SERVICE MANUAL

COURAGE™ SERIES
SV470-600
VERTICAL CRANKSHAFT

KOHLER® engines

Contents

Section 1
Safety and General Information

Safety Precautions

To ensure safe operation 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.

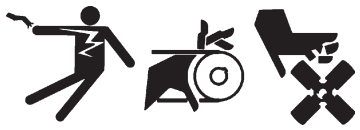
NOTE

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.

Stop engine before filling fuel tank.

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.

Do not operate engine in closed 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

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** of the engine.

The engine identification numbers appear on a decal affixed to the engine shrouding. See Figure 1-1. An explanation of these numbers is shown in Figure 1-2.

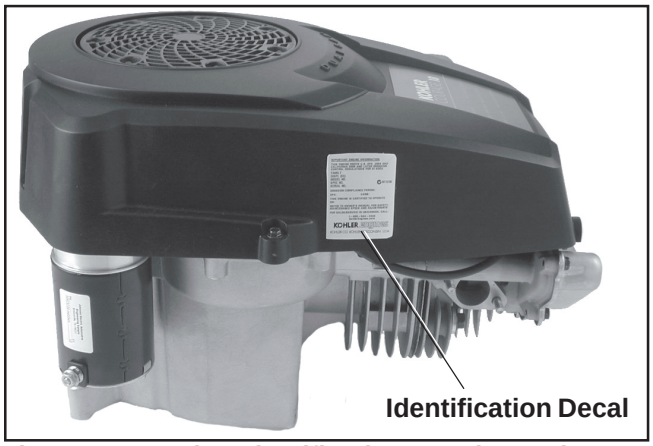


Figure 1-1. Engine Identification Decal Location.

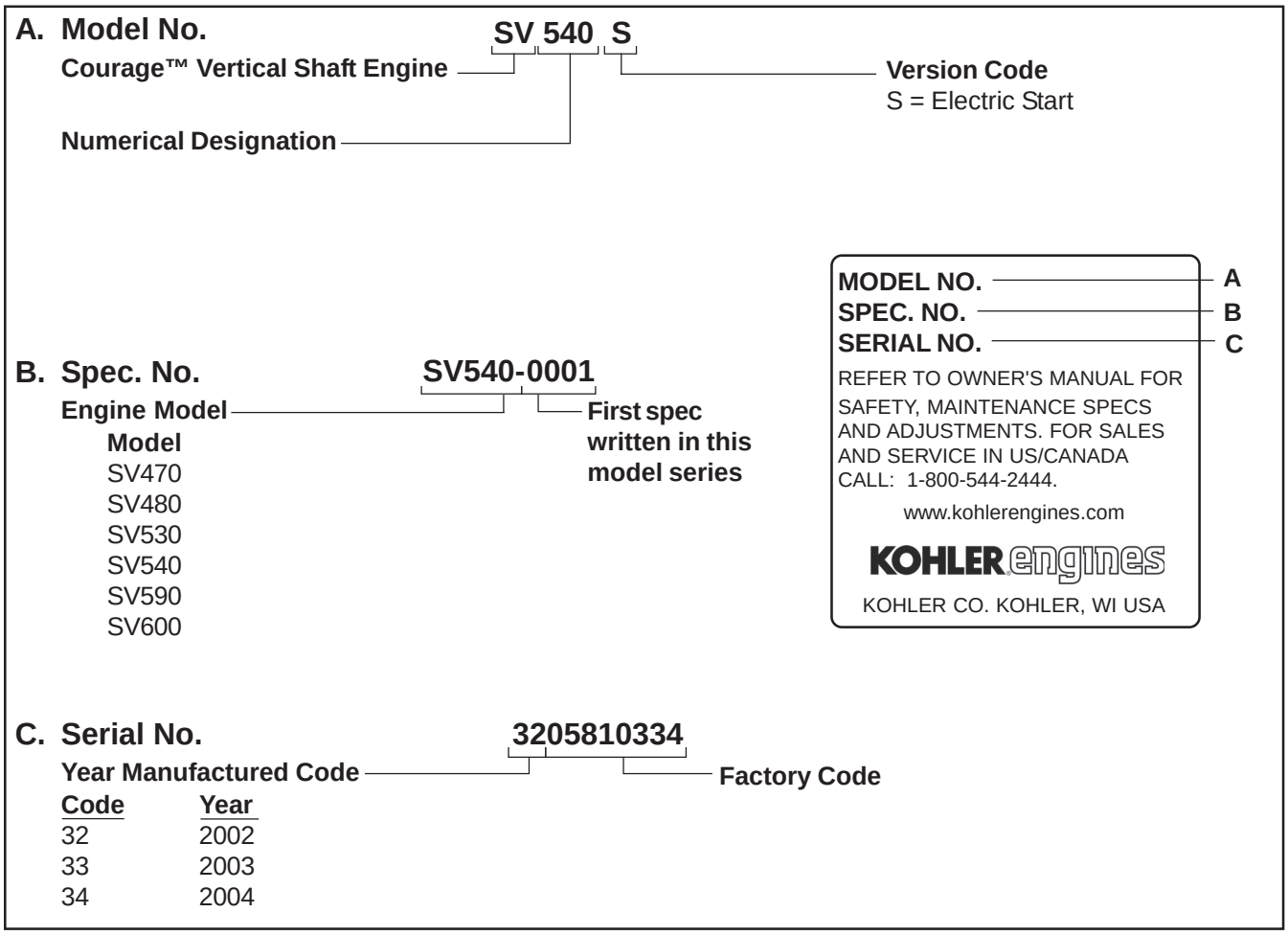


Figure 1-2. Explanation of Engine Identification Numbers.

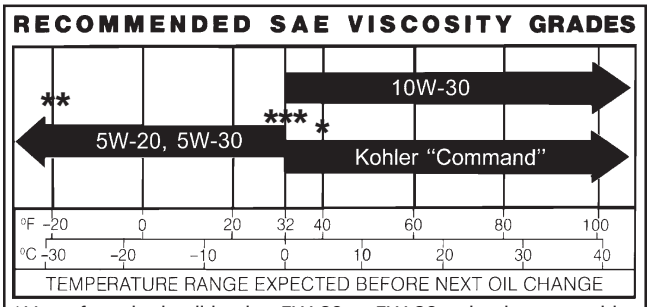
Section 1
Safety and General Information

Oil Recommendations

Using the proper type and weight of oil in the crankcase is extremely important, as 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 below.



*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).

***30 weight acceptable above 0°C (32°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.

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 oil check, oil change, and oil filter change procedures.

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. Leaded gasoline may be used in areas where unleaded is not available and exhaust emissions are not regulated. Be aware however, that the cylinder head will require more frequent service.

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 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
Daily or Before Starting Engine	• Fill fuel tank. • Check oil level. • Check air cleaner for dirty[1], loose, or damaged parts. • Check air intake and cooling areas, clean as necessary[1].
Every 2 Months or 25 Hours	• Service precleaner element[1] (if equipped). • Service air cleaner element[1] (if not equipped with precleaner).
Annually or Every 100 Hours	• Replace air cleaner element[1] (if equipped with precleaner). • Change oil and filter (refer to Viscosity Table, Page 1.4, based on seasonal temperatures). • Remove blower housing and clean cooling areas. • Check that all fasteners are in place and components are properly secured. • Replace fuel filter.
Every 2 Years or 200 Hours	• Check spark plug condition and gap.
Every 200 Hours	• Have bendix starter drive serviced[2]. • Have valve lash checked/adjusted[2].
Every 500 Hours	• Replace spark plug.

[1]Perform these maintenance procedures more frequently under extremely dusty, dirty conditions.
[2]Have a Kohler Engine Service Dealer perform this service.

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 engine.

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

3. 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 manufacturer’s 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.

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

4. Due to the deep recess around the spark plug, blow out the cavity with compressed air. Remove the spark plug. The spark plug is most accessible when the blower housing is removed for cleaning.

   Add one tablespoon of engine oil into the spark plug hole. Install the plug, but do not connect the plug lead. Crank the engine two or three revolutions. Connect the plug lead.

5. Reinstall the blower housing, if removed previously, and torque the blower housing screws to **7.5 N·m (65 in. lb.)**.

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

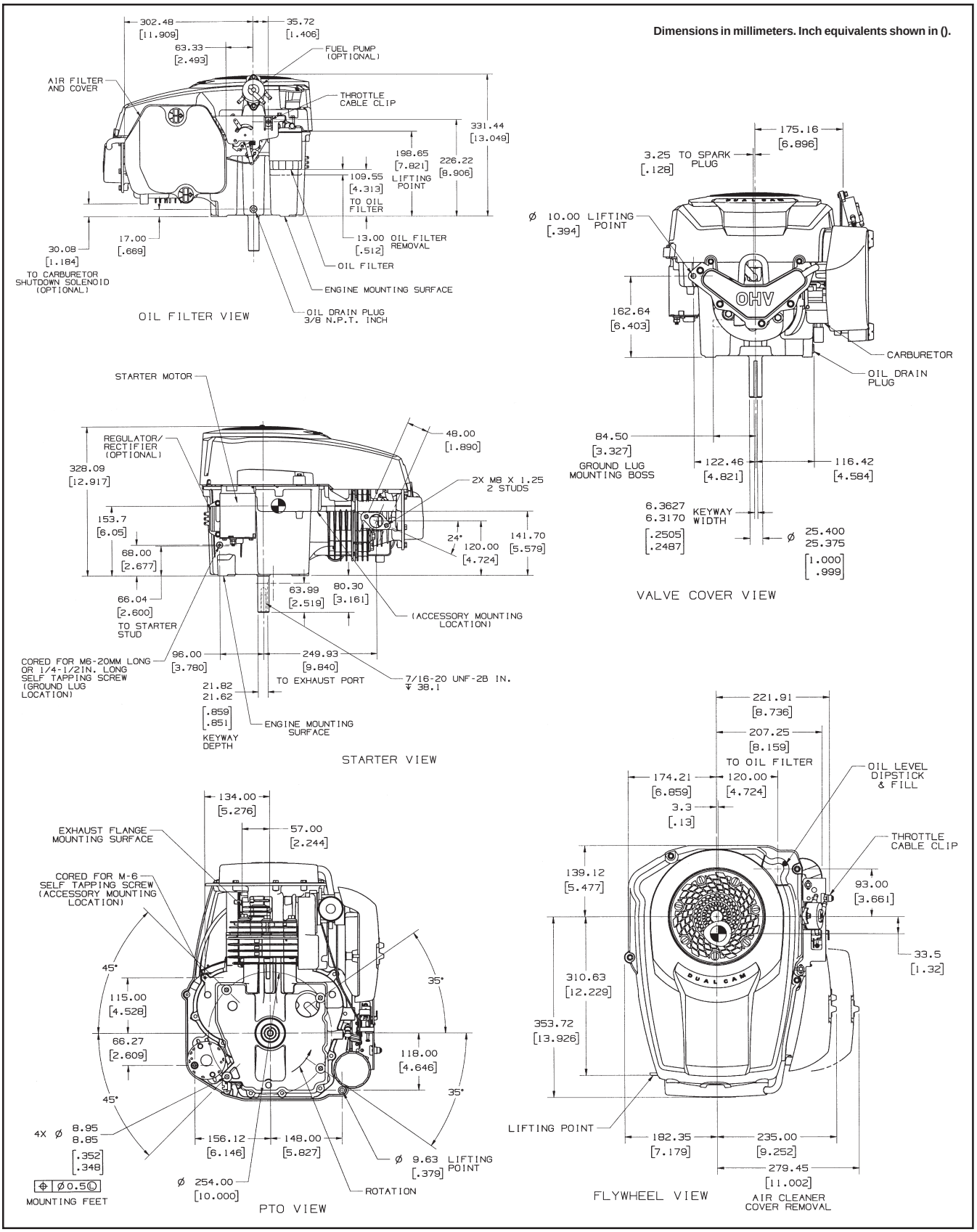


Figure 1-4. Typical Engine Dimensions.

General Specifications[1]

Power (@ 3600 RPM, corrected to SAE J1940)

SV470	11.2 kW (15 HP)
SV480	11.9 kW (16 HP)
SV530	12.7 kW (17 HP)
SV540	13.4 kW (18 HP)
SV590	14.1 kW (19 HP)
SV600	14.9 kW (20 HP)

Peak Torque

SV470 @ 2600 RPM	34.3 N·m (25.0 ft. lb.)
SV480 @ 2800 RPM	34.6 N·m (25.5 ft. lb.)
SV530 @ 2600 RPM	37.8 N·m (27.9 ft. lb.)
SV540 @ 2800 RPM	39.1 N·m (29.0 ft. lb.)
SV590 @ 2600 RPM	42.3 N·m (31.2 ft. lb.)
SV600 @ 2800 RPM	44.2 N·m (32.0 ft. lb.)

Bore

SV470S, SV480S	84 mm (3.30 in.)
SV530S, SV540S	89 mm (3.50 in.)
SV590S, SV600S	94 mm (3.70 in.)

Stroke	86 mm (3.38 in.)

Displacement

SV470S, SV480S	477 cc (29.1 cu. in.)
SV530S, SV540S	535 cc (32.6 cu. in.)
SV590S, SV600S	597 cc (36.4 cu. in.)

Compression Ratio	8.5:1
Dry Weight	35.8 kg (79 lb.)
Oil Capacity (with filter)	1.5 L (1.6 qt.)
Angle of Operation - Maximum (at Full Oil Level) All Directions	25° Intermittent

Air Cleaner Base

Hex. Nut Fastener Torque	5.5 N·m (48 in. lb.)
Mounting Screw Fastener Torque (Install Dry - DO NOT OIL)	8.0 N·m (70 in. lb.) Into new as-cast hole 5.5 N·m (48 in. lb.) Into used hole

Blower Housing and Sheet Metal

M6 Fasteners Torque	7.5 N·m (65 in. lb.)

Cam Lever

Cam Lever Fastener Torque	7.5 N·m (65 in. lb.)

Cam Gears

End Play	0.5/1.5 mm (0.019/0.059 in.)
Running Side Clearance	0.02/0.13 mm (0.001/0.005 in.)

[1]Values are in Metric units. Values in parentheses are English equivalents. Lubricate threads with engine oil prior to assembly, EXCEPT for air cleaner base thread forming screw - install dry.

Cam Gears (cont'd.)
Cam Gear-to-Cam Shaft Running Assembly ..... 0.02/0.10 mm (0.001/0.004 in.)

Carburetor
Fuel Bowl Retaining Screw Torque ..... 5.1-6.2 N·m (45-55 in. lb.)

Closure Plate
Closure Plate Fastener Torque ..... 24.5 N·m (216 in. lb.)

Balance Weight Guide Channel Width
- New ..... 17.95/18.05 mm (0.707/0.711 in.)
- Max. Wear Limit ..... 18.13 mm (0.714 in.)

Connecting Rod
Cap Fastener Torque (torque in 2 increments) ..... 5.5, 11.5 N·m (50, 100 in. lb.)

Connecting Rod-to-Crankpin Running Clearance
- New ..... 0.03/0.055 mm (0.0012/0.0022 in.)
- Max. Wear Limit ..... 0.07 mm (0.0025 in.)

Connecting Rod-to-Crankpin Side Clearance ..... 0.25/0.59 mm (0.0098/0.0232 in.)

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

Piston Pin End I.D.
- New ..... 22.015/22.023 mm (0.8667/0.8670 in.)
- Max. Wear Limit ..... 22.036 mm (0.8675 in.)

Crankcase
Governor Cross Shaft Bore I.D.
- New ..... 6.025/6.05 mm (0.2372/0.2382 in.)
- Max. Wear Limit ..... 6.063 mm (0.2387 in.)

Oil Drain Plug Torque ..... 14.0 N·m (125 in. lb.)

Crankshaft
End Play (free) ..... 0.225/1.025 mm (0.0089/0.040 in.)

Crankshaft Bore in Crankcase I.D.
- New ..... 41.965/41.990 mm (1.6521/1.6531 in.)
- Max. Wear Limit ..... 42.016 mm (1.654 in.)

Crankshaft Bore in Closure Plate I.D
- New ..... 44.965/44.990 mm (1.7703/1.7713 in.)
- Max. Wear Limit ..... 45.016 mm (1.7723 in.)

Flywheel End Main Bearing Journal
- O.D. – New ..... 44.913/44.935 mm (1.7682/1.7691 in.)
- O.D. – Max. Wear Limit ..... 44.84 mm (1.765 in.)
- Max. Taper ..... 0.0220 mm (0.0009 in.)
- Max. Out of Round ..... 0.025 mm (0.001 in.)

Crankshaft (cont'd.)

PTO End Main Bearing Journal	
O.D. – New	41.913/41.935 mm (1.6501/1.6510 in.)
O.D. – Max. Wear Limit	41.86 mm (1.648 in.)
Max. Taper	0.020 mm (0.0008 in.)
Max. Out of Round	0.025 mm (0.001 in.)
Crankshaft Bore in Closure Plate Running Clearance	
New	0.03/0.077 mm (0.0012/0.003 in.)
Crankshaft Bore in Crankcase Running Clearance	
New	0.03/0.077 mm (0.0012/0.003 in.)
Connecting Rod Journal O.D.	
New	40.982/41.000 mm (1.6134/1.6141 in.)
Max. Wear Limit	40.964 mm (1.612 in.)
Max. Taper	0.012 mm (0.0005 in.)
Max. Out of Round	0.025 mm (0.001 in.)
Crankshaft T.I.R.	
PTO End, Crankshaft in Engine	0.15 mm (0.0059 in.)
Entire Crankshaft, in V-Blocks	0.10 mm (0.0039 in.)
Crankshaft Eccentrics O.D.	
New	66.940/66.970 mm (2.6354/2.6366 in.)
Max. Wear Limit	66.89 mm (2.633 in.)
Balance Weight Bearing Surface I.D.	
New	67.011/67.086 mm (2.6382/2.6412 in.)
Max. Wear Limit	67.140 mm (2.6430 in.)
Balance Weight Screw Torque	10.0 N·m (90 in. lb.)
Guide Pin O.D.	
New	11.950/11.975 mm (0.4705/0.4715 in.)
Max. Wear Limit	11.900 mm (0.4685 in.)
Guide Shoe Width	
New	17.85/17.90 mm (0.703/0.705)
Max. Wear Limit	17.75 mm (0.6988 in.)
Guide Shoe Hole I.D.	
New	12.000/12.025 mm (0.4724/0.4734 in.)
Max. Wear Limit	12.050 mm (0.4744 in.)

Cylinder Bore

Cylinder Bore I.D.	
New	
SV470, SV480	84.000/84.025 mm (3.307/3.308 in.)
SV530, SV540	89.000/89.025 mm (3.504/3.505 in.)
SV590, SV600	94.010/94.035 mm (3.701/3.702 in.)
Max. Wear Limit	
SV470, SV480	84.073 mm (3.310 in.)
SV530, SV540	89.073 mm (3.507 in.)
SV590, SV600	94.073 mm (3.704 in.)

Cylinder Bore I.D. (cont'd.)

Max. Taper	0.05 mm (0.002 in.)
Max. Out of Round	0.12 mm (0.0047 in.)

Cylinder Head

Cylinder Head Fastener Torque (torque in 2 increments)	20.5, 41.0 N·m (180, 360 in. lb.)
Max. Out-of-Flatness	0.8 mm (0.003 in.)
Rocker Arm Pivot Stud Torque	13.5 N·m (120 in. lb.)
Rocker Arm Adjustment Nut Set Screw	5.5 N·m (50 in. lb.)

Electric Starter

Thru Bolt Torque	3.3-3.9 N·m (30-35 in. lb.)
Mounting Nut Torque	3.6 N·m (32 in. lb.)
Nut (Top) Positive (+) Brush Lead Terminal	1.6-2.8 N·m (15-25 in. lb.)
Nut (Flange) Positive (+) Brush Lead Terminal	2.2-4.5 N·m (20-40 in. lb.)

Fan/Flywheel

Flywheel Retaining Screw Torque	66.5 N·m (588 in. lb.)

Governor

Governor Cross Shaft-to-Crankcase Running Clearance	0.013/0.075 mm (0.0005/0.003 in.)
Governor Cross Shaft O.D.	
New	5.975/6.012 mm (0.2352/0.2367 in.)
Max. Wear Limit	5.962 mm (0.2347 in.)
Governor Gear Shaft-to-Governor Gear Running Clearance	0.09/0.16 mm (0.0035/0.0063 in.)
Governor Gear Shaft O.D.	
New	5.99/6.00 mm (0.2358/0.2362 in.)
Max. Wear Limit	5.977 mm (0.02353 in.)

Ignition

Spark Plug Type (Champion® or Equivalent)	RC12YC or QC12YC
Spark Plug Gap	0.76 mm (0.030 in.)
Spark Plug Torque	24-30 N·m (18-22 ft. lb.)
Ignition Module Air Gap	0.203/0.305 mm (0.008/0.012 in.)
Ignition Module Fastener Torque	6.0 N·m (55 in. lb.) Into new as-cast hole 4.0 N·m (35 in. lb.) Into used hole

Muffler

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

Oil Filter

Oil Filter Torque	10-13 N·m (90-110 in. lb.)

Oil Filter Pad Pipe Plug
1/8" N.P.T.F. Torque ..... 4.5-5.0 N·m (40-46 in. lb.)

Oil Pump
Mounting Screw Torque ..... 4.0 N·m (35 in. lb.)

Pump Gears-to-Crankcase Side Clearance ..... 0.165/0.315 mm (0.0065/0.0124 in.)

Oil Sentry™
Pressure Switch Torque ..... 4.5-5.0 N·m (40-45 in. lb.)

Piston, Piston Rings, and Piston Pin
Piston Pin Bore I.D.
- New ..... 22.006/22.012 mm (0.8685/0.8666 in.)
- Max. Wear Limit ..... 22.025 mm (0.8671 in.)

Piston Pin O.D.
- New ..... 21.995/22.0 mm (0.8659/0.8661 in.)
- Max. Wear Limit ..... 21.994 mm (0.8658 in.)

Top Compression Ring-to-Groove Side Clearance ..... 0.04 mm (0.0016 in.)

Middle Compression Ring-to-Groove Side Clearance ..... 0.04 mm (0.0016 in.)

Top and Middle Compression Ring End Gap
- New Bore
  - Top Ring ..... 0.15/0.40 mm (0.006/0.016 in.)
  - Middle Ring ..... 0.30/0.55 mm (0.012/0.022 in.)
- Used Bore (max.) ..... 0.77 mm (0.030 in.)

Piston Thrust Face O.D.[2]
- SV470, SV480
  - New ..... 83.948/83.962 mm (3.3050/3.3056 in.)
  - Max. Wear Limit ..... 83.828 mm (3.3003 in.)
- SV530, SV540
  - New ..... 88.948/88.962 mm (3.5018/3.5024 in.)
  - Max. Wear Limit ..... 88.828 mm (3.4972 in.)
- SV590, SV600
  - New ..... 93.928/93.942 mm (3.6980/3.6985 in.)
  - Max. Wear Limit ..... 93.828 mm (3.6940 in.)

Piston Thrust Face-to-Cylinder Bore[2] Running Clearance
- SV470, SV480, SV530, SV540 ..... 0.0575 mm (0.0023 in.)
- SV590, SV560 ..... 0.0875 mm (0.0034 in.)

Rectifier-Regulator
Mounting Screw Torque ..... 6.0 N·m (55 in. lb.) Into new as cast hole
4.0 N·m (35 in. lb.) Into used hole

Speed Control
Speed Control Bracket Assembly Fastener Torque ..... 11.0 N·m (95 in. lb.) Into new as-cast hole
7.5 N·m (65 in. lb.) Into used hole

[2]Measure 8 mm (0.314 in.) above the bottom of the piston skirt at right angles to the piston pin.

Stator

Stator Mounting Screw Torque ..... 6.0 N·m (55 in. lb.) Into new as-cast hole
4.0 N·m (35 in. lb.) Into used hole

Throttle/Choke Controls

Governor Control Lever Fastener Torque ..... 7.0-8.5 N·m (60-75 in. lb.)

Valve Cover

Valve Cover Fastener Torque ..... 11.0 N·m (95 in. lb.) Into new as-cast hole
7.5 N·m (65 in. lb.) Into used hole

Valves and Valve Lifters

Valve Lash[3] ..... 0.076 mm (0.003 in.)

