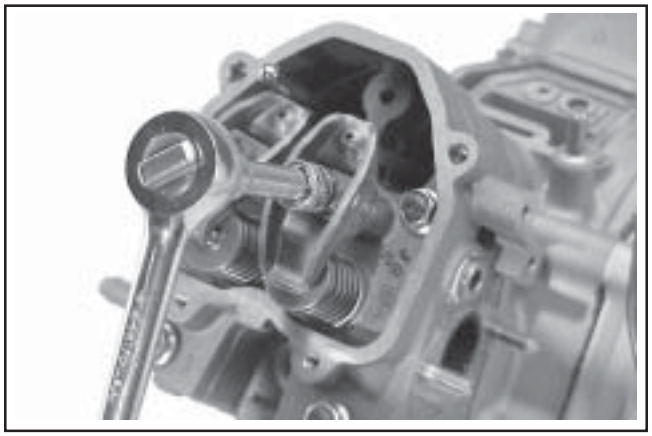


Figure 9-51. Loosening the Rocker Arm Screws.

2. Remove the push rods and mark their location as either intake or exhaust, and cylinder 1 or 2. The push rods should always be reinstalled in their original position.

3. Repeat for the opposite cylinder.

4. Remove the four hex flange nuts and washers from the cylinder head studs. Carefully remove the cylinder heads and head gaskets. See Figure 9-52.

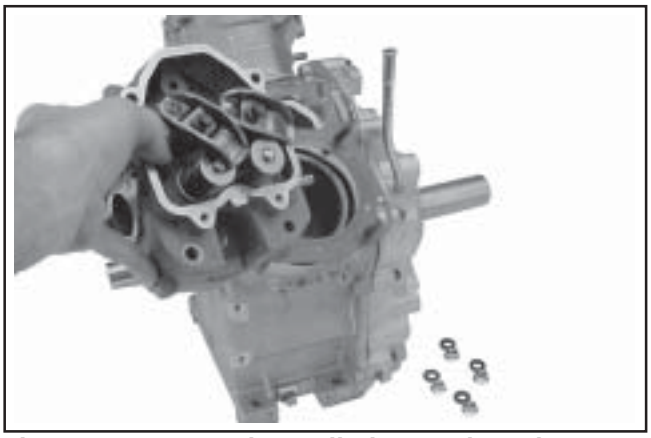


Figure 9-52. Removing Cylinder Heads and Gaskets.

5. Remove the hydraulic lifters using a hydraulic lifter removing tool (**do not use a magnet**). Mark them similar to the push rods (intake or exhaust and cylinder 1 or 2). Hydraulic lifters should always be reinstalled in their original location. See Figure 9-53.

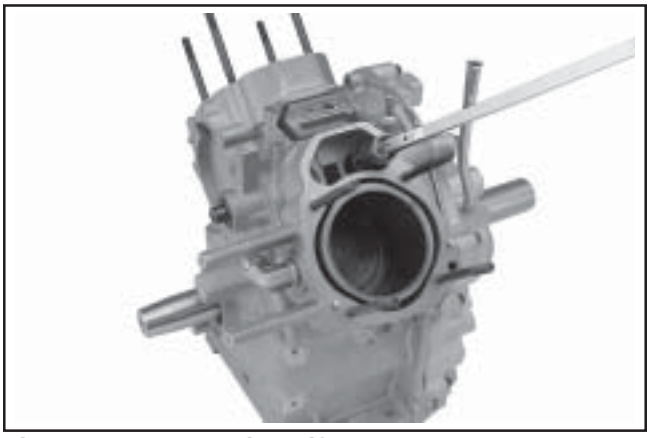


Figure 9-53. Removing Lifters.

NOTE: It is not necessary to remove the cylinder studs from the crankcase unless replacement is intended. If studs are removed for any reason, discard the old stud(s), do not reuse/reinstall. Use new studs and refer to the assembly sequence for proper installation.

Disassemble Cylinder Heads

1. Remove the two hex flange screws, rocker arms and pivots from the cylinder head(s). See Figure 9-54.

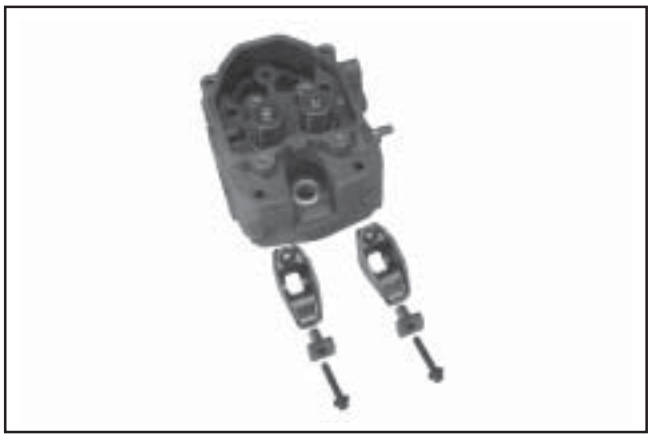


Figure 9-54. Removed Rocker Arms and Pivots.

2. Compress the valve springs using a valve spring compressor and remove the valve spring keepers. Remove the compressor. See Figure 9-55.

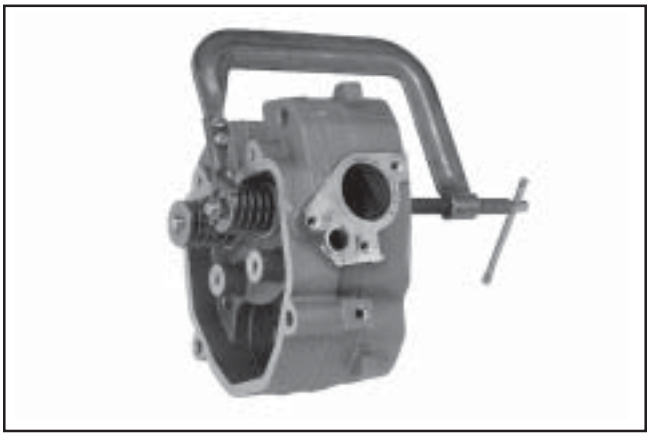


Figure 9-55. Compressing Valve Springs.

3. With the keepers taken out the following items can be removed. See Figure 9-56.

- valve spring retainers
- valve springs
- valve spring caps
- intake and exhaust valves
- valve stem seals (intake valve only)

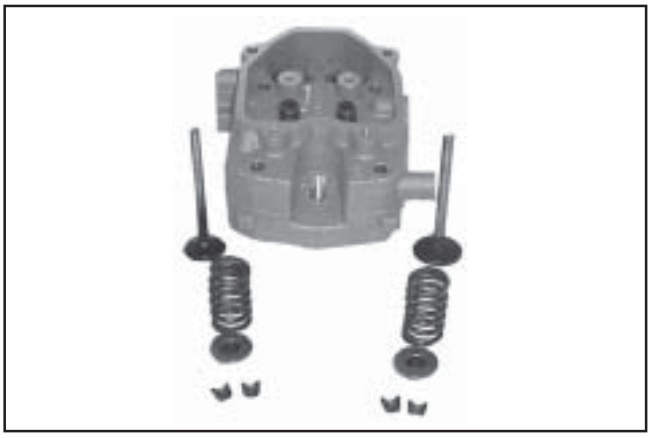


Figure 9-56. Disassembled Head and Valve Components.

NOTE: These engines use a valve stem seal on the intake and exhaust valves. Serial No. 3422000010 and lower used a seal on intake side only. See Figure 9-57. Always use new seals when the valves are removed from the cylinder head. Replace the seals if they are deteriorated or damaged in any way. **Never reuse an old seal.**

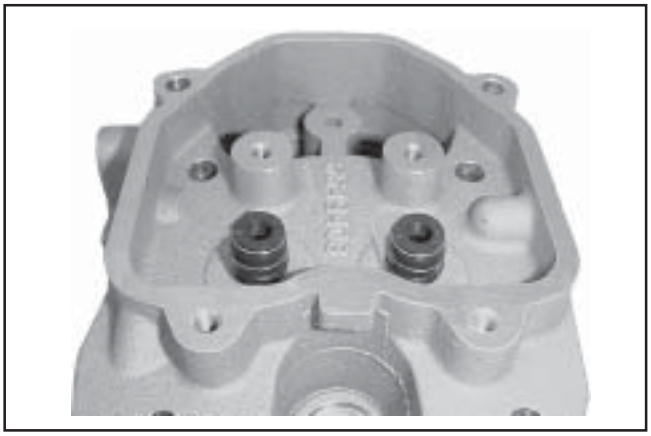


Figure 9-57. Cylinder Head Showing Intake Seal.

4. Repeat the above procedure for the other cylinder head. Do not interchange parts from one cylinder head with parts from the other cylinder head.

Remove Closure Plate

1. Remove the ten hex flange screws securing the closure plate to the crankcase. See Figure 9-58. If a thick washer is installed under the screw head in the #10 location, and/or one silver (ground) screw is used, (normally the No. 4 or 6 position), note these special assembly details for proper reassembly later.

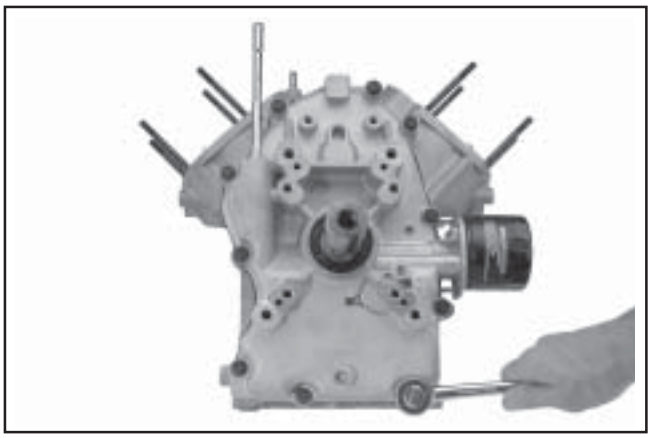


Figure 9-58. Removing Closure Plate Screws.

2. Locate the three splitting tabs, which are cast into the perimeter of the closure plate. Insert the drive end of a 1/2" breaker bar between the top splitting tab and the crankcase. Hold the handle horizontal and pull it toward you to break the RTV seal. See Figure 9-59. If necessary, pry at the bottom splitting tabs also. Do not pry on the sealing surfaces, as this could cause leaks. Carefully pull the closure plate from the crankcase.

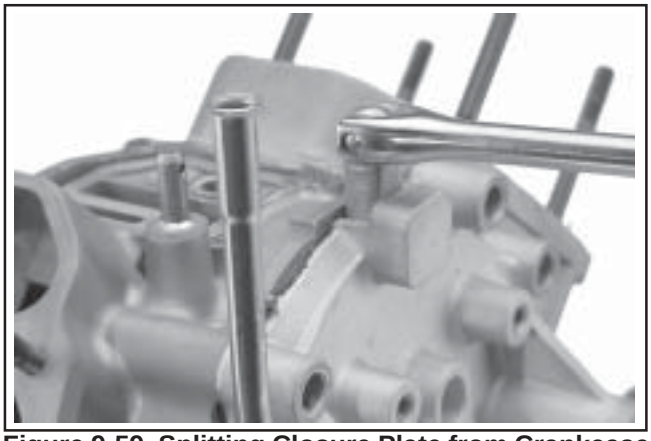


Figure 9-59. Splitting Closure Plate from Crankcase.

Governor Assembly

The governor assembly is located inside the closure plate. If service is required, refer to the service procedures under "Governor Assembly" in Section 10.

Oil Pump Assembly

The oil pump is mounted to the inside of the closure plate as well. If service is required, refer to the service procedures under "Oil Pump Assembly" in Section 10.

Remove Camshaft

1. Remove the camshaft and shims. See Figure 9-60.

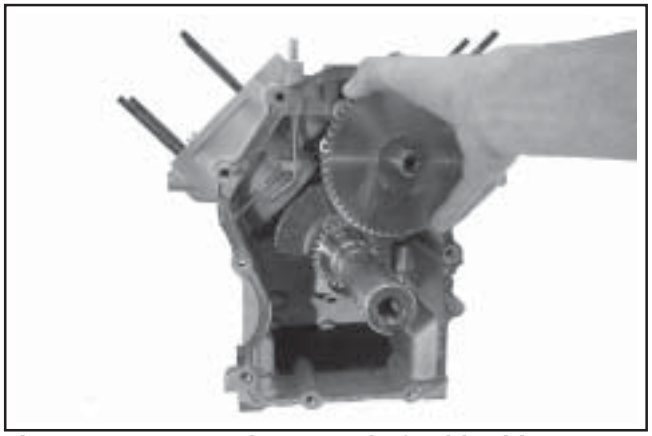


Figure 9-60. Removing Camshaft with Shim.

Remove Connecting Rods with Pistons and Rings

1. Remove the two hex flange screws securing the closest connecting rod end cap. Remove the end cap. See Figure 9-61.

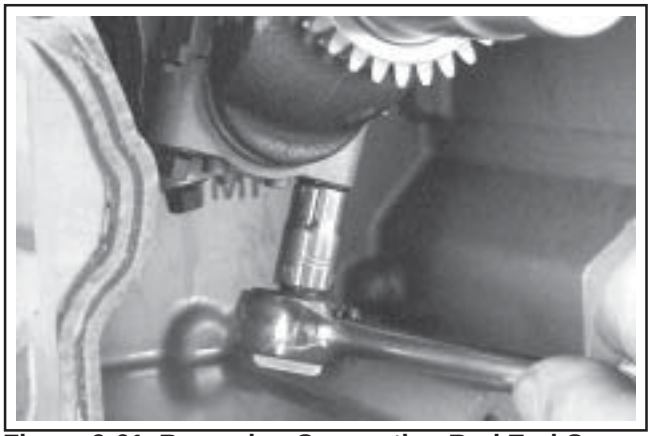


Figure 9-61. Removing Connecting Rod End Cap.

NOTE: If a carbon ridge is present at the top of either cylinder bore, use a ridge reamer tool to remove it before attempting to remove the piston.

NOTE: The cylinders are numbered on the crankcase. Use the numbers to mark each end cap and connecting rod/piston assembly for reassembly later. **Do not** mix the end caps and connecting rods.

2. Carefully remove the connecting rod and piston assembly from the cylinder bore. See Figure 9-62.

Figure 9-62. Removing Piston(s).

3. Repeat the above procedure for the other connecting rod and piston assembly.

Remove Crankshaft

1. Carefully pull the crankshaft from the crankcase. See Figure 9-63. Note the thrust washer and shims if used.

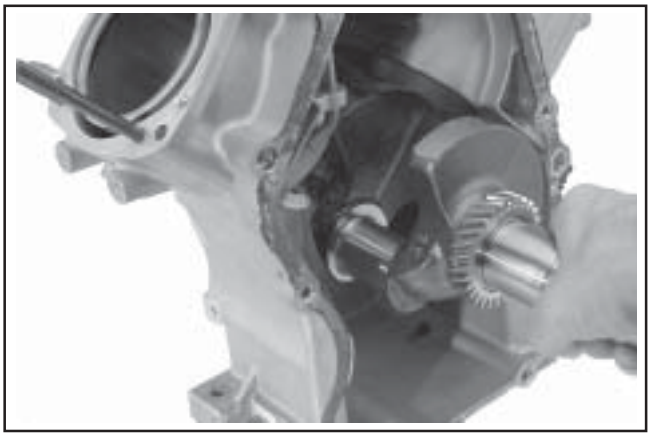


Figure 9-63. Removing Crankshaft.

Remove Governor Cross Shaft

1. Remove the retaining ring and nylon washer from the governor cross shaft. See Figure 9-64.

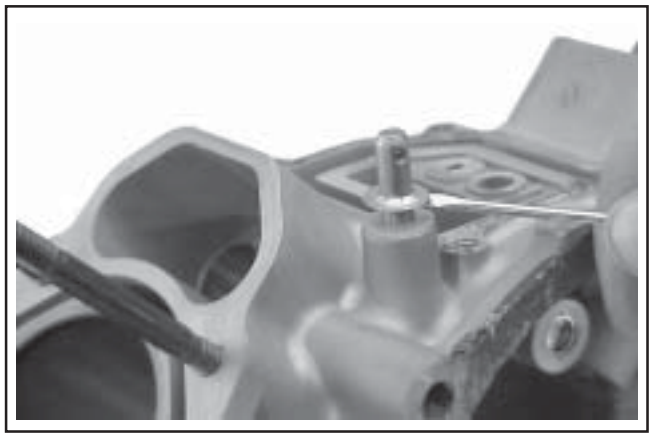


Figure 9-64. Removing Governor Shaft Retaining Ring and Washer.

NOTE: Always use a new retaining ring when reassembling. **Do not** reuse the old retaining ring.

2. Remove the cross shaft and small washer out through the inside of the crankcase. See Figure 9-65.

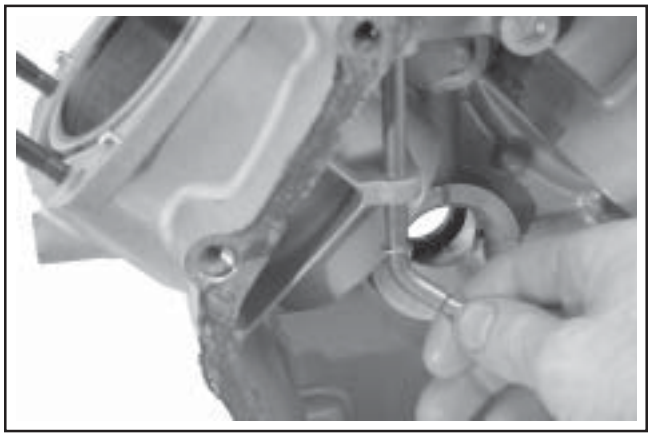


Figure 9-65. Removing Governor Cross Shaft.

Remove Flywheel End Oil Seals

1. Remove the flywheel end crankshaft and camshaft oil seals from the crankcase. See Figure 9-66.

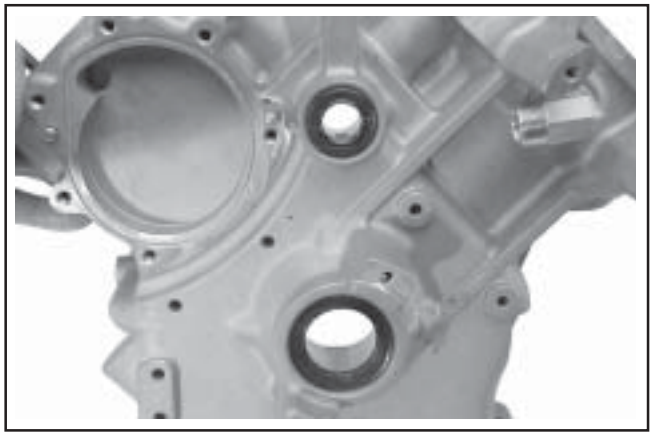


Figure 9-66. Oil Seals (Flywheel Side and Camshaft).

Section 10
Inspection and Reconditioning

This section covers the operation, inspection, and repair/reconditioning of major internal engine components. Also included are water pump, cooling system and fan drive belt inspection criteria. The following components are not covered in this section. They are covered in sections of their own:

Air Cleaner, Section 4
Carburetor & External Governor, Section 5
Ignition, Charging & Electric Starter, Section 8

Clean all parts thoroughly. Only clean parts can be accurately inspected and gauged for damage or wear. There are many commercially available cleaners that will quickly remove grease, oil, and grime from engine parts. When such a cleaner is used, follow the manufacturer's instructions and safety precautions carefully. Make sure all traces of the cleaner are removed before the engine is reassembled and placed into operation. Even small amounts of these cleaners can quickly break down the lubricating properties of engine oil.

Use an aerosol gasket remover, paint stripper, or lacquer thinner to remove any old sealant. Apply the solvent, allow time for it to work, and then brush the surface with a **brass** wire brush. After the old sealant is removed, clean the surface with isopropyl alcohol, lacquer thinner, or aerosol electrical contact cleaner. **Do not** scrape the surfaces, as any scratches, nicks, or burrs can result in leaks. See Service Bulletin 252 for further information.

Refer to A Guide to Engine Rebuilding (TP-2150-A) for additional information. Measurement Guide (TP-2159-B) and Engine Inspection Data Record (TP-2435) are also available; use these to record inspection results.

Camshaft and Crankshaft

Inspection and Service

Inspect the gear teeth of the camshaft and crankshaft. If the teeth are badly worn, chipped, or some are missing, replacement will be necessary. If there is tooth damage on either the camshaft gear or crankshaft gear, both the camshaft and crankshaft must be replaced.

Inspect the bearing surfaces for scoring, grooving, etc. Measure the running clearance between the bearing journals and their respective bores. Use an inside micrometer or telescoping gauge to measure the inside diameter of both bearing bores in the vertical and horizontal planes. Use an outside micrometer to measure the outside diameter of the bearing journals. Subtract the journal diameters from their respective bore diameters to get the running clearances. Check the results against the specifications in Section 1. If the running clearances are within specification, and there is no evidence of scoring, grooving, etc., no further reconditioning is necessary. If the bearing surfaces are worn or damaged, the crankcase and/or closure plate will need to be replaced.

Inspect the crankshaft keyways. If worn or chipped, replacement of the crankshaft will be necessary. Inspect the crankpin for score marks or metallic pick up. Slight score marks can be cleaned with crocus cloth soaked in oil. If wear limits, as stated in "Specifications and Tolerances," are exceeded, it will be necessary to either replace the crankshaft or regrind the crankpin to **0.25 mm (0.010 in.)** undersize. If reground, **0.25 mm (0.010 in.)** undersize connecting rods (big end) must then be used to achieve proper running clearance. Measure the crankpin for size, taper, and out-of-round.

NOTE: If the crankpin is reground, visually check to ensure that the fillet blends smoothly with the crankpin surface. See Figure 10-1.

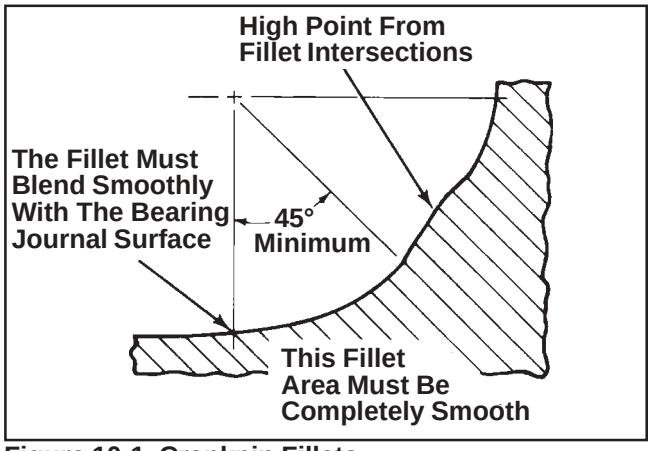


Figure 10-1. Crankpin Fillets.

When grinding a crankshaft, grinding stone deposits can get caught in oil passages which could cause severe engine damage. Removing the crankpin plug each time the crankshaft is ground provides easy access for cleaning any grinding deposits that may collect in the oil passages.

Use the following procedure to remove and replace the plug.

Procedure to Remove Crankshaft Plug:

1. Drill a 3/16" hole through the plug in the crankshaft.

2. Thread a 3/4" or 1" long self-tapping screw with a flat washer into the drilled hole. The flat washer must be large enough to seat against the shoulder of the plug bore. See Figure 10-2.

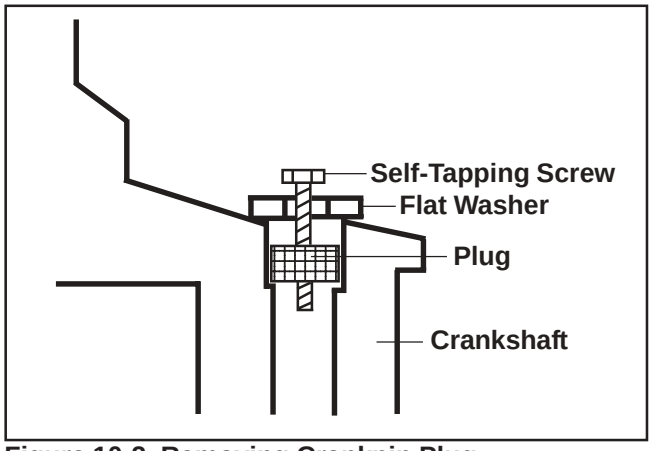


Figure 10-2. Removing Crankpin Plug.

3. Tighten the self-tapping screw until it draws the plug out of the crankshaft.

Procedure to Install New Plug:

1. Use a single cylinder camshaft pin, Kohler Part No. **47 380 09-S**, as a driver and tap the plug into the plug bore until it seats at the bottom of the bore. Make sure the plug is tapped in evenly to prevent leakage.

Crankcase

These engines contain a cast-iron cylinder liner that may be reconditioned as follows:

Inspection and Service

Check all gasket surfaces to make sure they are free of gasket fragments. Gasket surfaces must also be free of deep scratches or nicks.

Inspect the main bearing (if so equipped) for wear or damage (refer to Section 1, "Specifications, Tolerances, and Special Torque Values"). Replace the crankcase using a mini-block or short block if required.

Check the cylinder bore for scoring. In severe cases, unburned fuel can cause scuffing and scoring of the cylinder wall. It washes the necessary lubricating oils off the piston and cylinder wall. As raw fuel seeps down the cylinder wall, the piston rings make metal to metal contact with the wall. Scoring of the cylinder wall can also be caused by localized hot spots resulting from a cooling system problem or from inadequate or contaminated lubrication.

If the cylinder bore is badly scored, excessively worn, tapered, or out-of-round, resizing is necessary. Use an inside micrometer to determine amount of wear (refer to the “Specifications, Tolerances, and Special Torque Values”, in Section 1), then select the nearest suitable oversize of either **0.08 mm (0.003 in.), 0.25 mm (0.010 in.),** or **0.50 mm (0.020 in.)**. Resizing to one of these oversizes will allow usage of the available oversize piston and ring assemblies. Initially, resize using a boring bar, then use the following procedures for honing the cylinder.

NOTE: If the bore is beyond the wear limit, a new miniblock or short block will be required.

Honing

While most commercially available cylinder hones can be used with either portable drills or drill presses, the use of a low speed drill press is preferred as it facilitates more accurate alignment of the bore in relation to the crankshaft crossbore. Honing is best accomplished at a drill speed of about **250 RPM** and **60 strokes** per minute. After installing coarse stones in hone, proceed as follows:

1. Lower hone into bore and after centering, adjust so that the stones are in contact with the cylinder wall. Use of a commercial cutting-cooling agent is recommended.

2. With the lower edge of each stone positioned even with the lowest edge of the bore, start drill and honing process. Move the hone up and down while resizing to prevent the formation of cutting ridges. Check the size frequently.

3. When the bore is within **0.064 mm (0.0025 in.)** of desired size, remove the coarse stones and replace with burnishing stones. Continue with the burnishing stones until within **0.013 mm (0.0005 in.)** of desired size and then use finish stones (220-280 grit) and polish to final size. A crosshatch should be observed if honing is done correctly. The crosshatch should intersect at approximately 23-33° off the horizontal. Too flat an angle could cause the rings to skip and wear excessively, too steep an angle will result in high oil consumption. See Figure 10-3.

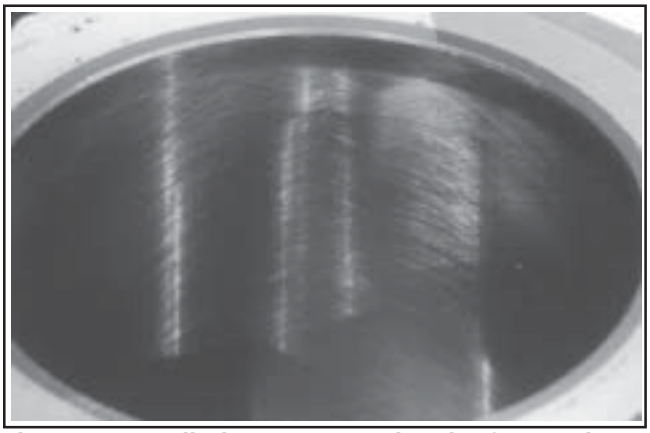


Figure 10-3. Cylinder Bore Crosshatch After Honing.