Intake Valve Minimum Lift ..... 8.9 mm (0.350 in.)

Exhaust Valve Minimum Lift ..... 8.9 mm (0.350 in.)

Nominal Valve Seat Angle ..... 45°

Intake Valve Stem-to-Valve Guide Running Clearance ..... 0.038/0.076 mm (0.0015/0.003 in.)

Exhaust Valve Stem-to-Valve Guide Running Clearance ..... 0.050/0.88 mm (0.0020/0.0035 in.)

Intake Valve Guide I.D.
- New ..... 6.038/6.058 mm (0.2377/0.2385 in.)
- Max. Wear Limit ..... 6.135 mm (0.2415 in.)

Intake Valve Stem Diameter
- New ..... 5.982/6.0 mm (0.2355/0.2362 in.)

Exhaust Valve Guide I.D.
- New ..... 6.038/6.058 mm (0.2377/0.2385 in.)
- Max. Wear Limit ..... 6.160 mm (0.2425 in.)

Exhaust Valve Stem Diameter
- New ..... 5.970/5.988 mm (0.235/0.2357 in.)

[3]Check valve lash every 200 hours, adjust as required.

General Torque Values

Metric Fastener Torque Recommendations for Standard Applications

Tightening Torque: N·m (in. lb.) + or - 10%

	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 - 10%

	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)

Oil Drain Plugs Tightening Torque: N•m (English Equiv.)

Size	Into Cast Iron	Into Aluminum
1/8" NPT	–	4.5 (40 in. lb.)
1/4"	17.0 (150 in. lb.)	11.3 (100 in. lb.)
3/8"	20.3 (180 in. lb.)	13.6 (120 in. lb.)
1/2"	27.1 (20 ft. lb.)	17.6 (13 ft. lb.)
3/4"	33.9 (25 ft. lb.)	21.7 (16 ft. lb.)
X-708-1	27.1/33.9 (20/25 ft. lb.)	27.1/33.9 (20/25 ft. lb.)

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

Section 2
Special Tools

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

Kohler special tools are handled by SPX Corp., a division of Owatonna Tool Corp. (OTC). The tools are easy to purchase by contacting SPX/OTC by phone, fax, or mail.

Phone:	1-800-533-0492 International: 1-507-455-7223 8:00 am – 8:00 pm EST	Fax:	1-800-578-7375 1-586-578-7375 International: 1-507-455-7063	Mail:	SPX Corp., OTC 28635 Mound Rd. Warren, MI 48092-3499

Some special tools for this engine are:

Flywheel Puller Kit	NU3226
Valve Guide Reamer	KO1026
Rocker Arm Spanner Wrench	(obtain locally)
Water Manometer	KO1048
Vacuum Gauge	KO3223
Cylinder Leakdown Tester	KO3219
Ignition System Tester	KO1046
Amp Meter	KO3218
Inductance Tachometer	KO3216

Some of the specialty tools are shown and mentioned at various points in this manual. A complete catalog of all available tools may be ordered under Kohler Part No. TP-2546. The tool price list is available under Kohler Part No. TP-2547.

Figure 2-1. Tool Catalog and Price List.

Special Tools You Can Make

Flywheel Holding Tool

Flywheel removal and reinstallation becomes a "snap" using a handy holding tool you can make out of a piece of an old "junk" flywheel ring gear as shown in Figure 2-2. Using an abrasive cut-off saw, cut out a six tooth segment of the ring gear as shown. Grind off any burrs or sharp edges. The segment can be used in place of a strap wrench. Invert the segment and place it between the ignition module bosses on the crankcase, so the tool teeth engage the ring gear teeth on the flywheel. The bosses will "lock" the tool and flywheel in position for loosening, tightening or removing with a puller.

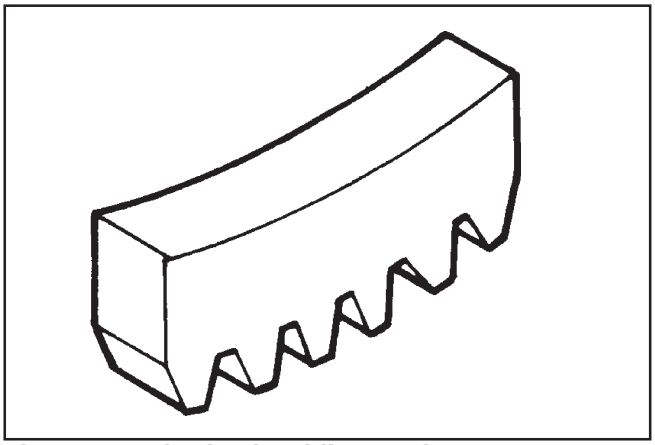


Figure 2-2. Flywheel Holding Tool.

Rocker Arm/Crankshaft Tool

If you don't have a spanner wrench to lift the rocker arms or to turn the crankshaft, you can make a tool for doing this out of an old junk connecting rod.

Find a used connecting rod from a 10 HP or larger engine. Remove and discard the rod cap. If it is a Posi-Lock rod, you will also need to remove the studs. If it is a Command rod, you will need to grind off the aligning steps, so the joint surface is flat. Find a 1" long capscrew with the correct thread size to match the threads in the connecting rod. Obtain a flat washer with the correct I.D. to slip on the capscrew and an O.D. of approximately 1". Kohler Part No. **12 468 05-S** can be used if you don't have the right size on hand. Assemble the capscrew and washer to the joint surface of the rod, as shown in Figure 2-3.

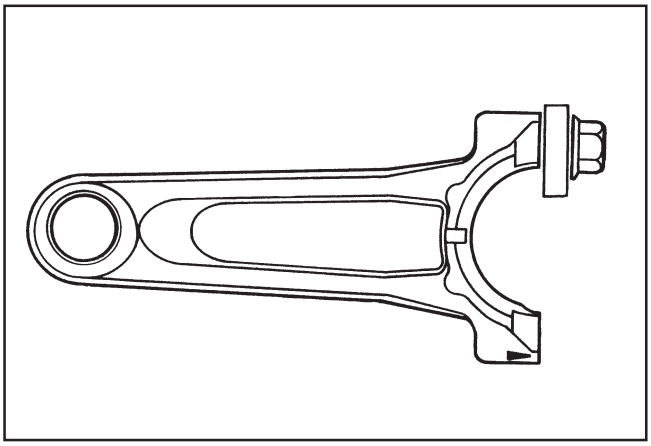


Figure 2-3. Rocker Arm/Crankshaft Tool.

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 types of engine troubles are listed below. Use these to help locate the possible cause(s).

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 disconnected.
6. Key switch or kill switch in ‘‘off’’ position.
7. Faulty spark plug.
8. Faulty ignition module.
9. Inoperative fuel solenoid.
10. Choke not closing.

Engine Starts But Does Not Keep Running

1. Vent in fuel cap restricted.
2. Dirt or water in the fuel system.
3. Faulty choke or throttle controls.
4. Loose wires or connections that short the kill terminal of ignition module to ground.
5. Faulty carburetor.
6. Faulty cylinder head gasket.

Engine 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 choke or throttle controls.
6. Faulty spark plug.
7. Low compression.
8. Faulty ACR mechanism.

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.
7. Seized internal engine components.

Engine Runs But Misses

1. Dirt or water in the fuel system.
2. Spark plug faulty or fouled.
3. Spark plug lead boot loose on plug.
4. Loose wires or connections that intermittently short the kill terminal of ignition module to ground.
5. Engine overheated.
6. Faulty ignition module or improperly gapped.

Engine Will Not Idle

1. Vent in fuel cap restricted.
2. Dirt or water in the fuel system.
3. Faulty spark plug.
4. Idle fuel adjusting needle improperly set.
5. Idle speed adjusting screw improperly set.
6. Low compression.
7. Stale fuel and/or gum in carburetor.

Engine Overheats

1. Air intake/grass screen, cooling fins, or cooling shrouds clogged.
2. Excessive engine load.
3. Low crankcase oil level.
4. High crankcase oil level.
5. Faulty carburetor.

Engine Knocks

1. Excessive engine load.
2. Low crankcase oil level.
3. Old/improper fuel.
4. Internal wear or damage.

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.
7. Faulty spark plug.
8. Low compression.
9. Exhaust restriction.

Engine Uses Excessive Amount of Oil

1. Incorrect oil viscosity/type.
2. Breather clogged or inoperative.
3. Worn or broken piston rings.
4. Worn cylinder bore.
5. Worn valve stems/valve guides.
6. Crankcase overfilled.

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 crankcase, cooling fins, grass screen and other external surfaces. Dirt or debris on these areas can cause overheating.

- Check for obvious oil leaks and damaged components. Excessive oil leakage can indicate a clogged or inoperative breather, worn or damaged seals or gaskets, or loose fasteners.

- Check the air cleaner cover and base for damage or indications of improper fit and seal.

- Check the air cleaner element. Look for holes, tears, cracked or damaged sealing surfaces, or other damage that could allow unfiltered air into the engine. Also note if the element is dirty or clogged. These could indicate improper maintenance.

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

- Check if the oil level is within the operating range on the dipstick. If it is above, sniff for gasoline odor.

- Check the condition of the oil. Drain the oil into a container; it should flow freely. Check for metal chips and other foreign particles.

Sludge is a natural by-product of combustion; a small accumulation is normal. Excessive sludge formation could indicate the wrong type or weight of oil was used, the oil was not changed at the recommended intervals, an over-rich fuel mixture, or weak ignition, to name a few possible causes.

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-operating breather) can cause oil to be forced out at oil seals, gaskets, or other available spots.

Crankcase vacuum is best measured with a water manometer or vacuum/pressure test gauge. See Section 2. Complete instructions are provided with the testers.

Test the crankcase vacuum with the manometer as follows:

1. Insert the rubber stopper into the oil fill hole. Be sure the pinch clamp is installed on the hose and use the tapered adapters to connect the hose between the stopper and one of the manometer tubes. Leave the other tube open to the atmosphere. Check that the water level in the manometer is at the “0” line. Make sure the pinch clamp is closed.
2. Start the engine and run at no-load high idle 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 the same as the open side (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 pinch clamp **before** stopping the engine.

To perform the test with the vacuum/pressure gauge:

1. Insert the stopper as in step 1.
2. Insert the barbed gauge fitting into the hole in the stopper. Be sure the gauge needle is at “0”.
3. Run the engine, as in step 2, and observe the gauge reading. Needle movement to the left of “0” is a vacuum, and movement to the right indicates a pressure. A minimum of 10.2 cm (4 in.) of vacuum should be present.

Incorrect Vacuum in Crankcase

Possible Cause	Solution
1. Crankcase breather clogged or inoperative.	1. Disassemble breather, clean parts thoroughly, reassemble, and recheck pressure.
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 with cylinder leakdown test.	3. Recondition piston, rings, cylinder bore, valves, and valve guides.
4. Restricted exhaust.	4. Repair/replace restricted muffler/exhaust system.

Compression Test
These engines are equipped with an automatic compression release (ACR) mechanism. Because of the ACR mechanism, it is difficult to obtain an accurate compression reading. As an alternate, use the leakdown test described below.

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.

SPX Part No. KO3219 (previously Kohler Part No. **25 761 05-S**) is a relatively simple, inexpensive leakdown tester for small engines. The tester includes a quick disconnect coupling for attaching the adapter hose and a holding tool.

Leakdown Test Instructions

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

2. Remove the spark plug.

3. Rotate the crankshaft until the piston is at top dead center of the 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, align the slot with one of the mounting holes on the PTO face, and tighten it onto the crankshaft. Install a 3/8" breaker bar into the slot of the holding tool, so it is perpendicular to both the holding tool and crankshaft, or insert a shoulder bolt through the slot and thread it into the mounting hole. 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 into the spark plug hole, but do not attach it to the tester at this time.

5. Connect an adequate air source (80-100 psi) 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 (right) end of the scale.

7. Connect the tester quick-disconnect to the adapter. Note the gauge reading and listen for escaping air at the carburetor inlet, exhaust outlet, and/or crankcase breather.

8. Check your test results against the table below:

Leakdown Test Results

Air escaping from crankcase breather	Defective rings or worn cylinder walls.
Air escaping from exhaust system	Defective exhaust valve.
Air escaping from carburetor	Defective intake valve.
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.

Section 4
Air Cleaner and Air Intake System

Air Cleaner

These engines are equipped with a replaceable, high density, paper air cleaner element. Some engines also have an oiled, foam precleaner, located in the outer air cleaner cover. See Figure 4-1.

Intake air is drawn in through the upper opening from the blower housing, passes through the precleaner (if so equipped), the paper element and then into the carburetor. The outer air cleaner cover is secured by two knobs, and removed by turning the knobs counterclockwise.

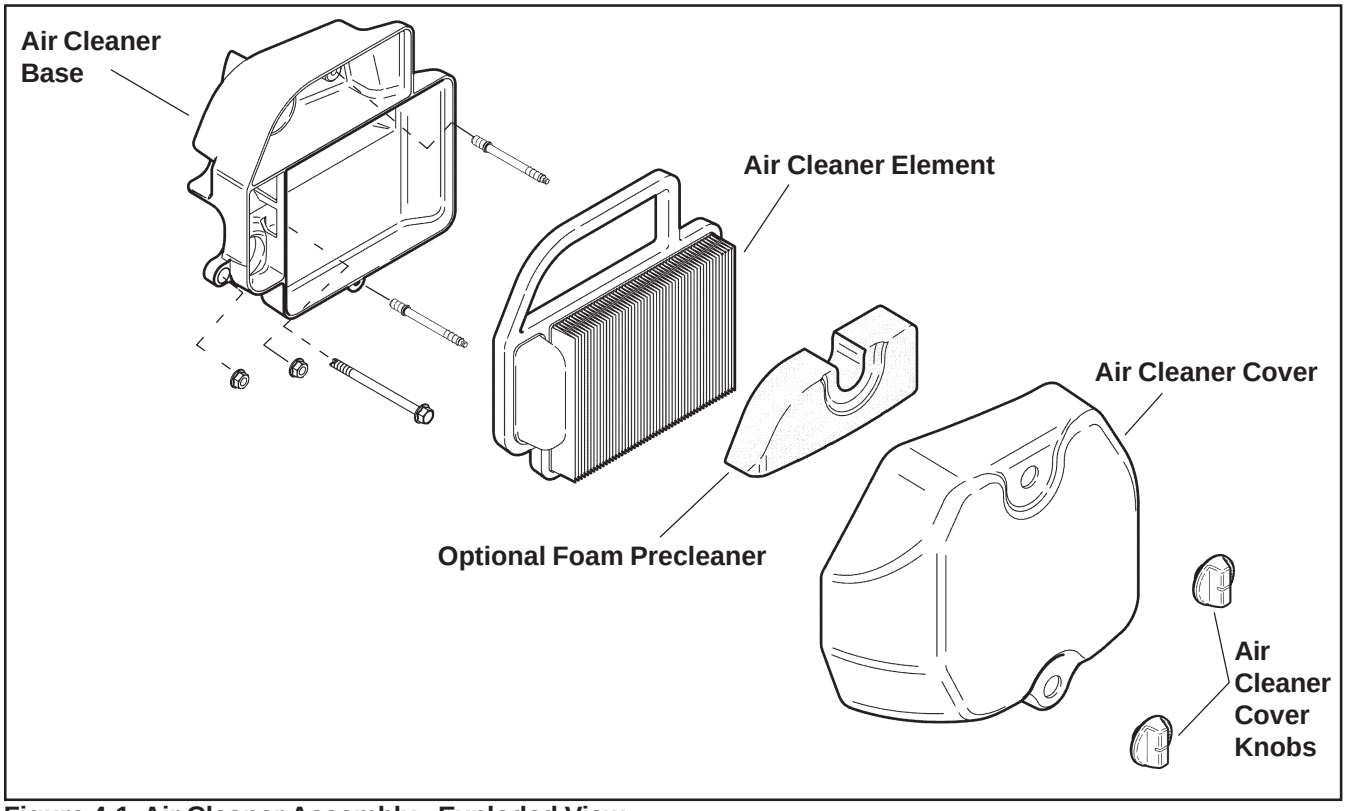


Figure 4-1. Air Cleaner Assembly - Exploded View.

Check the air cleaner **daily or before starting the engine**. Check for and correct any buildup of dirt and debris, and loose or damaged components.

NOTE: Operating the engine with loose or damaged air cleaner components could allow unfiltered air into the engine causing premature wear and failure.

Precleaner Service

If so equipped, wash and oil the precleaner **every two months** or **every 25 hours** of operation (more often under extremely dusty or dirty conditions).

1. Loosen the air cleaner cover knobs and remove the cover.
2. Remove the precleaner.

3. Wash the precleaner in warm water with detergent. Rinse the precleaner thoroughly until all traces of detergent are eliminated. Squeeze out excess water (do not wring). Allow the precleaner to air dry.

4. Saturate the precleaner with new engine oil. Squeeze out all excess oil.

5. Reinstall the precleaner into the outer cover.

6. Install the air cleaner cover and secure with the two knobs.

7. When precleaner replacement is necessary, order Kohler Part No. **20 083 01-S**.

Paper Element Service
Check the paper element **every two months** or **every 25 hours** of operation (more often under extremely dusty or dirty conditions). Clean or replace the element as necessary. Replace the air cleaner element **annually** or **every 100 hours**.

1. Remove the air cleaner cover and the precleaner (if so equipped), service as required.

2. Remove the air cleaner element with the integral rubber seal.

3. Gently tap the pleated side of the paper element to dislodge dirt. **Do not** wash the paper element or use pressurized air, as this will damage the element. Replace a dirty, bent, or damaged element with a genuine Kohler element. Handle new elements carefully; do not use if the rubber seal is damaged.

4. Clean all air cleaner components of any accumulated dirt or foreign material. Prevent any dirt from entering the throat of the carburetor.

5. Install the air cleaner element with the pleated side “out” and seat the rubber seal onto the edges of the air cleaner base.

6. Reinstall the precleaner (if so equipped), into the upper section of the air cleaner cover. Make sure the hole in the precleaner is aligned with the upper mounting knob. See Figure 9.

7. Reinstall the air cleaner cover and secure with the two knobs.

8. When element replacement is necessary, order Kohler Part No. **20 083 02-S**.

Inspect Air Cleaner Components
Whenever the air cleaner cover is removed, or the paper element or precleaner is serviced, check the following areas/components:

Outer Air Cleaner Cover - Make sure the air cleaner cover is in good condition, not cracked, damaged, or missing a retaining knob, which can affect the sealing ability of the air cleaner element.

Air Cleaner Base - Make sure the base is properly secured and not cracked or damaged. Since the air cleaner base and carburetor are secured to the intake port with common hardware, it is extremely important that the fasteners securing these components are tight at all times. The air cleaner base also provides the mounting points for the air cleaner cover retaining studs. Make sure the bosses are not cracked, broken or damaged, and the studs are properly secured.

Before reinstalling an air cleaner base that has been removed, make sure the metal bushings in the base mounting holes are present. See Figure 4-2. The bushings prevent damage to the base and maintain the proper mounting torque.

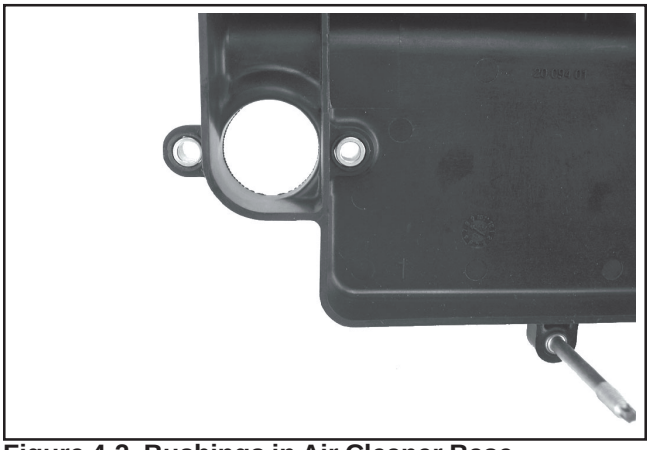


Figure 4-2. Bushings in Air Cleaner Base.

Breather Hose - Make sure the hose is not cracked or damaged, and attached to both the air cleaner base and valve cover.

NOTE: Damaged, worn, or loose air cleaner components can allow unfiltered air into the engine causing premature wear and failure. Tighten or replace all loose or damaged components.

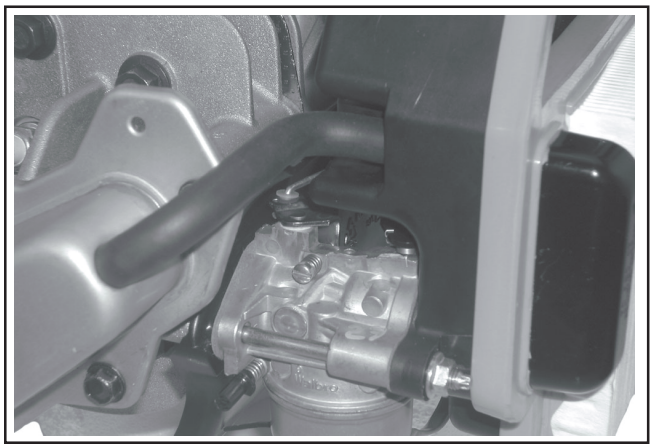


Figure 4-3. Breather Hose.

Disassembly
The following procedure is for complete disassembly of all air cleaner components. As the removal of the air cleaner base also affects carburetor mounting and governor adjustment, steps 3 and 4 should only be performed if required. Detailed photos are provided in Sections 5, 8, and 10 for the various individual steps.

1. Loosen the air cleaner cover retaining knobs and remove the air cleaner cover.

2. Remove the foam precleaner (if so equipped), and the air cleaner element with formed rubber seal.

3. Disconnect the breather hose from the valve cover or air cleaner base.

   NOTE: The air cleaner base should be removed only if necessary.

4. Remove the two hex. flange nuts from the mounting studs. If one stud and one thread forming screw is used; first remove the thread forming screw on the right side of the carburetor inlet, which secures the air cleaner base, carburetor and gaskets. Insert a 3/16" diameter rod approximately 4" long, into the hole to serve as a temporary alignment pin. Be careful not to force the rod or damage the threads. Then remove the hex. flange nut from the stud on the left side of the carburetor inlet. Carefully remove the air cleaner base and gasket. The cover mounting studs thread into the air cleaner base, and they should only be removed if necessary.

Reassembly
The following procedure is for complete assembly of all air cleaner components. Steps 1-3 are necessary only if the air cleaner base and/or the cover mounting studs were removed in "Disassembly".

1. Install the mounting studs into the air cleaner base if removed previously. Tighten the studs until bottomed, or to the end of threads (do not force).

2. Install the air cleaner base gasket and air cleaner base, with the two metal spacers, onto the mounting stud(s) and/or alignment pin. Make sure the upper mounting tab is located **above** the closure plate. Install and finger tighten the hex. flange nut(s). When a long M6 thread forming mounting screw is used, apply hand pressure to keep the parts from shifting, then remove the alignment pin and install the M6 thread forming screw. **DO NOT OIL**. Torque the nut(s) to **5.5 N·m (48 in. lb.)**. Torque the screw to **8.0 N·m (70 in. lb.)** into a new hole, or **5.5 N·m (48 in. lb.)** into a used hole, **do not** over tighten.

3. Reconnect the breather hose and perform the governor adjustment (See Section 5, "Initial Governor Adjustment").

4. Install the air cleaner element with the pleated side "out" and seat the rubber seal onto the edges of the air cleaner base.

5. Install the serviced precleaner (if so equipped) into the air cleaner cover. Make sure the hole in the precleaner is aligned with the upper mounting knob.

6. Reinstall the air cleaner cover and secure with the two knobs.

Section 4
Air Cleaner and Air Intake System

Air Intake/Cooling System

Clean Air Intake/Cooling Areas
To ensure proper cooling, make sure the grass screen, cooling fins, and other external surfaces of the engine are kept clean **at all times**.

Annually or **every 100 hours** of operation, (more often under extremely dusty, dirty conditions), remove the blower housing and any other cooling shrouds. Clean the cooling fins and external surfaces as necessary. Make sure all parts are reinstalled. Torque the M6 blower housing fasteners to **7.5 N·m (65 in. lb.)**.