4. After resizing, check the bore for roundness, taper, and size. Use an inside micrometer, telescoping gauge, or bore gauge to take measurements. The measurements should be taken at three locations in the cylinder-at the top, middle, and bottom. Two measurements should be taken (perpendicular to each other) at each of the three locations.

Clean Cylinder Bore After Honing

Proper cleaning of the cylinder walls following boring and/or honing is very critical to a successful overhaul. Machining grit left in the cylinder bore can destroy an engine in less than one hour of operation after a rebuild.

The final cleaning operation should always be a thorough scrubbing with a brush and hot, soapy water. Use a strong detergent that is capable of breaking down the machining oil while maintaining a good level of suds. If the suds break down during cleaning, discard the dirty water and start again with more hot water and detergent. Following the scrubbing, rinse the cylinder with very hot, clear water, dry it completely, and apply a light coating of engine oil to prevent rusting.

Measuring Piston-to-Bore Clearance

Before installing the piston into the cylinder bore, it is necessary that the clearance be accurately checked. This step is often overlooked, and if the clearances are not within specifications, engine failure will usually result.

NOTE: Do not use a feeler gauge to measure piston-to-bore clearance–it will yield inaccurate measurements. Always use a micrometer.

Use the following procedure to accurately measure the piston-to-bore clearance:

1. Use a micrometer and measure the diameter of the piston **6 mm (0.24 in.)** above the bottom of the piston skirt and perpendicular to the piston pin. See Figure 10-4.

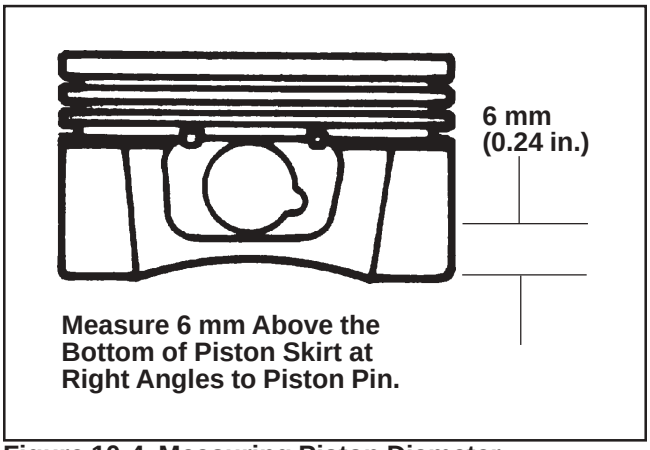


Figure 10-4. Measuring Piston Diameter.

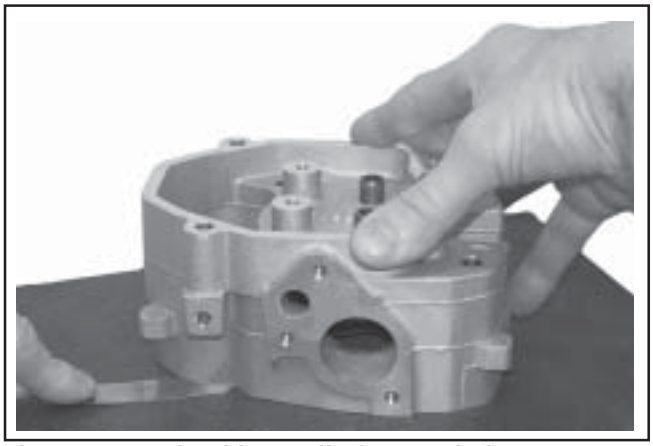


Figure 10-5. Checking Cylinder Head Flatness.

2. Use an inside micrometer, telescoping gauge, or bore gauge and measure the cylinder bore. Take the measurement approximately **63.5 mm (2.5 in.)** below the top of the bore and perpendicular to the piston pin.

3. Piston-to-bore clearance is the difference between the bore diameter and the piston diameter (step 2 minus step 1).

Flywheel

Inspection

Inspect the flywheel for cracks, and the flywheel keyway for damage. Replace flywheel if cracked. Replace the flywheel, the crankshaft, and the key if flywheel key is sheared or the keyway is damaged.

Inspect the ring gear for cracks or damage. Kohler does not provide ring gears as a serviceable part. Replace the flywheel if the ring gear is damaged.

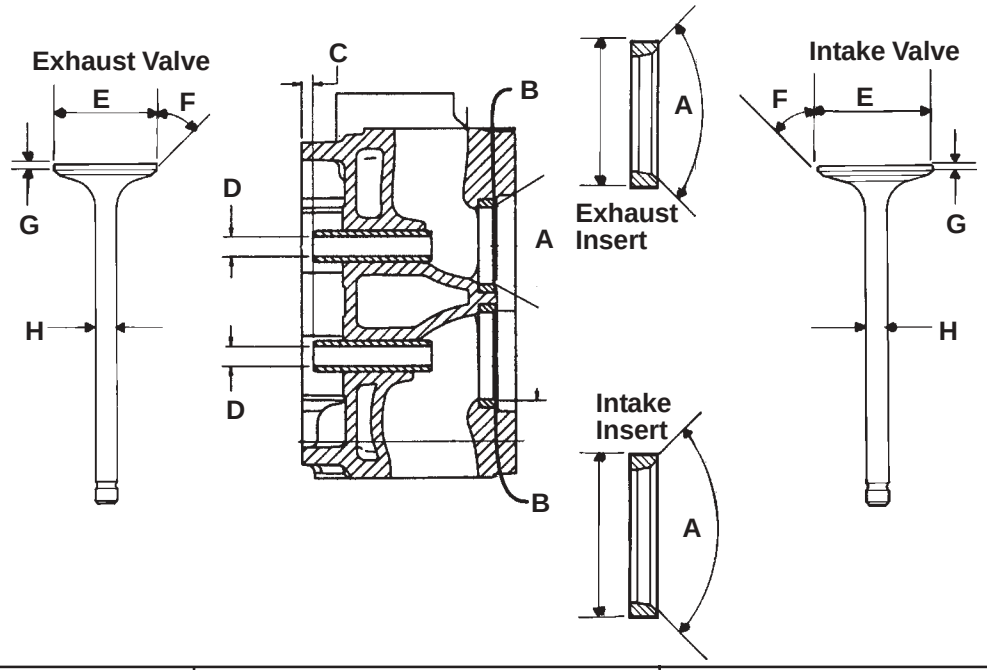
Check the charging system magnets to be sure they are not loose or cracked.

Cylinder Head and Valves

Inspection and Service

After cleaning, check the flatness of the cylinder head and the corresponding top surface of the crankcase, using a surface plate or piece of glass and feeler gauge as shown in Figure 10-5. The maximum allowable out of flatness is **0.076 mm (0.003 in.)**.

Carefully inspect the valve mechanism parts. Inspect the valve springs and related hardware for excessive wear or distortion. Check the valves and valve seat area or inserts for evidence of deep pitting, cracks, or distortion. Check clearance of the valve stems in guides. See Figure 10-6 for valve details and specifications.



	Dimension	Intake	Exhaust
A	Seat Angle	89°	89°
B	Insert O.D.	36.987/37.013 mm (1.4562/1.4572 in.)	32.987/33.013 mm (1.2987/1.2997 in.)
C	Guide Depth	4 mm (0.1575 in.)	6.5 mm (0.2559 in.)
D	Guide I.D.	7.038/7.058 mm (0.2771/0.2779 in.)	7.038/7.058 mm (0.2771/0.2779 in.)
E	Valve Head Diameter	33.37/33.63 mm (1.3138/1.3240 in.)	29.37/29.63 mm (1.1563/1.1665 in.)
F	Valve Face Angle	45°	45°
G	Valve Margin (Min.)	1.5 mm (0.0591 in.)	1.5 mm (0.0591 in.)
H	Valve Stem Diameter	6.982/7.000 mm (0.2749/0.2756 in.)	6.970/6.988 mm (0.2744/0.2751 in.)

Figure 10-6. Valve Details.

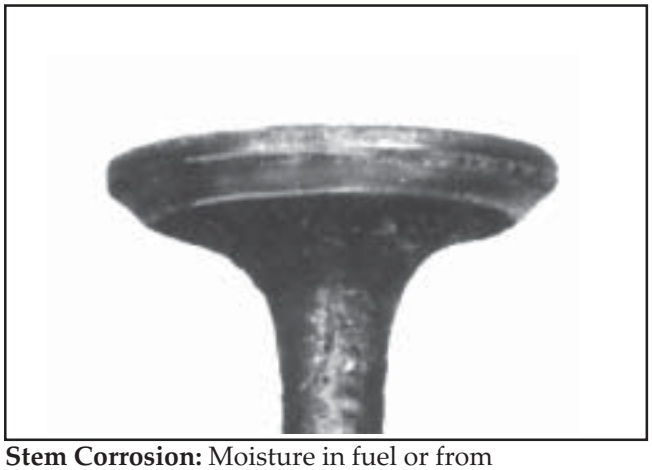
Hard starting, or loss of power accompanied by high fuel consumption may be symptoms of faulty valves. Although these symptoms could also be attributed to worn rings, remove and check the valves first. After removal, clean the valve heads, faces, and stems with a power wire brush. Then, carefully inspect each valve for defects such as warped head, excessive corrosion, or worn stem end. Replace valves found to be in bad condition. A normal valve and valves in bad condition are shown in the accompanying illustrations.

Normal: Even after long hours of operation a valve can be reconditioned and reused if the face and margin are in good shape. If a valve is worn to where the margin is less than 1/32" do not reuse it. The valve shown was in operation for almost 1000 hours under controlled test conditions.

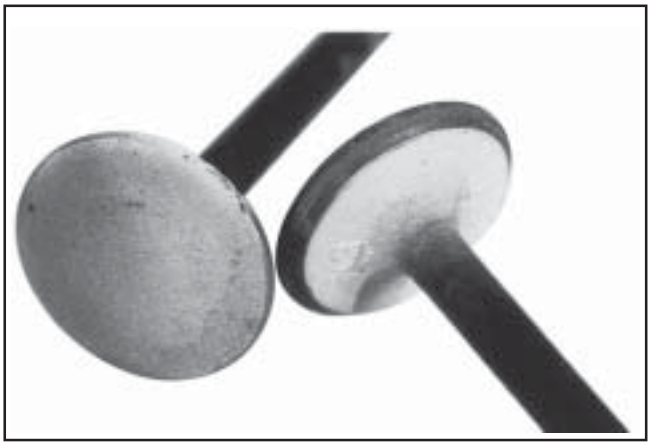
Leakage: A poor grind on face or seat of valve will allow leakage resulting in a burned valve on one side only.

Bad Condition: The valve depicted here should be replaced. Note the warped head; margin damaged and too narrow. These conditions could be attributed to excessive hours or a combination of poor operating conditions.

Gum: Gum deposits usually result from using stale gasoline. Gum is a prevalent cause of valve sticking. The cure is to ream the valve guides and clean or replace the valves, depending on their condition.



Stem Corrosion: Moisture in fuel or from condensation are the most common causes of valve stem corrosion. Condensation occurs from improper preservation during storage and when engine is repeatedly stopped before it has a chance to reach normal operating temperatures. Replace corroded valves.



Excessive Combustion Temperatures: The white deposits seen here indicate very high combustion temperatures, usually due to a lean fuel mixture.

Coking: Coking is normal on intake valves and is not harmful. If the seat is good, the valve could be reused after cleaning.

Overheating: An exhaust valve subject to overheating will have a dark discoloration in the area above the valve guide. Worn guides and faulty valve springs may cause this condition. Also check for clogged air intake, and blocked fins when this condition is noted.

Valve Guides

If a valve guide is worn beyond specifications, it will not guide the valve in a straight line. This may result in burnt valve faces or seats, loss of compression, and excessive oil consumption.

To check valve guide-to-valve stem clearance, thoroughly clean the valve guide and, using a split-ball gauge, measure the inside diameter. Then, using an outside micrometer, measure the diameter of the valve stem at several points on the stem where it moves in the valve guide. Use the largest stem diameter to calculate the clearance. If the **intake** clearance exceeds **0.038/0.076 mm (0.0015/0.003 in.)** or the **exhaust** clearance exceeds **0.050/0.088 mm (0.0020/0.0035 in.)**, determine whether the valve stem or guide is responsible for the excessive clearance.

Maximum (I.D.) wear on the **intake** valve guide is **7.134 mm (0.2809 in.)** while **7.159 mm (0.2819 in.)** is the maximum allowed on the exhaust guide. The guides are not removable but can be reamed **0.25 mm (0.010 in.)** oversize. Valves with **0.25 mm** oversize stems must then be used.

If the guides are within limits but the valve stems are worn beyond limits, replace with new valves.

Valve Seat Inserts

Hardened steel alloy intake and exhaust valve seat inserts are press fitted into the cylinder head. The inserts are not replaceable on the engines but can be reconditioned if not too badly pitted or distorted. If cracked or badly warped, the cylinder head should be replaced.

Recondition the valve seat inserts following the instructions provided with the valve seat cutter being used. A typical cutter is shown in Figure 10-7. The final cut should be made with an 89° cutter as specified for the valve seat angle in Figure 10-6. With the proper 45° valve face angle as specified in Figure 10-6 and the valve seat cut properly (44.5° as measured from centerline when cut 89°) this would result in the desired 0.5° (1.0° full cut) interference angle where the maximum pressure occurs on the outside diameters of valve face and seat.

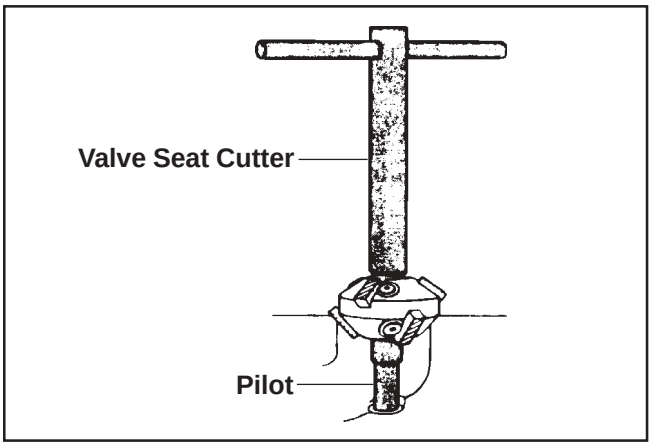


Figure 10-7. Typical Valve Seat Cutter.

Lapping Valves

Reground or new valves must be lapped in, to provide fit. Use a hand valve grinder with suction cup for final lapping. Lightly coat valve face with "fine" grade of grinding compound, then rotate valve on seat with grinder. Continue grinding until smooth surface is obtained on seat and on valve face. Thoroughly clean cylinder head in soap and hot water to remove all traces of grinding compound. After drying cylinder head, apply a light coating of engine oil to the seats to prevent rusting.

Intake Valve Stem Seal

These engines use valve stem seals on the intake valves. Always use a new seal when valves are removed from cylinder head. The seals should also be replaced if deteriorated or damaged in any way. **Never reuse an old seal.**

Pistons and Rings

Inspection

Scuffing and scoring of pistons and cylinder walls occurs when internal temperatures approach the welding point of the piston. Temperatures high enough to do this are created by friction, which is usually attributed to improper lubrication, and/or overheating of the engine.

Normally, very little wear takes place in the piston boss-piston pin area. If the original piston and connecting rod can be reused after new rings are installed, the original pin can also be reused but new piston pin retainers are required. The piston pin is included as part of the piston assembly. If the pin bosses or pin are worn or damaged, a new piston assembly is required.

Ring failure is usually indicated by excessive oil consumption and blue exhaust smoke. When rings fail, oil is allowed to enter the combustion chamber where it is burned along with the fuel. High oil consumption can also occur when the piston ring end gap is incorrect, because the ring cannot properly conform to the cylinder wall. Oil control is also lost when ring gaps are not staggered during installation.

When cylinder temperatures get too high, lacquer and varnish collect on pistons causing rings to stick which results in rapid wear. A worn ring usually takes on a shiny or bright appearance.

Scratches on rings and pistons are caused by abrasive material such as carbon, dirt, or pieces of hard metal. Detonation damage occurs when a portion of the fuel charge ignites spontaneously from heat and pressure shortly after ignition. This creates two flame fronts which meet and explode to create extreme hammering pressures on a specific area of the piston. Detonation generally occurs from using low octane fuels.

Preignition or ignition of the fuel charge before the timed spark can cause damage similar to detonation. Preignition damage is often more severe than detonation damage. Preignition is caused by a hot spot in the combustion chamber from sources such as glowing carbon deposits, improperly seated valve, or wrong spark plug. See Figure 10-8 for some common types of piston and ring damage.

Stuck, Broken Rings

Abrasive Scratched Rings

Overheated or Deteriorated Oil

Scored Piston and Rings

Figure 10-8. Common Types of Piston and Ring Damage.

Replacement pistons are available in STD bore size, **0.08 mm (0.003 in.), 0.25 mm (0.010 in.), and 0.50 mm (0.20 in.)** oversizes. Replacement pistons include new piston ring sets and new piston pins. The ring sets are also available separately. Always use new piston rings when installing pistons. **Never reuse old rings.**

Some important points to remember when servicing piston rings:

1. The cylinder bore must be deglazed before service ring sets are used.

2. If the cylinder bore does not need reboring and if the old piston is within wear limits and free of score or scuff marks, the old piston may be reused.

3. Remove old rings and clean up grooves. **Never reuse old rings.**

4. Before installing the new rings on the piston, place the top two rings, each in turn, in its running area in cylinder bore and check end gap (see Figure 10-9) against the specifications listed in Section 1.

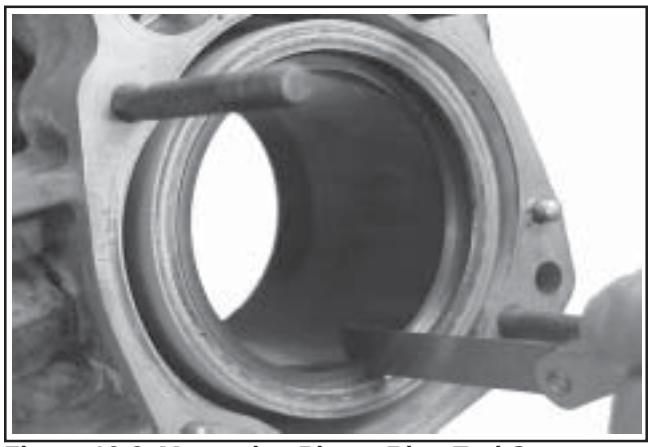


Figure 10-9. Measuring Piston Ring End Gap.

5. After installing the new top and middle compression rings on piston, check piston-to-ring side clearance. Compare findings against the specifications listed below. If clearance is greater than specified, a new piston **must** be used. Refer to Figure 10-10.

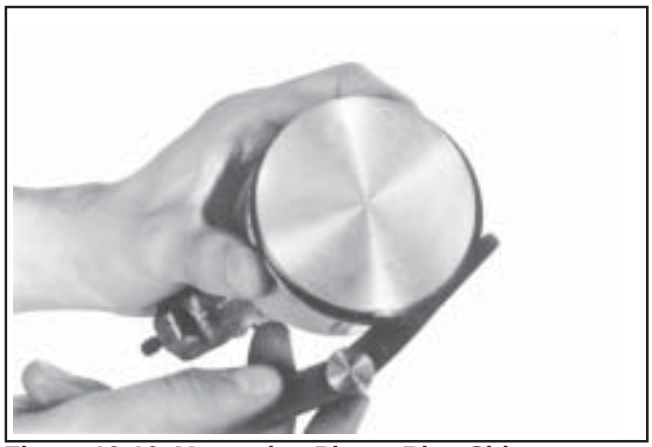


Figure 10-10. Measuring Piston Ring Side Clearance.

Install Piston Rings

To install piston rings, proceed as follows:

NOTE: Rings must be installed correctly. Ring installation instructions are usually included with new ring sets. Follow instructions carefully. Use a piston ring expander to install rings (see Figure 10-11). Install the bottom (oil control) ring first and the top compression ring last. Refer to Figure 10-12.

Figure 10-11. Installing Piston Rings With Expander.

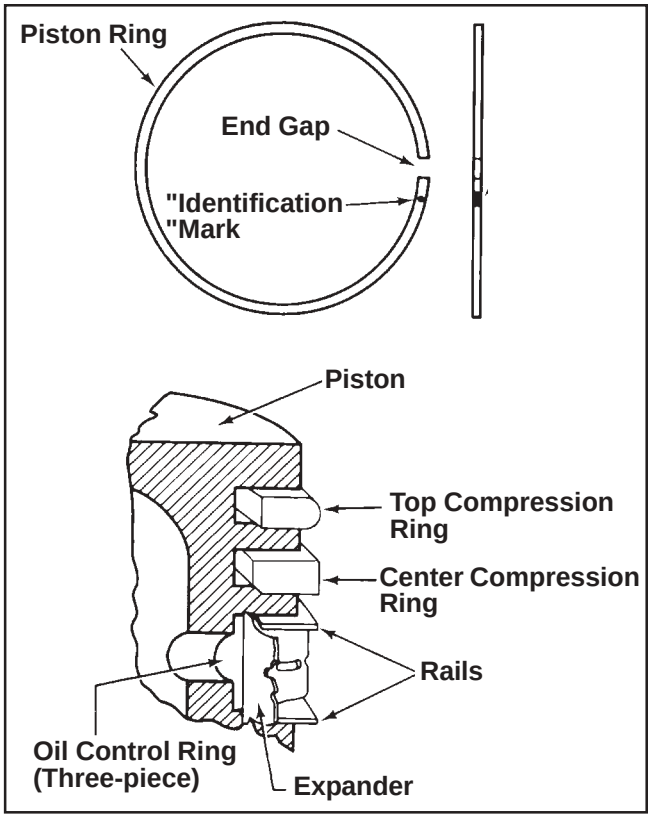


Figure 10-12. Piston Ring Installation.

1. Oil Control Ring (Bottom Groove): Install the expander and then the rails. Make sure the ends of expander are not overlapped.

2. Second Compression Ring (Center Groove): Install the center ring using a piston ring installation tool. Make sure the "pip" mark is up.

3. First Compression Ring (Top Groove): Install the top ring using a piston ring installation tool. If no "identification" mark exists to denote "up" the ring is symmetrical and may be installed with either side up.

Connecting Rods

Offset Stepped-Cap Connecting Rods are used in all these engines.

Inspection and Service

Check bearing area (big end) for excessive wear, score marks, running and side clearances (refer to Section 1, ''Specifications, Tolerances, and Special Torque Values''). Replace rod and cap if scored or excessively worn.

Service replacement connecting rods are available in STD crankpin size and **0.25 mm (0.010 in.)** undersize. The undersized rod is marked US 0.25 mm with purple ink on the rod shank. Always refer to the appropriate parts information to ensure that correct replacements are used.

Closure Plate Assembly

Inspection

Inspect the oil seal in the closure plate and remove it if it is worn or damaged. The new oil seal is installed after the closure plate is assembled to the crankcase. See ''Install Closure Plate Oil Seal'' in Section 11.

Inspect main bearing (if so equipped) for wear or damage (refer to Section 1, ''Specifications, Tolerances, and Special Torque Values''). Replace closure plate assembly if required.

Governor Assembly (Internal)

Inspection

Inspect the governor gear teeth. Replace the gear if it is worn, chipped, or if any teeth are missing.

Inspect the governor weights. They should move freely in the governor gear.

Disassembly

The governor gear **must** be replaced once it is removed from the closure plate.

NOTE: The governor gear is held onto the shaft by small molded tabs in the gear. When the gear is removed from the shaft, these tabs are destroyed and the gear must be replaced. Therefore, remove the gear **only if** absolutely necessary.

1. Remove the regulating pin and governor gear assembly. See Figure 10-13.

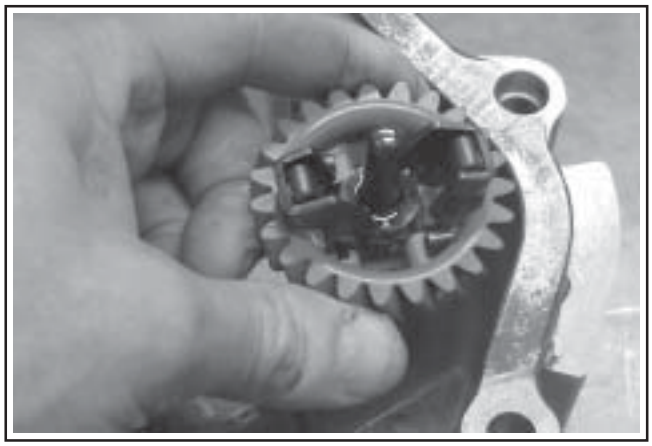


Figure 10-13. Removing Governor Gear.

2. Remove the locking tab thrust washer located under the governor assembly.

3. Carefully inspect the governor gear shaft and replace it only if it is damaged. After pulling damaged shaft, press or lightly tap replacement shaft into closure plate to depth shown in Figure 10-14.

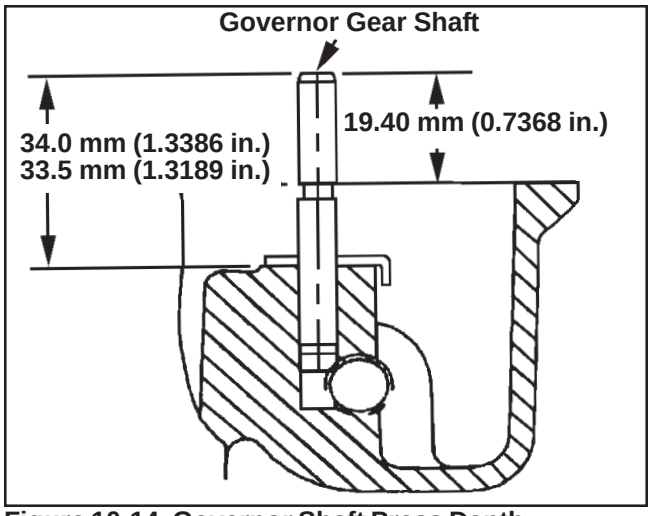


Figure 10-14. Governor Shaft Press Depth.

Reassembly

1. Install the locking tab thrust washer on the governor gear shaft with the tab down.

2. Position the regulating pin to the governor gear/flyweight assembly and slide both onto the governor shaft.

Oil Pump Assembly

Disassembly

1. Remove the two hex flange screws.

2. Remove the oil pump assembly from the closure plate.

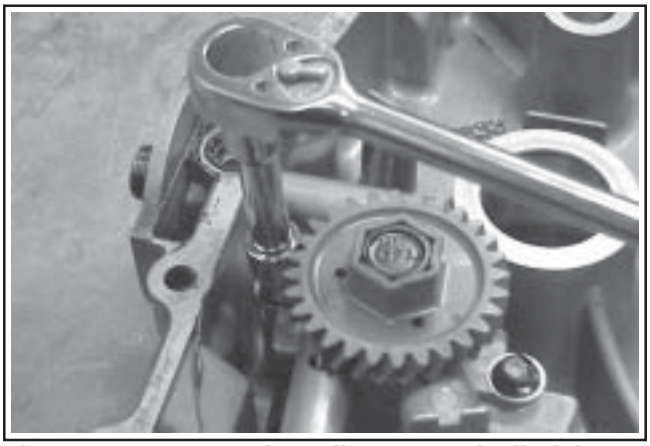


Figure 10-15. Removing Oil Pump and Oil Pickup.