NOTE: Operating the engine with a blocked grass screen, dirty or plugged cooling fins, and/or cooling shrouds removed, will cause engine damage due to overheating.

Section 5
Fuel System and Governor

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 insure 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. Leaded gasoline may be used in areas where unleaded is not available and exhaust emissions are not regulated. Be aware however, that the cylinder head will require more frequent service.

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 System

The typical fuel system and related components include the fuel tank, in-line fuel filter, fuel pump, carburetor, and fuel lines. Some applications use gravity feed without a fuel pump.

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 and gravity moves the fuel.

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.

Troubleshooting

Use the following procedure to check if fuel is reaching the combustion chamber.

Section 5
Fuel System and Governor

Fuel System Troubleshooting Guide

Test	Conclusion
1. Check for the following: a. Make sure the fuel tank contains clean, fresh, proper fuel. b. Make sure the vent in fuel cap is open. c. Make sure the fuel valve is open.	
2. Check for fuel in the combustion chamber. a. Disconnect and ground spark plug lead. b. Close the choke on the carburetor. c. Crank the engine several times. d. Remove the 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 the fuel pump. b. Hold the line below the bottom of the tank. Open the shutoff valve (if so equipped) and observe flow.	3. If fuel **does** flow from the line, reconnect line and check for faulty fuel pump (Test 4). If fuel **does not** flow from the line, check for clogged fuel tank vent, fuel pickup screen, shutoff valve, and fuel lines.
4. Check the operation of fuel pump. a. Remove the fuel line from the inlet fitting of the 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 clogged fuel line. If the fuel line is unobstructed, the fuel pump is faulty and must be replaced.

Fuel Filter

Some engines are equipped with an in-line fuel filter. Periodically inspect the filter and replace when dirty. Replacement is recommended **annually** or every **100 hours**. Use a genuine Kohler filter.

Fuel Pump

Some engines are equipped with an optional pulse fuel pump. See Figure 5-1.

Operation

The fuel pump has two internal chambers separated by a diaphragm. The air chamber is connected to the engine crankcase by a rubber hose. The fuel chamber has an inlet from the fuel tank, and an outlet to the carburetor. The inlet and outlet each have an internal, one-way check valve.

Alternating negative and positive pressures in the crankcase activate the pump. When the piston moves upward in the cylinder, negative pressure (vacuum) is created in the crankcase and in the air chamber of the pump. The diaphragm flexes toward the negative pressure, and the suction draws fuel past the inlet check valve, into the fuel chamber. Downward movement of the piston causes a positive pressure in the crankcase and air chamber, pushing the diaphragm in the opposite direction, putting pressure on the fuel. The inlet check valve has now closed, so the fuel is forced past the outlet check valve, to the carburetor.

Repair

Pulse fuel pumps are not serviceable and must be replaced when faulty.

Removal

1. Disconnect the inlet, outlet, and pulse lines from the fuel pump. Mark the lines for proper reassembly.

2. Remove the hex. flange screws attaching the fuel pump.

Installation

1. Install the new fuel pump, and secure with the hex. flange screws. Torque the hex. flange screws to **5.9 N·m (52 in. lb.)**. **Do not** over tighten.

2. Connect the inlet, outlet, and pulse lines to their respective fittings on pump. Secure with the clamps. See Figure 5-1.

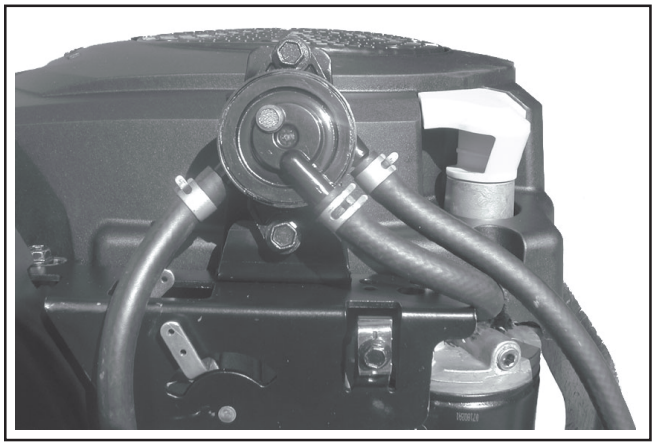


Figure 5-1. Pulse Fuel Pump.

Carburetor

These engines are equipped with a Walbro fixed main jet carburetor. See Figure 5-2. The carburetors will have a low idle speed adjustment screw, and either fixed idle, or a limiter cap on the idle fuel adjustment needle.

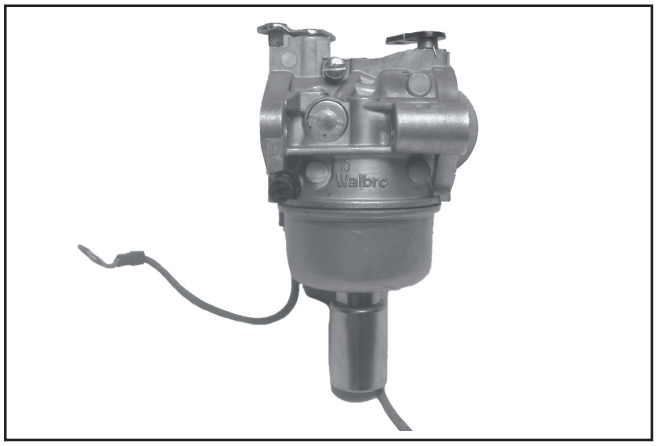


Figure 5-2. Carburetor.

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.

Troubleshooting – Fuel System

If engine troubles are experienced that appear to be fuel system related, 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 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 (as equipped), for restrictions or faulty components.
- 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, after checking the items listed above, starting problems or conditions similar to those listed in the following table exist, it may be necessary to adjust or service the carburetor.

Troubleshooting – Fuel System

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, then adjust the low idle fuel needle. b. Improper choke adjustment.
2. Engine runs rich. (Indicated by black, sooty exhaust smoke, misfiring, loss of speed and power, governor hunting, or excessive throttle opening).	2a. Choke partially closed during operation. Check the choke lever/linkage to ensure choke is operating properly. b. Low idle fuel mixture is improperly adjusted. Adjust low idle fuel needle. c. Float level is set too high. With fuel bowl removed and carburetor inverted, the exposed surface of float must be parallel with the bowl gasket surface of the carburetor body. d. Dirt under fuel inlet needle. Remove needle; clean needle and seat and blow with compressed air. e. Bowl vent or air bleeds plugged. Remove fuel bowl, low idle fuel adjusting needle, and welch plugs. Clean vent, ports, and air bleeds. Blow out all passages with compressed air. f. Fuel bowl gasket leaks. Remove fuel bowl and replace gasket. g. 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. Low idle fuel mixture is improperly adjusted. Adjust low idle fuel needle. b. Float level is set too low. With fuel bowl removed and carburetor inverted, the exposed surface of float must be parallel with the bowl gasket surface of the carburetor body. c. Idle holes plugged; dirt in fuel delivery channels. Remove fuel bowl, low idle fuel adjusting needle, and welch plugs. Clean main fuel jet and all passages; blow out with compressed air.
4. Fuel leaks from carburetor.	4a. Float level set too high. See Remedy 2c. b. Dirt under fuel inlet needle. See Remedy 2d. c. Bowl vent plugged. Remove fuel bowl and clean bowl vent. Blow out with compressed air. d. Float is cracked or damaged. Replace float. e. Bowl retaining screw gasket damaged. Replace gasket. f. Bowl retaining screw loose. Torque screw to specifications.

Carburetor Adjustment

NOTE: Carburetor adjustments should be made only after the engine has warmed up.

The carburetor is designed to deliver the correct fuel-to-air mixture to the engine under all operating conditions. The main fuel jet is calibrated at the factory and is not adjustable*. The idle fuel adjustment needle is also set at the factory and normally does not need adjustment. If the engine is hard starting or does not operate properly, however, it may be necessary to adjust or service the carburetor.

*NOTE: Engines operating at altitudes above approximately 1830 m (6000 ft.) may require a special ”high altitude” main jet. Refer to “High Altitude Operation” later in this section.

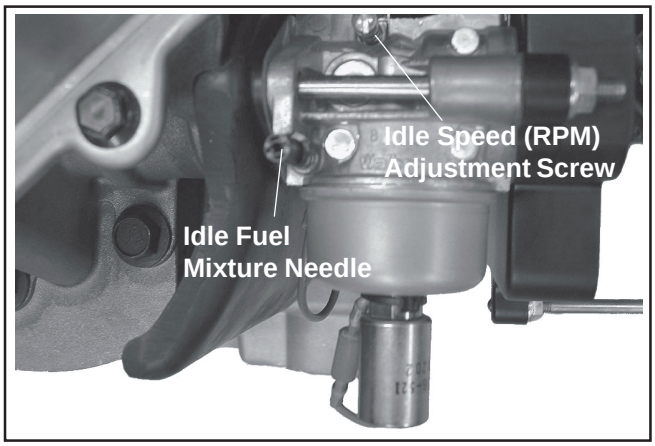


Figure 5-3. Fixed Main Jet Carburetor.

Low Idle Mixture Adjustment*

NOTE: Engines will have fixed idle (no adjustment possible) or a limiter cap on the idle fuel adjustment needle. Step 2 can only be performed within the limits allowed by the cap.

1. Start the engine and run at half throttle for 5 to 10 minutes to warm up. The engine must be warm before doing steps 2 and 3.

2. **Low Idle Fuel Needle Setting:** Place the throttle into the **"idle"** or **"slow"** position.

   Turn the low idle fuel adjustment needle out (counterclockwise) from the preliminary setting until engine speed decreases (rich). Note the position of the needle.

   Now turn the adjusting needle in (clockwise). The engine speed may increase, then it will decrease as the needle is turned **in** (lean). Note the position of the needle.

   Set the adjusting needle midway between the rich and lean settings. See Figure 5-4.

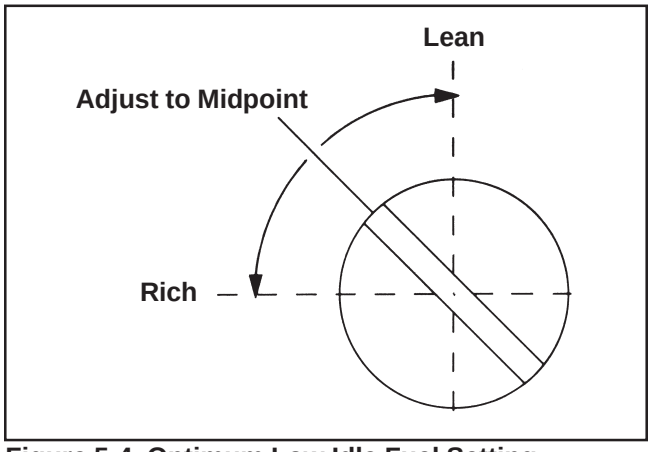


Figure 5-4. Optimum Low Idle Fuel Setting.

*NOTE: If the engine is equipped with a governed idle adjustment (See Figure 5-19), the governor will compensate for speed changes due to the low idle mixture adjustment. Disable the governed idle control by backing out the governed idle adjusting screw and setting a fixed idle speed using the idle speed screw on the carburetor. Make the low idle mixture adjustment and then reset the governed idle speed at the adjusting screw.

Low Idle Speed Setting

1. Start the engine and run at half throttle for 5 to 10 minutes to warm up. The engine must be warm before doing step 2.

2. **Low Idle Speed Setting:** Place the throttle control into the **"idle"** or **"slow"** position. Set the low idle speed 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 equipment manufacturer's recommendations. The recommended low idle speed for basic engines is 1500 RPM. To ensure best results when setting the low idle fuel needle, the low idle speed must not exceed 1500 RPM (±75 RPM).

Disassembly

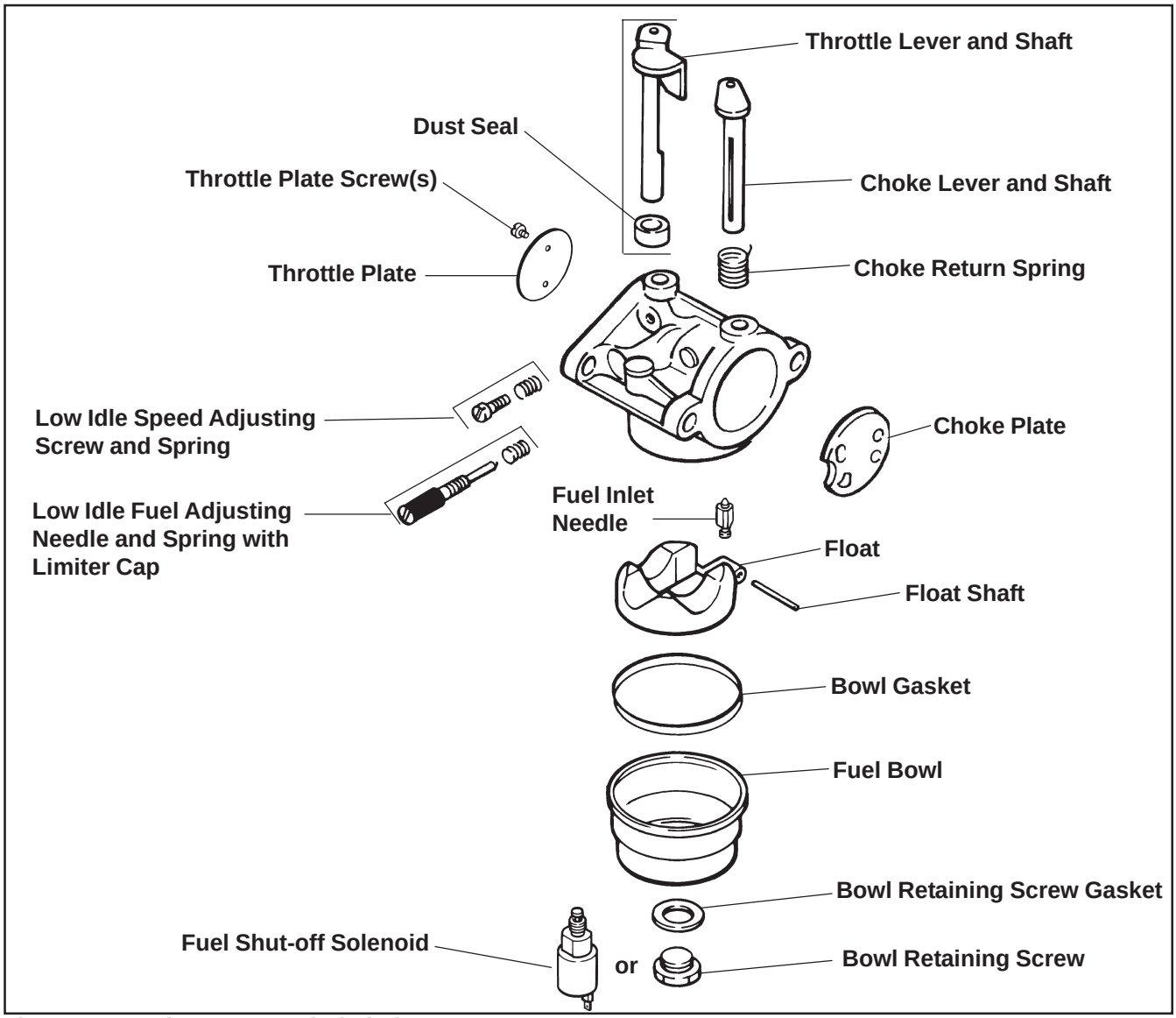


Figure 5-5. Carburetor - Exploded View.

1. Remove the bowl retaining screw or fuel shut-off solenoid, retaining screw gasket, and fuel bowl.

2. Remove the bowl gasket, float shaft, float, and fuel inlet needle.

3. **Do not** attempt to remove the low idle fuel adjustment needle if it has a limiter cap.

   Further disassembly to remove the welch plugs, main fuel jet, throttle plate and shaft, and choke plate and shaft is recommended only if these parts are to be cleaned or replaced.

Welch Plug Removal
In order to clean the idle ports and bowl vent thoroughly, remove the welch plugs covering these areas.

Use SPX Tool No. **KO1018** and the following procedure to remove the welch plugs. See Figure 5-6.

1. Pierce the welch plug with the tip of the tool.

   NOTE: To prevent damage to the carburetor, do not allow the tool to strike the carburetor body.

2. Pry out the welch plug with the tip of the tool.

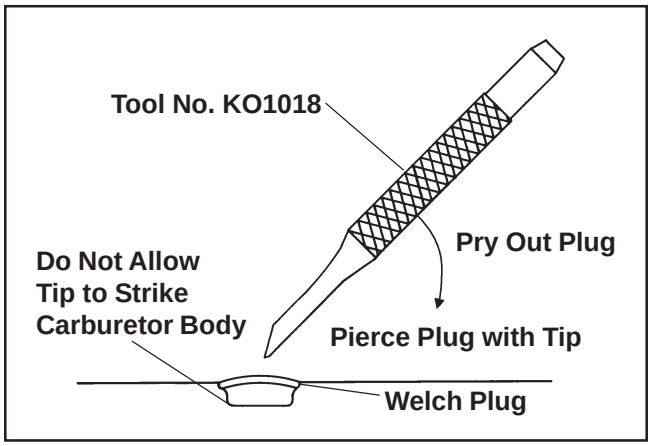


Figure 5-6. Removing Welch Plug.

Main Fuel Jet Removal
The main jet is pressed into the side of the tower portion of the body. Removal is not recommended, unless a high-altitude kit is being installed, in which case the removal instructions will be included in the kit.

Fuel Inlet Seat Removal
The fuel inlet seat is pressed into the carburetor body, **do not** attempt to remove it. If necessary, clean it in place with aerosol carburetor cleaner.

Choke Shaft Removal

1. Because the edges of the choke plate are beveled, mark the choke plate and carburetor body, to ensure correct reassembly. See Figure 5-7.

   Also note the choke plate position in the bore, and the position of the choke lever and choke return spring.

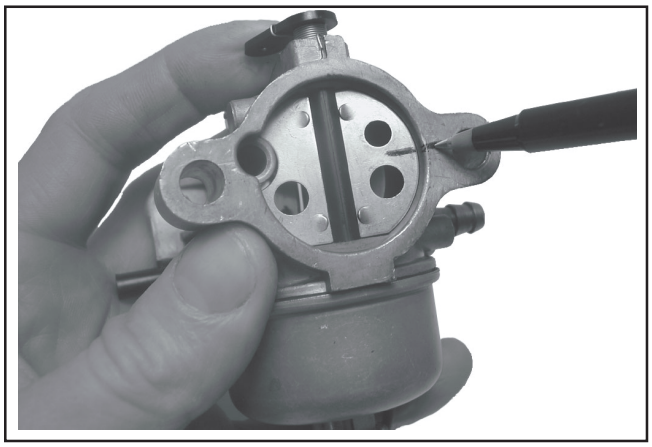


Figure 5-7. Marking Choke Plate and Carburetor Body.

2. The choke plate is inserted into a slot in the choke shaft. Grasp the choke plate with pliers, and pull it out of the slot. See Figure 5-8.

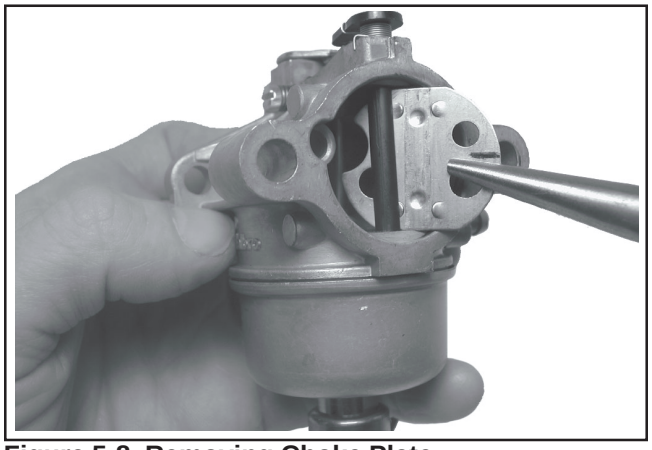


Figure 5-8. Removing Choke Plate.

3. Remove the choke shaft and choke return spring.

Throttle Shaft Removal
Do not attempt to remove the throttle shaft, as repair kits are not available. Throttle shaft wear is normally accompanied by corresponding wear to the carburetor body, making it impractical to attempt a cost-effective repair. Replace the entire carburetor if the throttle shaft is worn.

Cleaning

WARNING: 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.

All parts should be cleaned thoroughly using a commercial carburetor cleaner. Make sure all gum deposits are removed from the following areas.

- Carburetor body and bore; especially the areas where the throttle plate, choke plate and shafts are seated.
- Idle fuel and idle ports in carburetor bore, main jet, bowl vent, and fuel inlet needle and seat.
- Float and float hinge.
- Fuel bowl.

- Throttle plate, choke plate, throttle shaft, and choke shaft.

  NOTE: Do not submerge the carburetor in cleaner or solvent when plastic, fiber, rubber, foam seals or gaskets are installed. The cleaner may damage these components.

Inspection

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 tabs. Check the float hinge and pin for wear or damage.
- Inspect the fuel inlet needle and seat for wear or damage.
- Inspect the tip of the low idle fuel adjustment needle for wear or grooves.
- Inspect the throttle and choke shaft and plate assemblies for wear or excessive play.

Repair

Always use new gaskets when servicing or reinstalling carburetors. Repair kits are available which include new gaskets and other components. Always refer to the Parts Manual for the engine being serviced to ensure the correct repair kits are ordered.

Reassembly

Choke Shaft Installation

1. Install the choke return spring to the choke shaft.
2. Insert the choke shaft with the return spring into the carburetor body.
3. Rotate the choke lever approximately 1/2 turn **counterclockwise**. Make sure the choke return spring hooks on the carburetor body.
4. Position the choke plate as marked during disassembly. Insert the choke plate into the slot in the choke shaft. Make sure the choke shaft is locked between the tabs on the choke plate.

Welch Plug Installation

Use SPX Tool No. **KO1017** and install new plugs as follows:

1. Position the carburetor body with the welch plug cavities to the top.
2. Place a new welch plug into the cavity with the raised surface **up**.
3. Use the end of the tool that is about the same size as the plug and flatten the plug. **Do not** force the plug below the surface of the cavity. See Figure 5-9.

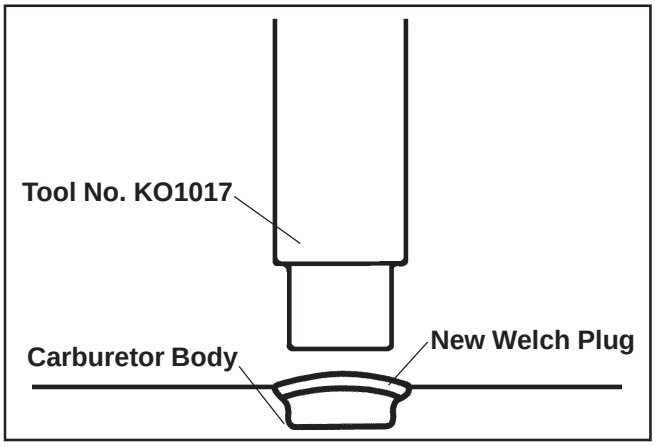


Figure 5-9. Installing Welch Plugs.

4. After the plugs are installed, seal them with Glyptal™ (or an equivalent sealant). Allow the sealant to dry.

   NOTE: If a commercial sealant is not available, fingernail polish can be used.

Carburetor Reassembly

1. Install the low idle speed adjusting screw and spring.
2. If the low idle fuel adjusting needle contains a limiter, adjust to the midpoint within the adjustment range.
3. Insert the fuel inlet needle into the float. Align the needle with the seat and lower the float into the carburetor body. See Figure 5-10. Install the float shaft.