3. Remove the oil pump rotor.

4. Remove the oil pickup by unhooking the locking clip, and pulling it free from the oil pump body.

5. If the relief valve is a one-piece style, staked to the oil pump housing (See Figure 10-16) removal should not be attempted, nor is internal servicing possible. If a problem with the relief valve is encountered, the oil pump should be replaced.

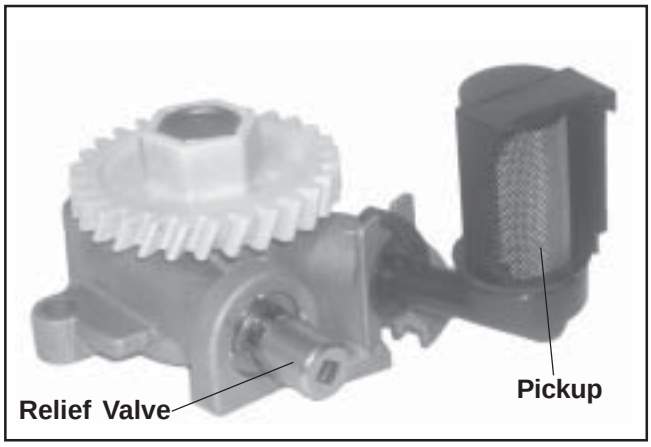


Figure 10-16. Oil Pump, Oil Pickup, and One-Piece Relief Valve.

Inspection

Inspect the oil pump housing, gear, and rotors for nicks, burrs, wear, or any visible damage. If any parts are worn or damaged, replace oil pump.

Reassembly

1. Install the oil pickup to the oil pump body. Lubricate the O-Ring with oil and make sure it remains in the groove as the pickup is being installed.

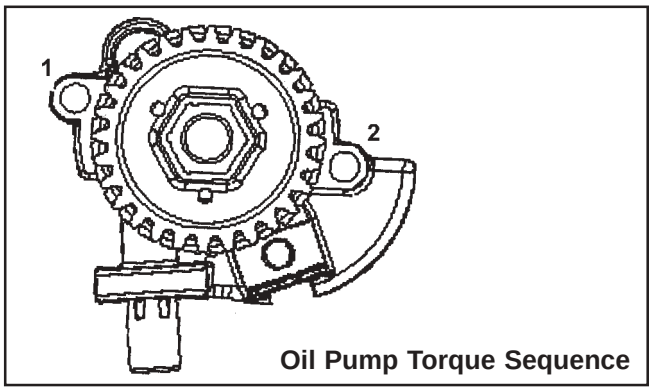
2. Install the rotor.

3. Install the oil pump body to the closure plate and secure with the two hex flange screws. Torque the hex flange screws as follows:

   a. Install fastener into location No. 1 and lightly tighten to position pump.

   b. Install fastener into location No. 2 and fully torque to the recommended value.

   c. Torque fastener in location No. 1 to the recommended value.



Oil Pump Torque Sequence

First Time Installation: 10.7 N·m (95 in. lb.)
All Reinstallations: 6.7 N·m (60 in. lb.)

4. After torquing, rotate the gear and check for freedom of movement. Make sure there is no binding. If binding occurs, loosen the screws, reposition the pump, retorque the hex flange screws and recheck the movement.

Governor Cross Shaft Oil Seal

If the governor cross shaft seal is damaged and/or leaks, replace it using the following procedure.

Remove the oil seal from the crankcase and replace it with a new one. Install the new seal to depth shown in Figure 10-17.

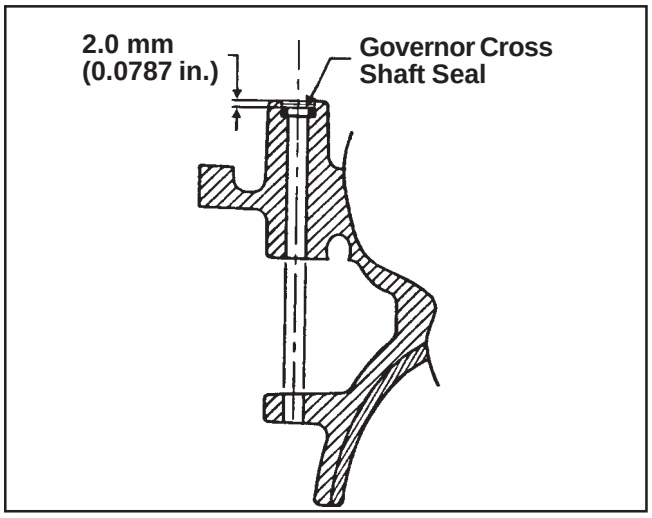


Figure 10-17. Governor Cross Shaft Oil Seal Position.

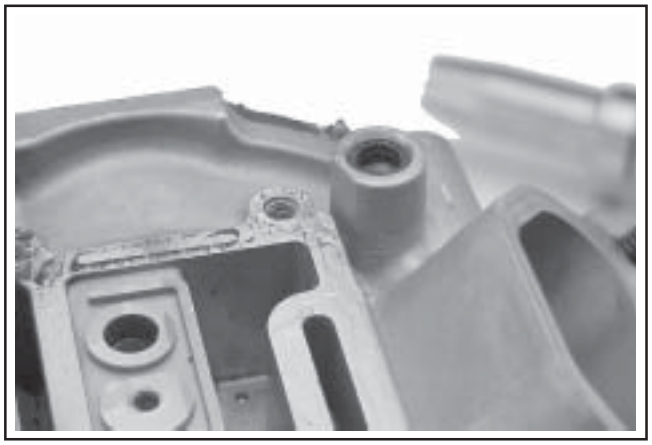


Figure 10-18. Governor Shaft Seal Installed.

Water Pump

The water/coolant pump consists of a sealed impeller assembly, which includes the outer cover and a cogged drive pulley. When the pump is mounted to the crankcase, the impeller fits into a cast recess, and the cover seals against an O-Ring outside the perimeter of the recess. See Figure 10-19.

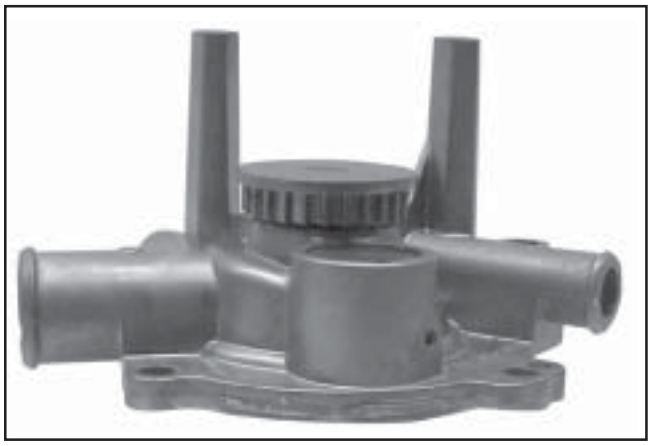


Figure 10-19. Water Pump.

The impeller assembly is not serviceable, but it should be inspected for wear or damage.

1. Inspect the impeller to make sure the blades are in good condition and free of any cracks, nicks, or damage.

2. The impeller shaft should rotate smoothly, without binding or wobbling, and there should be no sign that coolant has leaked past the shaft to the outer surface of the cover.

3. Check that the drive pulley is not cracked or damaged in any way.

If your inspection causes you to doubt its reliability, the water pump assembly should be replaced. Always use a new O-Ring whenever the water pump is removed. **Do not** reuse the old O-Ring or try to use RTV in its place.

Cooling Fan and Drive

The cooling fan assembly consists of a fan attached to a v-pulley and bearing carrier (hub), rotating on a dual ball-bearing fan shaft (arbor). The assembly is mounted with a bracket to the intake manifold and driven via a split pulley off the flywheel. See Figure 10-20.

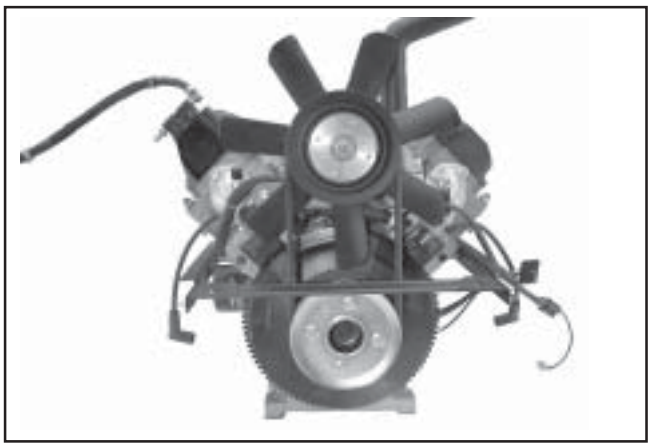


Figure 10-20. Front View of Engine Cooling System.

Inspect the components carefully for signs of wear or damage.

1. Inspect the fan to make sure the blades are in good condition and free of any cracks, nicks, or damage. The area around the fan mounting holes must also be free of any cracks or damage.

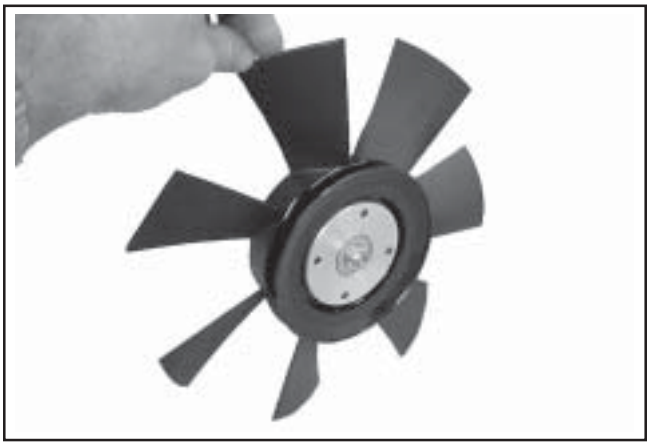


Figure 10-21. Fan Assembly (Pulley Side).

2. The fan and hub assembly, when mounted to the center arbor shaft, must rotate smoothly without noticeable bearing play, wobble, or binding.

3. Check the v-belt for excessive wear, cracking or damage. If proper belt tension cannot be obtained, or the condition of the belt is suspect; replace it with Kohler Part No. **66 203 02-S**. **Do not** use a substitute belt.

Section 11
Reassembly

General

NOTE: Make sure the engine is assembled using all specified torque values, tightening sequences and clearances. Failure to observe specifications could cause severe engine wear or damage. Always use new gaskets. Apply a small amount of oil to the threads of critical fasteners before assembly, unless a Sealant or Loctite® is specified or preapplied.

Make sure all traces of any cleaner are removed before the engine is assembled and placed into operation. Even small amounts of these cleaners can quickly break down the lubricating properties of engine oil.

Check the closure plate, crankcase, cylinder heads, and valve covers to be certain that all old sealing material has been removed. Use gasket remover, lacquer thinner, or paint remover to remove any remaining traces. Clean the surfaces with isopropyl alcohol, acetone, lacquer thinner, or electrical contact cleaner.

Typical Reassembly Sequence

The following sequence is suggested for complete engine reassembly. This procedure assumes that all components are new or have been reconditioned, and all component subassembly work has been completed. The sequence may vary to accommodate options or special equipment. Detailed procedures follow:

1. Install flywheel end oil seal and camshaft seal.
2. Install governor cross shaft.
3. Install crankshaft.
4. Install connecting rods with pistons and rings.
5. Install camshaft.
6. Check camshaft end play.
7. Install closure plate assembly.
8. Install cylinder studs.
9. Install reed and breather cover assembly.
10. Install hydraulic lifters.
11. Assemble and install cylinder heads.
12. Install push rods and rocker arms.
13. Install valve covers.
14. Install coolant drain plugs.
15. Install water pump, drive belt, and transfer tube assembly.
16. Install intake manifold assembly.
17. Install stator assembly.
18. Install starter adapter.
19. Install flywheel.
20. Install ignition modules.
21. Install spark plugs.
22. Install starter assembly.
23. Install carburetor and adapter.
24. Install external governor controls and main control bracket.
25. Install lower crankshaft pulley, pulley adapter, and cooling fan assembly.
26. Install air cleaner assembly.
27. Install radiator assembly.
28. Install flywheel cover, rectifier-regulator and mounting plate.
29. Install muffler.
30. Install oil filter and fill crankcase with oil.
31. Install coolant.
32. Connect battery cables and spark plug leads.

Install Flywheel End Oil Seal and Camshaft Oil Seal

1. Check to make sure that there are no nicks or burrs in the crankshaft and camshaft seal bores of the crankcase.

2. Apply a light coat of engine oil to the outside diameter of the flywheel end oil seal.

3. Install the oil seal into the crankcase using a seal driver. Make sure the oil seal is installed straight and true in bore, until the tool bottoms against the crankcase. See Figure 11-1.

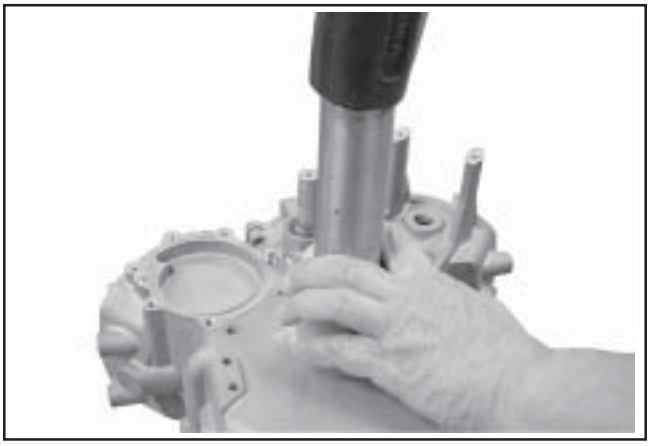


Figure 11-1. Installing Crankshaft PTO Side Seal Using Tool.

4. Apply a light coat of engine oil to the outside diameter of the camshaft oil seal.

5. Install the camshaft oil seal to a depth of **1.0-1.5 mm (0.039-0.059 in.)** below the top of the seal bore. See Figure 11-2. Do not bottom the seal in the bore or the oil passage may be obstructed.

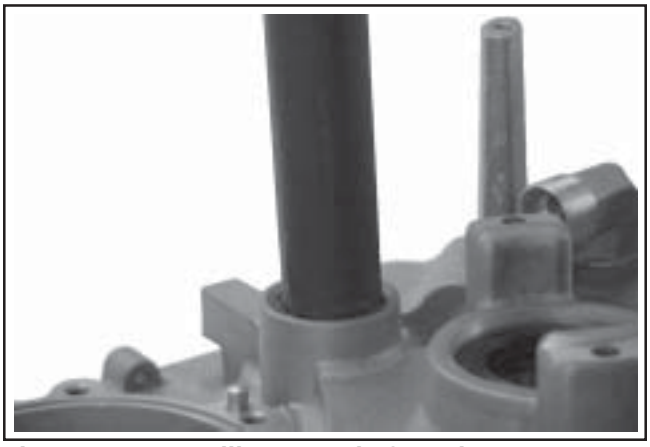


Figure 11-2. Installing Camshaft Seal.

Install Governor Cross Shaft

1. Lubricate the governor cross shaft bearing surfaces in the crankcase with engine oil. Apply a small amount of grease to the lips of the oil seal.

2. Slide the small lower washer onto the governor cross shaft and install the cross shaft from the inside of the crankcase. See Figure 11-3.

Figure 11-3. Installing Governor Shaft.

3. Install the nylon washer onto the governor cross shaft, then start the push-on retaining ring. Hold the governor shaft up in position, then place a **0.25 mm (0.010 in.)** feeler gauge on top of the nylon washer, and push the retaining ring down the shaft to secure. Remove the feeler gauge, which will have established the proper end play. See Figure 11-4.

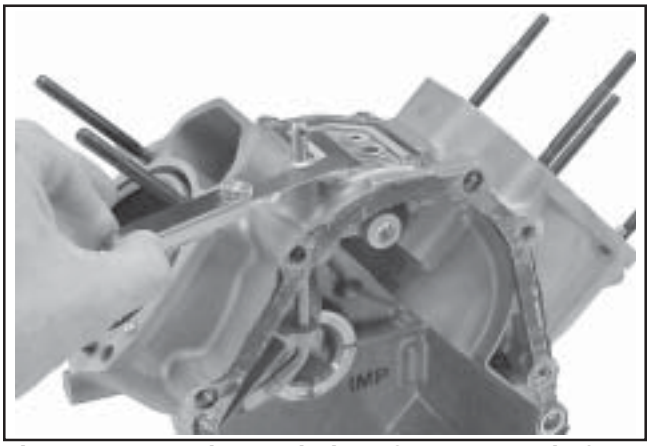


Figure 11-4. Setting End Play of Governor Shaft.

4. Pivot the governor cross shaft so the bottom end faces the #1 side cylinder.

Install Crankshaft

1. Lightly lubricate the lips of crankshaft seal with grease.

   NOTE: Apply cellophane tape over the crankshaft keyway to prevent cutting the oil seal during installation.

2. Carefully slide the flywheel end of the crankshaft into the crankcase through the oil seal. See Figure 11-5.

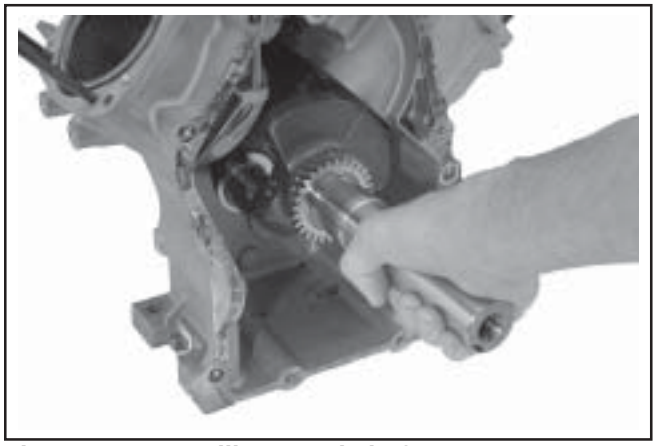


Figure 11-5. Installing Crankshaft.

Install Connecting Rods with Pistons and Rings

NOTE: The cylinders are numbered on the crankcase. Make sure to install the piston, connecting rod and end cap into its appropriate cylinder bore, as previously marked at time of disassembly. Do not mix the end caps and connecting rods.

NOTE: Proper orientation of the piston/connecting rod assemblies inside the engine is extremely important. Improper orientation can cause extensive wear or damage.

1. Stagger the piston rings in the grooves until the end gaps are 120° apart. The oil ring rails should also be staggered.

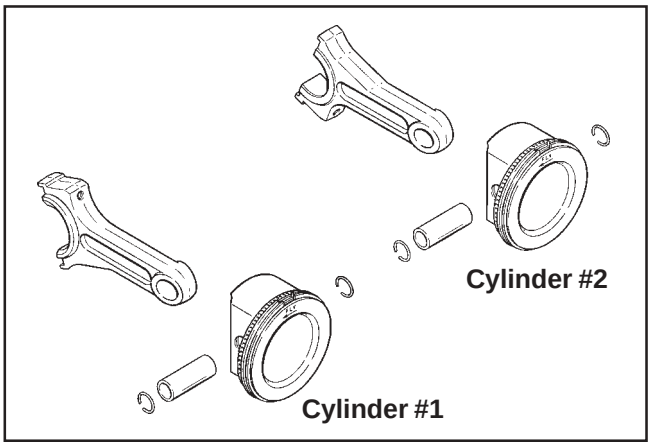


Figure 11-6. Piston, Connecting Rod and End Cap Detail.

2. Lubricate the cylinder bore, piston, and piston rings with engine oil. Compress the rings of the #1 piston using a piston ring compressor.

3. Lubricate the crankshaft journals and connecting rod bearing surfaces with engine oil.

4. Make sure the "FLY" stamping on the pistons is facing towards the flywheel side of the engine. Use a hammer with rubber grip and gently tap the piston down into cylinder as shown in Figure 11-7. Be careful that oil ring rails do not spring free, between the bottom of the ring compressor and the top of the cylinder.

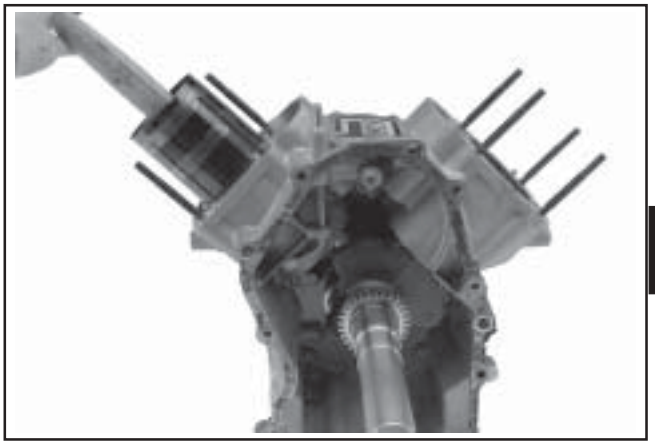


Figure 11-7. Installing #1 Piston.

5. Guide the lower end of connecting rod and rotate the crankshaft to join the two. Install the rod cap to the connecting rod using the two hex flange screws and torque in increments to **11.3 N·m (100 in. lb.)**. See Figures 11-8 and 11-9.

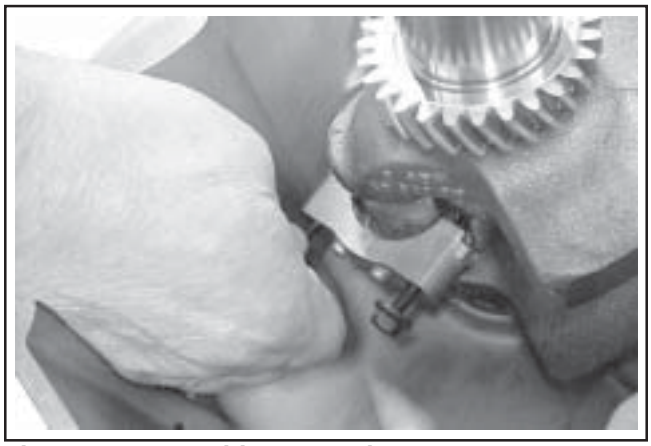


Figure 11-8. Attaching #1 Rod Cap.

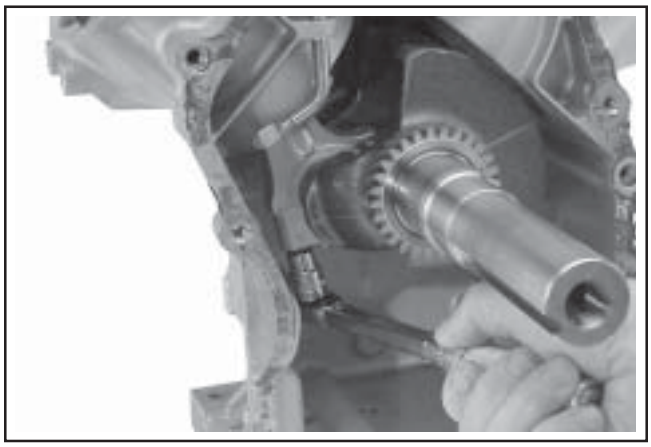


Figure 11-9. Torquing #1 Rod Cap.

NOTE: Make sure to align the chamfer of the connecting rod with the chamfer of its mating end cap. When installed, the flat faces of the connecting rods should face each other. The faces with the raised rib should be toward the outside.

6. Repeat the above procedure for the other connecting rod and piston assembly.

Install Camshaft

1. Inspect the edges of the camshaft keyway, make sure they are not nicked or burred. Use a seal protector (11/16") to prevent damaging the seal lips, or dislodging inner spring when the camshaft is installed. Cellophane tape over the keyway is also recommended. See Figure 11-10.

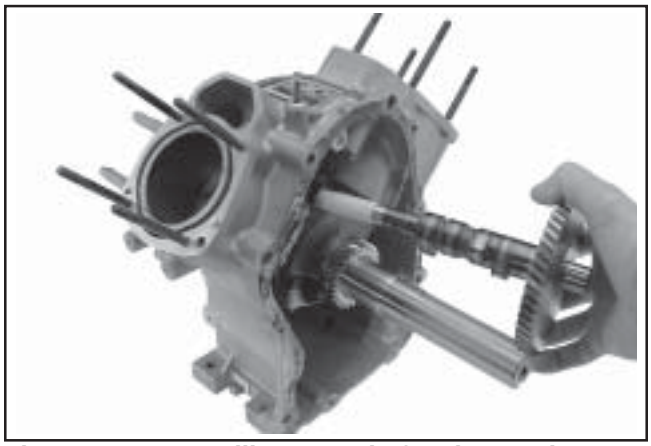


Figure 11-10. Installing Camshaft using Seal Protector.

2. Lubricate the camshaft bearing surfaces of the crankcase and camshaft with engine oil. Apply a small amount of grease to the lips of the oil seal.

3. Rotate the crankshaft and position the timing mark of the crankshaft gear at the 12 o'clock position.

4. Turn the governor cross shaft clockwise until the lower end of shaft contacts the crankcase (#1 side). Make sure the cross shaft remains in this position while installing the camshaft.

5. Slide the camshaft into the bearing surface of the crankcase, positioning the timing mark of the camshaft gear at the 6 o'clock position. Make sure that the camshaft gear and crankshaft gear mesh, and the timing marks are aligned. See Figure 11-11.

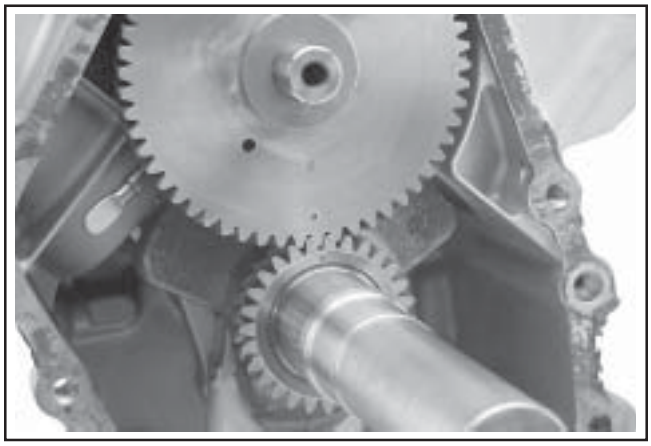


Figure 11-11. Timing Marks Aligned.

Checking/Setting Camshaft End Play

1. Install the shim removed during disassembly onto the camshaft.

2. Position the end play tool on the camshaft.

3. Apply pressure on the end play checking tool (pushing the camshaft toward the crankshaft). Use a feeler gauge to measure the end play between the shim and the end play tool. See Figure 11-12. The camshaft end play should be **0.076/0.127 mm (0.003/0.005 in.)**.

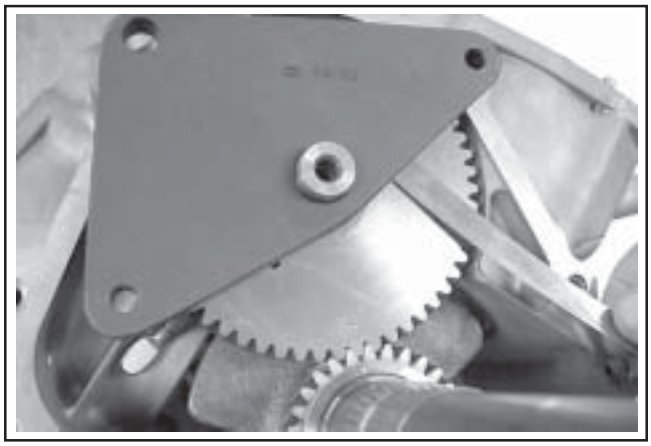


Figure 11-12. Checking Camshaft End Play with Tool.

4. If the camshaft end play is not within the specified range, remove the original shim and reinstall the end play tool. Use a feeler gauge to determine the clearance between the camshaft and the tool. Subtract **0.100 mm** (**0.004 in**) from the measured clearance to obtain the required shim thickness. Refer to the table below and install the shim that matches the calculated thickness. See Figure 11-13. Repeat steps 1-3 to verify that the correct end play exists.

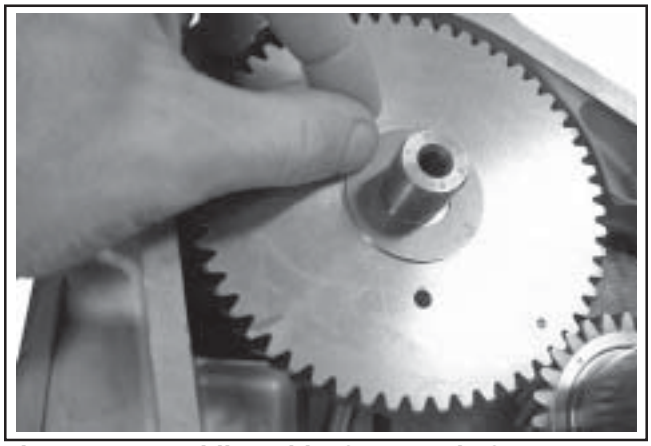


Figure 11-13. Adding Shim for Camshaft.

Camshaft Shims

White:	0.69215/0.73025 mm (0.02725/0.02875 in.)
Blue:	0.74295/0.78105 mm (0.02925/0.03075 in.)
Red:	0.79375/0.83185 mm (0.03125/0.03275 in.)
Yellow:	0.84455/0.88265 mm (0.03325/0.03475 in.)
Green:	0.89535/0.99345 mm (0.03525/0.03675 in.)
Gray:	0.94615/0.98425 mm (0.03725/0.03875 in.)
Black:	0.99695/1.03505 mm (0.03925/0.04075 in.)

Oil Pump Assembly

The oil pump is mounted to the inside of the closure plate. If service was required, and the oil pump was removed, refer to the assembly procedures under "Oil Pump Assembly" in Section 10.

Governor Assembly

The governor assembly is located inside the closure plate. If service was required, and the governor was removed, refer to the assembly procedures under "Governor Assembly" in Section 10.

Thrust Bearing, Washer and Shim

Some specifications use a thrust bearing, thrust washer, and shim to control the end play of the crankshaft. See Figure 11-14. If these items were noted during disassembly, make sure they were reinstalled in the proper sequence, as illustrated. A different procedure must be followed to check and adjust crankshaft end play on these models.

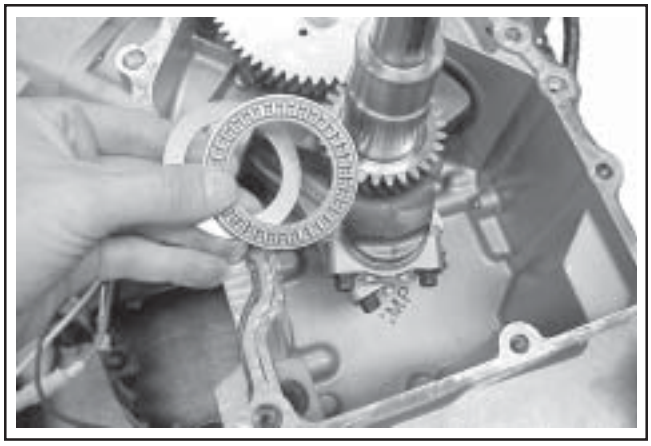


Figure 11-14. Thrust Bearing, Washer and Shim used on Some Models.

The race for the thrust bearing presses loosely into the closure plate. If it is not already installed, push it into the crankshaft bore inside the closure plate. Pack the thrust bearing with heavy grease and stick the bearing into the race. Wipe some grease on the face of the thrust washer and stick it onto the thrust bearing. Wipe some grease on the face of the original shim and stick it onto the thrust washer.

Install the closure plate onto the crankcase **without** applying RTV sealant and secure it with only two or three of the fasteners at this time. Use a dial indicator to check the crankshaft end play. End play should be **0.070/0.590 mm (0.0027/0.0232 in.)**. Shims are available in the five color-coded thicknesses listed below if adjustment is needed.

Crankshaft End Play Shims

BLUE 0.48-0.52 mm (0.050 mm Nominal) **(0.019 in.)**

BLACK 0.667-0.705 mm (0.686 mm Nominal) **(0.27 in.)**

GREEN 0.8366-0.9127 mm (0.8750 mm Nominal) **(0.34 in.)**

YELLOW 1.9652-1.1414 mm (1.1033 mm Nominal) **(0.043 in.)**

RED 1.2938-1.3700 mm (1.3319 mm Nominal) **(0.052 in.)**

Remove the closure plate. If end play requires adjustment, remove the original shim and install the appropriate size replacement.

Install Closure Plate Oil Seal

1. Check to make sure that there are no nicks or burrs in the crankshaft bore of the closure plate.

2. Apply a light coat of engine oil to the outside diameter of the oil seal.

3. Drive the oil seal into the closure plate using a seal driver. Make sure the oil seal is installed straight and true in bore to depth shown in Figure 11-15.

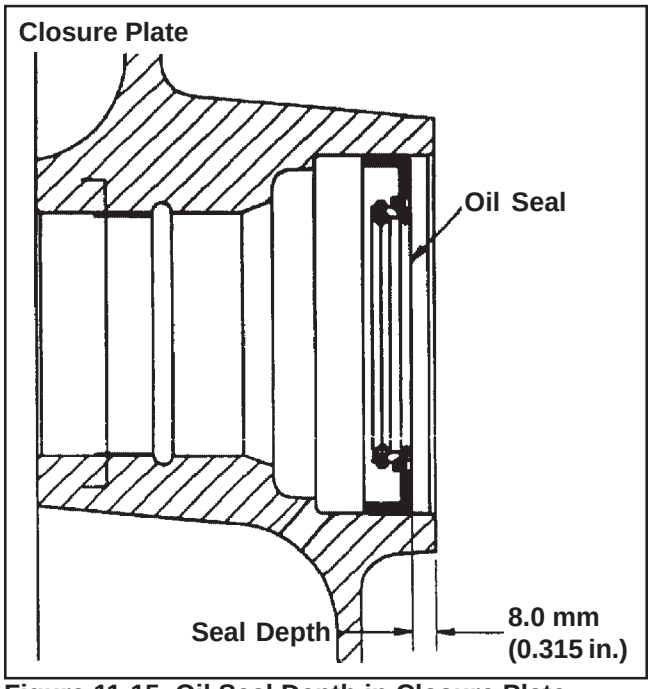


Figure 11-15. Oil Seal Depth in Closure Plate.

Install Closure Plate Assembly

RTV silicone sealant is used as a gasket between the closure plate and the crankcase. Refer to Section 2, of this manual for a listing of approved sealants. Always use fresh sealant. Using outdated sealant can result in leakage.

1. Be sure the sealing surfaces have been cleaned and prepared as described at the beginning of Section 10 or in Service Bulletin 252.

2. Check to make sure that there are no nicks or burrs on the sealing surfaces of the closure plate or crankcase.

3. Apply a 1/16" bead of sealant to the sealing surface of the closure plate. See Figure 11-16 for sealant pattern.

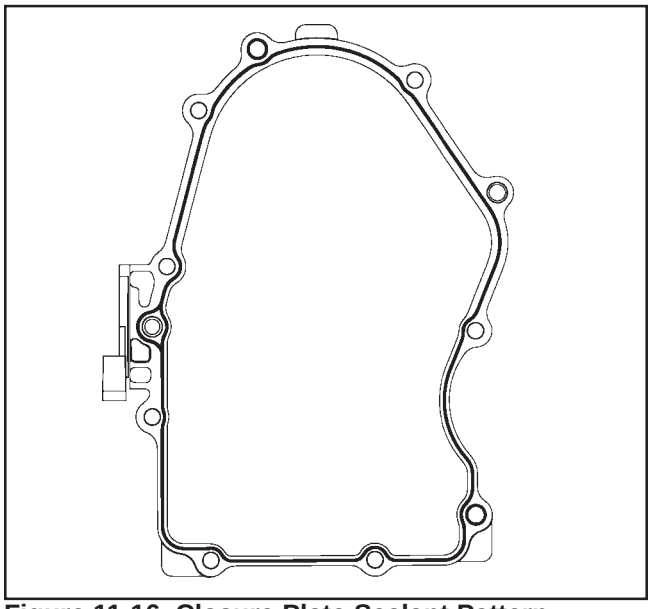


Figure 11-16. Closure Plate Sealant Pattern.

4. Make sure end of governor cross shaft is lying against the bottom of cylinder #1 inside of the crankcase. See Figure 11-17.

5. If alignment pins were removed previously, install them in their respective locations in the crankcase. See Figure 11-17.

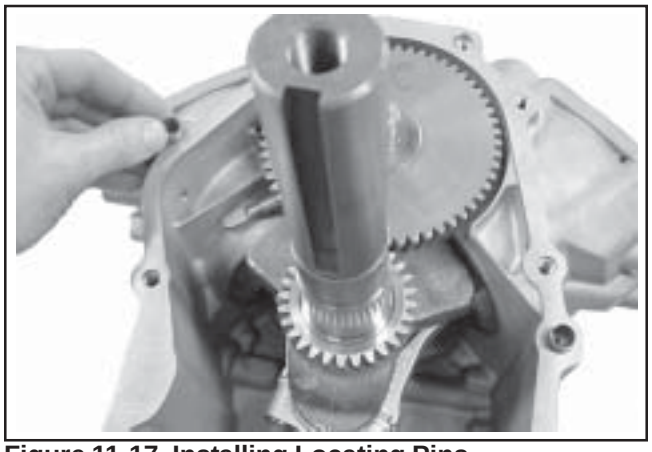


Figure 11-17. Installing Locating Pins.

6. Install the closure plate on the crankcase. Carefully seat the camshaft and crankshaft into their mating bearings. Rotate the crankshaft to help engage the oil pump and governor gear meshes. See Figure 11-18.

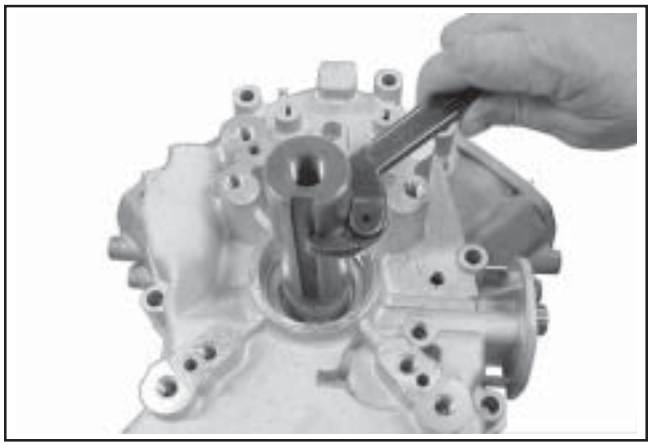


Figure 11-18. Rotating Crankshaft to Seat Closure Plate.

7. Install the ten hex flange screws securing the closure plate to the crankcase. If a thick flat washer was used on one of the screws, install it in the #10 location. Install the silver plated (ground) screw in its original location (normally the #4 or #6 location). Torque the fasteners, in the torque sequence shown in Figure 11-19 to **24.4 N·m (216 in. lb.)**.

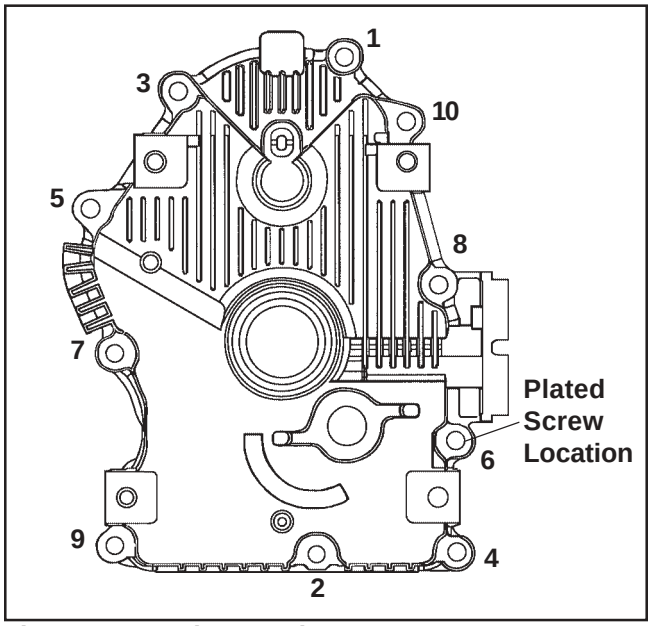


Figure 11-19. Closure Plate Torque Sequence.

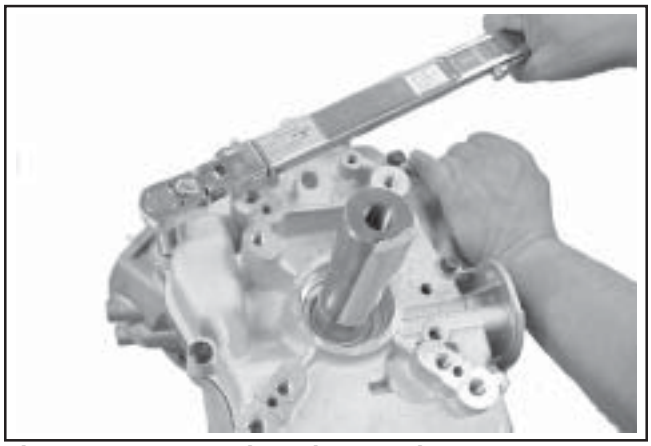


Figure 11-20. Torquing Closure Plate Screws.

Install Cylinder Studs

NOTE: Do not reinstall or attempt to reuse any cylinder studs that have been removed. Discard any removed stud(s) and replace with new.

If any of the cylinder studs were removed, install new stud(s) as follows:

1. Identify the longer threaded end of the new stud containing the Loctite® Dri-Loc®. See Figure 11-21.

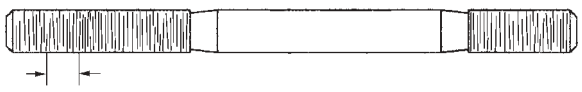


Figure 11-21. New Cylinder Stud.

2. Tighten two hex nuts together on the shorter threaded section, with the identification mark on the end.

3. Thread the end of the stud with the Loctite® into the crankcase, until an exposed stud height of **75 mm (2 61/64 in.)** is obtained. The end with the dash mark must be **out**. See Figure 11-22. When threading in the studs, use a steady tightening motion, without interruption, until the proper height is obtained. The frictional heat from the engaging threads may otherwise cause the locking compound to set up prematurely. Remove the two nuts.

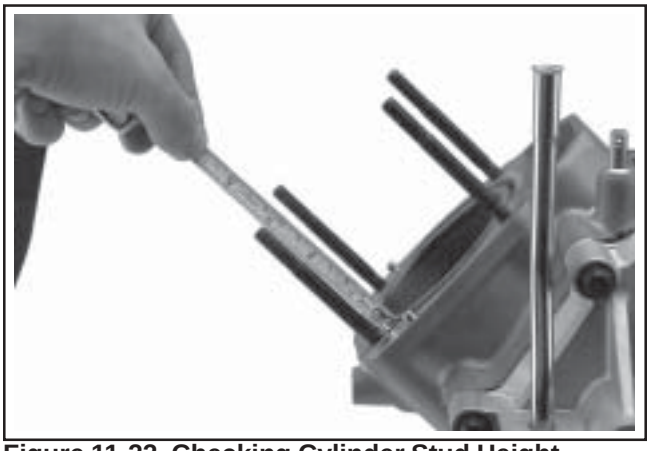


Figure 11-22. Checking Cylinder Stud Height.

4. Repeat steps 1-3 for each of the studs.

Install Reed and Breather Cover Assembly

1. Make sure sealing surfaces of the crankcase and breather cover are clean and free of all old gasket material. Clean with an aerosol type gasket remover or cleaning solvent. DO NOT scrape the surfaces as this can result in leakage.

2. Check to make sure there are no nicks or burrs on the sealing surfaces.

3. Install the breather reed and breather reed retainer onto the crankcase and secure with the hex flange screw. Hold the assembly in line when tightening. Torque the screw to **3.9 N·m (35 in. lb.)**. See Figure 11-23.

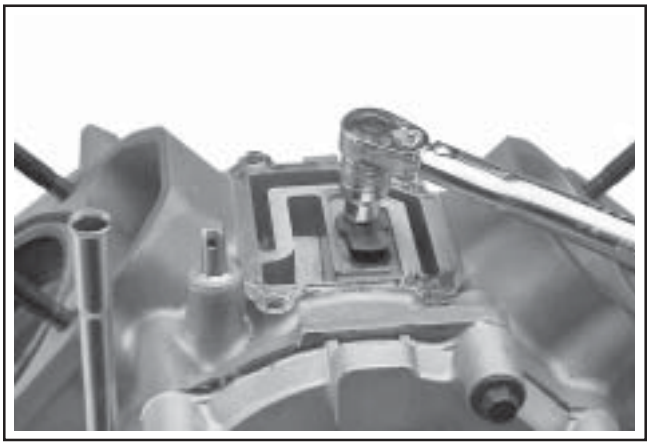


Figure 11-23. Installing Breather Reed.

4. Install the breather filter into the cavity in the crankcase. See Figure 11-24.

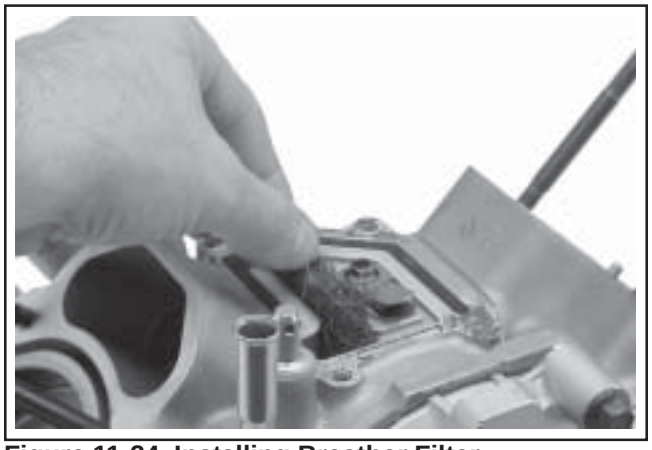


Figure 11-24. Installing Breather Filter.

5. Carefully install the breather cover gasket and breather cover onto the crankcase. See Figure 11-25.

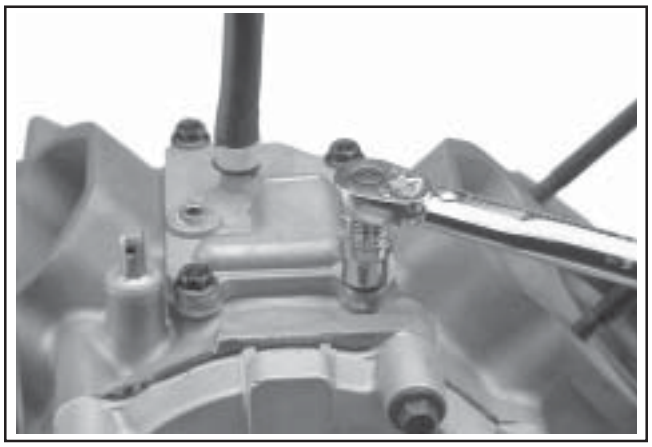


Figure 11-25. Installing and Torquing Breather Cover/Screws.

6. Install and torque the four breather cover hex flange screws to **7.3 N·m (65 in. lb.)** in the sequence shown in Figure 11-26.

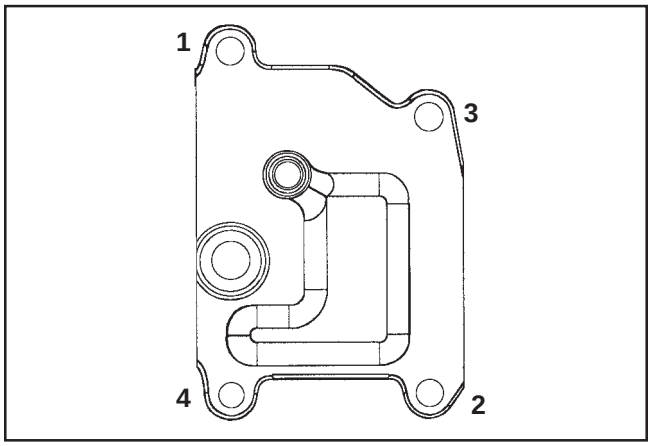


Figure 11-26. Breather Cover Fastener Torque Sequence.

7. Install the pipe plug or Oil Sentry™ switch (as equipped), into the tapped breather port if removed earlier. Apply **pipe sealant with Teflon®** (Loctite® 59241 or equivalent) to the threads. Torque to **4.5 N·m (40 in. lb.)**. If Oil Sentry™ switch is mounted to the side of crankcase, torque the switch to **12.4 N·m (110 in. lb.).**

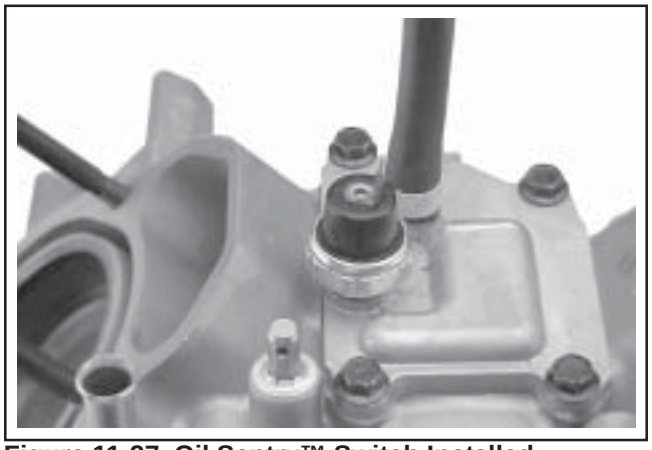


Figure 11-27. Oil Sentry™ Switch Installed.

8. If the vacuum fitting was removed from the crankcase (vacuum fuel pump), apply **pipe sealant with Teflon®** (Loctite® 59241 or equivalent) to the threads of the fitting and install. With the crankcase upright, the fitting must point to the 1:30 position. See Figure 11-28.

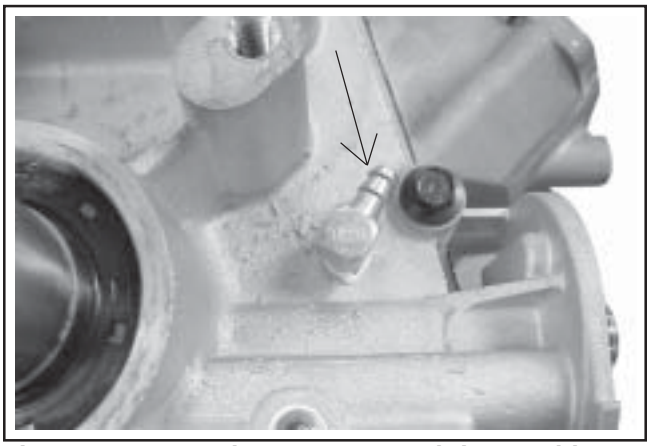


Figure 11-28. Crankcase Vacuum Fitting Position.

Install Hydraulic Lifters

1. Lubricate the lifters and lifter bores in the crankcase with engine oil.

   NOTE: Hydraulic lifters should always be installed in the same position as before disassembly.

2. Install the lifters into their respective lifter bores according to location and cylinder number marked during assembly. See Figure 11-29.

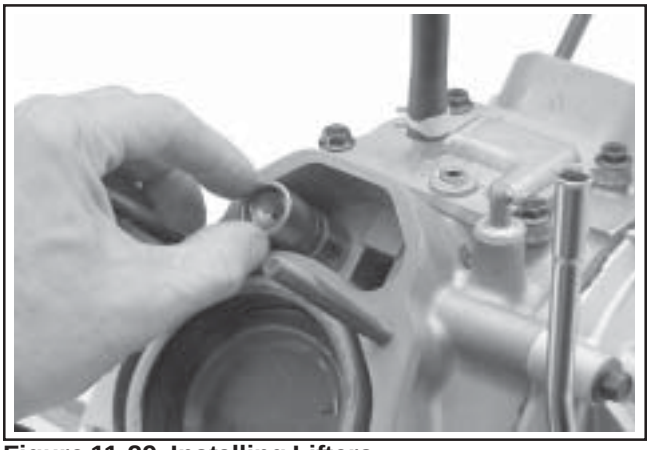


Figure 11-29. Installing Lifters.

Valve Stem Seals

NOTE: These engines use valve stem seals on the intake and exhaust valves. Always use a new seal before valves are installed in the cylinder head. Also, replace the seals if they are deteriorated or damaged in any way. Never reuse an old seal. See Figure 11-30.

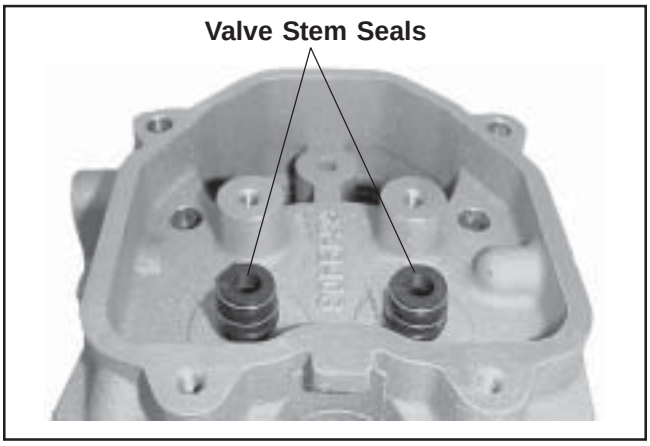


Figure 11-30. Cylinder Head Showing Intake Seal.

Assemble Cylinder Heads

Prior to installation, lubricate all components with engine oil, paying particular attention to the lip of the valve stem seal, valve stems and valve guides. Install the following items in the order listed below using a valve spring compressor. See Figures 11-31 and 11-32.

- Valve stem seals
- Intake and exhaust valves
- Valve spring caps
- Valve springs
- Valve spring retainers
- Valve spring keepers

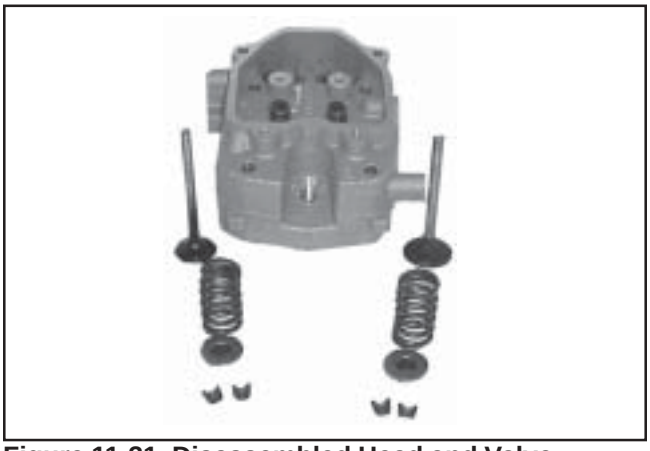


Figure 11-31. Disassembled Head and Valve Components.

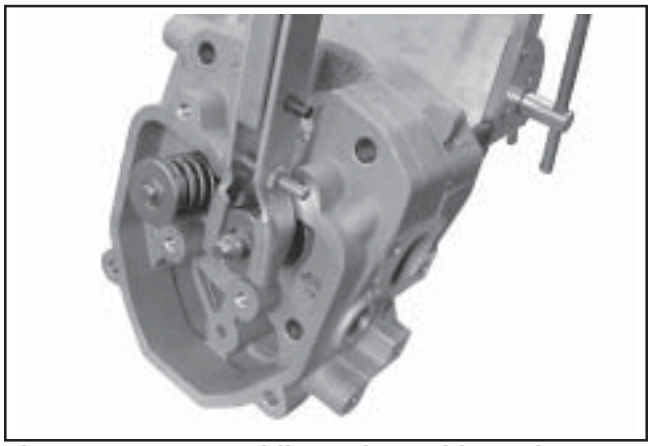


Figure 11-32. Assembling Valves with a Valve Spring Compressor.