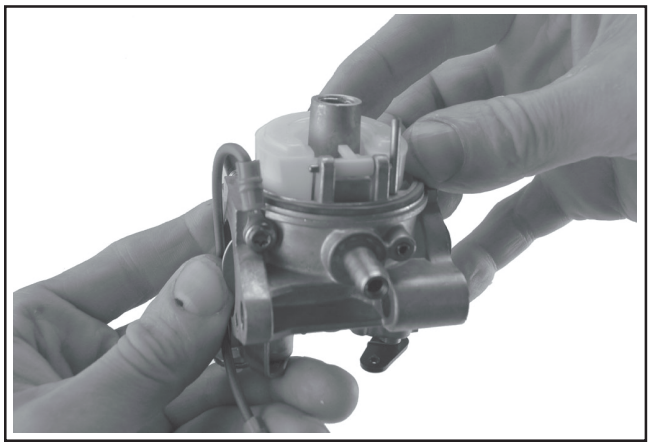


Figure 5-10. Installing Float and Fuel Inlet Needle.

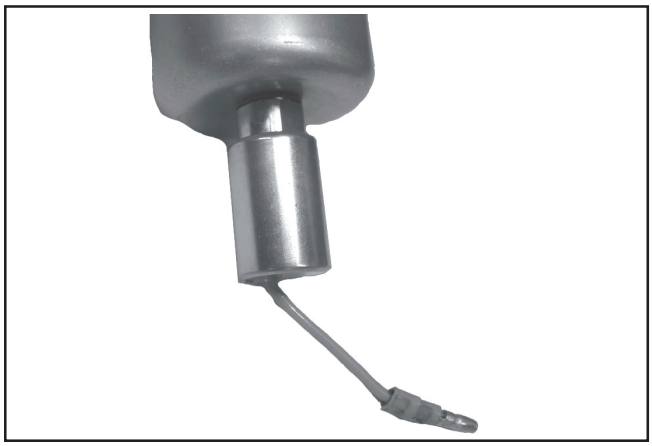


Figure 5-11. Fuel Shut-Off Solenoid.

4. Install the bowl gasket, fuel bowl, bowl retaining screw gasket, and bowl retaining screw or fuel solenoid.

   Torque the bowl retaining screw to **5.1-6.2 N·m (45-55 in. lb.)**.

Fuel Shut-off Solenoid

Many engines are equipped with a fuel shut-off solenoid installed in place of the bowl retaining screw to eliminate backfiring when the engine is shut down. If backfiring occurs on engines equipped with this solenoid, verify that the correct shutdown procedure is being used. In order for the solenoid to be effective, the engine must be running between **half and full throttle** when the key is turned off. Next, check the battery to ensure that it is not discharged or faulty. A minimum of 7.3 volts DC is required to activate the solenoid. Also check to see that the ground lead from the carburetor body to the air cleaner base mounting screw is properly connected.

If these check out, the solenoid should be removed for bench testing. Remember to shut off the fuel supply and catch any fuel spilling from the carburetor as the solenoid is removed.

Bench test the solenoid by grounding the solenoid case and applying 12 volt DC to the spade terminal. If the plunger does not retract, the solenoid is faulty and must be replaced. Always use a new fuel bowl gasket whenever the solenoid is installed. Refer to the wiring diagram in Section 7 and connect the fuel shut-off solenoid.

High Altitude Operation

When operating the engine at altitudes of 1830 m (6000 ft.) and above, the main fuel mixture tends to get over rich. An over-rich mixture 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 engine being serviced for the correct kit number.

Unitized Throttle and Choke Control

Some engines are equipped with a ‘‘unitized’’ throttle and choke control. This assembly controls the choke and engine speed with a single lever. See Figure 5-12.

Throttle Cable Adjustment

1. Loosen the throttle control cable clamp. See Figure 5-12.

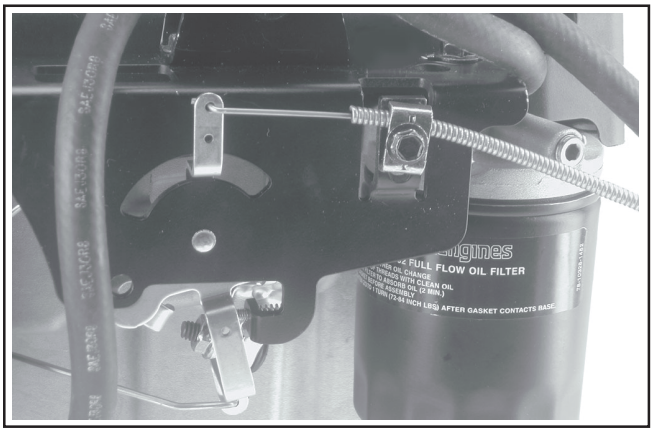


Figure 5-12. Speed Control Bracket with Unitized Throttle/Choke Control.

2. Place the throttle control lever of the equipment into the “fast” or high speed position. The actuating “tab” of the choke lever should be just below the end of the choke adjusting screw. See Figure 5-13.

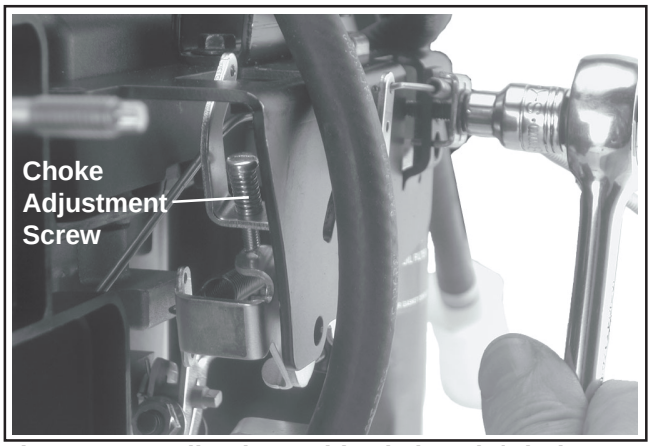


Figure 5-13. Adjusting Unitized Throttle/Choke Control.

NOTE: The choke is placed “on” by moving the throttle control slightly past the “fast” position. If the throttle control does not have a designated “choke on” position, be sure to leave sufficient throttle control travel past the “fast” position. This will enable the choke to be placed “on”. See Figure 5-14.

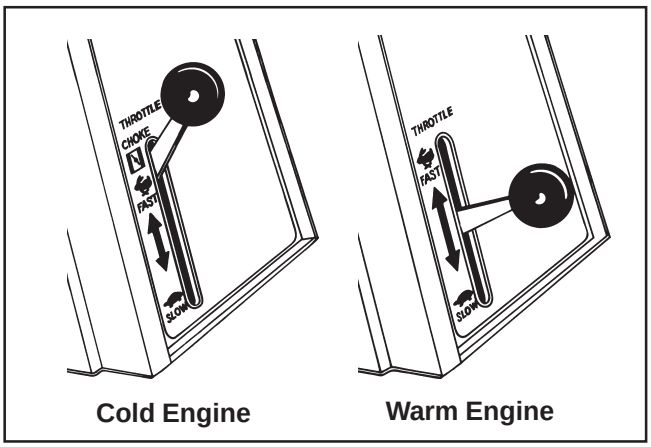


Figure 5-14. Typical Throttle/Choke Controls.

3. Align the hole in the throttle lever with the hole in the speed control bracket by inserting a pencil or 6.35 mm (1/4 in.) drill bit. See Figure 5-15.

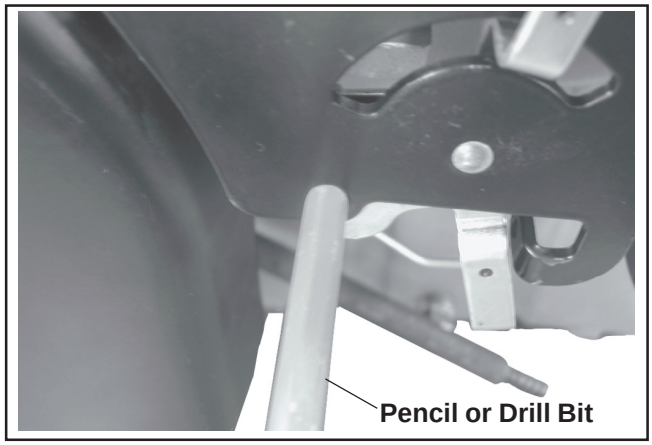


Figure 5-15. Aligning Holes in Speed Control Bracket and Throttle Lever.

4. Pull on the outer shield of the throttle control cable to remove any slack. Tighten the cable clamp securely.

Starting an Engine Equipped with Unitized Throttle and Choke Control

1. **For a Cold or Warm Engine** – Place the throttle/choke control into the **“fast/choke on”** position. This will also place the choke into the **“on”** position. See Figure 5-16.

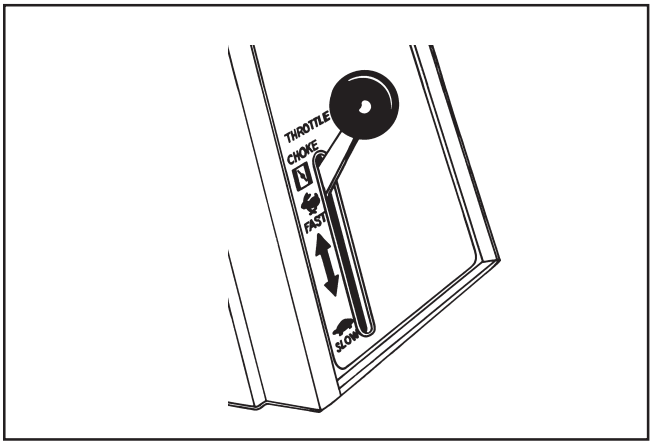


Figure 5-16. Throttle Position for Starting Engine.

2. Make sure the equipment is in neutral.

3. Activate the starter switch. Release the switch as soon as the engine starts.

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 but does not keep running (a false start), 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.

If the starter does not turn the engine over, shut the starter off immediately. **Do not** make further attempts to start the engine until the condition is corrected. Do not jump start using another battery (refer to "Battery"). See your Kohler Engine Service Dealer for trouble analysis.

3. **For Operation** – After the engine starts, move the throttle/choke control from the **"fast/choke on"** position and set the desired engine operating speed (between the **"slow"** and **"fast"** position).

High Speed (RPM) Adjustment
The recommended maximum no-load high speed (RPM) for most engines is **3300 RPM**. The actual high speed (RPM) depends on the application. Refer to the equipment manufacturer's instructions for specific information.

WARNING: Over speed is Hazardous!
Do not tamper with the governor setting. Over speed is hazardous and could cause personal injury.

1. Make sure the throttle cable is adjusted properly (see ''Throttle Cable Adjustment").

2. Start the engine and allow it to warm up. Place the throttle control lever into the ''fast'' or high speed position. Turn the choke adjustment screw (See Figure 5-13) out/conterclockwise, so there is clearance from the choke lever, and that contact cannot occur during Step 4. See Figure 5-13.

3. Align the hole in the throttle lever with the hole in the speed control bracket by inserting a pencil or 6.35 mm (1/4 in.) drill bit. See Figure 5-15.

4. Loosen the speed control bracket mounting screws. Slide the bracket forward or backward, until the desired high speed (RPM) is reached. See Figure 5-17. Check the speed with a tachometer.

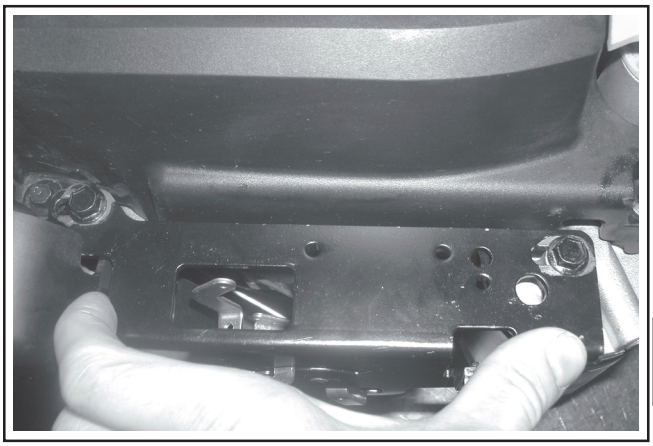


Figure 5-17. Adjusting High Speed (RPM).

To increase the high speed (RPM), move the bracket toward the carburetor.

To decrease the high speed (RPM), move the bracket away from the carburetor.

5. Tighten the speed control bracket mounting screws. Recheck the speed with a tachometer and readjust if necessary.

   Torque the mounting screws as follows:

   Into new as-cast hole – **11.0 N·m (95 in. lb.)**.
   Into used hole – **7.5 N·m (65 in. lb.)**.

6. Adjust the choke (see ''Choke Adjustment'' which follows).

Choke Adjustment
This procedure must follow the "High Speed Adjustment" just described. If not already completed, perform that operation first.

1. Turn the choke adjusting screw **out** (counterclockwise), until it no longer contacts the choke lever. Then turn it back **in** (clockwise), until it *just* makes contact.

2. While observing the choke link, move the throttle control lever to the low idle (slow) position, then back to full throttle (fast). The choke link should not move as the throttle moves through the normal range. If it does, back the adjusting screw out until it no longer moves.

3. Move the throttle control lever to the choke position. Check if the choke has fully closed by placing your finger on the right side of the lower end of the choke lever/choke link and applying gentle pressure towards the carburetor. If the controls have been properly set, the link should not move.

Separate Throttle and Choke Control

Some engines are equipped with separate throttle and choke controls. This allows you to adjust the choke and throttle controls individually.

Install Separate Control Cables (See Figure 5-18).

Throttle Control Installation

1. Loosen the two cable clamp screws on the speed control bracket assembly.

2. Move the application throttle control lever to the maximum full (fast) throttle position, and then move it back 3/16" or 4.75 mm. Insert the cable boden wire into the throttle control lever on the control plate.

3. Position the throttle cable under the cable clamp.

4. Pull on the throttle cable until it stops, hold it, and tighten the cable clamp screw.

5. Move the application throttle lever to the slow position, then to full throttle. Check the engine control to ensure it stops against the stop screw, which means it is properly set.

Choke Control Installation

1. Connect the choke cable boden wire to the engine choke control lever on the speed control bracket assembly.

2. Position the choke cable under the cable clamp.

3. Push/move the choke control to the “off “ position in the application panel until it bottoms, then pull it back approximately 1/16”.

4. Push on the choke cable, ahead of the clamp on the engine control plate, until the choke lever stops. Do not force. Then tighten the cable clamp screw.

5. Move the choke control until it stops (“on” position). Check that the choke link cannot be moved towards the carburetor by applying finger pressure on the lower link/lever below the engine control plate. If the choke link moves, readjust by following steps 3 and 4.

6. Push/move the choke control in/down until it bottoms. The choke lever and link should be to the right at the end of its travel, with linkage free so the engine does not run on partial choke.

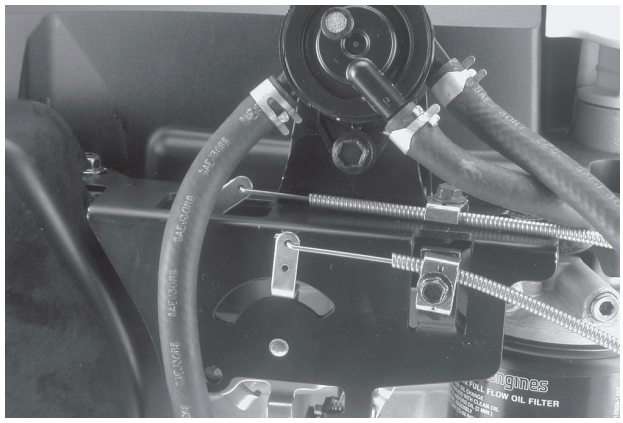


Figure 5-18. Separate Choke and Throttle Cable Controls.

Starting an Engine Equipped with Separate Control Cables

1. Place the throttle control midway between the **“slow”** and **“fast”** positions. Place the choke control into the **“on”** position.

2. Start the engine.

3. **For a Cold Engine –** Gradually return the choke control to the “off” position after the engine starts and warms up.

   The engine/equipment may be operated during the warm up period, but it may be necessary to leave the choke partially on until the engine warms up.

4. **For a Warm Engine –** Return choke to “off” position as soon as engine starts.

Changing the High Speed (RPM) on the Engines with Separate Controls (Increase or Decrease RPM)

1. Check that the governor spring and installation matches the intended high speed RPM operating range. Refer to Figure 5-23.

2. Start the engine, move the application throttle lever to full throttle/fast, and loosen the mounting screws of the main speed control bracket to allow repositioning. See Figure 5-17.

3. **To increase the RPM:** Move the speed control bracket, towards the carburetor. **To decrease the RPM:** Move the speed control bracket, away from the carburetor. Check the RPM with a tachometer and tighten screws when correct setting has been obtained.

4. To ensure that the RPM has been obtained, move the throttle lever to low idle/slow then back to full throttle/fast position and check the RPM with a tachometer.

Setting the Low Idle RPM

1. Move the application control to slow position.

2. Using a tachometer, check the RPM. Then, using a screwdriver, turn the low idle speed screw (see Figure 5-3) inward (clockwise) to increase the RPM, and outward (counterclockwise) to lower the RPM.

Governed Idle Adjustment

An optional governed idle control system is supplied on some engines. The purpose of this system is to maintain a desired idle speed regardless of ambient conditions (temperature, parasitic load, etc.) that may change.

The system requires an additional procedure for setting the idle speed. If speed adjustments are required proceed as follows.

1. Make any necessary speed or control adjustments following the appropriate instructions already covered in this section.

2. Move the throttle control to the idle position. Hold the governor lever away from the carburetor, so the throttle lever is tight against the idle speed adjusting screw. Check the speed with a tachometer and adjust it to 1500-1750 RPM.

3. Release the governor lever and allow the engine to return to the governed idle speed. Check it with a tachometer against the equipment manufacturers recommended idle speed. If adjustment is necessary, use the governed idle adjusting screw on the speed control assembly (see Figure 5-19). Turn the screw clockwise to increase the governed idle speed and counterclockwise to decrease it.

Figure 5-19. Location of Governed Idle Adjusting Screw.

Governor

These engines are equipped with a centrifugal flyweight mechanical governor, designed to hold the engine speed constant under changing load conditions. The governor gear/flyweight mechanism is mounted on the closure plate in the crankcase, and is driven off a gear on the crankshaft. See Figure 5-20.

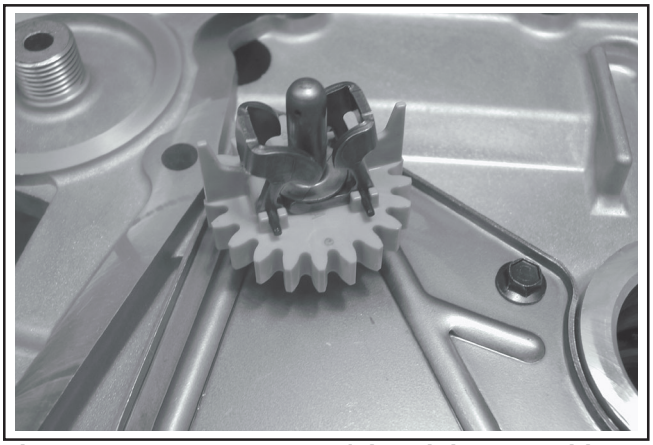


Figure 5-20. Governor Gear/Flyweight Assembly.

Operation
As the governor gear rotates, centrifugal force causes the flyweights to move outward as speed increases. 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 side of the crankcase. The governor lever is clamped on the protruding end of the shaft and connected with linkage to the throttle lever on the carburetor, so any rotation of the shaft causes corresponding movement of the throttle plate.

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 are in "equilibrium" during operation, holding the engine speed constant.

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. This action takes place very rapidly, so a reduction in speed is hardly noticed. As the speed reaches the governed setting, the governor spring tension and the force applied by the regulating pin will again be in equilibrium. This maintains the engine speed at a relatively constant level.

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

Initial Adjustment
Make this initial adjustment whenever the governor arm is loosened or removed from the cross shaft. To ensure proper setting, make sure the throttle linkage is connected to the governor arm and the throttle lever on the carburetor. See Figures 5-21 and 5-22.

1. Move the governor lever toward the carburetor (wide open throttle). **Do not** apply excess force flexing or distorting the throttle link.

2. Grasp the cross shaft with pliers, and turn the shaft **counterclockwise** as far as it will go, then tighten the hex. nut. Torque the hex. nut to **7.0-8.5 N·m (60-75 in. lb.)**.

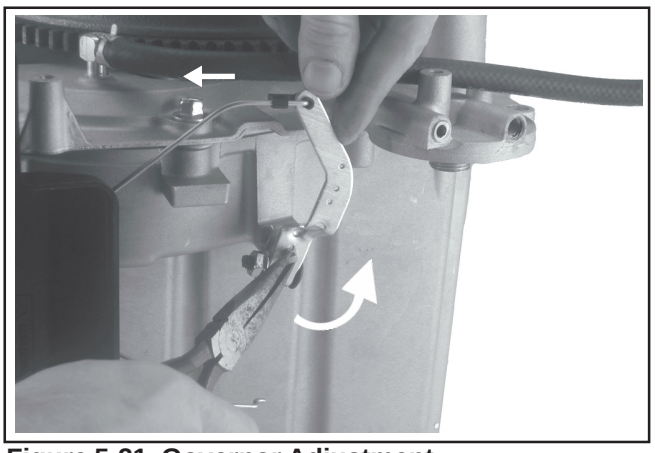


Figure 5-21. Governor Adjustment.

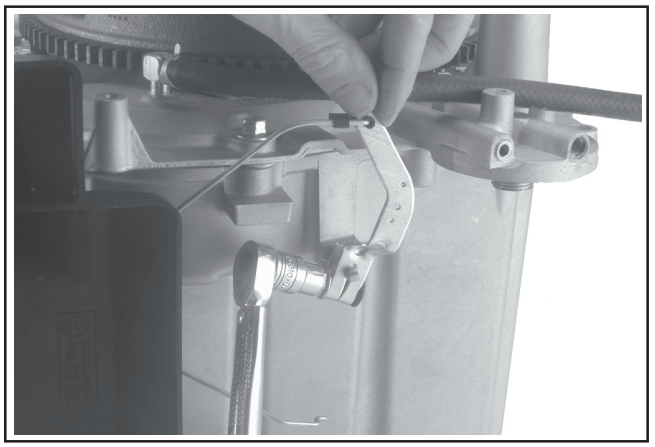
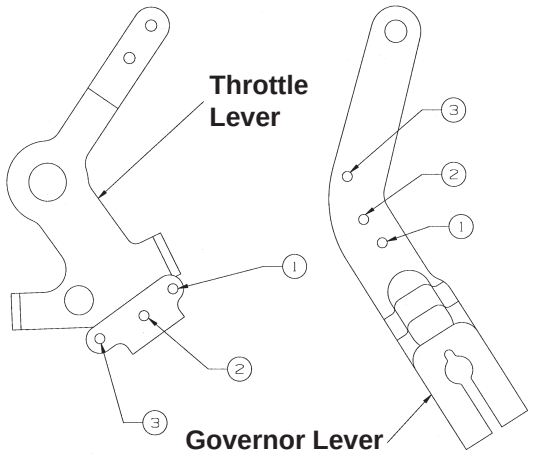


Figure 5-22. Tightening Governor Lever Nut.

Governor Sensitivity Adjustment
Governor sensitivity is adjusted by repositioning the governor spring in the holes in the governor lever. If speed surging occurs with a change in load, the governor is set too sensitive. If a big drop in speed occurs when a normal load is applied, the governor should be set for greater sensitivity.

The desired high speed setting (RPM) will determine the governor spring position in the governor lever and the throttle lever, as well as the spring used. See Figure 5-23.



High Speed RPM	Governed Idle RPM	Governor Lever Hole No.	Throttle Lever Hole No.	White Spring	Green Spring
3201-3400		2	2		X
3201-3400	1601-1800	2	2	X	

Figure 5-23. Governor Spring Location Chart.

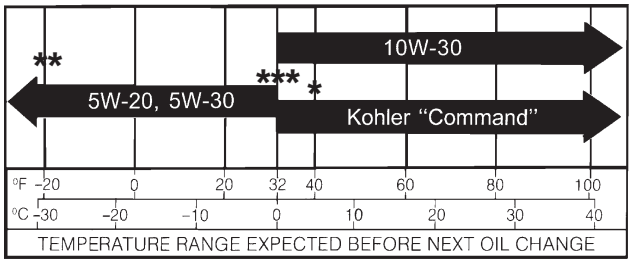
Section 6
Lubrication System

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).

***30 weight acceptable above 0°C (32°F).

Figure 6-1. Viscosity Grades Table.

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

A logo or symbol on oil containers identifies the API service class and SAE viscosity grade. See Figure 6-2.

Figure 6-2. Oil Container Logo.

Check 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 is cool so the oil has had time to drain into the sump.

2. To keep dirt, grass clippings, etc., out of the engine, clean the area around the oil fill cap/ dipstick before removing it.

3. Remove the oil fill cap/dipstick; wipe oil off. Reinsert the dipstick into the tube and fully seat the dipstick in the tube. See Figure 6-3.

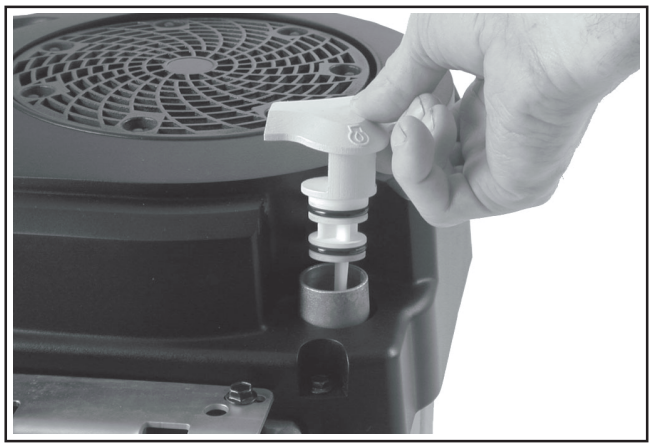


Figure 6-3. Removing Dipstick.

Figure 6-4. Dipstick Seated.

4. Remove the dipstick and check the oil level. The oil level should be up to, but not over the ‘‘F’’ mark on the dipstick. See Figure 6-5.

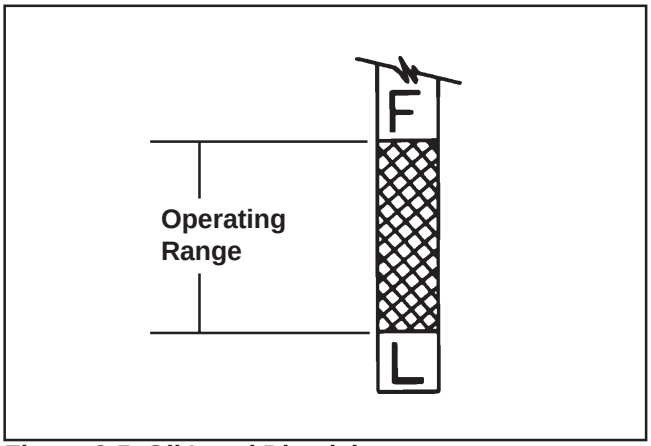


Figure 6-5. Oil Level Dipstick.

5. If the level is low, add oil of the proper type, up to the ‘‘F’’ mark on the dipstick. Always check the level with the dipstick before adding more oil.

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 over the ‘‘F’’ mark on the dipstick.

Change Oil and Oil Filter

Change the oil and oil filter **annually** or every **100 hours** of operation. Change the oil and oil filter while the engine is still warm. The oil will flow more freely and carry away more impurities. Make sure the engine is level when filling or checking oil. Change the oil and filter as follows (see Figure 6-6). *Always use a genuine Kohler oil filter*.

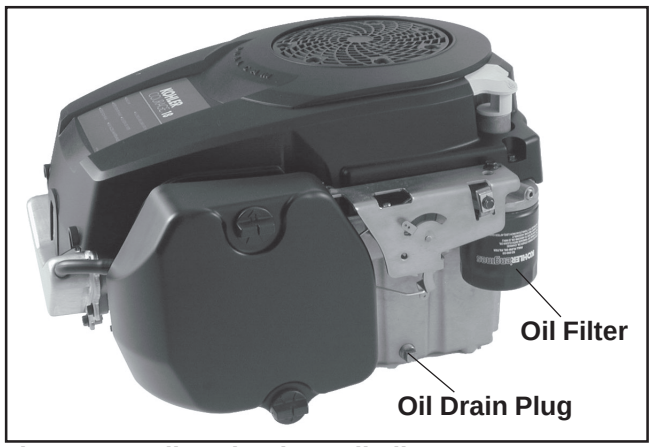


Figure 6-6. Oil Drain Plug, Oil Filter.

1. To keep dirt, grass clipping, etc., out of the engine, clean the area around the oil fill cap/ dipstick before removing it.

2. Remove the drain plug and oil fill cap/dipstick. Be sure to allow ample time for complete drainage.

3. Remove the old filter and wipe off the mounting pad.

4. Reinstall the oil drain plug and torque to **14 N·m (125 in. lb.)**.

5. Place the new replacement 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. Put a drop of oil on your fingertip and wipe it on the rubber gasket.

7. Install the replacement oil filter to the mounting pad. Turn the oil filter clockwise until the rubber gasket contacts the pad, and then tighten the filter an additional **2/3 to 1 turn**.

8. Fill the crankcase with new oil of the proper type, to the “F” mark on the dipstick.

9. Reinstall the oil fill cap/dipstick and push firmly into place.

10. Test run the engine to check for leaks. Stop the engine, allow a minute for the oil to drain down, and recheck the level on the dipstick. Add more oil, as necessary, so the oil level is up to but not over the “F” mark.

    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 over the ‘‘F’’ mark on the dipstick.

Full-Pressure Lubrication System

Operation
This engine uses a full-pressure lubrication system to deliver oil for internal lubrication. A cam driven, high efficiency Gerotor™ oil pump located in the crankcase maintains proper oil flow and oil pressure even at low speeds and high operating temperatures. Oil is supplied from the pump via two circuits to the crankshaft main bearings, crankshaft, connecting rod bearing surfaces, cam gears, and axis shafts. An integral pressure relief valve within the oil pump limits the maximum pressure of the system.

For a cold engine at start up, the oil pressure can go up to 20-25 psi. For a warm (normal operating temperature) engine at idle speed, the oil pressure can go down to 5 psi.

Service
The oil pump rotors typically require no servicing, if normal maintenance is performed as outlined in Section 1.

The closure plate must be removed for access to the oil pump and the rotors. Refer to the “Disassembly “ and “Reassembly” Sections (8 and 10), for removal and reinstallation procedures.

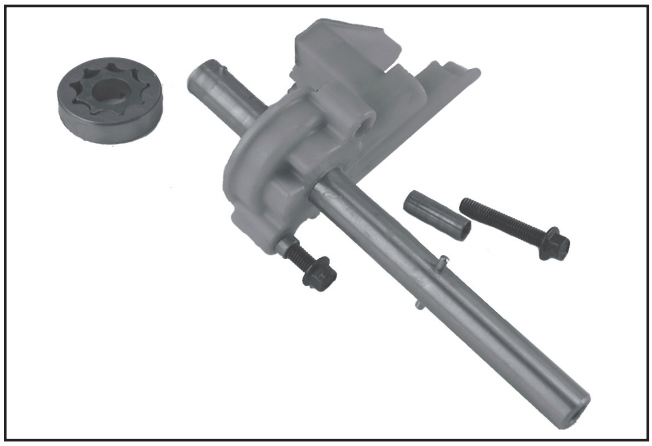


Figure 6-7. Oil Pump on Intake Cam Shaft (Gerotors Removed from Pump Housing).

Oil Filter

These engines are equipped with a full-flow oil filter. See Figure 6-8.

The oil filter helps remove sludge and other combution by-products from the oil. It also extends the oil change interval and cools the oil.

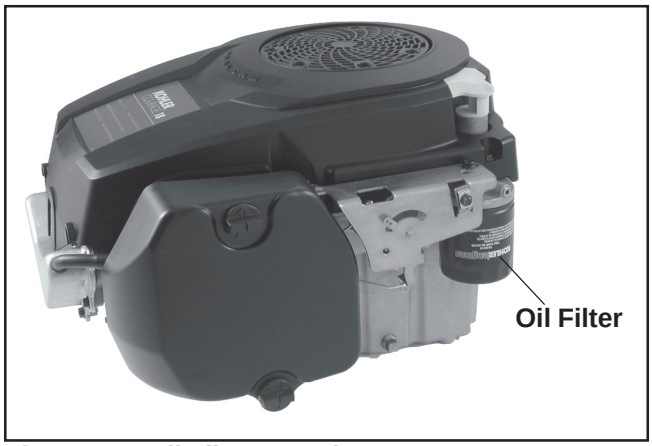


Figure 6-8. Oil Filter Location.

Oil Sentry™

Some engines are equipped with an optional Oil Sentry™ oil pressure monitor. If the oil pressure gets low, Oil Sentry™ will either activate a ‘‘low oil’’ warning light or stop the engine, 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 **2 to 5 psi**, the switch contacts open. At oil pressures below approximately **2 to 5 psi,** the switch contacts close.

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

NOTE: Oil Sentry™ is not a substitute for checking the oil level BEFORE EACH USE. Make sure the oil level is maintained up to the ''F'' mark on the dipstick.

Installation
The pressure switch is installed into the center oil galley of the filter adapter casting on the closure plate. Based on the application an elbow adapter may also be used. See Figure 6-9. On engines not equipped with Oil Sentry™, the oil galley is sealed with a 1/8" pipe plug.

Figure 6-9. Oil Sentry™ Pressure Switch Location.

To install the Oil Sentry™ switch:

1. Remove and discard the pipe plug from the center passage of oil filter mounting pad.

2. Apply **pipe sealant with Teflon®** (Loctite® No. 59241 or equivalent) to the threads of the 90° adapter (if used), and the Oil Sentry™ switch.

3. Install the adapter (if used), and carefully tighten it to the intended position. Do not over tighten or damage the adapter.

4. Install the switch into the adapter or center passage. Torque the switch to **4.5-5.0 N·m (40-45 in. lb.)**.

5. Connect the lead to the terminal on the Oil Sentry™ switch.

Testing the Oil Sentry™ Switch
The Oil Sentry™ pressure monitor is a normally closed switch. It is calibrated to open (break contact) with increasing pressure and close (make contact) with decreasing pressure within the range of **2.0/5.0 psi**.

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

1. Connect the continuity tester across 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. The tester should indicate a change to **no continuity (switch open)** as the pressure increases through the range of **2.0/5.0 psi**.

   The switch should remain open as the pressure is increased to **90 psi maximum**.

3. Gradually *decrease* the pressure to the switch. The tester should indicate a change to **continuity (switch closed)** as the pressure decreases through the range of **2.0/5.0 psi; approaching 0 psi**.

   If the switch does not operate as specified, replace the switch.

Testing Oil Pressure

The engine oil pressure can be tested using an oil pressure tester. Follow the instructions included with the tester. The pressure can be tested by removing the oil filter and installing the tester adapter on the mounting pad, or by removing the Oil Sentry™ pressure switch (or pipe plug) and threading the tester hose directly into the mounting hole. See Figure 6-10.

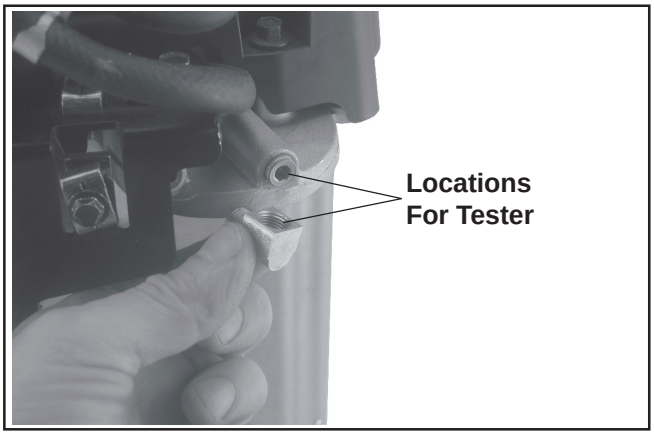


Figure 6-10. Tester Locations.

Section 7
Electrical System and Components

This section covers the operation, service, and repair of the electrical system and electrical system components.

Major electrical systems and components covered in this section include the ignition system, battery, battery charging systems, electric starter, and optional Oil Sentry™ oil level pressure switch.

WARNING: Electrical Shock

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

Spark Plug

Engine misfire or starting problems are often caused by a spark plug that is in poor condition or has an improper gap setting.

The engine is equipped with the following spark plug:

Type:	Champion® RC12YC or QC12YC
Gap	0.76 mm (0.030 in.)
Thread Size:	14 mm
Reach:	19.1 mm (3/4 in.)
Hex. Size:	15.9 mm (5/8 in.)

Spark Plug Service

Every 2 years or **200 hours** of operation, remove the spark plug. Check its condition, and reset the gap or replace with a new plug as necessary. Spark plug replacement is recommended at **500 hours**.

1. Before removing the spark plug, clean the area around the base of the plug to keep dirt and debris out of the engine. Due to the deep recess around the spark plug, blowing out the cavity with compressed air is usually the most effective method for cleaning. The spark plug is most accessible when the blower housing is removed for cleaning.

2. Remove the plug and check its condition. Replace the plug if worn or reuse is questionable.

   NOTE: Do not clean the 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 by carefully bending the ground electrode. Gap plugs to **0.76 mm (0.030 in.)**. See Figure 7-1.

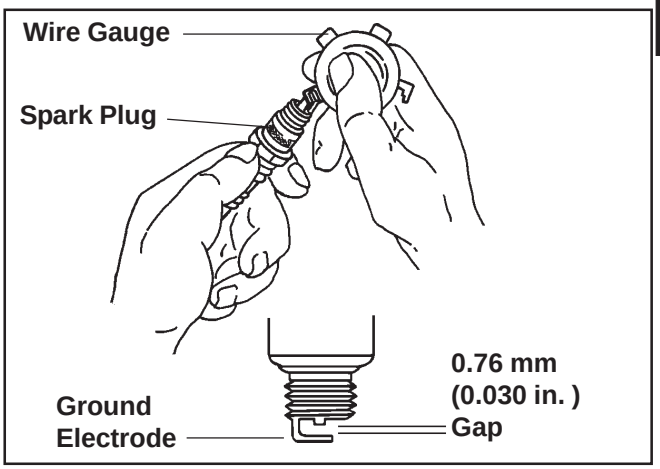


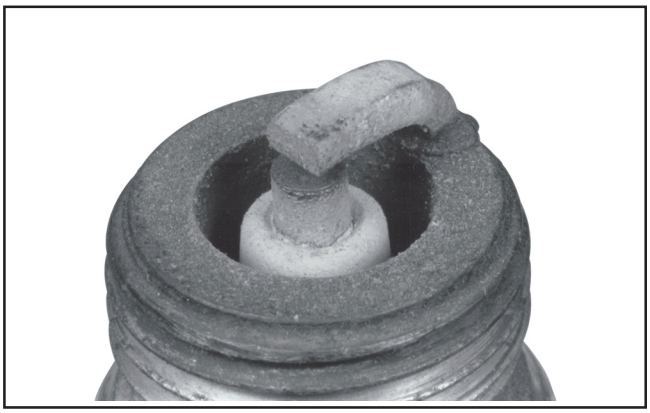
Figure 7-1. Servicing Spark Plug.

4. Reinstall the spark plug into the cylinder head. Torque the spark plug to **24-30 N·m (18-22 ft. lb.)**.

5. Reconnect the spark plug lead and reinstall the blower housing, if removed previously. Torque the blower housing screws to **7.5 N·m (65 in. lb.)**.

Inspection
Inspect the spark plug as soon as it is removed from the cylinder head. The deposits on the tip are an indication of the general condition of the piston rings, valves, and carburetor.

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 regapped and reused.

Worn: On a worn plug, the center electrode will be rounded and the gap will be eroded .010" or more than the correct gap. Replace a worn spark plug immediately.

Chalky White Deposits: Chalky white colored deposits indicate overheating. This condition is usually accompanied by excessive gap erosion. A clogged grass screen, clogged cooling fins, and lean carburetion are some causes of overheating.

Carbon Fouled: Soft, sooty, black deposits indicate incomplete combustion. Incomplete combustion is usually caused by over-rich carburetion, weak ignition, or poor compression.

Wet Fouled: A wet plug is caused by excess fuel, or oil in the combustion chamber. Excess fuel could be caused by operating the engine with too much choke or a dirty air filter. Oil in the combustion chamber is usually caused by worn piston rings or valve guides.

Electronic CD Ignition System

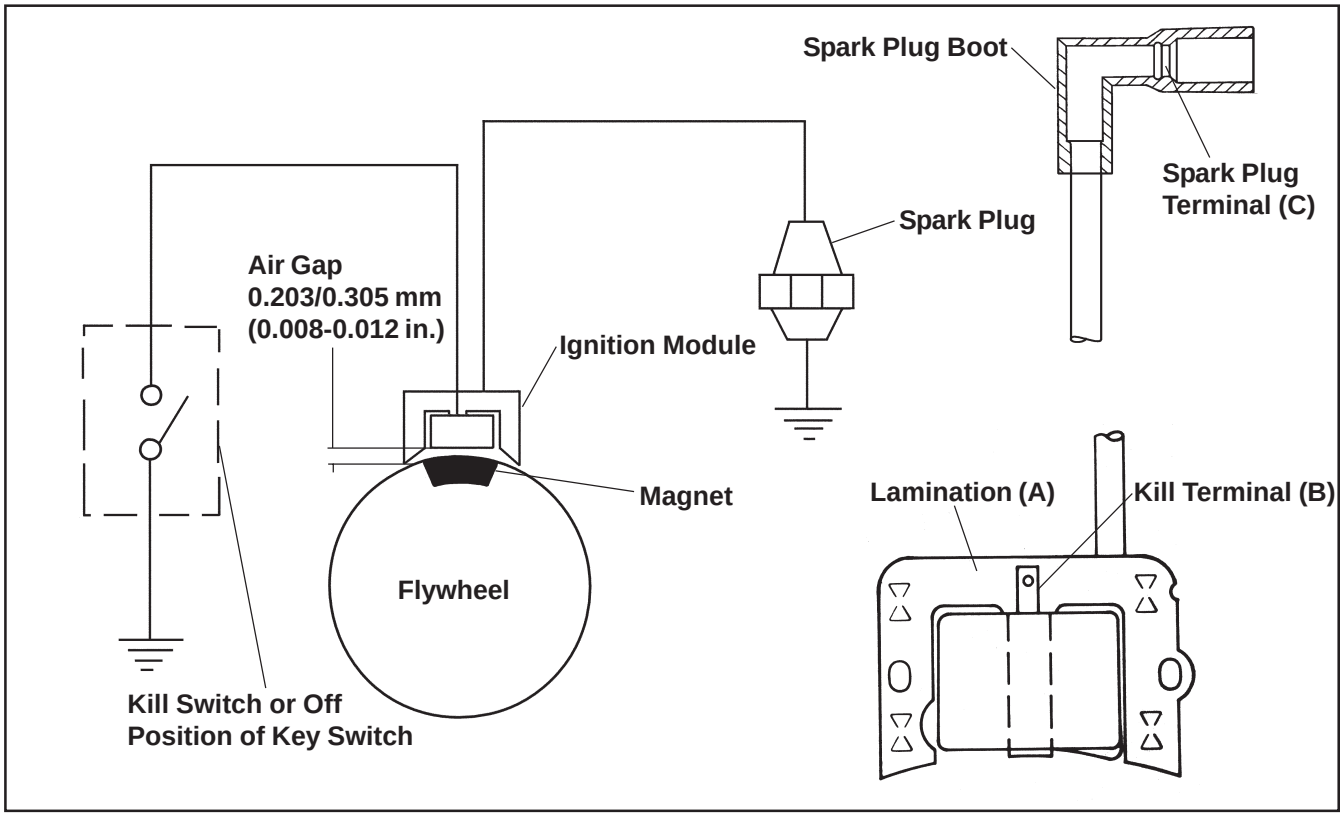


Figure 7-2. Electronic CD Ignition System.

These engines are equipped with a dependable electronic, capacitive discharge (CD) ignition system. The system consists of the following components:

- A magnet assembly which is permanently affixed to the flywheel.
- An electronic, capacitive discharge ignition module which mounts on the engine crankcase.
- A spark plug.
- A kill switch (or key switch), which grounds the module to stop the engine.

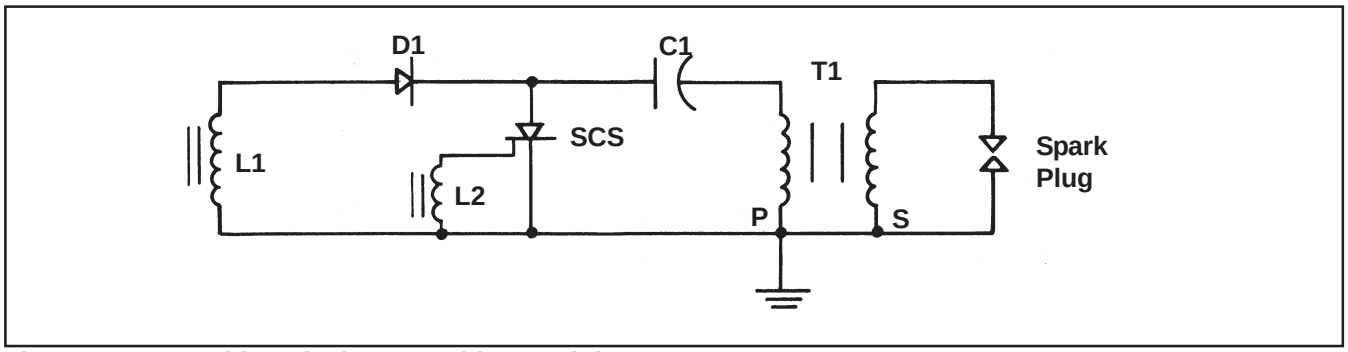


Figure 7-3. Capacitive Discharge Ignition Module.

Operation
As the flywheel rotates, and the magnet passes the ignition module, the magnetic field induces current in the input coil (L1). The current pulse is rectified by a diode (D1) and charges a high-voltage capacitor (C1). As the magnet completes its pass, it induces current in a small triggering coil (L2), which turns on the semiconductor switch (SCS). With the switch on, the charged capacitor is directly connected to the primary winding (P) of the transformer (T1). As the capacitor discharges through the primary, the current initiates a fast-rising flux field in the transformer core. The flux field induces a high voltage in the secondary winding (S) of the transformer. The high voltage pulse is delivered to the spark plug, where it arcs across the electrode gap and ignites the fuel-air mixture in the combustion chamber.

Troubleshooting and Testing CD Ignition Systems

The CD ignition system is designed to be trouble free for the life of the engine. Other than periodically checking/replacing the spark plug, no maintenance or timing adjustment is necessary or possible. The ignition module automatically controls the timing of the spark. Mechanical systems do occasionally fail or break down, however, so the following troubleshooting information is provided to help systematically determine the cause of a reported problem.

Reported ignition problems are most often due to poor or loose connections. Before beginning the test procedure check all external wiring, including ground leads for wiring harness and rectifier-regulator (if so equipped). Be certain all ignition-related wires are connected, including the spark plug lead, and 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. Customer complaints of hard starting, low power, or misfire under load may be due to excessive draw on the kill circuit. Disconnect any auxiliary kill wires or safety switches connected to the kill circuit and operate the engine to determine if the reported problem is gone.

Preliminary Test
To be certain the reported problem is in the engine ignition system, it should be isolated from the unit, as follows.

1. Locate the plug connectors where the wiring harnesses from the engine and unit are joined. Separate the connectors and separate 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, continue with the following troubleshooting procedure. Leave the kill lead isolated until all testing is completed.

CD Ignition System Troubleshooting Guide

The following guide will help locate and correct ignition system problems.