Install Cylinder Heads

1. Check to make sure there are no nicks or burrs on the sealing surfaces of the cylinder head or crankcase.

2. Rotate the crankshaft to position the piston in cylinder #1 to top dead center (TDC) on the compression stroke.

3. Install a new cylinder head gasket. See Figure 11-33.

   NOTE: Match numbers embossed on cylinder heads and crankcase.

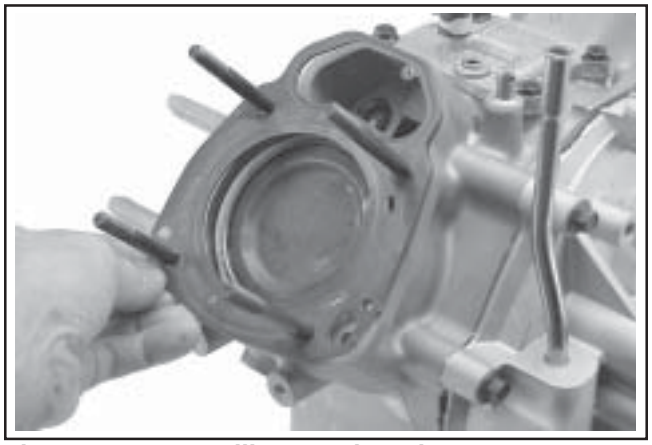


Figure 11-33. Installing Head Gasket.

4. Install the #1 cylinder head onto the #1 side mounting studs. See Figure 11-34.

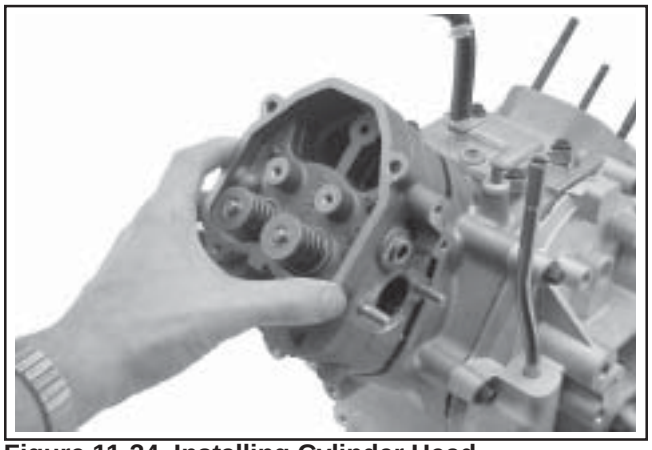


Figure 11-34. Installing Cylinder Head.

5. Install a plain washer onto each stud and secure with a hex flange nut.

6. Torque the four hex flange nuts in two steps, first to **16.9 N·m (150 in. lb.)** and then to **33.9 N·m (300 in. lb.)**, using the torque sequence shown in Figure 11-36.

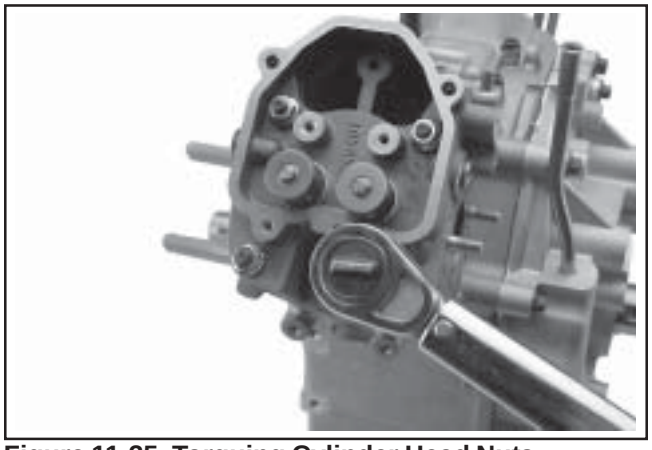


Figure 11-35. Torquing Cylinder Head Nuts.

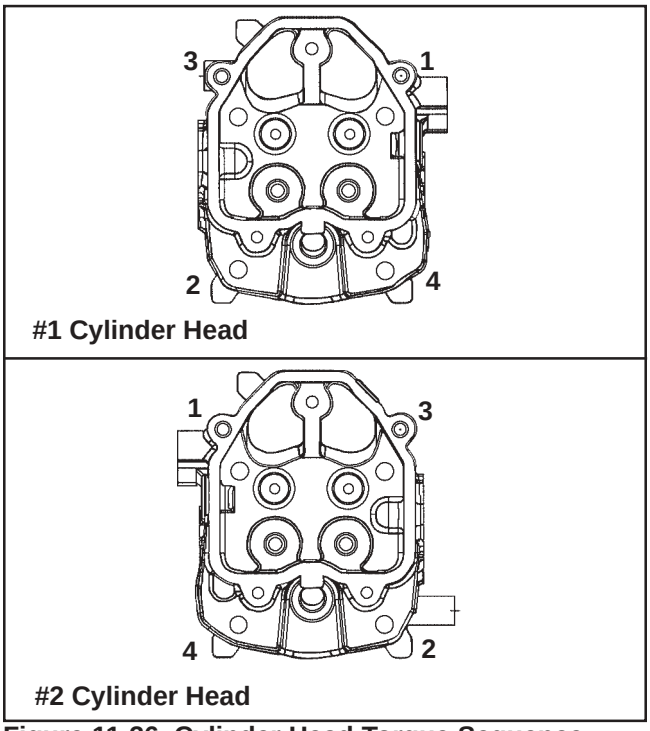


Figure 11-36. Cylinder Head Torque Sequence.

7. Repeat the installation procedure for the #2 side cylinder head.

Install Push Rods and Rocker Arms

1. Note the mark or tag identifying the push rod as either intake or exhaust for cylinder #1. Lightly apply engine oil or grease to the ends of push rods and install. Make sure that each push rod ball seats in its respective hydraulic lifter socket. See Figure 11-37.

   NOTE: Push rods must always be installed in the same position as before disassembly.

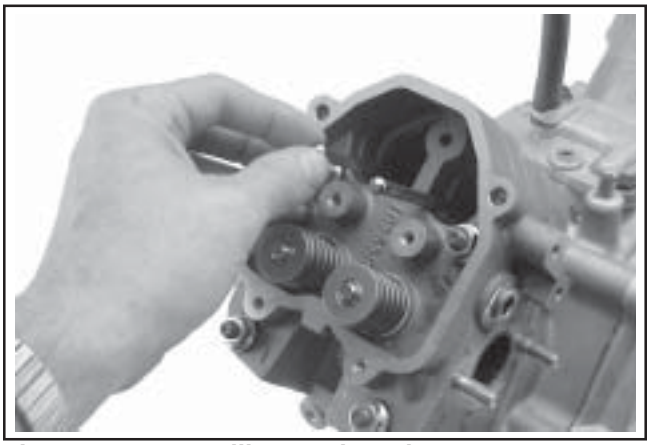


Figure 11-37. Installing Push Rods.

2. Apply grease to the contacting surfaces of the rocker arms and rocker arm pivots. Install the rocker arms and rocker arm pivots on the cylinder head.

3. Install two **new** hex flange rocker arm screws with Dri-Loc® thread locking compound on the threads. Torque the screws to **11.3 N·m (100 in. lb.)**. When tightening, use a steady motion, without interruption, until the proper torque is achieved. The frictional heat from the engaging threads may otherwise cause the locking compound to set prematurely. If new screws are not available, apply Loctite® No. 242 to the bottom four or five threads. Then install and torque the screws to **11.3 N·m (100 in. lb.)**. See Figure 11-38.

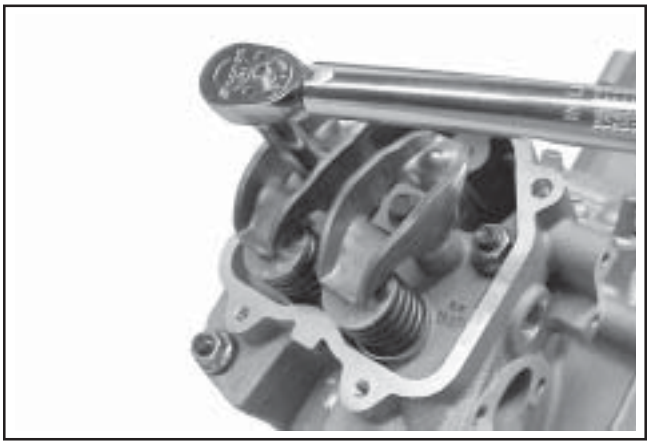


Figure 11-38. Installing and Torquing Rocker Arm Mounting Screws.

4. Use a spanner wrench or rocker arm lifting tool (see Section 2) to lift the rocker arms and position the push rods underneath.

5. Rotate the crankshaft so the piston in cylinder #2 is at top dead center on the compression stroke, and repeat the steps for the remaining cylinder. Do not interchange parts from one cylinder head with parts from the other cylinder head.

6. Rotate the crankshaft to check for free operation of the valve train. Check the clearance between valve spring coils at full lift. The minimum allowable clearance is **0.25 mm (0.010 in)**.

Install Valve Covers

1. Make sure the sealing surfaces of cylinder heads and valve covers are clean and free of all old gasket material.

2. Install new valve cover gaskets onto the valve covers. See Figure 11-39.

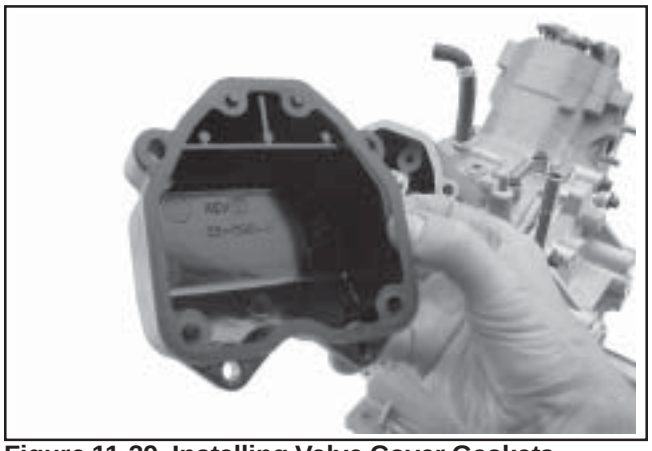


Figure 11-39. Installing Valve Cover Gaskets.

3. Install the valve covers with gaskets in their original locations.

4. Install the lower two mounting screws in each cover, and finger tighten only. Upper screws will be installed later. See Figure 11-40.

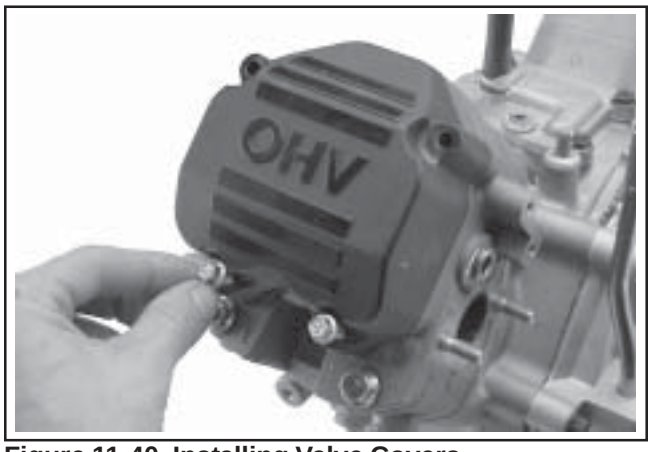


Figure 11-40. Installing Valve Covers.

Reinstall Coolant Drain Plugs

1. Reinstall the brass coolant drain plugs in the sides of the crankcase, (and also the cylinder head plugs, if removed during head servicing). Apply **pipe sealant with Teflon®** (Loctite® 59241 or equivalent) to the threads and reinstall the plugs. Torque the plugs to **13.5 N·m (120 in. lb.)**. See Figure 11-41.

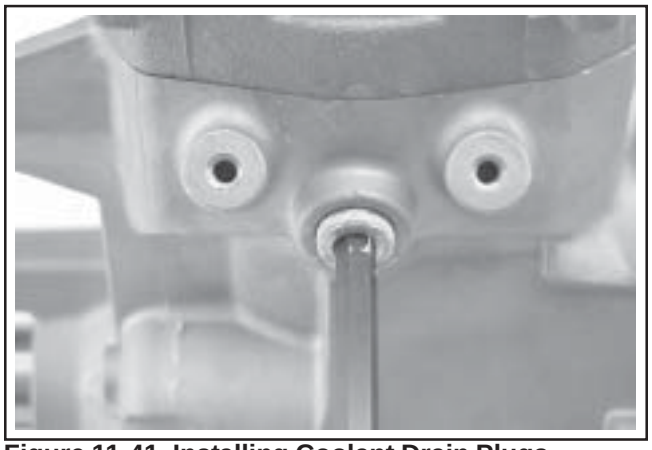


Figure 11-41. Installing Coolant Drain Plugs.

Install Water Pump, Drive Belt, and Transfer Tube Assembly

1. Remove the seal protector and/or protective tape (if used) from over the keyway and make sure the end of the camshaft is clean and free of any nicks or damage. Install and fully seat the key, squarely into the keyway. Be careful not to contact the camshaft seal. Test fit the cam pulley onto the shaft and key; it must slide on **without force or restriction**. Remove the pulley. See Figures 11-42 and 11-43.

   NOTE: A mark or dot of paint applied to the top, of the pulley, indicating the keyway location, will make installation easier.

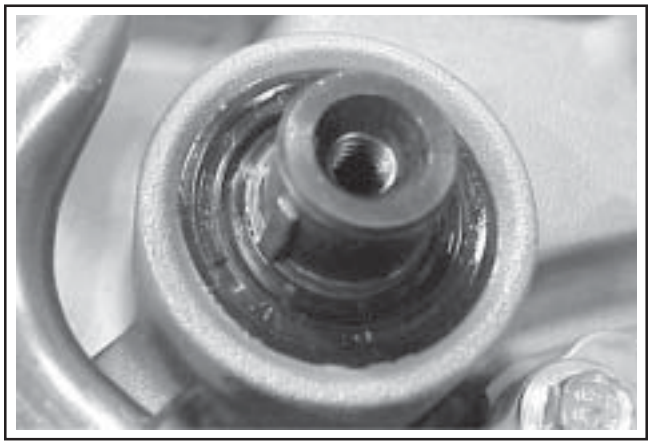


Figure 11-42. Installing Camshaft Key into Keyway.

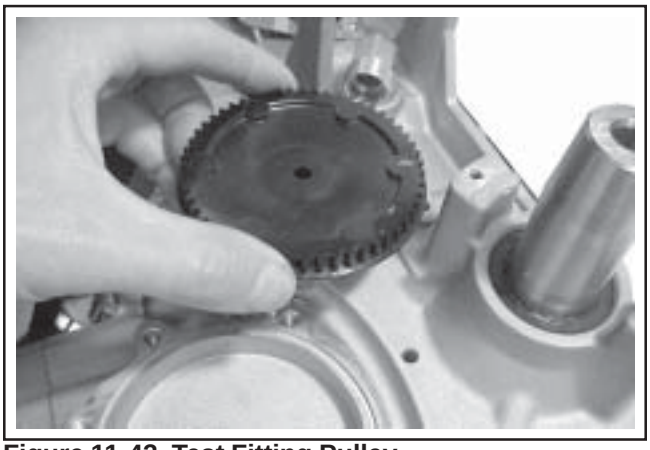


Figure 11-43. Test Fitting Pulley.

2. If the water pump by-pass hose fitting was removed previously, apply **pipe sealant with Teflon®** (Loctite® 59241 or equivalent) on the threads and tighten it into pump. Orient the fitting so the outlet points in the 11 o'clock position as shown in Figure 11-44.

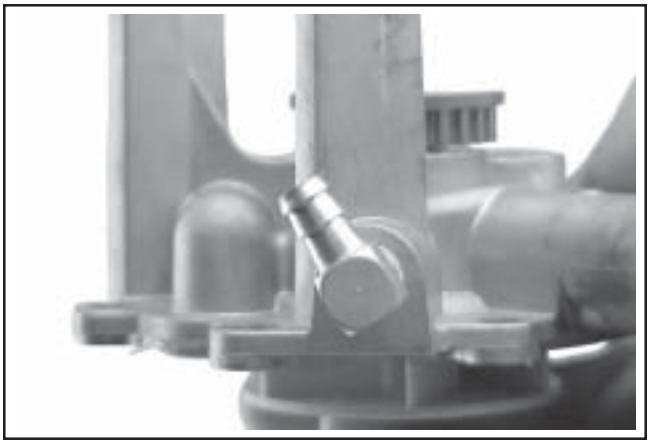


Figure 11-44. Water Pump By-pass Fitting.

3. Check the sealing surfaces of the water pump and crankcase. They must be clean and free of any nicks or damage.

4. Apply a small amount of grease in several locations to hold the new water pump O-Ring in place. Install a **new** O-Ring in the groove of crankcase. See Figures 11-45 and 11-46. **Do not** use RTV sealant in place of the O-Ring, or attempt to reinstall a used O-Ring.

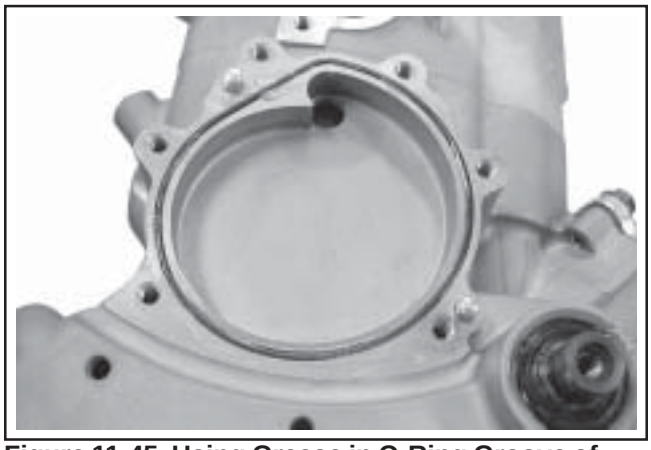


Figure 11-45. Using Grease in O-Ring Groove of Pump Cavity.

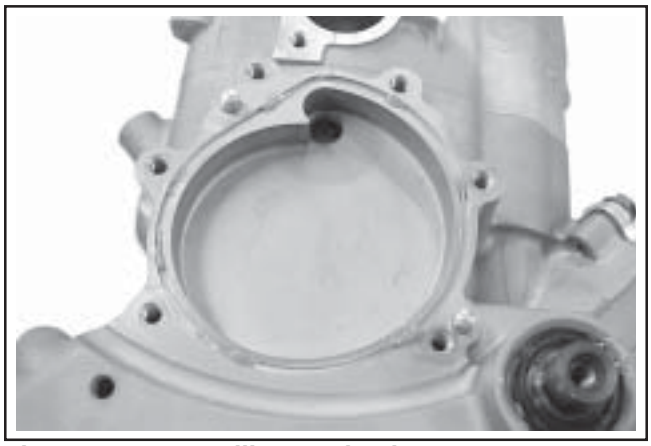


Figure 11-46. Installing O-Ring in Groove.

5. Apply rubber lubricant to the inner surfaces of the short hose section. Assemble the hose to the outlet of the water pump and secure with the larger diameter clamp. Orient the clamp so the tangs extend out in the 3 to 4 o'clock position. See Figures 11-47 and 11-48.

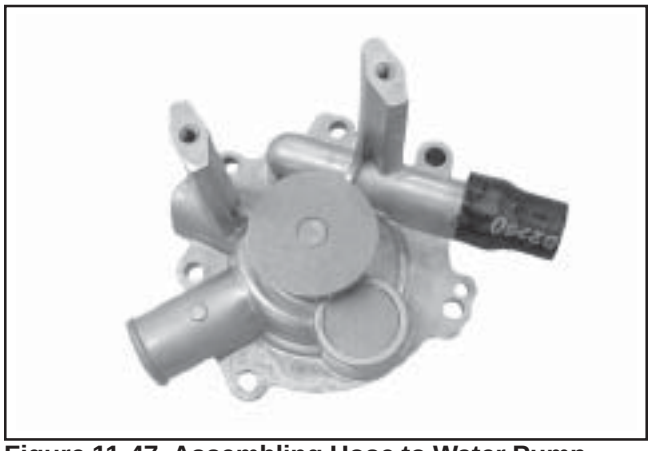


Figure 11-47. Assembling Hose to Water Pump.

6. Slide the smaller diameter clamp onto the extruded end of the formed metal tube and insert this end of the tube into the hose section. Position the tube so its formed offset leads down and away from outlet, perpendicular to the pump. Install the clamp onto the hose and position the tangs of the clamp parallel to those of the first clamp. See Figure 11-48.

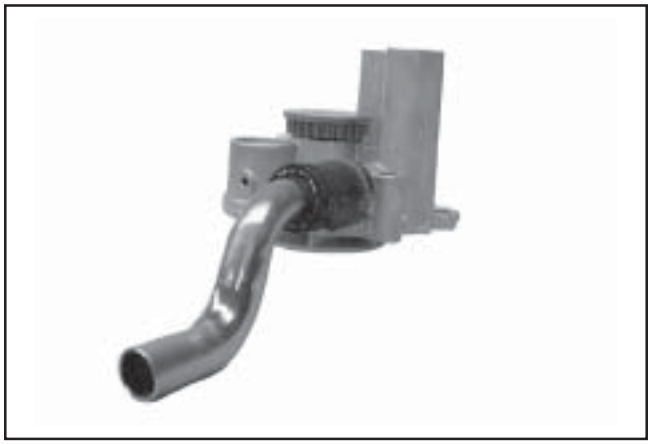


Figure 11-48. Transfer Tube, Hose and Water Pump as Assembly.

7. Holding the pump assembly elevated, assemble the transfer tube to the 90° fitting in the crankcase as follows:

   a. For new/first time tube installation:

   1. Place a new ferrule/compression ring in the 90° fitting of the crankcase and loosely install the hex cap onto the threads of the fitting.

   2. Insert the plain end of the transfer tube through the hex and compression ring.

   b. For reinstallation of an existing tube:

   1. Insert the end of transfer tube, with the compression ring, into the 90° fitting of the crankcase.

   2. Start the hex cap onto the threaded section of the fitting.

   IMPORTANT: The 90° fitting in the crankcase is installed and sealed at the factory, in a specific position. Special tools and procedures are involved. **Do not** loosen, remove, or alter the mounting position of this fitting at any time.

8. Carefully push the water pump down from the raised position, thereby rotating the tube 90° within the end connections. Guide the pump into position over the O-Ring; aligning the two mounting pins and five screw hole locations. See Figure 11-49. Start all of the screws, with the longer screw nearest the pump outlet. Torque the screws to **9.9 N·m (88 in. lb.)** in the sequence shown in Figure 11-51.

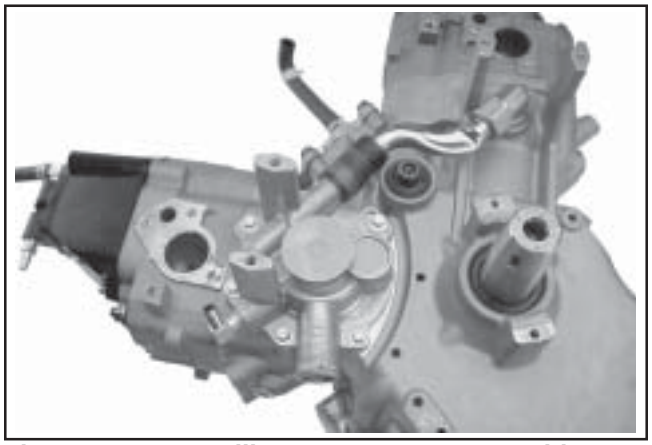


Figure 11-49. Installing Water Pump Assembly.

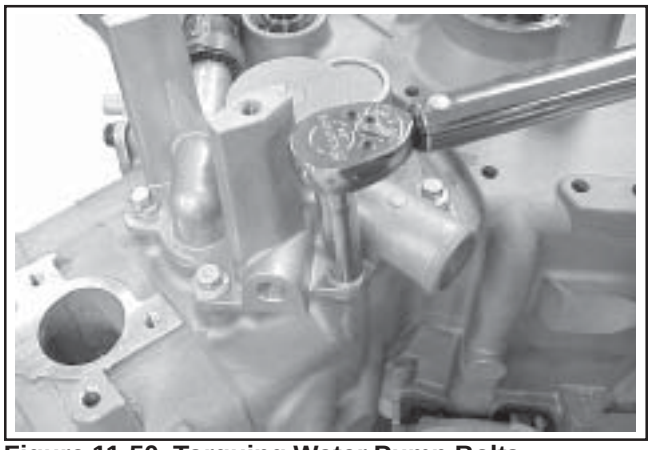


Figure 11-50. Torquing Water Pump Bolts.

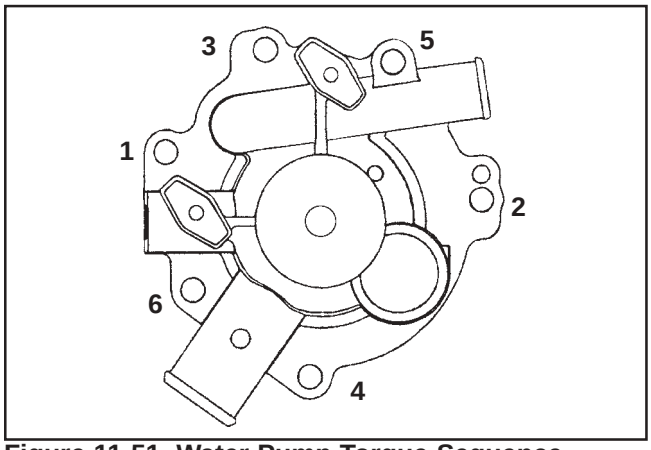


Figure 11-51. Water Pump Torque Sequence.

NOTE: When installation is complete, the tangs of the two hose clamps should face outward, away from the flywheel and slightly down. See Figure 11-52.

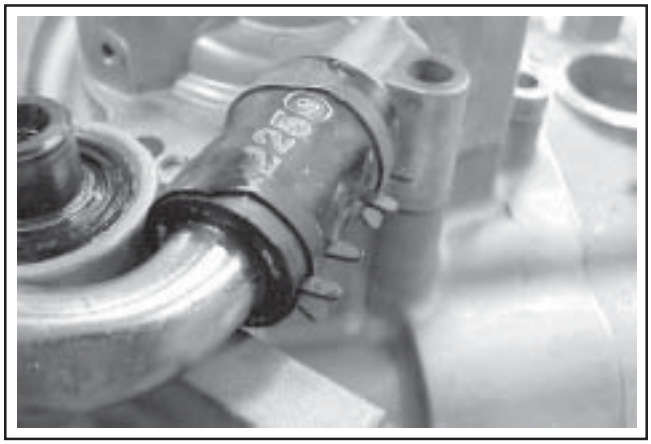


Figure 11-52. Transfer Tube Hose Clamp(s) Detail.

9. Push down on the formed tube and hold in this position to prevent it from pivoting upward when tightening the hex cap. Torque the hex cap to **22.6 N·m (200 in. lb.)**, to secure the joint connection. Support the fitting with a wrench while torquing, if possible, to prevent applying unnecessary pressure on fitting and joint. See Figure 11-53. Check that the formed tube and hose section have not been pulled up.

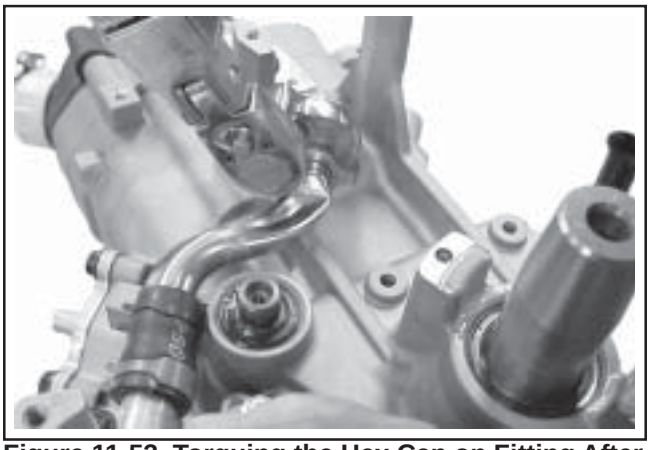


Figure 11-53. Torquing the Hex Cap on Fitting After Pump Installation.

10. Install the drive belt onto the cogged pulley of water pump, then around the cam pulley. Slide the cam pulley, with the belt attached, down onto the keyway end of the camshaft. Be careful not to push the key out of the keyway and/or into the seal when installing the pulley. See Figure 11-54.

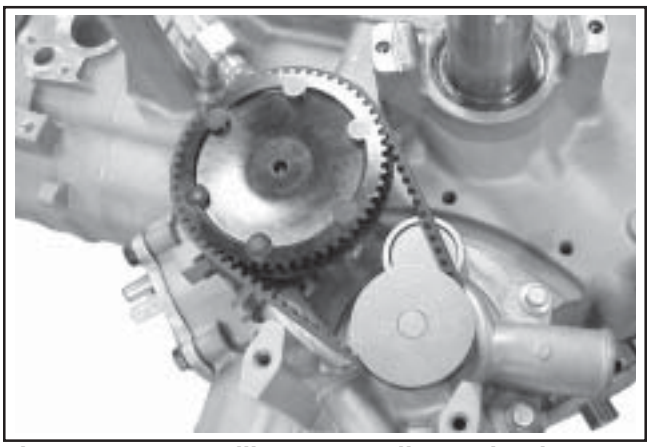


Figure 11-54. Installing Cam Pulley and Belt.

11. Check or use a feeler gauge to see that there is at least **3.17 mm (0.125 in.)** clearance between the underside of the pulley, and the hose, tube, and clamps. Remove the pulley and reposition the tube or clamps if required. Install the flat washer and hex flange screw, to secure the pulley in place. Torque the screw to **9.9 N·m (88 in. lb.)**. See Figure 11-55.

Figure 11-55. Torquing Mounting Screw of Cam Pulley.

Install Intake Manifold Assembly

1. Check that the gasket surfaces of the intake manifold and cylinder heads are clean and free of any nicks or damage.

2. Install new intake manifold gaskets onto the port surfaces of the cylinder heads. See Figure 11-56.

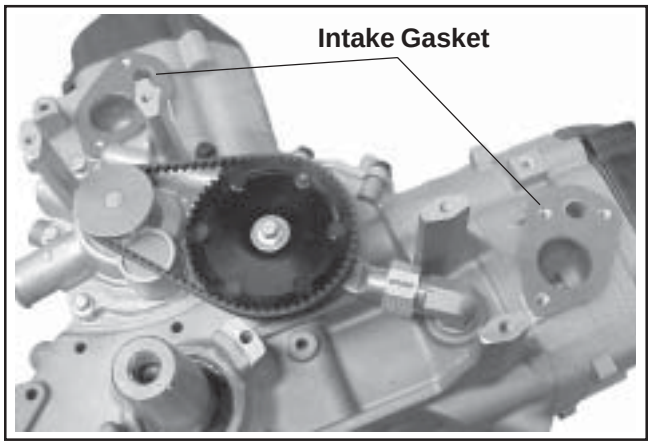


Figure 11-56. Installing Intake Gaskets.

3. Set the intake manifold, with by-pass hose and wiring harness attached, down into position onto the gaskets and cylinder heads. Install and finger tighten the six hex flange screws in their appropriate locations. Make sure the clamps for the wiring harness are positioned on the long screw on each side. Torque the six intake manifold mounting screws in two steps: first to **7.4 N·m (66 in. lb.)**, finally to **9.9 N·m (88 in. lb.)** in the sequence shown. See Figure 11-58.

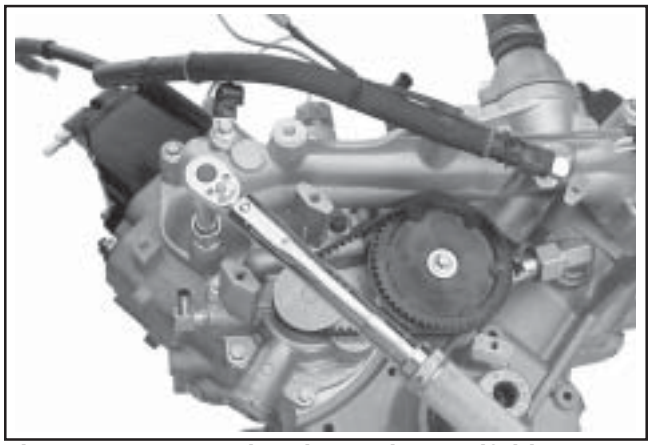


Figure 11-57. Torquing the Intake Manifold Screws.

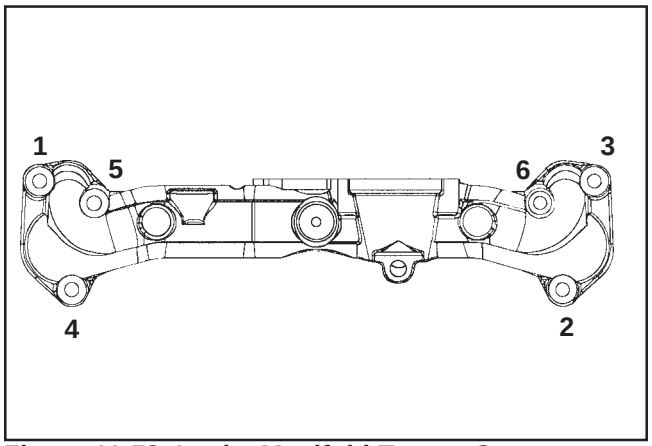


Figure 11-58. Intake Manifold Torque Sequence.

4. Install and tighten the pipe plug or temperature warning switch, if removed previously from the threaded port of the intake manifold. Use **pipe sealant with Teflon®** (Loctite® 59241 or equivalent) on the threads. Torque to **22.6 N·m (200 in. lb.)**. See Figure 11-59.

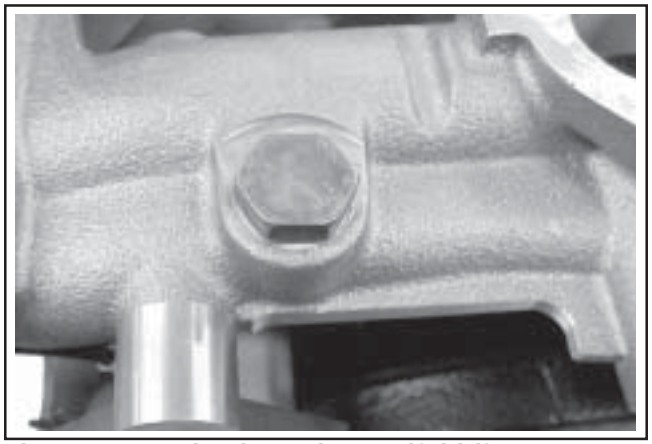


Figure 11-59. Plug in Intake Manifold (for Temperature Sensor).

5. Connect the wire leads to the temperature warning switch, audible alarm, and/or Oil Sentry™ switch as equipped.

If the thermostat and thermostat housing were removed from the intake manifold, reassemble them at this time.

6. Make sure the sealing surfaces of housing and manifold are clean and free of nicks or damage.

7. Install the thermostat into the recess in the intake manifold, so the larger spring end is **down**. Place a new thermostat housing gasket onto the manifold surface, aligning the screw holes. Make sure that one of the notches in the gasket is aligned with the by-pass slot in the manifold and the thermostat housing. **Do not use a substitute gasket.** See Figure 11-60.

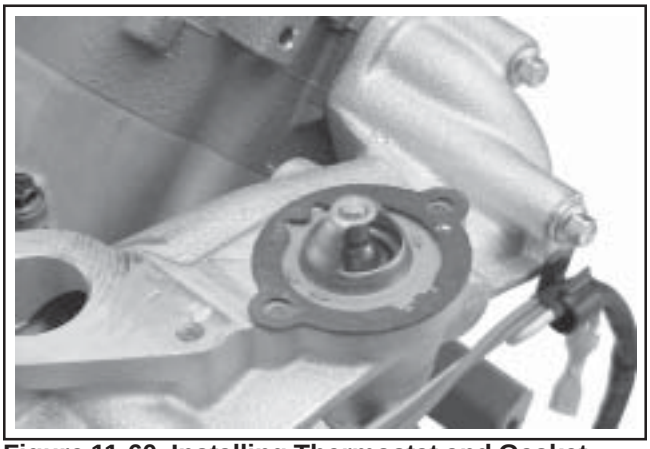


Figure 11-60. Installing Thermostat and Gasket.

8. Position the thermostat housing on the gasket and intake manifold. The notch in manifold, gasket and thermostat housing must all be aligned. Install and torque the two hex flange screws to **9.9 N·m (88 in. lb.)**. See Figure 11-61.

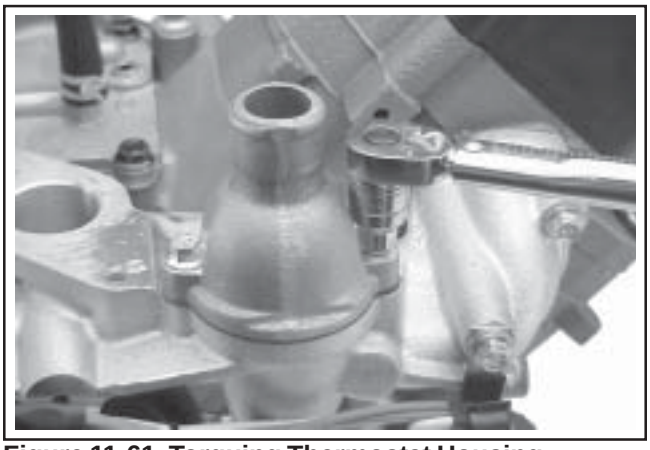


Figure 11-61. Torquing Thermostat Housing Screws.

9. Apply rubber lubricant to the inside end of the upper radiator hose, and install the hose to the thermostat housing, if separated for servicing. Secure with the clamp. Make sure tangs of clamp point toward the #1 cylinder, away from the fan.

Install Coolant By-pass Hose (If separated from intake manifold through individual component servicing)

1. If the connector fitting for the by-pass hose was removed from the manifold, reinstall it at this time. Apply **pipe sealant with Teflon®** (Loctite® 59241 or equivalent) onto the threads and tighten, so the fitting faces/points toward the #2 side, long intake manifold screw.

2. Attach the coolant by-pass hose to the fittings in the water pump and intake manifold. Secure with the clamps.

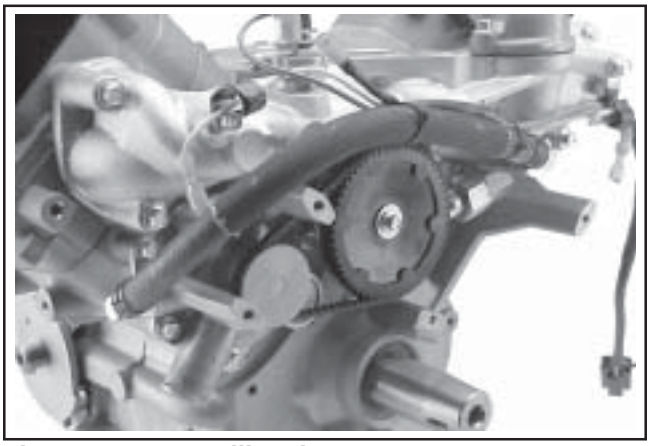


Figure 11-62. Installing the By-pass Hose.

3. Connect the wire leads to the temperature warning switch, audible alarm, and/or Oil Sentry™ switch, as equipped.

Install Stator Assembly

1. Place a small amount of **pipe sealant with Teflon®** (Loctite® 59241 or equivalent) into the holes for the two stator mounting screws. Position the stator assembly onto the mounting studs so the leads are at the bottom, and directed out toward the #1 side, in the 3 o'clock position. Align the mounting holes and install the two hex flange screws. Torque each screw to **6.2 N·m (55 in. lb.)**. See Figure 11-63.

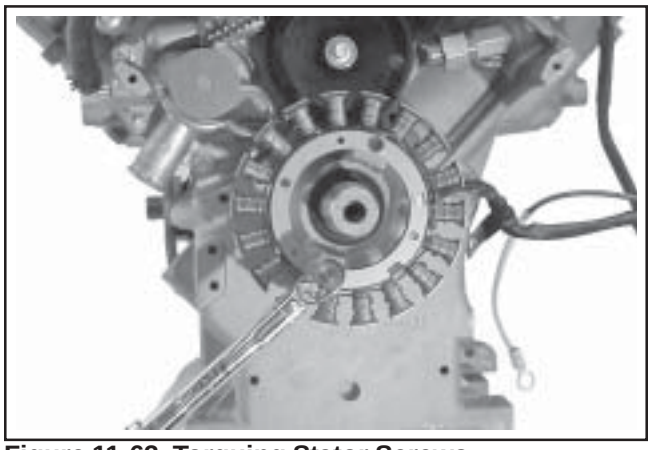


Figure 11-63. Torquing Stator Screws.

Install Starter Adapter

1. Install the starter adapter to the crankcase, so the cutout is offset down and facing away from the flywheel side. Install the two mounting screws, and position the clamp for the stator leads on the upper screw. See Figure 11-64. Torque the screws to **15.3 N·m (135 in. lb.)**.

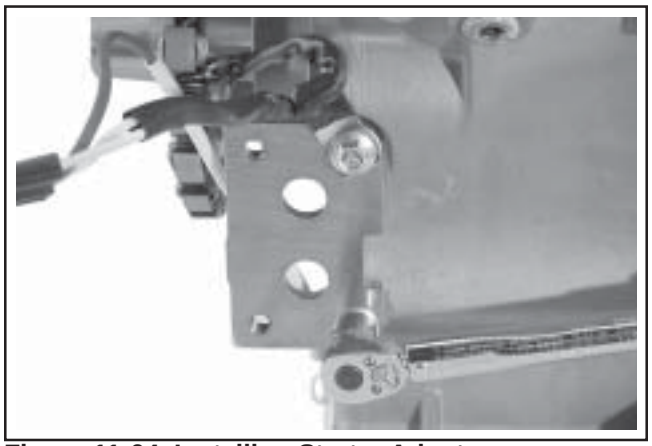


Figure 11-64. Installing Starter Adapter.

2. Place the stator leads within the clamp and close the loop. See Figure 11-65.

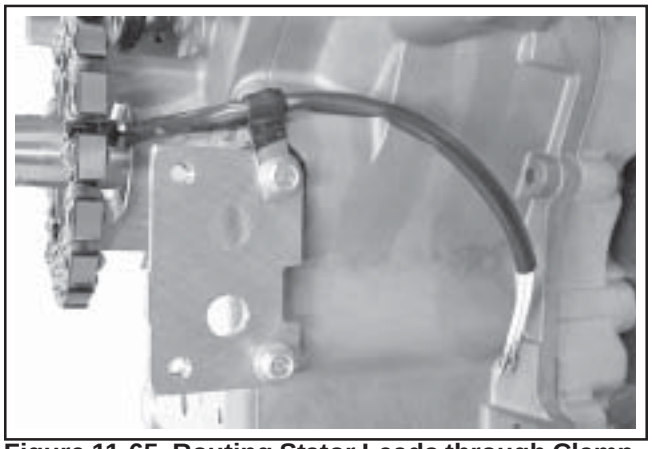


Figure 11-65. Routing Stator Leads through Clamp on Adapter.

3. If the violet B+ charge lead is separate from the main harness, secure it to the wiring harness with a tie strap, directly above the clamp. See Figure 11-66.

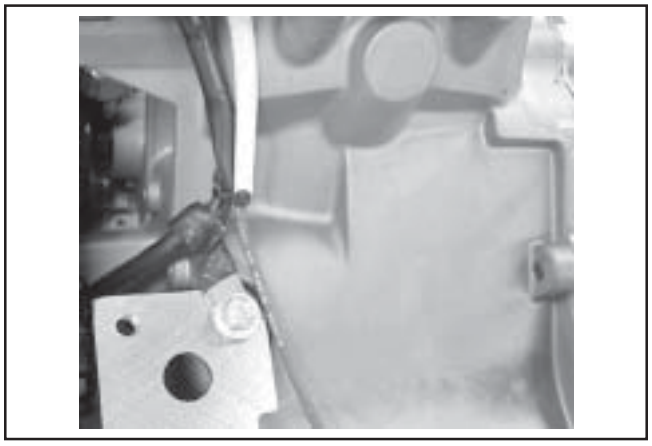


Figure 11-66. Side View of Stator and B+ Leads Tied to Clamp on Adapter.

Install Flywheel

WARNING: Damaging Crankshaft and Flywheel Can Cause Personal Injury!

Using improper procedures to install the flywheel can crack or damage the crankshaft and/or flywheel. This not only causes extensive engine damage, but can also cause personal injury, since broken fragments could be thrown from the engine. Always observe and use the following precautions and procedures when installing the flywheel.

NOTE: Before installing the flywheel make sure the crankshaft taper and flywheel hub are clean, dry, and completely free of lubricants. The presence of lubricants can cause the flywheel to be overstressed and damaged when the hex flange screw is torqued to specifications.

NOTE: Always use a flywheel strap wrench or holding tool to hold the flywheel when tightening the flywheel fastener. Do not use any type of bar or wedge to hold the flywheel, as component damage and personal injury could result.

1. Install the woodruff key into the keyway of the crankshaft. Make sure that the key is properly seated and parallel with the shaft. See Figure 11-67.

   NOTE: Make sure the flywheel key is installed properly in the keyway. The flywheel can become cracked or damaged if the key is improperly installed.

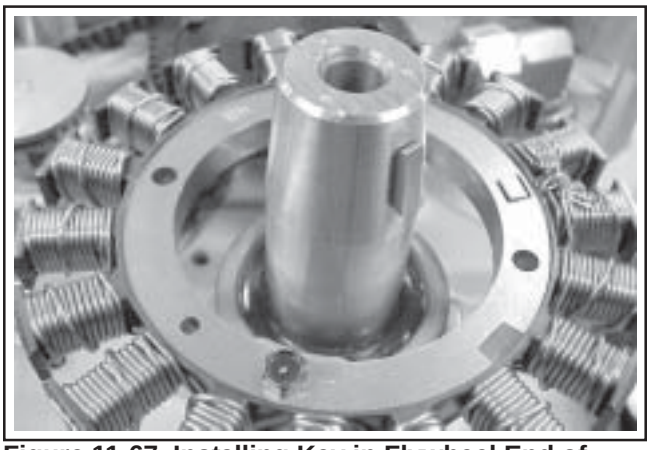


Figure 11-67. Installing Key in Flywheel End of Crankshaft.

2. Thread the two starter mounting bolts into the hub of flywheel, or use the flywheel puller to serve as a "handle" and set the flywheel in place. See Figure 11-68.

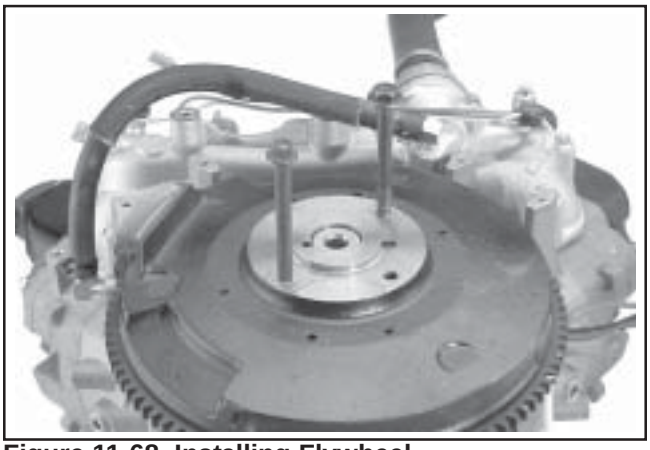


Figure 11-68. Installing Flywheel.

3. Install the hex flange screw and washer. See Figure 11-69.

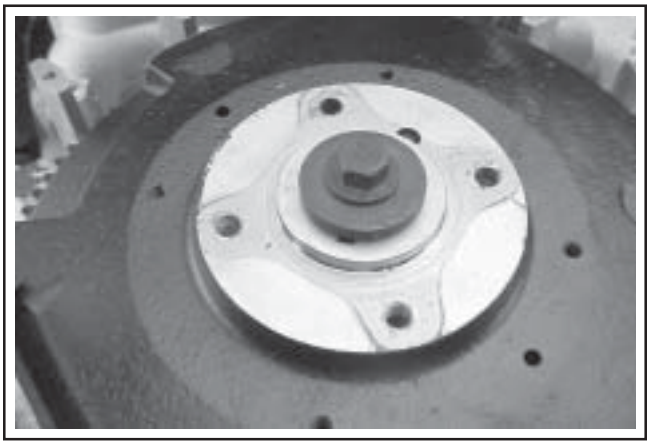


Figure 11-69. Installing Flywheel Mounting Hardware.

4. Use a flywheel holding tool to hold the flywheel and torque the hex flange screw to **66.4 N·m (49 ft. lb.)**. See Figure 11-70.

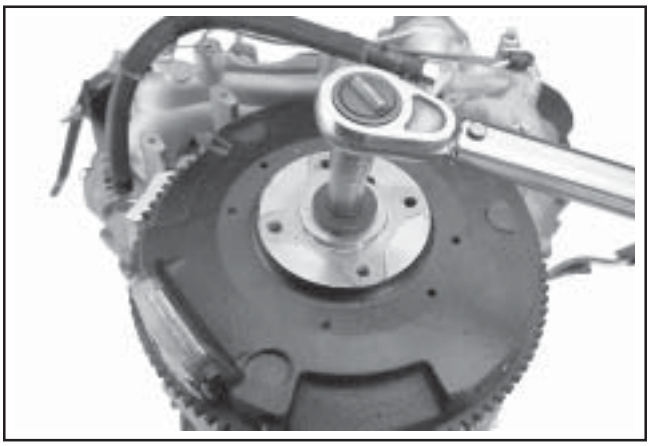


Figure 11-70. Torquing Flywheel Bolt.

5. Using a light, visually check that sufficient clearance exists between the cooling system components and bottom of flywheel. See Figure 11-71.

   - If clearance is OK, continue with installation of ignition modules.

   - If clearance is insufficient or contact is noted, remove the flywheel and adjust as required. Reinstall the flywheel and recheck for adequate clearance.

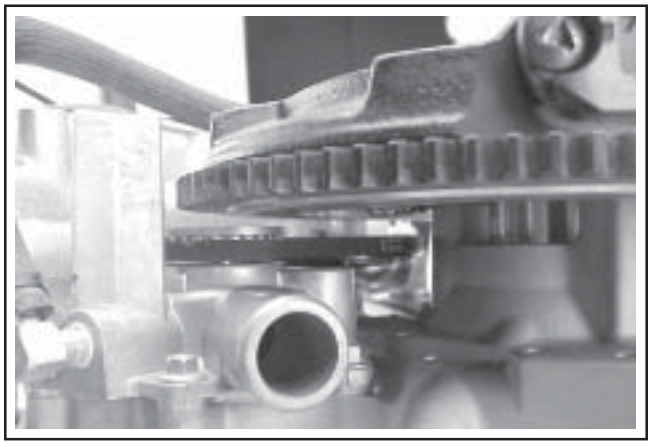


Figure 11-71. Clearance Check/Verification.

Install Ignition Modules

1. Rotate the flywheel magnet away from the ignition module mounting bosses.

2. Install the two ignition modules, with the ground terminal "out", onto the crankcase mounting bosses, using the four hex flange screws. Slide the ignition modules away from the flywheel as far as possible, and tighten the four screws.

3. Rotate the flywheel to position the magnet directly under one of the ignition modules.

4. Insert a **0.25 mm (0.010 in.)** flat feeler gauge or shim stock between the magnet and ignition module. Loosen the hex flange screws enough to allow the magnet to pull the module against the feeler gauge.

5. Torque the two hex flange screws to **4.0 N·m (35 in. lb.)**. See Figure 11-72.

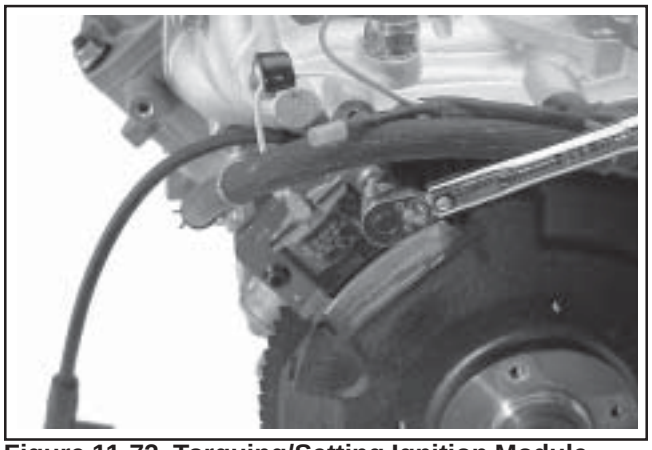


Figure 11-72. Torquing/Setting Ignition Module Gap.

6. Repeat steps 3 to 5 for the other ignition module.

7. Rotate the flywheel back and forth checking for clearance between the magnet and ignition modules. Make sure the magnet does not strike the modules. Recheck the gap with a feeler gauge and readjust if necessary. Final air gap: **0.203/0.305 mm (0.008/0.012 in.)**.

8. Connect the kill leads to the ignition modules. Route the wiring harness and kill leads as shown in Figures 11-73 and 11-74. Push (bend) the loop portion of the clamp on the #1 side back, as far as possible, for maximum clearance from fan.

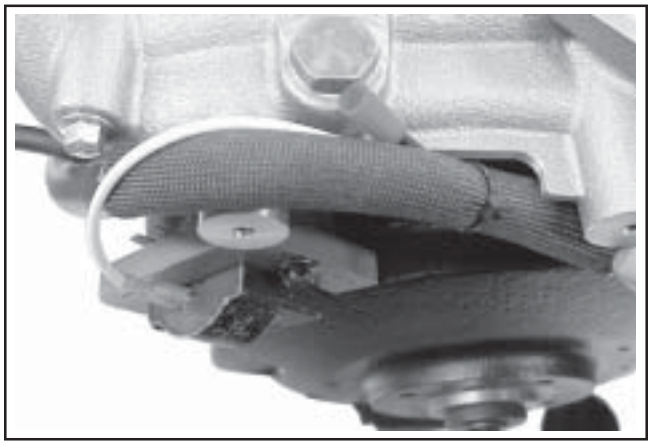


Figure 11-73. By-pass Hose and Wiring Routed within Cutout of Intake Manifold (Some Models).

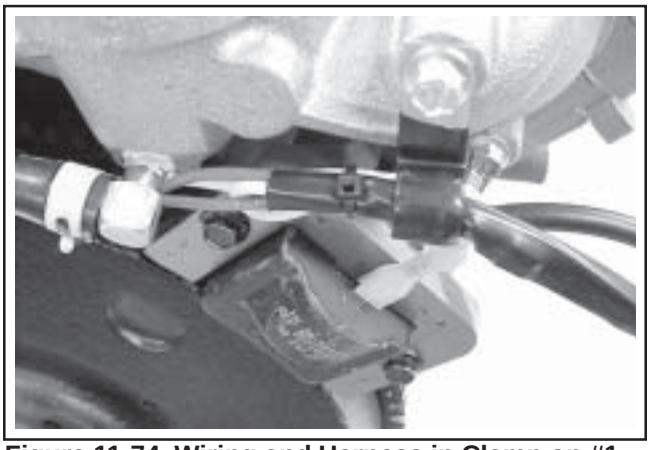


Figure 11-74. Wiring and Harness in Clamp on #1 Side.