Problem	Test	Conclusion
Engine Will Not Start	1. Make sure the spark plug lead is connected to the spark plug.	
	2. Check the condition of spark plug. Make sure gap is set to 0.76 mm (0.030 in.).	2. If plug is in good condition, check/adjust gap and reinstall.
	3. a. Test for spark with ignition tester SPX No. KO1046. Disconnect spark plug lead and connect it to the post terminal of the tester. See Figure 7-4. Connect the clip to a good ground, **not** the spark plug. NOTE: To maintain engine speeds normally obtained during cranking, do not remove the engine spark plug. b. Make sure the engine ignition switch, kill switch, or key switch is in the ''run'' position. c. Crank the engine (minimum speed 500 RPM), and observe the tester. Visible and audible sparks should be produced.	3. If visible and audible sparks **are** produced, the ignition module is OK. If visible and audible sparks **are** not produced: a. Make sure the engine ignition switch, kill switch, or key switch is in the ''run'' position. b. Check wires and terminals of ignition module and other components for accidental grounding and damaged insulation. c. If wires and terminals are OK, the ignition module is probably faulty and should be replaced. Test module further using an ohmmeter (Test 4).
	4. Measure the resistance of module secondary using an ohmmeter (see Figures 7-2 and 7-5): Zero ohmmeter before testing. Connect one ohmmeter lead to laminations (A). Connect the other lead to the spark plug terminal (C) of high-terminal lead. With the ohmmeter leads connected in this manner, the resistance of secondary should be **7,900 to 18,400 ohms**. NOTE: This test cannot be performed unless module has been fired at least once.	4. If the resistance is **low or 0 ohms**, the module secondary is shorted. Replace the module.* If the resistance is **high or infinity ohms**, the module secondary is open. Replace the module.* If the resistance is within the specified range, the module secondary is OK. *Refer to the Disassembly and Reassembly Sections for complete ignition module removal and installation procedures.

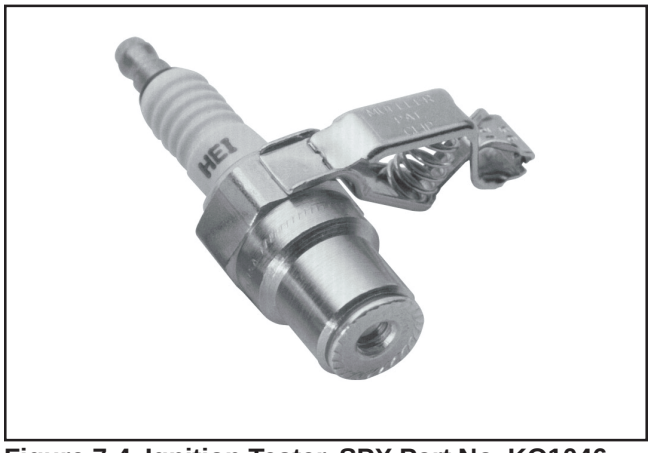


Figure 7-4. Ignition Tester, SPX Part No. KO1046.

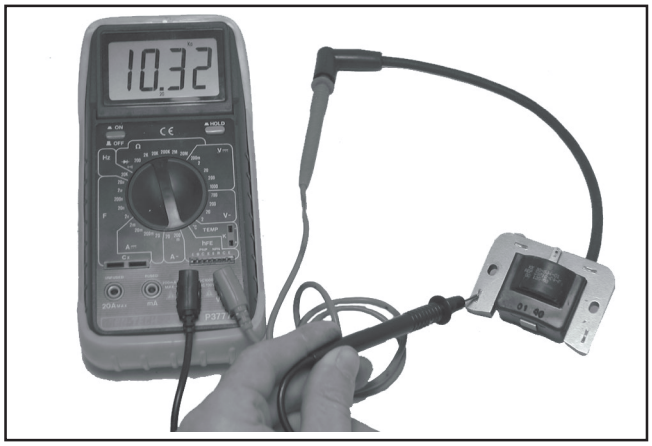


Figure 7-5. Testing CD Ignition Module Secondary.

Battery

A 12 volt battery with a minimum current rating of 250 cold cranking amps is recommended. The actual cold cranking amp requirement depends on engine size, application and starting temperatures. As temperatures decrease, cranking requirements increase but battery capacity shrinks. Refer to the operating instructions of the equipment this engine powers for specific battery requirements.

If the battery charge is not sufficient to crank the engine, recharge the battery. **Do not** jump start using another battery.

Battery Charging

WARNING: Explosive Gases!

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.

Battery Maintenance

Regular maintenance will ensure the battery will accept and hold a charge.

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 self-discharge the battery. Self-discharging happens rapidly when moisture is present.

3. Wash the cables, terminals, and external surfaces with a baking soda and water solution. Rinse thoroughly with clear water.

   NOTE: Do not allow the baking soda solution to enter the cells of the battery, as this will destroy the electrolyte.

Battery Test

Test the battery voltage by connecting a DC voltmeter across the battery terminals and cranking the engine. If the battery drops below 9 volts while cranking, the battery is discharged or faulty. Refer to Figure 7-6.

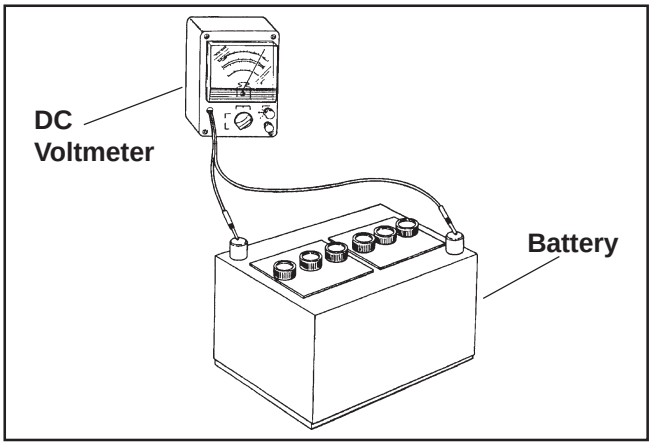


Figure 7-6. Checking Battery Voltage.

Electrical Systems Wiring Diagrams and Battery Charging Systems

Most engines are equipped with either a 9 or 15 amp, regulated battery charging system. Some have a 3 amp, unregulated system with a 70 watt lighting circuit.

Refer to the following wiring diagrams and troubleshooting guides to test and service the system.

NOTE: Observe the following guidelines to prevent damage to the electrical system and components.

1. Make sure the battery polarity is correct. A negative (-) ground system is used.

2. Disconnect the battery cables (negative (-) cable first), before doing electric welding on the equipment powered by the engine.

3. Prevent the stator leads from touching or shorting while the engine is running. This could damage the stator.

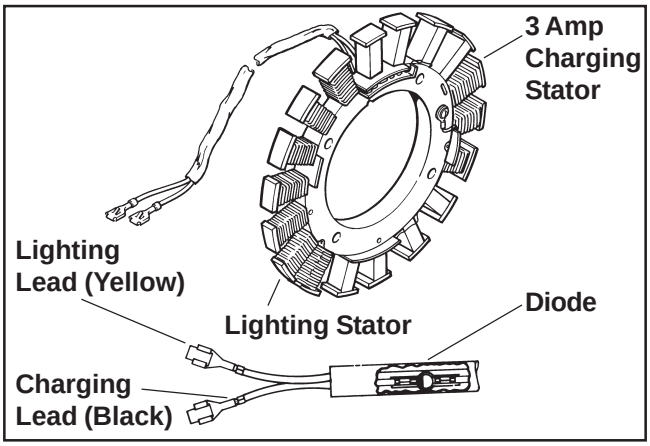


Figure 7-7. 3 Amp/70 Watt Stator.

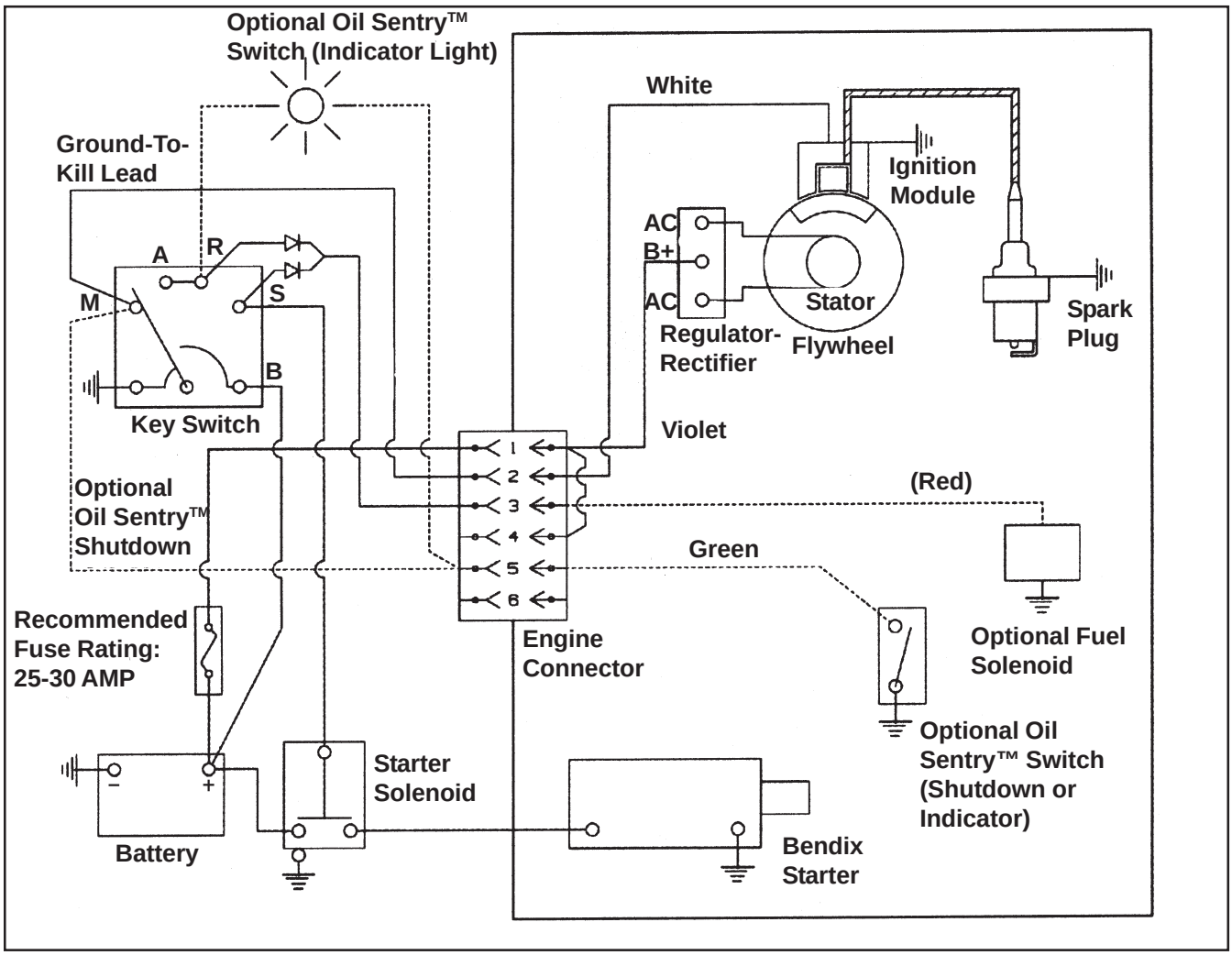


Figure 7-8. 3 amp Unregulated Battery Charging System/70 Watt Lighting.

Troubleshooting Guide 3 amp Battery Charging System with 70 Watt Lighting Stator

NOTE: Zero ohmmeteres on each scale to ensure accurate readings. Voltage tests should be made with engine running at full throttle - no load. Battery must be fully charged.

Problem	Test	Conclusion
No Charge To Battery	1. With engine running in the fast setting, measure voltage across battery terminals using a DC voltmeter.	1. If voltage is **more than 12.5 volts**, charging system is OK. If voltage is **12.5 volts or less**, the stator or diode are probably faulty. Test the stator and diode (Test 2, 3, and 4).
	2. Disconnect the charging lead from battery. With engine running in the fast setting, measure voltage from charging lead to ground using a DC voltmeter.	2. If voltage is **20 volts or more**, stator winding is OK. If voltage is **less than 20 volts**, test stator using an ohmmeter (Tests 3 and 4).
	3. With charging lead disconnected from battery and engine stopped, measure resistance from charging lead to ground using an ohmmeter. Note reading. Reverse the leads and measure resistance again. In one direction, the resistance should be infinity ohms (open circuit). With the leads reversed, some resistance should be measured (about midscale on Rx1 range).	3. If resistance is **low** in both directions, the diode is shorted. Replace the diode. If resistance is **high** in both directions, the diode or stator winding is open. (Use Test 4).
	4. Cut the sleeving on the charging lead to expose the diode connections. Measure the resistance from the stator side of diode to ground using an ohmmeter.	4. If resistance is approximately **0.5 ohms**, stator winding is OK, diode is open. Replace diode. If resistance is **0 ohms**, stator winding is shorted. Replace stator. If resistance is **infinity ohms**, stator winding or lead is open. Replace stator.
No Lights	1. Make sure lights are not burned out.	1. Replace burned out lights.
	2. Disconnect the lighting lead from the wiring harness. With engine running at in the fast setting, measure voltage from lighting lead to ground using an AC voltmeter.	2. If voltage is **13 volts or more**, stator is OK. Check for loose connections or shorts in wiring harness. If voltage is **less than 13 volts**, test stator using an ohmmeter (Test 3).
	3. With engine stopped, measure the resistance of stator from lighting lead to ground using an ohmmeter.	3. If resistance is approximately **0.2 ohms**, stator is OK. If resistance is **0 ohms**, stator is shorted. Replace stator. If resistance is **infinity ohms**, stator or lighting lead is open. Replace stator.

Troubleshooting Guide 3 amp/70 Watt Braking Stator

NOTE: Zero ohmmeteres on each scale to ensure accurate readings. Voltage tests should be made with engine running at full throttle - no load. Battery must be fully charged.

Problem	Test	Conclusion
No Charge To Battery	1. With engine running in the fast setting, measure voltage across battery terminals using a DC voltmeter.	1. If voltage is **more than 12.5 volts**, charging system is OK. If voltage is **12.5 volts or less**, the stator or diode are probably faulty. Test the stator and diode (Test 2, 3, and 4).
	2. Disconnect the charging lead (black) from the wiring harness. With engine running in the fast setting, measure voltage from charging lead to ground using a DC voltmeter.	2. If voltage is **5 volts or more**, stator winding is OK. If voltage is **less than 5 volts**, test stator using an ohmmeter (Tests 3 and 4).
	3. With charging lead disconnected from battery and engine stopped, measure resistance from charging lead to ground using an ohmmeter. Note reading. Reverse the leads and measure resistance again. In one direction, the resistance should be infinity ohms (open circuit). With the leads reversed, some resistance should be measured (about midscale on Rx1 range).	3. If resistance is **low** in both directions, the diode is shorted. Replace the diode. If resistance is **high** in both directions, the diode or stator winding is open. (Use Test 4.)
	4. Disconnect the lighting lead (yellow) from the wiring harness. Measure the resistance from the lighting lead to ground using an ohmmeter.	4. If resistance is approximately **0.15 ohms**, stator winding is OK, diode is open. Replace diode. If resistance is **0 ohms**, stator winding is shorted. Replace stator. If resistance is **infinity ohms**, stator winding or lead is open. Replace stator.
No Lights	1. Make sure lights are not burned out.	1. Replace burned out lights.
	2. Disconnect the lighting lead (yellow) from the wiring harness. With engine running in the fast setting, measure voltage from lighting lead to ground using an AC voltmeter.	2. If voltage is **13 volts or more**, stator is OK. Check for loose connections or shorts in wiring harness. If voltage is **less than 13 volts**, test stator using an ohmmeter (Test 3).
	3. With engine stopped, measure the resistance of stator from lighting lead to ground using an ohmmeter.	3. If resistance is approximately **0.15 ohms**, stator is OK. If resistance is **0 ohms**, stator is shorted. Replace stator. If resistance is **infinity ohms**, stator or lighting lead is open. Replace stator.

Troubleshooting Guide 3 amp/70 Watt Braking Stator (cont.)

Problem	Test	Conclusion
No Lights Or Battery Charging (Braking System Test)	1. Make sure lights are not burned out.	1. Replace burned out lights.
	2. Disconnect the braking lead (green) from the wiring harness. With engine running in the fast setting, measure voltage from braking lead to ground using an AC voltmeter.	2. If voltage is **35 volts or more**, stator is OK. Circuitry on unit that grounds braking lead is shorted. If voltage is **less than 35 volts**, test stator using an ohmmeter (Test 3).
	3. With the engine stopped, measure the resistance from braking lead to ground using an ohmmeter.	3. If resistance is approximately **0.2-0.4 ohms**, stator is OK. If resistance is **0 ohms**, stator is shorted. Replace stator. If resistance is **infinity ohms**, stator or lighting lead is open. Replace stator.

9 or 15 amp Battery Charging System

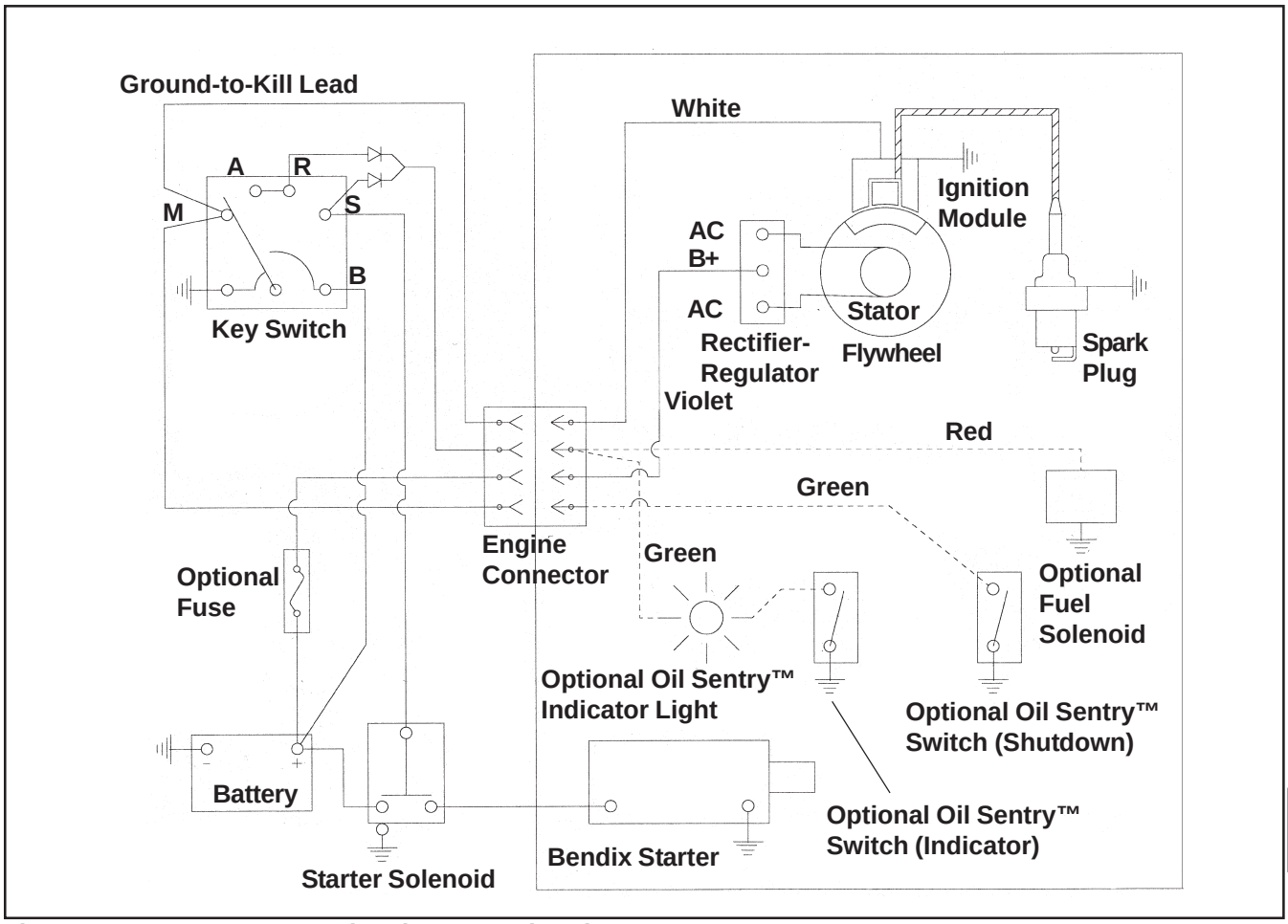


Figure 7-9. 9 or 15 amp Regulated Battery Charging System.

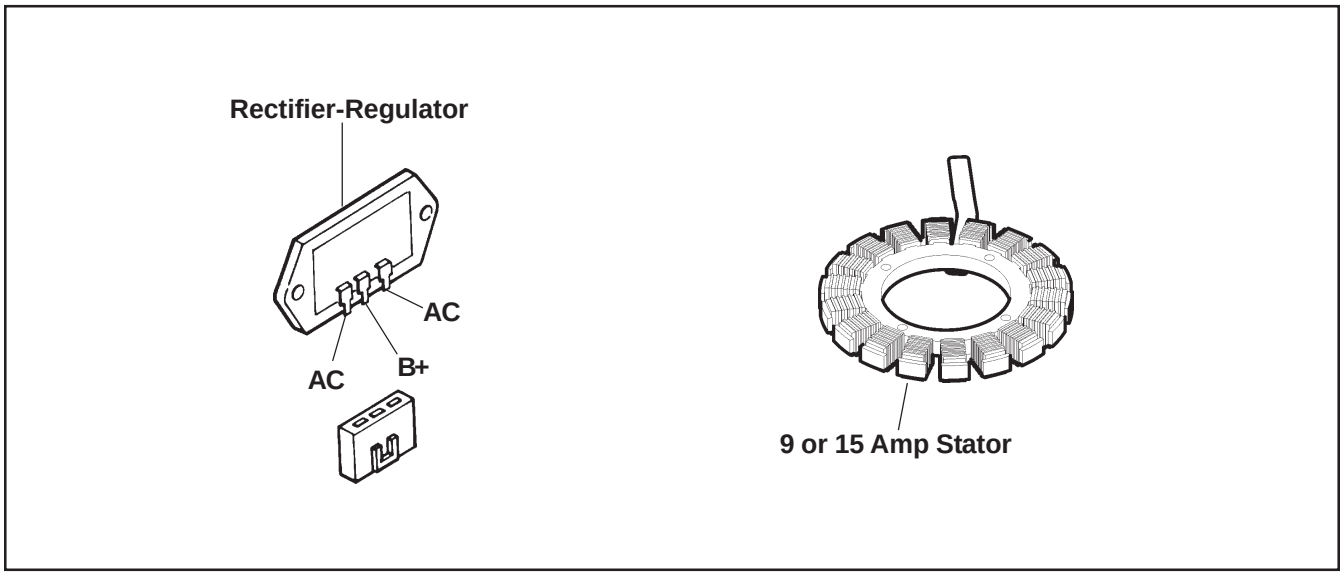


Figure 7-10. 9 or 15 amp Stator and Rectifier-Regulator.