Install Spark Plugs

1. Use new Champion® RC14YC (Kohler Part No. **66 132 01-S**) or equivalent spark plugs.

2. Set the spark plug gap to **0.76 mm (0.030 in.).**

3. Install the plugs and torque to **24.4-29.8 N·m (18-22 ft. lb.).** See Figure 11-75.

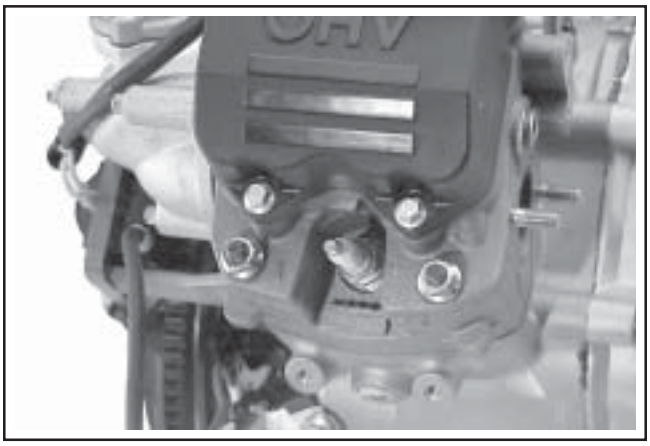


Figure 11-75. Installing Spark Plug.

Install Starter Assembly

1. Mount the starter to the adapter plate using the two hex flange screws.

   NOTE: The stator leads and rectifier-regulator plug must be above the starter.

2. Make sure the starter is square to the flywheel, and torque the two hex flange screws to **15.3 N·m (135 in. lb.)**. See Figure 11-76.

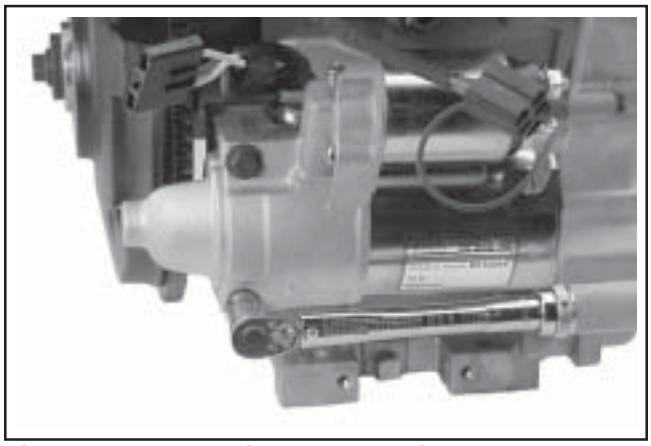


Figure 11-76. Torquing Starter Bolts.

3. Attach the leads to the appropriate starter solenoid terminals. See Figure 11-77.

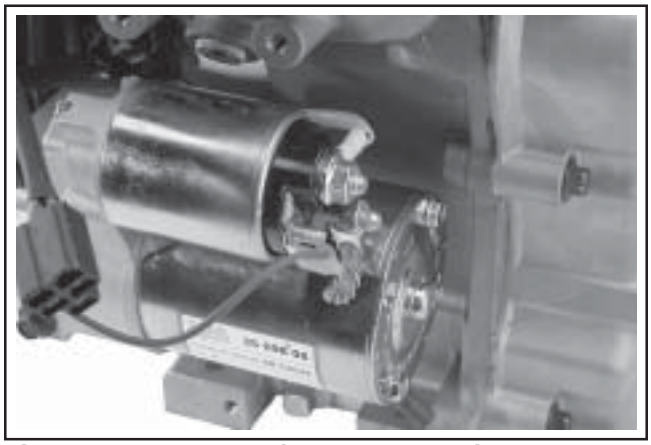


Figure 11-77. Connecting Starter Leads to Starter.

4. To avoid damage or breakage, do not over-tighten the hex flange nut when attaching the positive battery cable. Torque the nut to **6-9 N·m (53-79 in. lb.)**.

Install Carburetor and Adapter

1. If separated, install the breather tube to breather cover as shown in Figure 11-78.

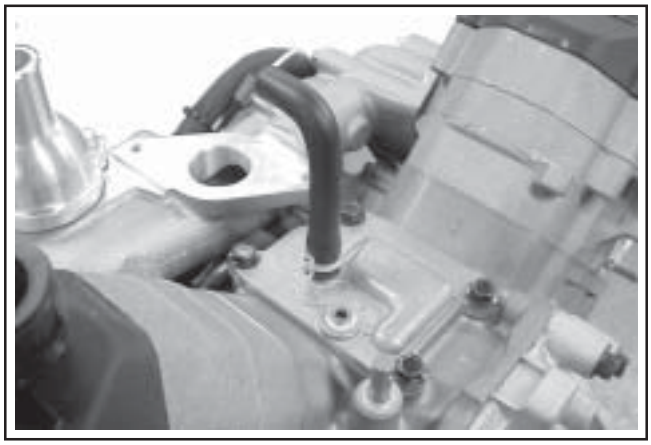


Figure 11-78. Breather Hose Installed onto Breather Cover.

2. Install the carburetor gasket on the intake manifold. See Figure 11-79.

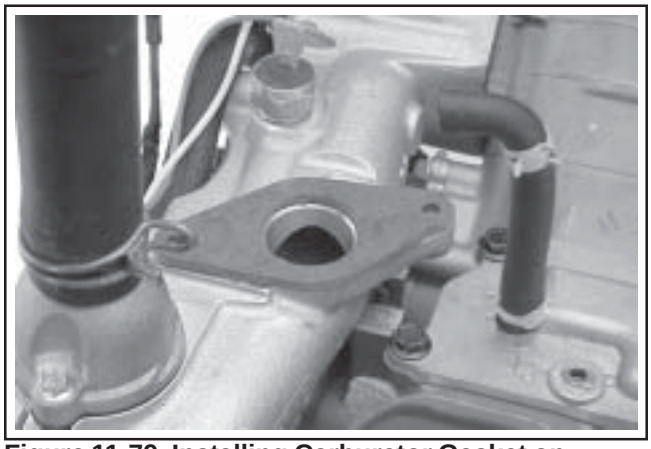


Figure 11-79. Installing Carburetor Gasket on Intake Manifold.

3. Attach the longer ends of the throttle linkage and spring to the carburetor (if disconnected previously), then install the carburetor onto the intake manifold. Install and torque the two mounting screws to **6.2-7.3 N·m (55-65 in. lb.)**. See Figures 11-80 and 11-81.

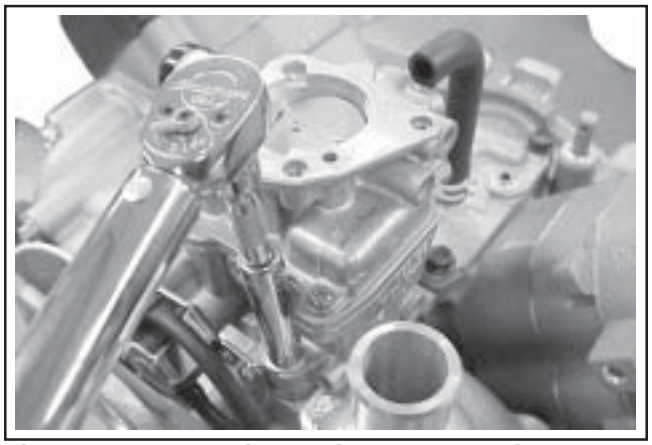


Figure 11-80. Torquing Carburetor Mounting Screws.

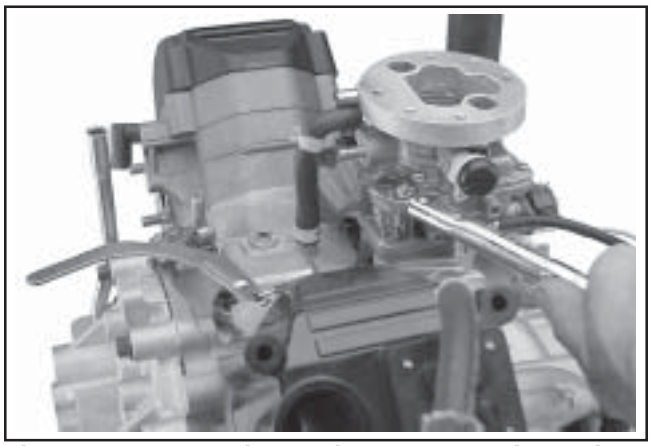


Figure 11-81. Torquing Carburetor Mounting Bolts.

4. If the adapter was separated from the carburetor, install a new gasket and mount the adapter with the breather hose connection port facing the rear. Install and torque the mounting screws to **7.3 N·m (65 in. lb.)**.

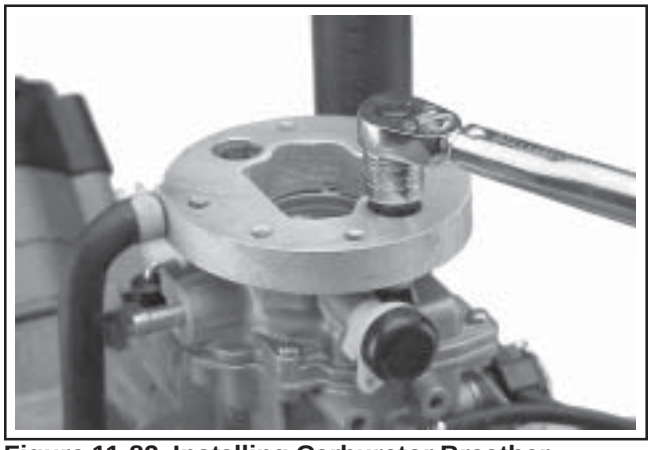


Figure 11-82. Installing Carburetor Breather Adapter.

5. Connect the upper end of the breather hose to the fitting on the rear of the adapter. See Figure 11-82.

6. Connect the long end of the choke linkage to carburetor as shown in Figure 11-83.

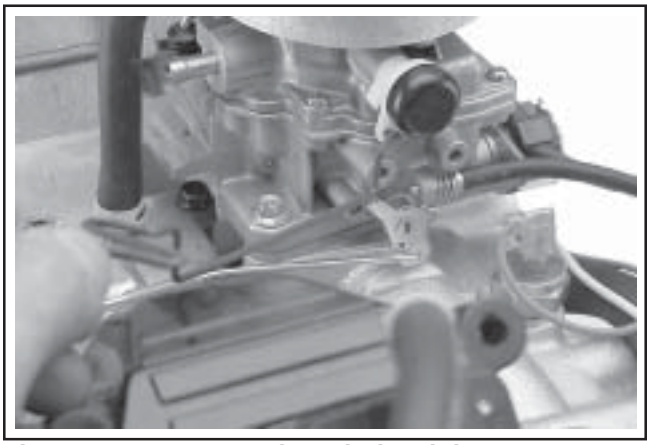


Figure 11-83. Connecting Choke Linkage.

7. If a mechanical fuel pump is used, install the fuel line between the outlet of the fuel pump and the carburetor inlet, and secure with the clamps. See Figure 11-84.

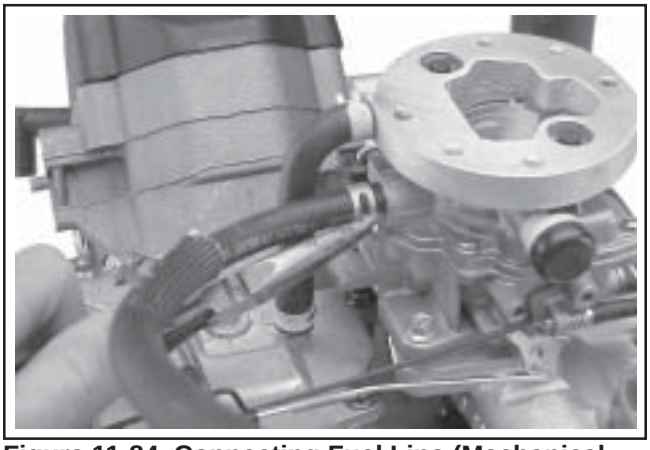


Figure 11-84. Connecting Fuel Line (Mechanical Fuel Pump).

Install External Governor Controls and Main Control Bracket

1. Install the governor lever onto the governor cross shaft. If separated, connect the throttle link to governor lever with the plastic bushing. Hook the dampening spring into the small (middle) hole.

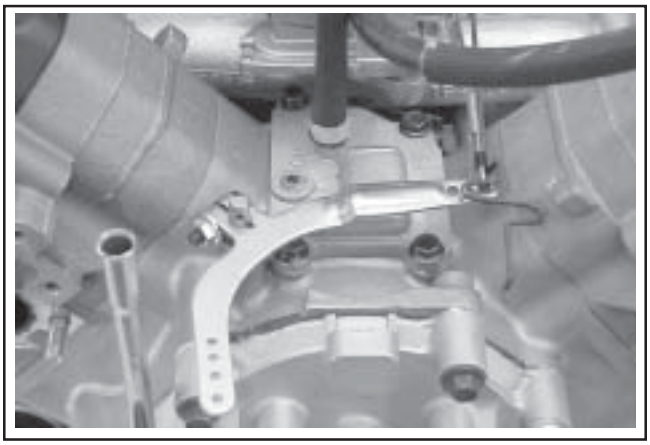


Figure 11-85. Installing/Connecting Governor Linkage.

2. Move the governor lever **TOWARDS** the carburetor as far as it will go (wide open throttle) and hold in this position.

3. Insert a nail into the hole in the cross shaft and rotate the shaft **COUNTERCLOCKWISE** as far as it will turn. Then torque the hex nut to **6.8 N·m (60 in. lb.)**. See Figure 11-86.

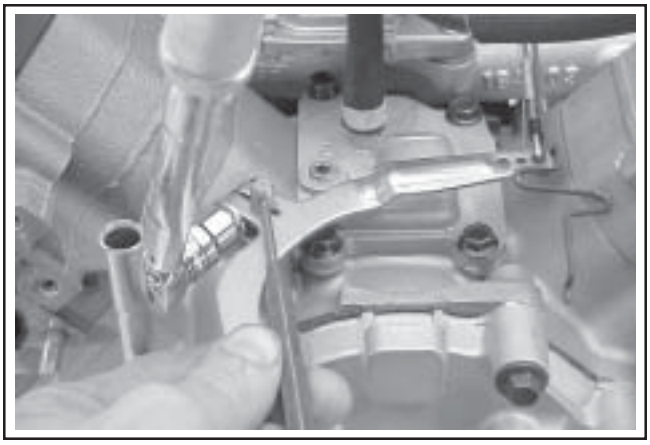


Figure 11-86. Setting Governor and Tightening Nut.

4. Connect the choke lever of the main control bracket to the choke linkage from the carburetor. Mount the main control bracket to the cylinder heads with the four screws. Torque the screws to **10.7 N·m (95 in. lb.)** into new holes, or **7.3 N·m (65 in. lb.)** into used holes. See Figure 11-87.

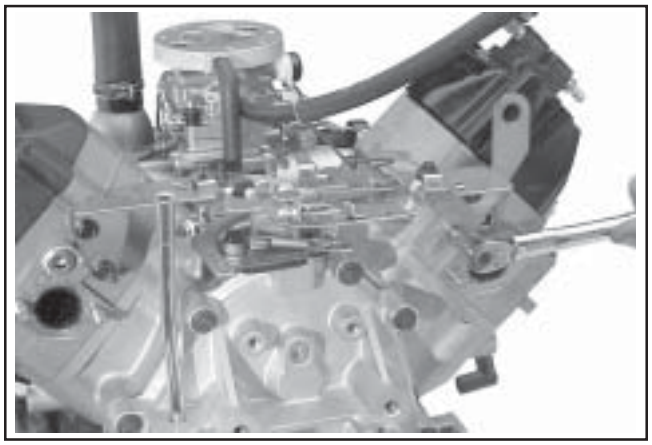


Figure 11-87. Installing Main Throttle Bracket.

5. Connect the dampening spring to the throttle lever as shown. Hook the governor spring from the throttle control bracket in the appropriate governor lever hole, as indicated in the chart below. Note that the hole positions are counted from the pivot point of the governor lever. See Figure 11-88.

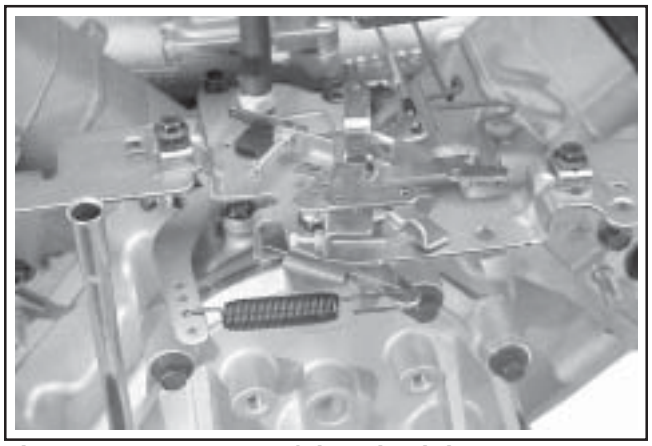


Figure 11-88. Governor/Throttle Linkage Connection Details.

Governor Spring Chart

High Idle RPM	Governor Lever Hole No.	Governor Spring Color Code
3888	4	Red
3780	3	Purple
3672	3	Black
3564	3	Red
3456	2	Purple
3348	2	Green
3240	2	Red
3132	2	Clear
3024	1	Red

Install Lower Crankshaft Pulley, Pulley Adapter, and Cooling Fan Assembly

1. Make sure the shoulder of the flywheel hub and the adjacent face surface are clean and free of any nicks or damage.

2. Install the crankshaft pulley adapter onto the flywheel hub, so the offset for the pulley is out, and the holes are aligned. Make sure the adapter rests squarely on the face of the flywheel. See Figure 11-89.

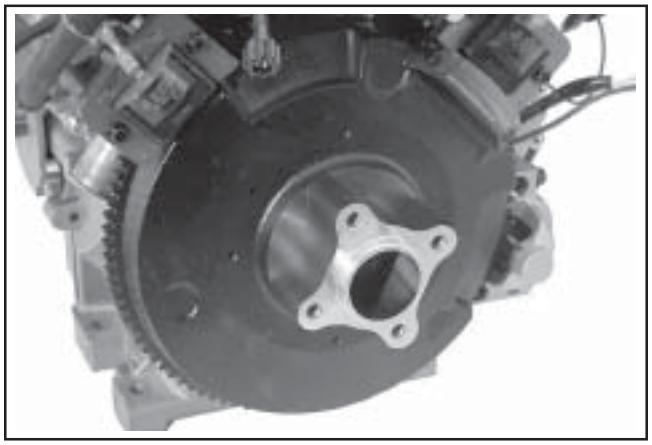


Figure 11-89. Lower Adapter on Flywheel.

3. Assemble the front and rear pulley halves placing the shims as indicated.

   a. For a **new** belt: Assemble with two or three shims between the pulley halves, and remaining shim (if any) on the outside (front) of the outer pulley half.

   b. For a **used** belt: Assemble with two shims between the pulley halves and remaining shim(s) on the outside (front) of the outer pulley half.

   Install and snug the pulley assembly. See Figures 11-90 and 11-91. Final belt tension and pulley assembly will be made after fan/upper pulley assembly is installed.

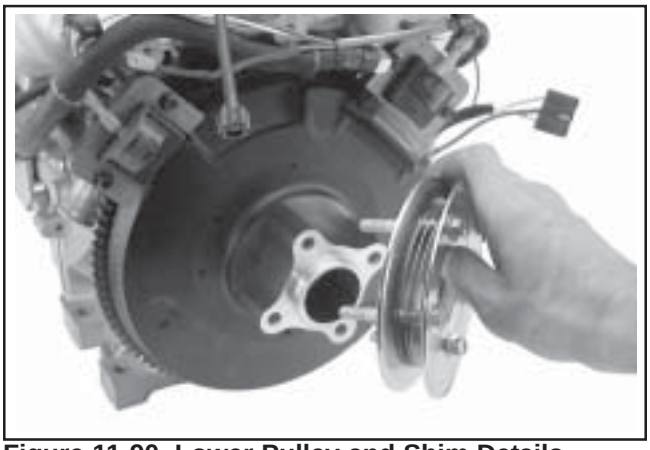


Figure 11-90. Lower Pulley and Shim Details.

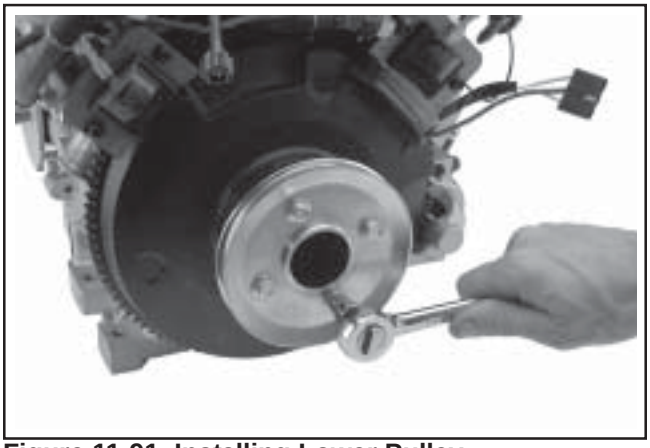


Figure 11-91. Installing Lower Pulley.

4. Install the upper fan mounting bracket to the intake manifold with the two screws. See Figure 11-92. Torque:

   M6 Screws to 7.3 N·m (65 in. lb.)
   M8 Screws to 24. 4 N·m (216 in. lb.)

   The by-pass hose and wires must be positioned within the cutout in the intake manifold, as shown in Figure 11-93. Be careful not to pinch the harness wires between the bracket and intake manifold when tightening.

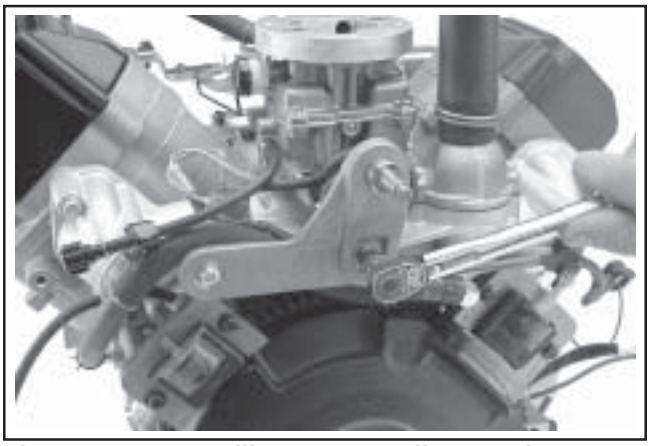


Figure 11-92. Installing Upper Pulley Bracket.

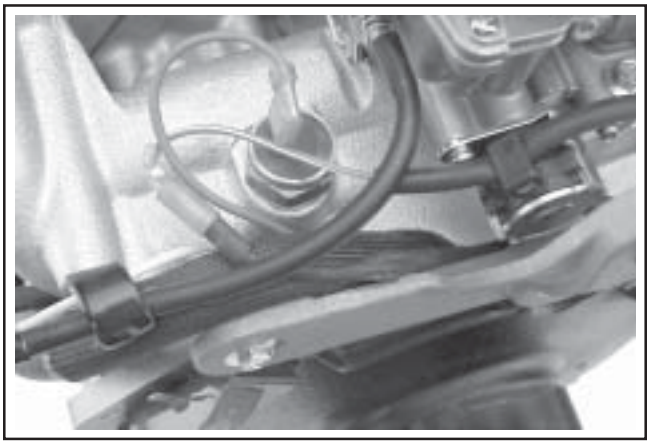


Figure 11-93. Wiring Through Intake Manifold Cutout and Behind Upper Bracket.

5. If disassembled, reassemble the fan and pulley assembly as shown in Figures 11-94, 11-95, and 11-96.

Figure 11-94. Fan Assembly Components - Disassembled Layout.

Figure 11-95. Fan Assembly (Front View).

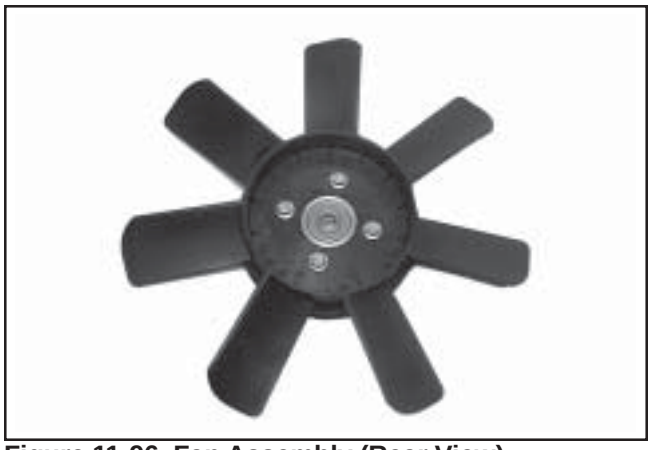


Figure 11-96. Fan Assembly (Rear View).

Make sure one flat washer is placed between the two bearings in the hub. The other washer is located under the front hex flange nut. Torque the four fan/pulley/hub mounting screws to **6.8 N·m (60 in. lb.)**.

6. If the fan shaft was removed from the upper mounting bracket, apply Loctite® No. 242 to the rear threads. Install and torque the rear hex nut to **15.8 N·m (140 in. lb.)**. Install the fan and pulley assembly onto the fan shaft and upper mounting bracket.

7. Apply Loctite® No. 242 to the front threads of the fan shaft. Install the flat washer and the hex flange nut to secure. Torque hex flange nut to **15.8 N·m (140 in. lb.)**. See Figure 11-97.

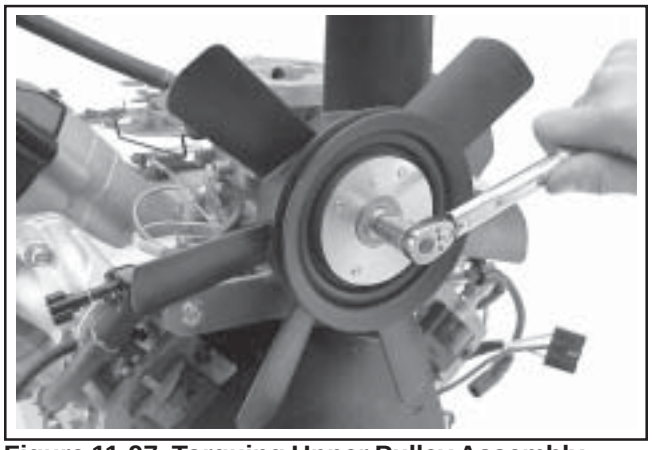


Figure 11-97. Torquing Upper Pulley Assembly.

8. Carefully work the belt into place on the pulleys. See Figure 11-98. Check the belt tension. There should be no more than **9.53 - 12.7 mm (3/8" - 1/2")** belt deflection per side with **10 lbs.** of applied tension. See Figure 11-99.

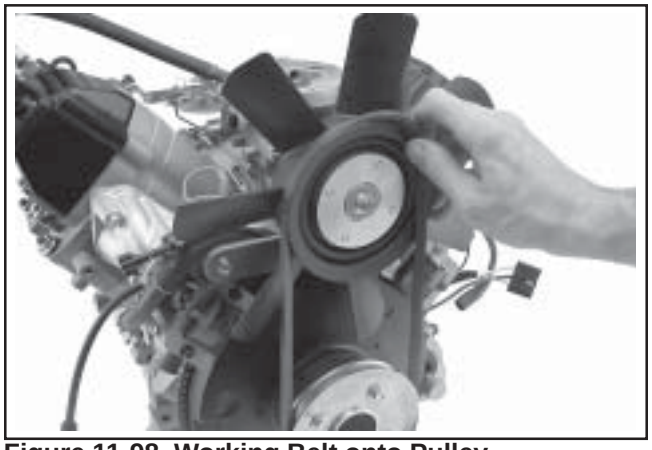


Figure 11-98. Working Belt onto Pulley.