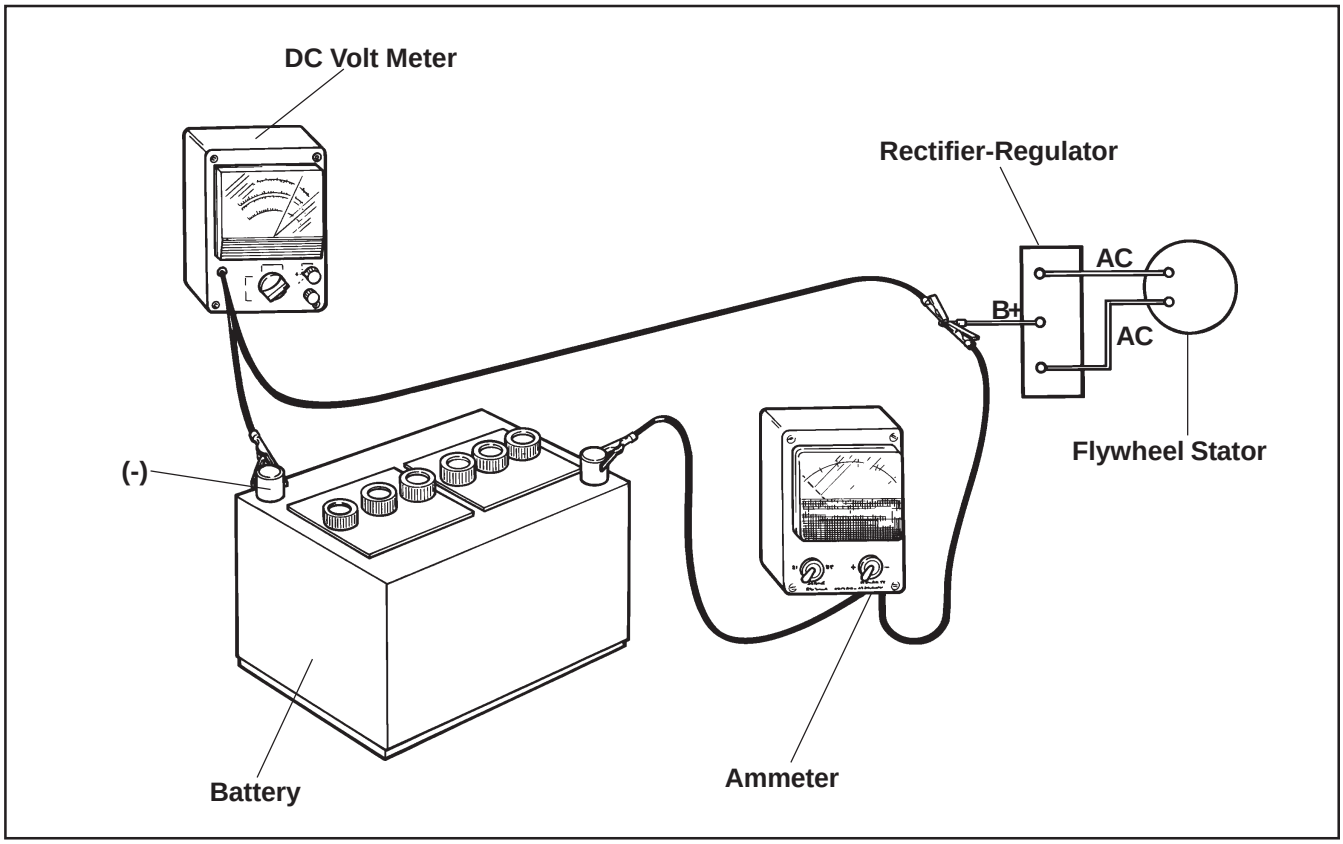


Figure 7-11. Proper Connection to Test 9 or 15 amp Charging System.

Troubleshooting Guide 9 or 15 amp Regulated Battery Charging System

NOTE: Zero ohmmeters on each scale to ensure accurate readings. Voltage tests should be made with engine running at full throttle - 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. See Figure 7-11. With engine running in the fast position, 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 in the fast position, measure AC voltage across stator leads using an AC voltmeter.	2. If voltage is **28 volts or more**, stator is OK. Rectifier-regulator is probably faulty. Verify with Rectifier-regulator tester KO3221. 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 **0.1/0.2 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 is 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 Starters

These engines use inertia drive starting motors.

Operation

When power is applied to the starter, the armature rotates. As the armature rotates, the drive pinion moves out on the splined drive shaft and into mesh with the flywheel ring gear. When the pinion reaches the end of the drive shaft, it rotates the flywheel and "cranks" the engine.

When the engine starts, the flywheel rotates faster than the starter armature and drive pinion. This moves the drive pinion out of mesh with the ring gear and into the retracted position. When power is removed from the starter, the armature stops rotating and the drive pinion is held in the retracted position by the anti-drift spring.

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 inertia drive starter 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 or end cap. Doing so can damage the starter.

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.
	Starter Switch or Solenoid	1. Bypass the switch or solenoid with a jumper wire. If starter cranks normally, replace the faulty components.
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 250 cold-cranking amps.
	Brushes	1. Check for excessively dirty or worn brushes and commutator. Clean commutator 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.

Starter Removal and Installation

Refer to the “Disassembly” and “Reassembly” Sections for starter removal and installation procedures.

Starter Drive Service

Every **three years** or **150 hours** of operation, clean and lubricate the splines on the starter drive shaft. If the drive pinion is worn, or has chipped or broken teeth, it must be replaced. See Figure 7-12.

It is not necessary to completely disassemble the starter to service the drive components.

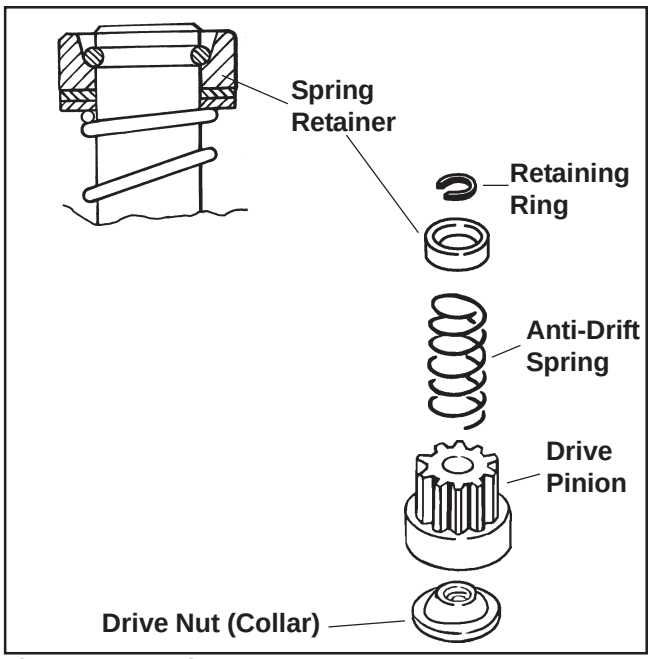


Figure 7-12. Drive Components.

1. Disassemble removal tool Kohler Part No. **25 761 18-S**.

2 Referring to Figure 7-12, grasp the spring retainer and push it toward the starter, compressing the anti-drift spring and exposing the retaining ring.

3. Holding the spring retainer in the retracted position, assemble the inner halves of the removal tool around the armature shaft with the retaining ring in the inner groove (see Figure 7-13). Slide the collar over the inner halves to hold them in position.

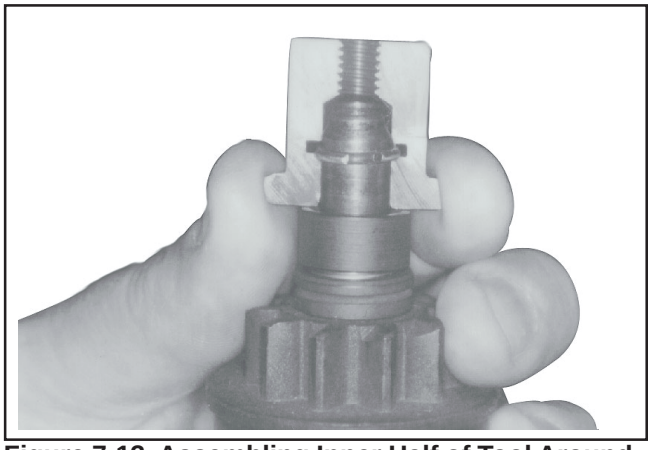


Figure 7-13. Assembling Inner Half of Tool Around The Armature Shaft and Retaining Ring.

4. Thread the center screw into the removal tool until you feel resistance. Use a wrench (1 1/8" or adjustable) to hold the base of the removal tool. Use another wrench or socket (1/2" or 13 mm) to turn the center screw clockwise (see Figure 7-14). The resistance against the center screw will tell you when the retaining ring has popped out of the groove in the armature shaft.

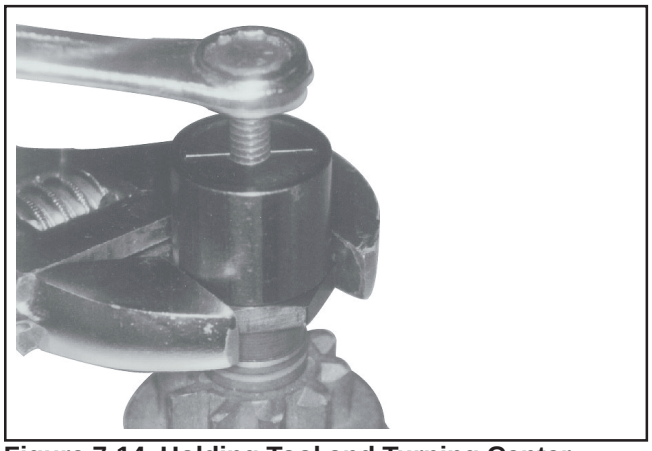


Figure 7-14. Holding Tool and Turning Center Screw (Clockwise) to Remove Retaining Ring.

5. Remove the drive components, and drive nut (collar) from the armature shaft, paying attention to the sequence. If the splines are dirty, clean them with solvent.

6. The splines should have a light film of lubricant. Relubricate as necessary with Kohler bendix starter lubricant (Part No. **52 357 01-S**). Reinstall or replace the drive components, assembling them in the same sequence as they were removed.

Retaining Ring Installation

1. Position the retaining ring in the groove in one of the inner halves. Assemble the other half over the top and slide on the outer collar.

2. Be certain the drive components are installed in correct sequence onto the armature shaft.

3. Slip the tool over the end of the armature shaft, so the retaining ring inside is resting on the end of the shaft. Hold the tool with one hand, exerting slight pressure toward the starter. Tap the top of the tool with a hammer until you feel the retaining ring snap into the groove. Disassemble and remove the tool.

4. Squeeze the retaining ring with pliers to compress it into the groove.

5. Assemble the inner halves with the larger cavity around the spring retainer (see Figure 7-15). Slide the collar over them and thread the center screw in until resistance is felt.

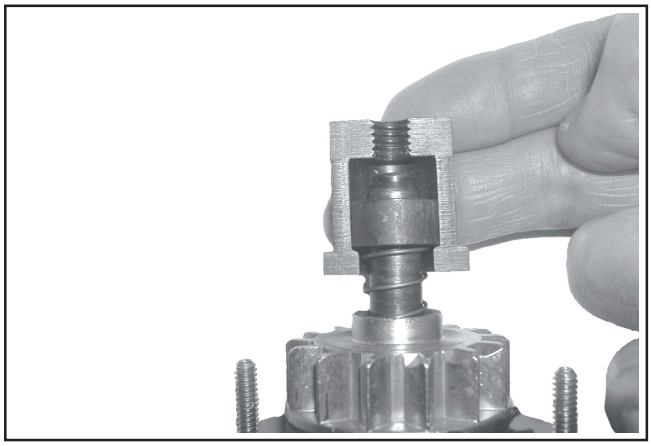


Figure 7-15. Assembling Larger Inner Half Around Spring Retainer.

6. Hold the base of the tool with a 1 1/8" wrench and turn the center screw clockwise with a 1/2" or 13 mm wrench to draw the spring retainer up around the retaining ring. Stop turning when the resistance increases. Disassemble and remove the tool.

Starter Disassembly

1. Remove the drive components following the instructions for servicing the drive.

2. Remove the hex. flange nut and insulating washer from the positive (+) brush lead stud.

3. Remove the thru bolts and recessed hex. nuts.

4. Remove the commutator end cap and lift out the brush carrier assembly with the brushes and springs.

5. Remove the drive end cap, then pull the armature with the thrust washer and wave washer (as equipped) out of the starter frame.

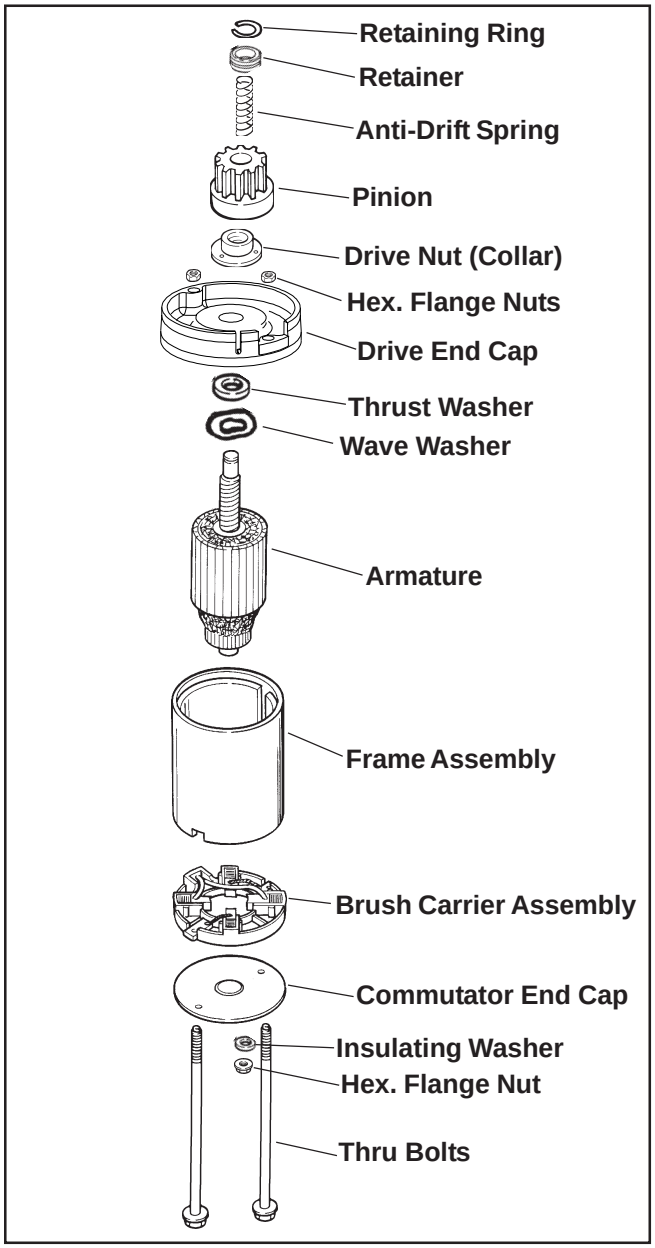


Figure 7-16. Inertia Drive Electric Starter.

Brush Replacement

1. Remove the hex. flange nut and insulating washer from the positive (+) brush lead stud.

2. Remove the thru bolts and captured hex. nuts.

3. Remove the commutator end cap, then pull the brush carrier assembly out of the frame. See Figure 7-17.

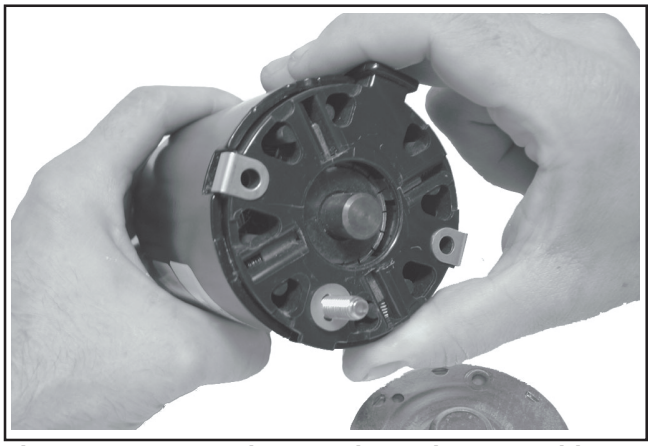


Figure 7-17. Removing Brush Carrier Assembly.

Commutator Service

Clean the commutator with a coarse, lint free cloth. Do not use emery cloth.

If the commutator is badly worn or grooved, turn it down on a lathe or replace the armature.

Starter Reassembly

1. Place the wave washer, followed by the thrust washer onto the drive shaft of the armature. See Figure 7-18.

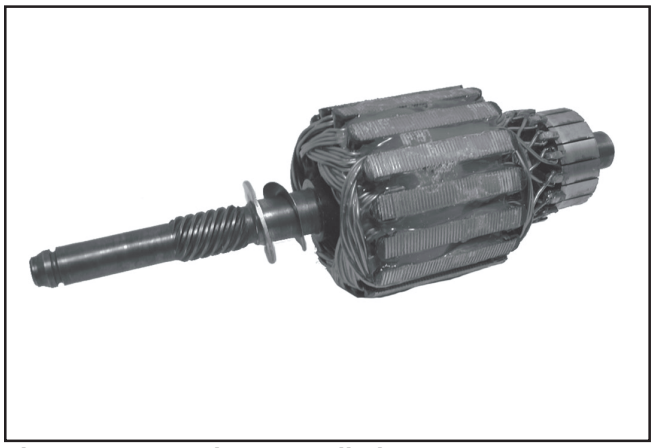


Figure 7-18. Washers Installed on Armature.

2. Insert the armature into the starter frame. The magnets will hold it in place. See Figure 7-19.

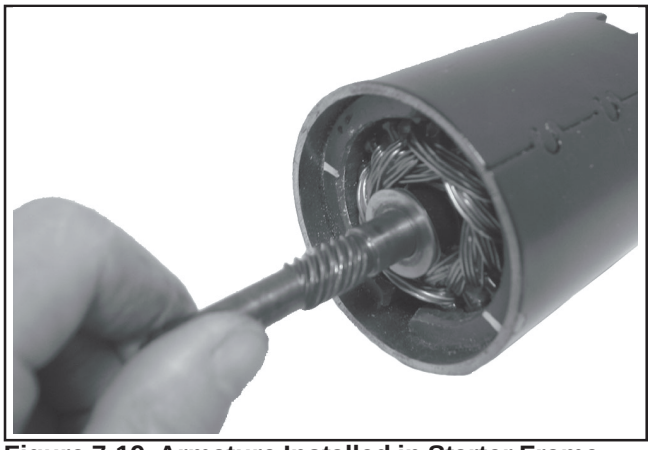


Figure 7-19. Armature Installed in Starter Frame.

3. Align the holes with the spaces between the magnets and install the drive end cap onto the front of the frame.

4. If the brush assembly is not being replaced, position the springs and brushes within their pockets in the carrier; move them to the retracted position, and install carton staples to retain them. See Figure 7-20. Replacement brushes come pre-assembled in the carrier housing, retained with two carton staples.

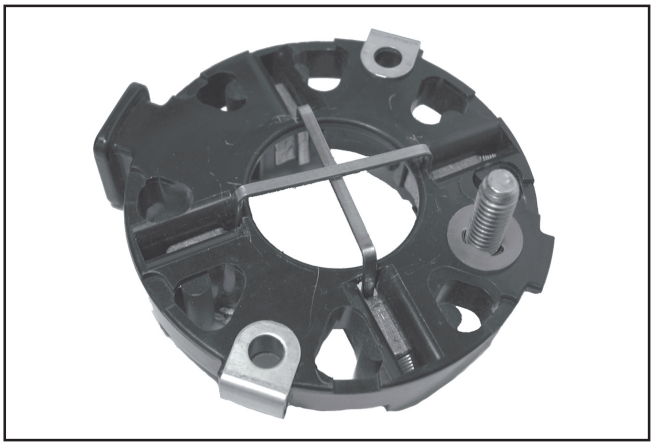


Figure 7-20. Brush Carrier Assembly with Staples.

5. Hold the brush holder assembly with the positive brush lead stud **up**. Align the molded sections with the corresponding cutouts in the starter frame and slide the brush carrier assembly into place. The commutator will push the carton staples out as the brush assembly is inserted. See Figure 7-21.

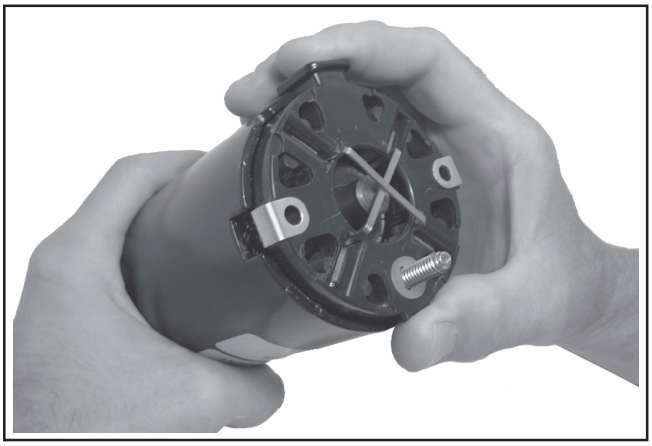


Figure 7-21. Installing Brush Carrier Using Staples.

6. Position the commutator end cap over the brush assembly, aligning the holes for the stud terminal and the thru bolts.

7. Install the thru bolts and hex. nuts. Torque to **3.3-3.9 N·m**. **(30-35 in. lb.)**. See Figure 7-22.

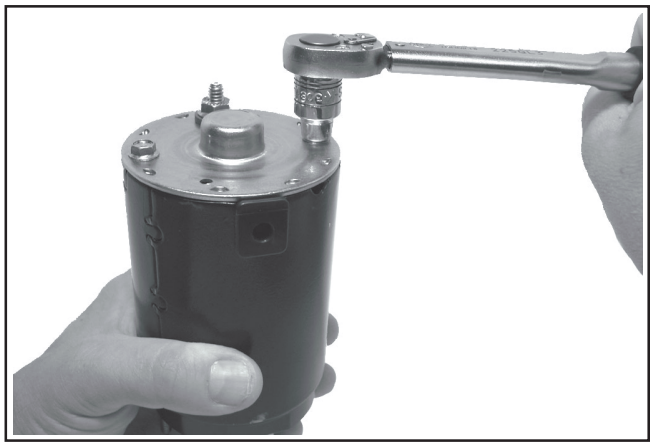


Figure 7-22. Torquing Thru Bolts.

8. Install the insulating washer and hex. flange nut onto the positive (+) brush lead stud. Make sure the stud is centered and does not touch the metal end cap. Torque the hex. flange nut to **2.2-4.5 N·m (20-40 in. lb.)**.

   NOTE: After installation and connection of the starter lead, torque the outer nut to **1.6-2.8 N·m (12-25 in. lb.), do not over torque**.

9. Lubricate the drive shaft with Kohler bendix starter drive lubricant (Part No. **52 357 01-S**). Install the drive components following the instructions for servicing the drive. The completed starter is shown in Figure 7-23.

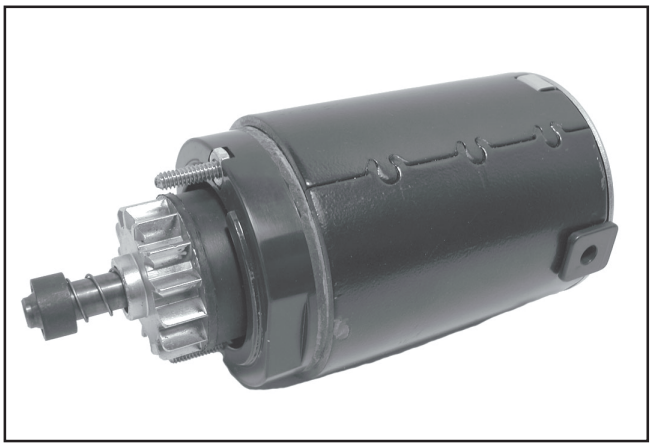


Figure 7-23. Assembled Starter.

Section 8
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. 2) Disconnect negative (-) battery cable from battery.*

The following sequence is suggested for complete engine disassembly. This procedure can be varied to accommodate options or special equipment.

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

1. Drain oil from the crankcase and remove oil filter.
2. Remove blower housing.
3. Disconnect spark plug lead.
4. Remove muffler.
5. Remove rectifier-regulator
6. Remove electric starter
7. Remove air cleaner
8. Remove external governor components, carburetor and fuel pump.
9. Remove ignition module.
10. Remove grass screen, fan, and flywheel.
11. Remove stator.
12. Remove valve cover and cylinder head.
13. Remove closure plate and wiring harness.
14. Remove cam gears, cam shafts, and oil pump.
15. Remove connecting rod and piston.
16. Remove piston from connecting rod.
17. Remove piston rings.
18. Remove crankshaft and balance weight assembly.
19. Remove balance weight assembly from crankshaft.
20 Remove governor cross shaft.
21. Remove PTO and flywheel side oil seals.

Drain Oil from Crankcase and Remove Oil Filter

1. Remove the oil drain plug and oil fill cap/dipstick. See Figure 8-1.

2. Allow ample time for the oil to drain from the crankcase.

3. Remove and discard the oil filter.

Figure 8-1. Oil Drain Location, Oil Filter, and Oil Fill Cap/Dipstick.