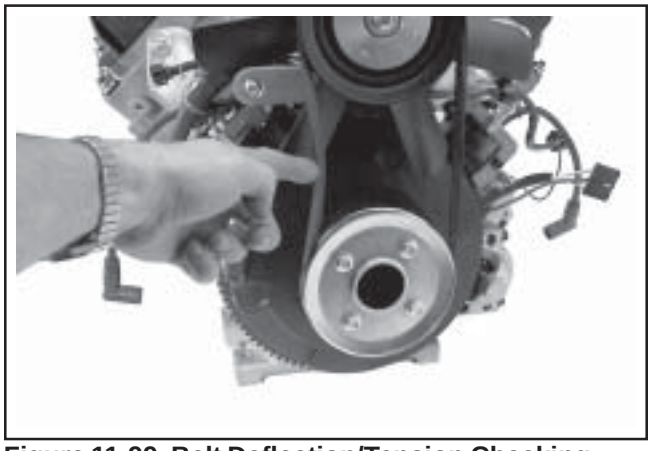


Figure 11-99. Belt Deflection/Tension Checking.

If the belt tension is low, remove the belt and relocate a shim from between the pulley halves to the outside (front). Reinstall the belt and recheck the tension. Repeat the procedure until the correct tension is reached. if the shims have all been moved to the outside, and the belt is still too loose, replace the belt.

NOTE: Do not assemble the lower pulley with the belt between the pulley halves, as pinching of the belt or damage to the pulley can occur.

When proper tension is obtained, individually remove each capscrew, apply Loctite® No. 242 to the threads of lower pulley and reinstall. Torque the four bolts in a criss-cross sequence to **24.3 N·m (215 in. lb.)**. See Figure 11-100.

Figure 11-100. Torquing Lower Pulley Screws.

9. Mount the RH and LH lower radiator supports with cross support bracket attached, to the crankcase, using the four hex flange screws. Snug the screws only at this time. See Figure 11-101.

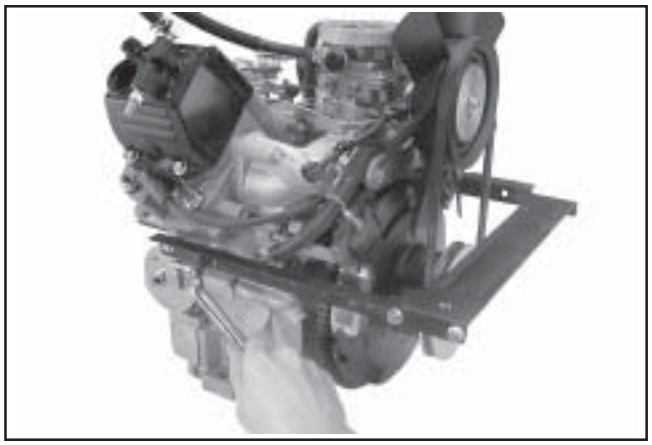


Figure 11-101. Mounting Lower Radiator Supports.

Install Air Cleaner Assembly

1. Install a new elbow adapter gasket onto the carburetor adapter. See Figure 11-102.

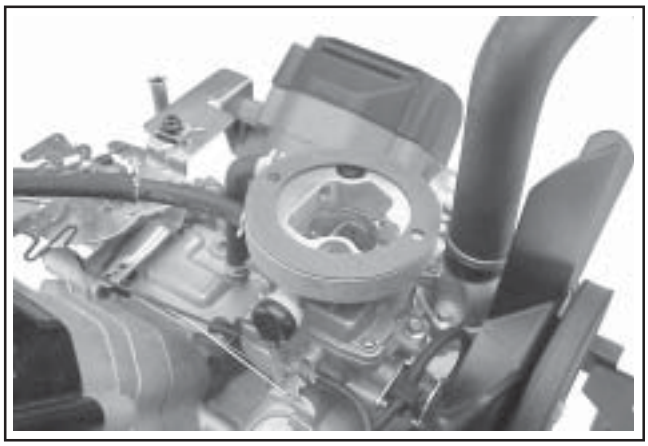


Figure 11-102. Installing Elbow Adapter Gasket.

2. Set the air cleaner/mounting bracket assembly, with the hose and elbow attached, in position on the engine. Align all of the mounting holes. Start and **finger tighten** each of the mounting screws. Make sure the fuel line is outside of the main bracket when installed. See Figures 11-103 and 11-104.

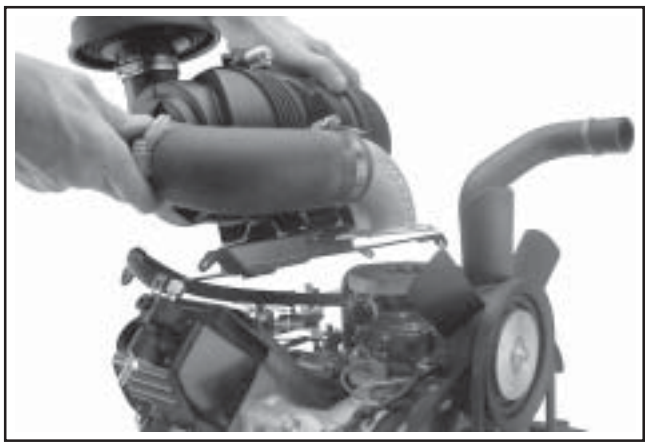


Figure 11-103. Installing Air Cleaner Assembly.

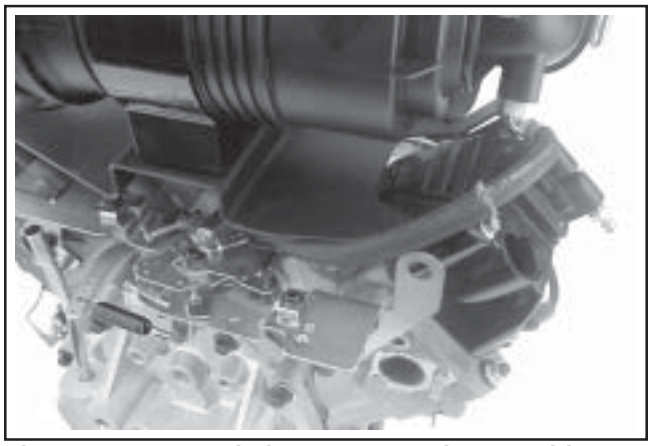


Figure 11-104. Fuel Line Hose Routing Outside Leg of Air Cleaner Bracket.

3. Torque the two elbow mounting screws to **7.3 N·m (65 in. lb.)**. See Figure 11-105. Then torque the eight valve cover mounting screws to **6.2 N·m (55 in. lb.)** in the sequence shown in Figure 11-107.

Figure 11-105. Torquing Elbow Mounting Screws.

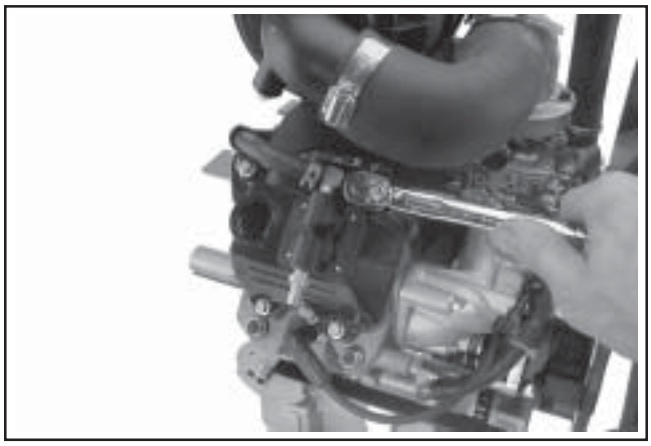


Figure 11-106. Torquing Valve Cover Screws.

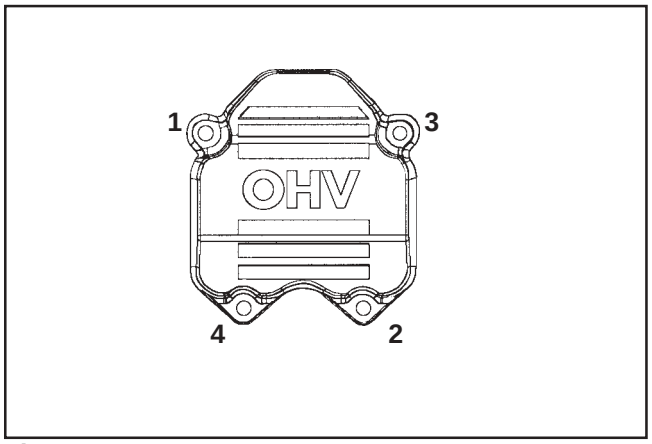


Figure 11-107. Torque Sequence.

4. If removed, install the rain cap and secure with the clamp. Check the position of the dust ejector, it should face downward. Adjust the end cap position as required. See Figure 11-108.

Figure 11-108. Dust Ejector Valve and Rain Cap Position.

5. Connect the wires for the audible alarm, if used.

Install Radiator Assembly

1. Reassemble the components of the radiator assembly, including upper and lower radiator hoses. Rubber lubricant may be applied to the inner surfaces of the hoses to make installation easier. Secure with the hose clamps. The radiator subassembly should look as shown in Figure 11-109.

Figure 11-109. Preassembled Radiator for Installation.

2. Tighten the radiator drain plug. See Figure 11-110.

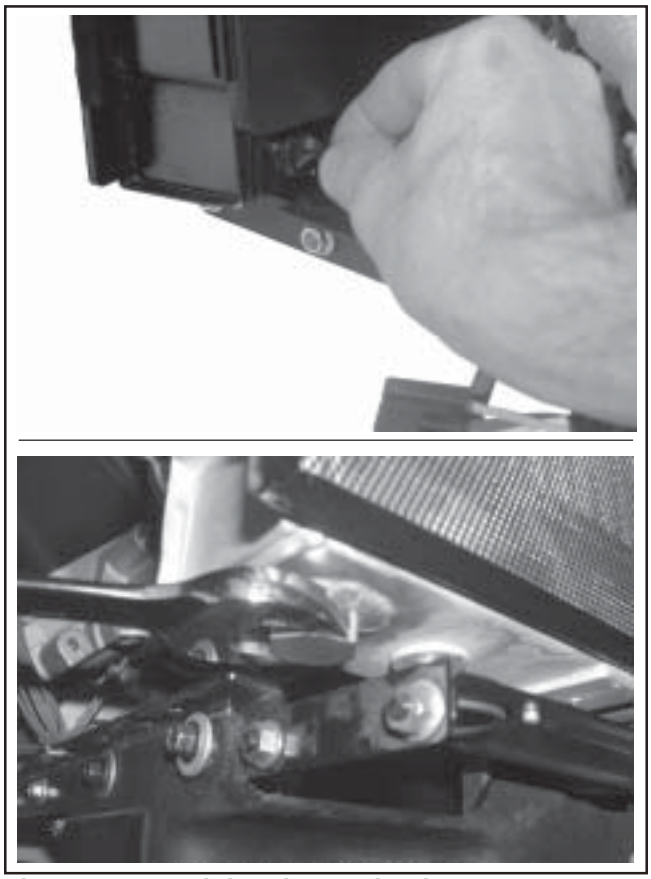


Figure 11-110. Tightening Drain Plug.

3. Carefully set the radiator assembly into place, guiding the lower radiator hose inside RH support bracket. Make sure that cooling fins do not come in contact with the fan blades as radiator is installed.

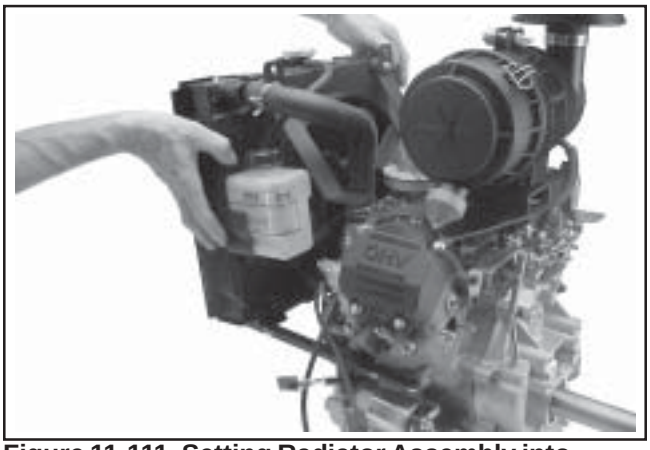


Figure 11-111. Setting Radiator Assembly into Place.

4. Position the upper radiator support brackets on **top** of the air cleaner mounting bracket. Install and finger tighten the four mounting screws.

Figure 11-112. Installing Upper Support Screws.

5. Connect the upper and lower radiator hoses to the inlets of the radiator and water pump. Secure with the hose clamps. See Figures 11-113 and 11-114. Make sure the tangs of upper clamp face away from the fan.

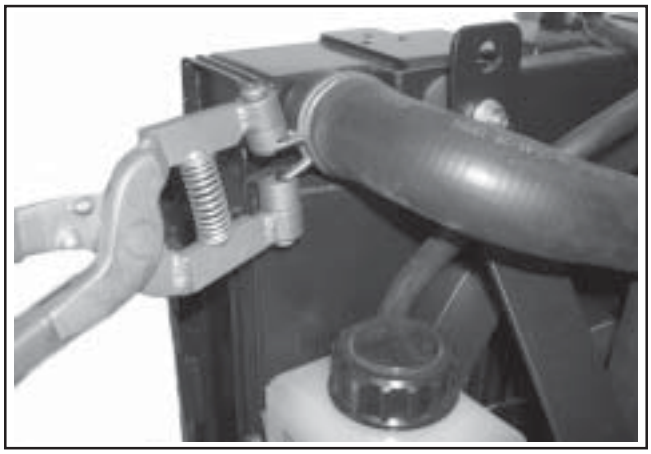


Figure 11-113. Installing Upper Hose Connection.

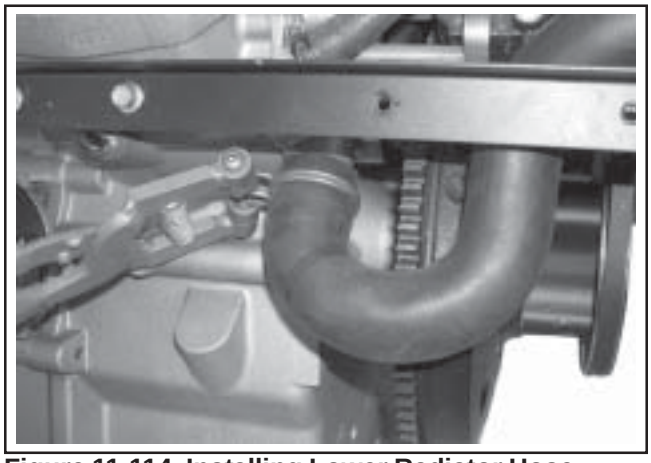


Figure 11-114. Installing Lower Radiator Hose Clamp.

6. Check for adequate clearance between fan and shroud. Adjust the lower radiator supports as required, then torque the four mounting screws to **9.9 N·m (88 in. lb.)**. See Figures 11-115 and 11-116.

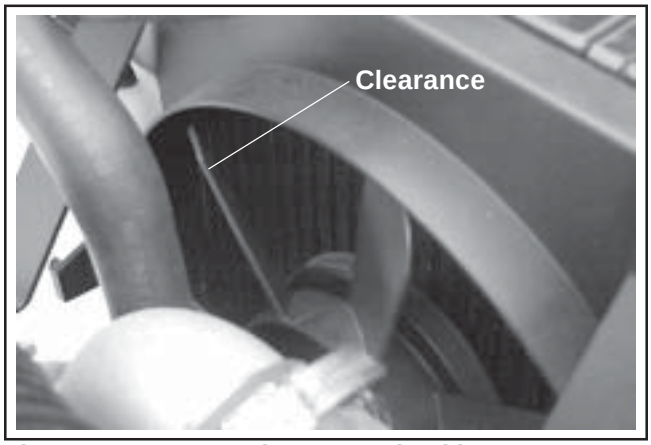


Figure 11-115. Fan Clearance Checking.

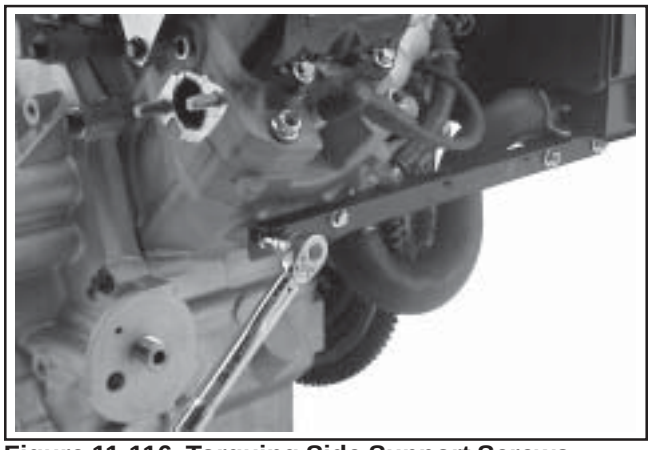


Figure 11-116. Torquing Side Support Screws.

7. Hold the radiator assembly in position; then torque the screws securing the two upper radiator supports to **9.9 N·m (88 in. lb.)**. See Figure 11-117.

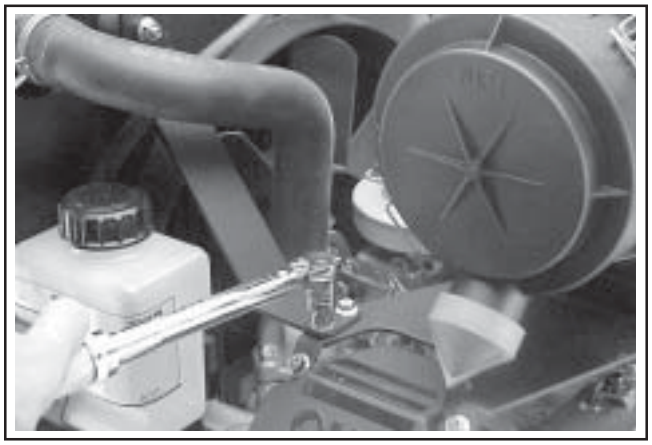


Figure 11-117. Torquing Upper Bracket Screws.

8. If the two flange nuts securing the upper brackets to the top radiator mounts were loosened, torque to **9.9 N·m (88 in. lb.)**. See Figure 11-118.

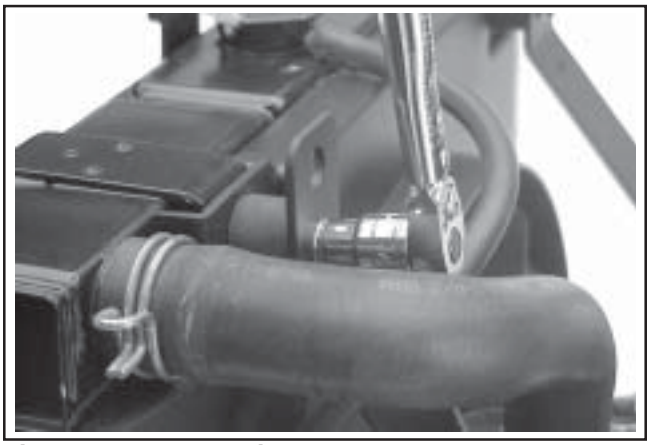


Figure 11-118. Torquing Top Nuts on Upper Brackets.

9. If a "pulse" style fuel pump is used, install it to the tapped holes in the #2 side, upper radiator support bracket and torque the two screws to **6.8-7.3 N·m (60-65 in. lb.)**. Connect the outlet line between the pump and carburetor and the vacuum line to the crankcase fitting. Secure with the clamps. See Figure 11-119.

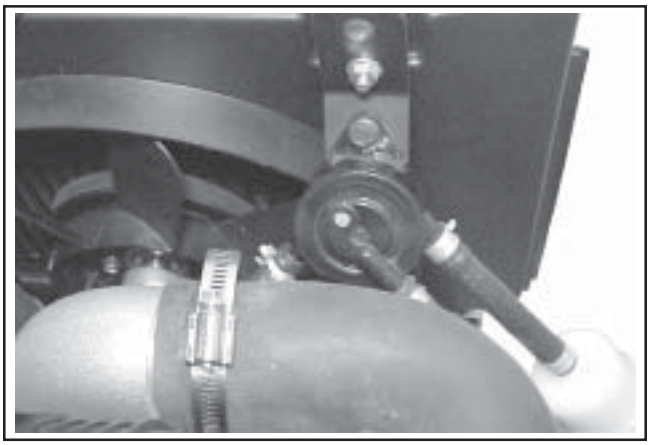


Figure 11-119. Fuel Line and Pump "Pulse" Fuel Pump.

Install Lower Flywheel Cover, Rectifier-Regulator and Mounting Plate

1. Install/make sure the small metal spacers are positioned in the mounting holes of the lower flywheel cover.

2. Attach the lower flywheel cover to the #2 (oil filter) side lower radiator support bracket, using two M6 screws and flat washers. Finger tighten only at this time.

3. Align the lower flywheel cover with the #1 (starter) side lower radiator support bracket holes. Position the rectifier-regulator mounting plate, behind the cover and install the remaining two screws or nuts and flat washers. Torque the four fasteners to **9.9 N·m (88 in. lb.)**. See Figure 11-120. If screws and Timmerman nuts/clips are used torque to **2.2-2.8 N·m (20-25 in. lb.)**.

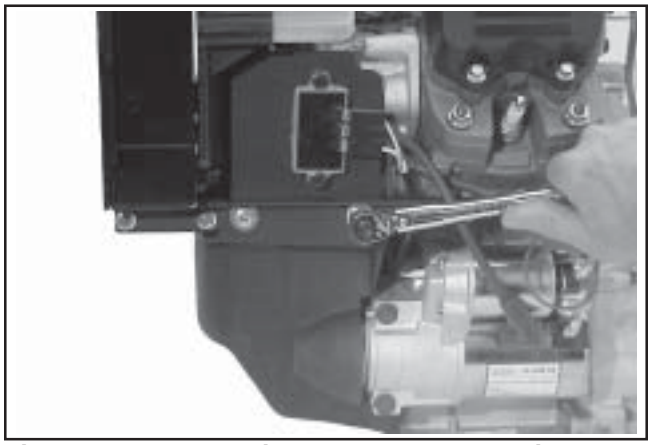


Figure 11-120. Torquing Lower Screws and Rectifier-Regulator Mounting.

4. If removed, mount the rectifier-regulator to the plate with the two screws and attach the connector plug. See Figure 11-120.

Install Muffler

1. Install new exhaust gaskets and attach the muffler and mounting hardware. Torque the screws to **9.9 N·m (88 in. lb.)**.

2. Install the hex flange nuts to the exhaust studs. Torque the nuts to **24.4 N·m (216 in. lb.)**.

Install Oil Filter and Fill Crankcase with Oil

1. Place a new oil filter in a shallow pan with the open end up. Pour new oil of the proper type through the threaded center hole. Stop pouring when the oil reaches the bottom of the threads. Allow a minute or two for the oil to be absorbed by the filter material.

2. Apply a thin film of oil to the rubber gasket on the new filter.

3. Install the new oil filter to the filter adapter. Turn the oil filter clockwise until the rubber gasket contacts the surface, then tighten the filter an additional 3/4-1 turn. See Figure 11-121.

Figure 11-121. Installing Oil Filter.

4. Remove the oil fill cap from the valve cover. Fill the crankcase with new oil to the "F" mark on the dipstick. Refer to "Oil Type" and "Check Oil Level" on pages 6.1 and 6.2. Check oil level again after initial running. Always check the level with the dipstick before adding more oil. Push dipstick in completely.

5. Reinstall the oil fill cap and tighten securely. See Figure 11-122.

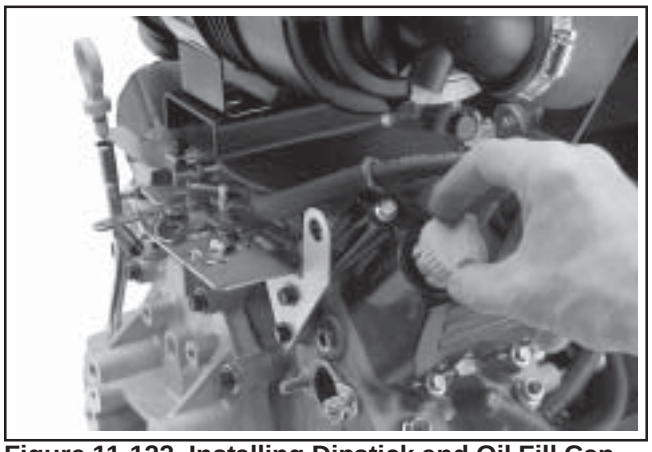


Figure 11-122. Installing Dipstick and Oil Fill Cap.

Install Coolant

1. Use equal parts of ethylene glycol (antifreeze) and water only. Distilled or deionized water is recommended, especially in areas where the water contains a high mineral content. Propylene glycol based antifreeze is not recommended.

2. Fill the cooling system, through the radiator, with the coolant mix. Allow the coolant to drain into the lower areas. Fill the overflow reservoir midway between the "FULL" and "ADD" marks, then install the radiator and reservoir caps. See Figures 11-123 and 11-124.

Figure 11-123. Radiator Cap (Install After Filling).

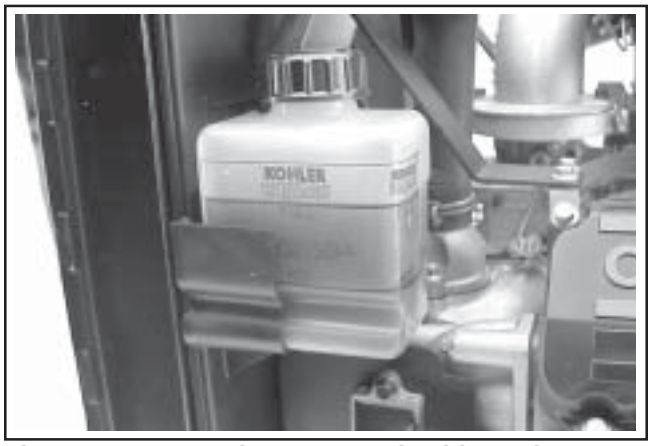


Figure 11-124. Coolant Reservoir with Coolant.

Reconnect Battery and Spark Plug Leads

Connect the leads to the spark plugs. Reconnect the positive (+) battery lead first, and the negative (-) lead last when connecting the battery.

Testing the Engine

It is recommended that the engine be appropriately secured and operated on a test stand or bench, prior to installation in the application.

1. Make sure all hardware is tightened, and hose clamps are properly secured.

2. Set up the engine on a test stand. Install an oil pressure gauge. Start the engine and check to be certain that oil pressure (20 psi or more) is present. Run for 5-10 minutes between idle and mid-range.

3. Check all cooling system components and joint connections for leaks.

4. Make sure the maximum engine speed does not exceed 3750 RPM (no load). Adjust the throttle, choke controls and high speed stop as necessary. Refer to the "Fuel System and Governor" section.

5. Place the throttle control into the "**idle" or "slow**" position and check the low idle speed (RPM). Refer to Section 5 if adjustment is required.

6. Stop the engine.

7. Recheck the oil and coolant levels. Oil level should be at the "F" mark on the dipstick, and the coolant level in the reservoir should be midway between the "ADD" and "FULL" marks. Add additional amounts as required.

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