Section 8
Disassembly

Remove Oil Sentry™ Pressure Switch (on models so equipped)

1. Disconnect the lead from the Oil Sentry™ pressure switch.

2. Remove the pressure switch from the center passage or adapter elbow in the closure plate. See Figure 8-2.

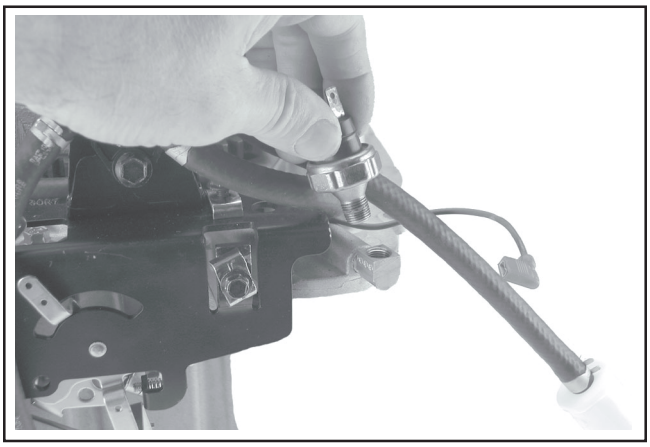


Figure 8-2. Removing Oil Sentry™ Switch.

Remove Blower Housing

1. Remove the four shoulder screws securing the blower housing to the closure plate. Figure 8-3.

2. Lift the blower housing and separate the spark plug lead from the corresponding slot.

Figure 8-3. Removing Blower Housing Screws.

Disconnect Spark Plug Lead

1. Carefully pull on the boot section and disconnect the spark plug lead.

Remove Muffler

1. Remove the hex. flange nuts from the exhaust studs. If a muffler bracket is used, remove the hex. flange screws attaching the muffler or exhaust system to the bracket.

2. Remove the muffler and gasket from the exhaust port studs. See Figure 8-4.

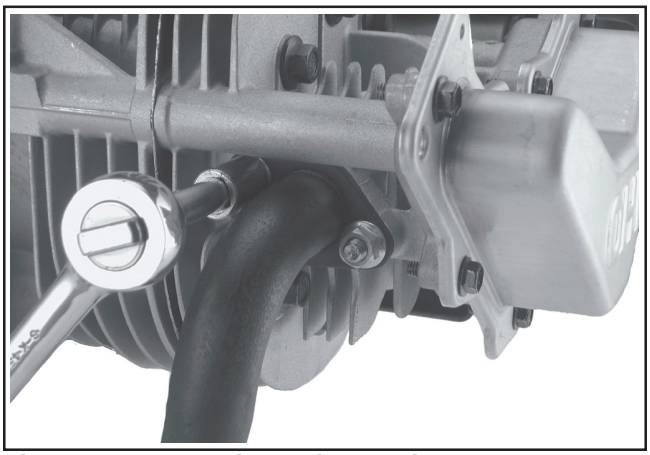


Figure 8-4. Removing Exhaust Flange Nuts.

Remove Rectifier-Regulator

1. Unplug the connector from the rectifier-regulator.

2. Remove the two screws securing the rectifier-regulator to the crankcase. Remove the rectifier-regulator. See Figure 8-5.

Figure 8-5. Removing Rectifier-Regulator.

Remove Electric Starter

1. Disconnect the starter lead from the terminal stud.

2. Remove the two hex. flange nuts securing the starter to the closure plate. Remove the starter. See Figure 8-6.

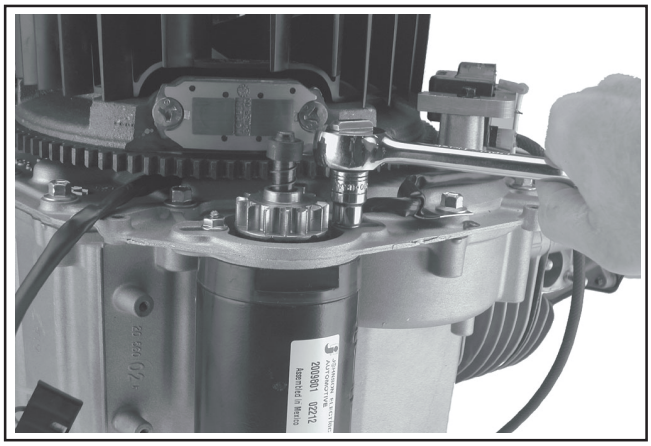


Figure 8-6. Removing Electric Starter.

Remove Air Cleaner

1. Loosen the two knobs and remove the air cleaner cover. See Figure 8-7.

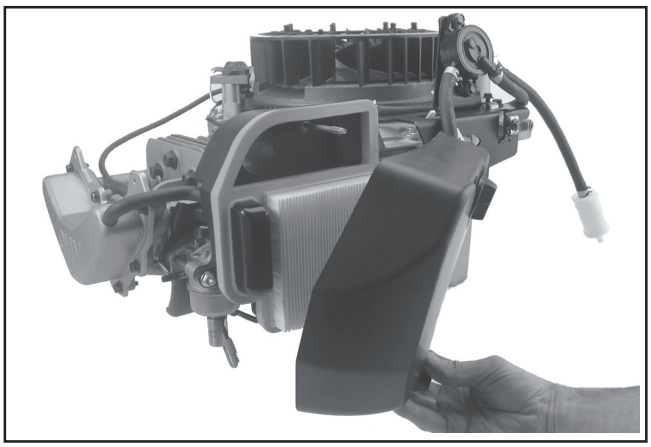


Figure 8-7. Removing Air Cleaner Cover.

2. Remove the precleaner (if so equipped), and the air cleaner element with the formed rubber seal. See Figure 8-8.

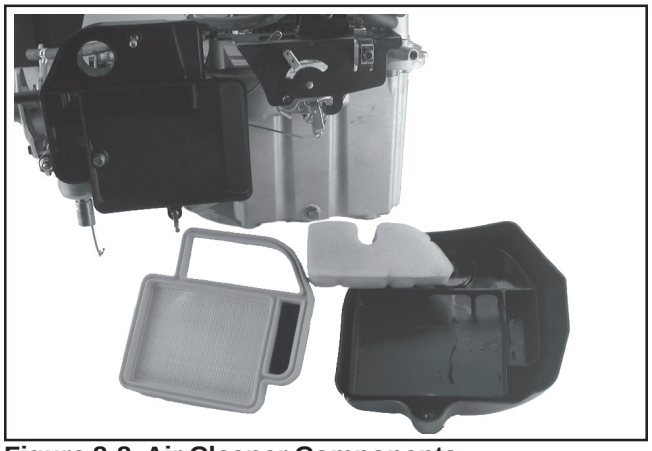


Figure 8-8. Air Cleaner Components.

3. Remove the two hex. flange nuts, or single nut and long mounting screw securing the air cleaner base. See Figure 8-9.

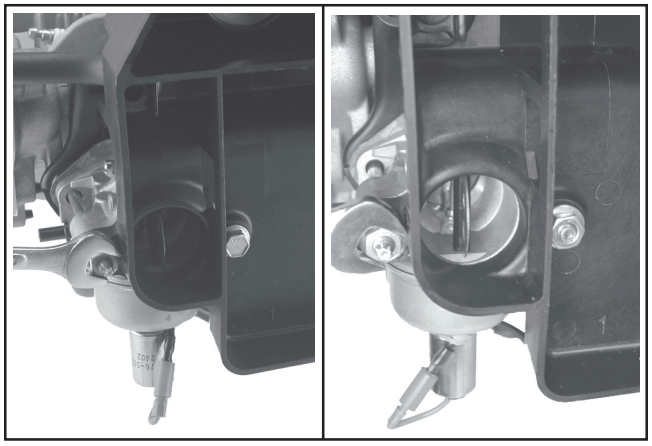


Figure 8-9. Removing Air Cleaner Base Fasteners.

4. Disconnect the breather hose from the valve cover and remove the air cleaner base and gasket. See Figure 8-10.

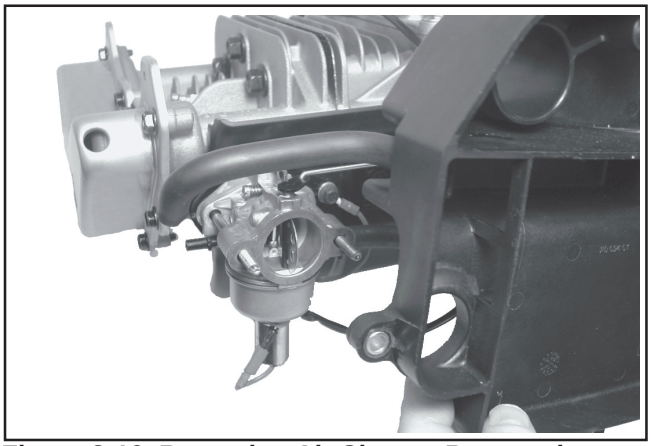


Figure 8-10. Removing Air Cleaner Base and Breather Hose.

Remove External Governor Components, Carburetor, and Fuel Pump

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. Shut off the fuel supply. Disconnect the fuel line from the carburetor inlet fitting. See Figure 8-11. If a fuel pump is used, disconnect the pulse line from the fitting on the closure plate. See Figure 8-12.

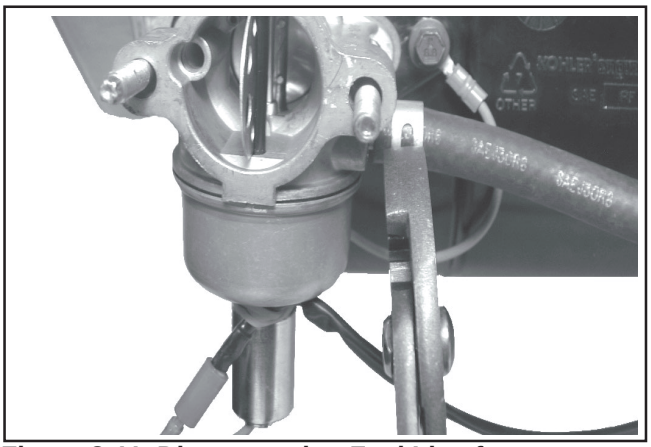


Figure 8-11. Disconnecting Fuel Line from Carburetor.

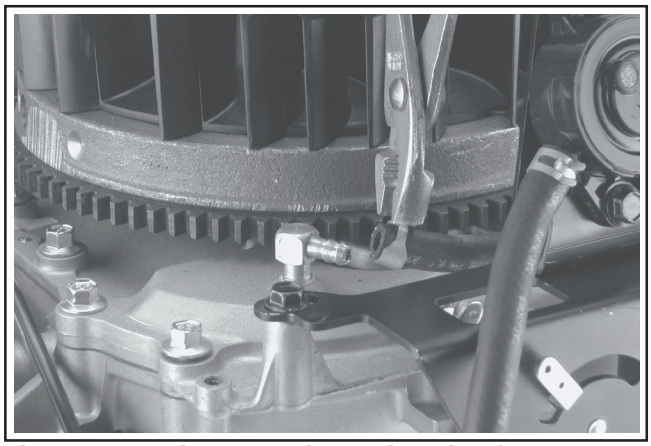


Figure 8-12. Disconnecting Pulse Line from Fitting.

2. Remove the heat deflector mounting screw and special washer, which also secures the ground lead for the fuel shut-off solenoid, if so equipped. See Figure 8-13.

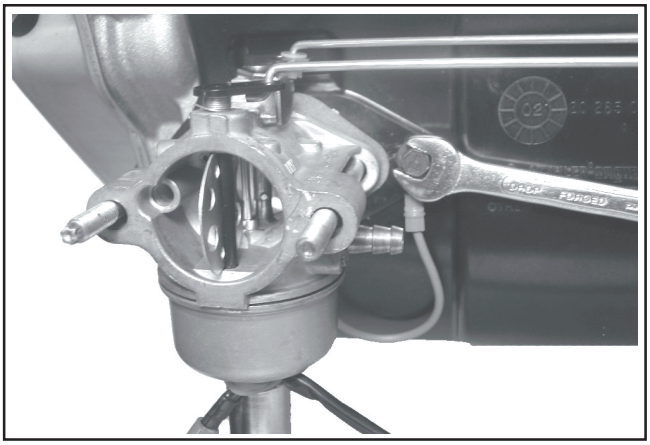


Figure 8-13. Removing Heat Deflector Screw and Ground Lead.

3. If the carburetor uses a fuel solenoid, carefully cut the plastic tie strap and disconnect the fuel solenoid lead from the wiring harness. See Figure 8-14.

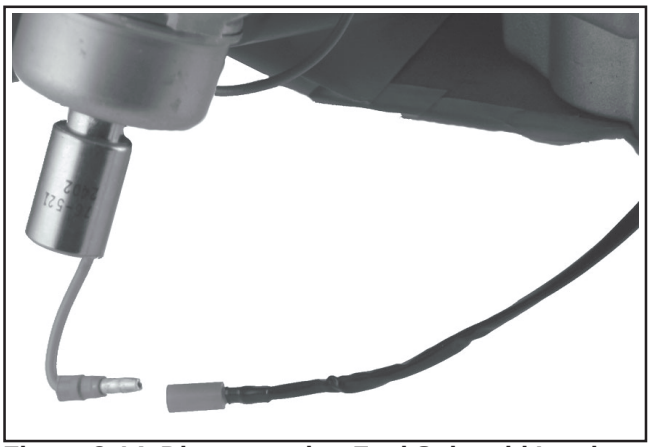


Figure 8-14. Disconnecting Fuel Solenoid Lead.

4. Slide the carburetor outward and disconnect the throttle and choke linkages. See Figure 8-15.

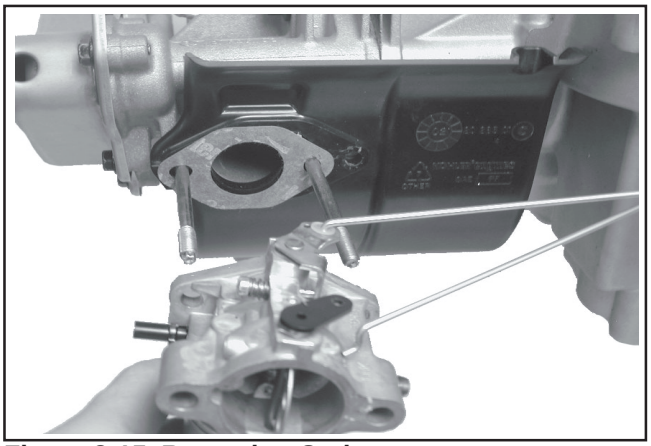


Figure 8-15. Removing Carburetor.

5. Mark the mounted position of the speed control bracket in the slotted holes and remove the two screws securing the speed control bracket to the closure plate. Note or mark the governor spring hole for correct installation later. Unhook the governor spring, then remove the control bracket (with fuel pump attached, if equipped) and linkages from the engine. See Figures 8-16 and 8-17.

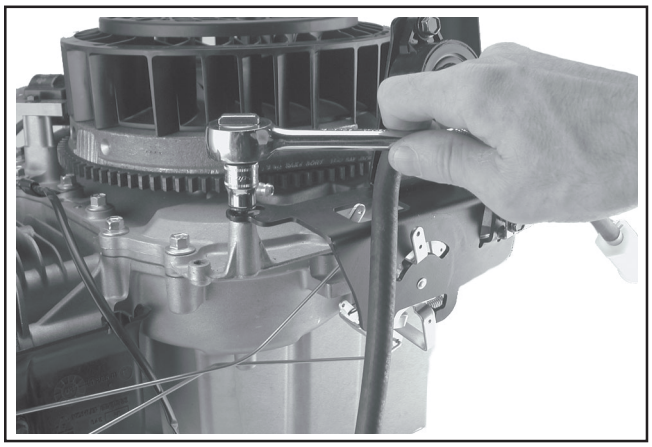


Figure 8-16. Removing Speed Control Bracket from Closure Plate.

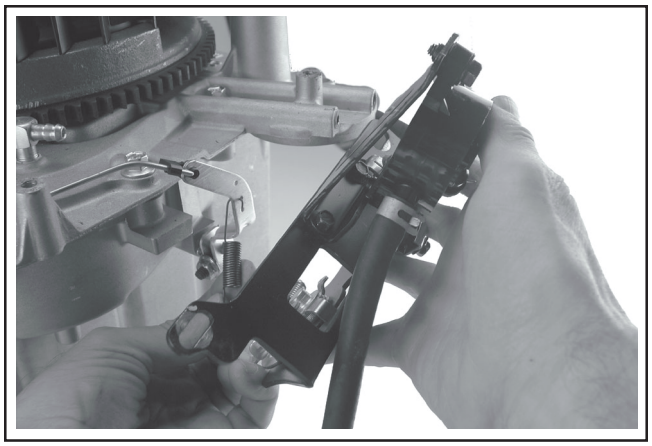


Figure 8-17. Disconnecting Governor Spring.

6. Loosen the hex. flange nut and remove the governor lever* from the governor cross shaft. See Figure 8-18.

*NOTE: It is recommended that a new governor lever be installed whenever removal is performed.

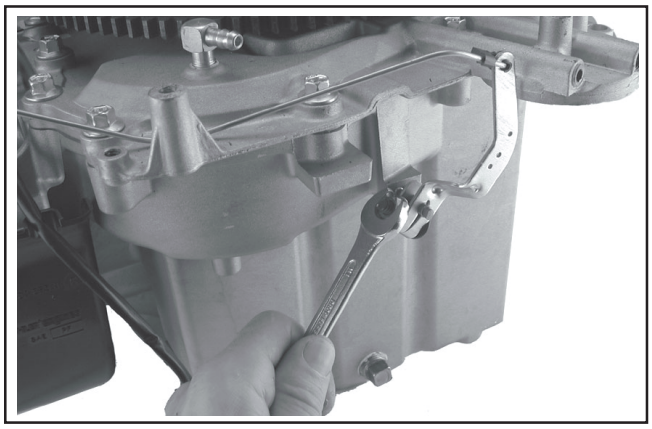


Figure 8-18. Removing Governor Lever.

7. Remove the carburetor gasket, then carefully remove the heat deflector and gasket from the intake stud. The heat deflector is made from a plastic that is quite brittle. Do not pry on the corners, or you risk cracking/breaking the deflector. If prying is necessary to loosen the deflector, carefully pry near the intake stud only. See Figure 8-19. Remove the mounting stud from the cylinder only if required.

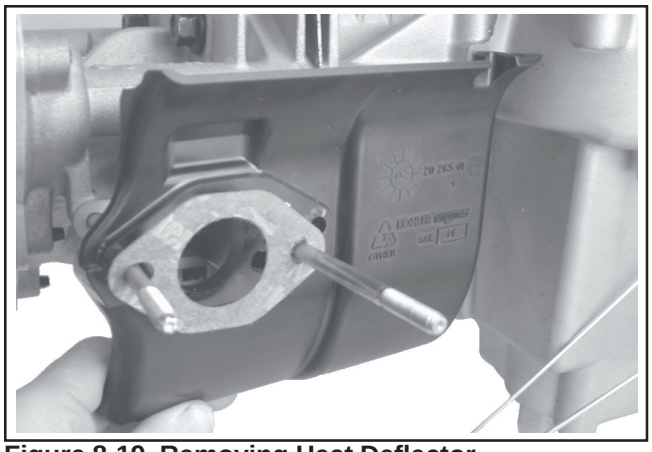


Figure 8-19. Removing Heat Deflector.

Remove Ignition Module

1. Disconnect the kill lead from the ignition module.

2. Rotate the flywheel magnet away from the module.

3. Remove the RFI sheathed spark plug lead with from retaining clip, if so equipped. See Figure 8-20.

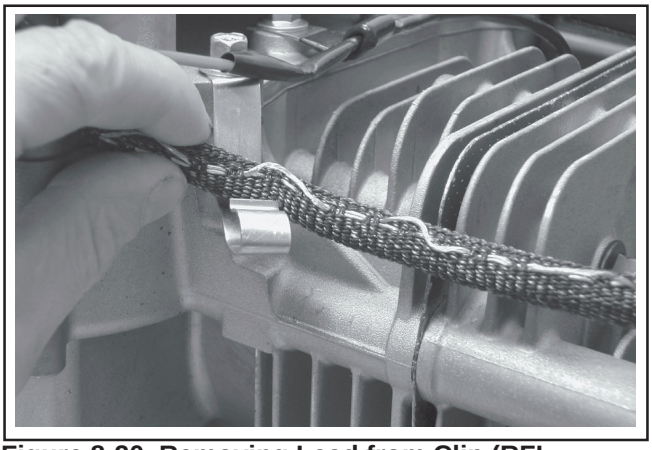


Figure 8-20. Removing Lead from Clip (RFI Suppression Equipped Units.

4. Remove the two hex. flange screws and the ignition module. See Figure 8-21.

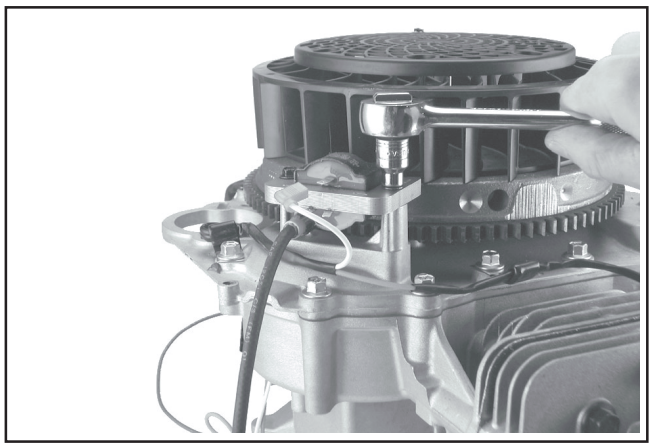


Figure 8-21. Removing Ignition Module.

Remove Grass Screen, Fan, and Flywheel

1. Unsnap the grass screen from the cooling fan. See Figure 8-22.

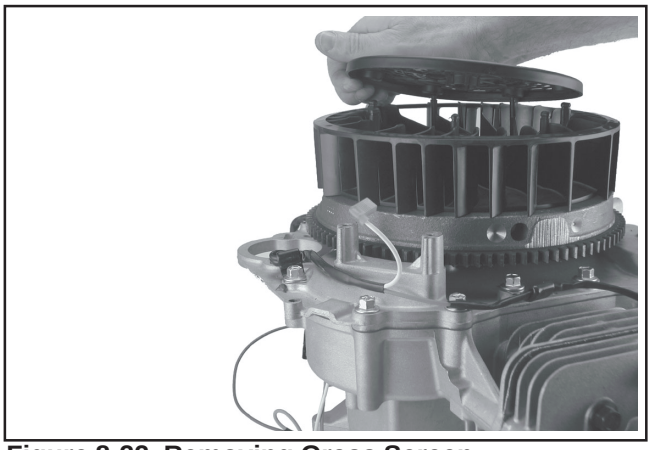


Figure 8-22. Removing Grass Screen.

NOTE: Always use a flywheel strap wrench or flywheel holding tool (see Section 2) to hold the flywheel when loosening or tightening the flywheel and fan retaining fasteners. Do not use any type of bar or wedge between the fins of the cooling fan, as the fins could become cracked or damaged.

2. Remove the retaining screw, washer and the fan mounting plate, securing the fan and flywheel to the crankshaft. See Figure 8-23.

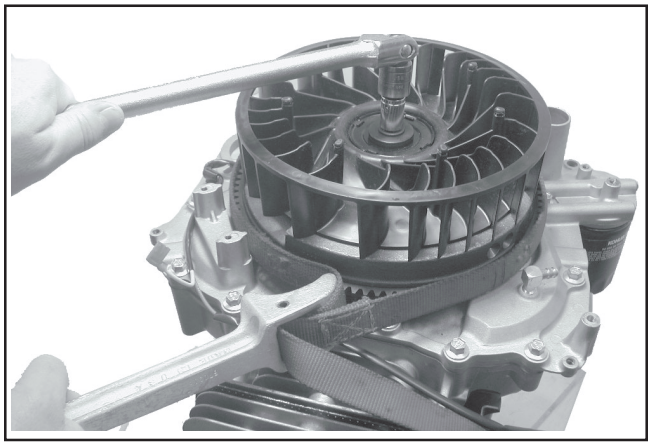


Figure 8-23. Removing Fan and Flywheel Mounting Hardware.

3. Carefully lift the cooling fan to disengage the two drive pins and remove it from the flywheel.

4. Remove the flywheel from the crankshaft using a puller. See Figure 8-24.

NOTE: Always use a puller to remove the flywheel from the crankshaft. Do not strike the crankshaft or flywheel, as they could be cracked or damaged.

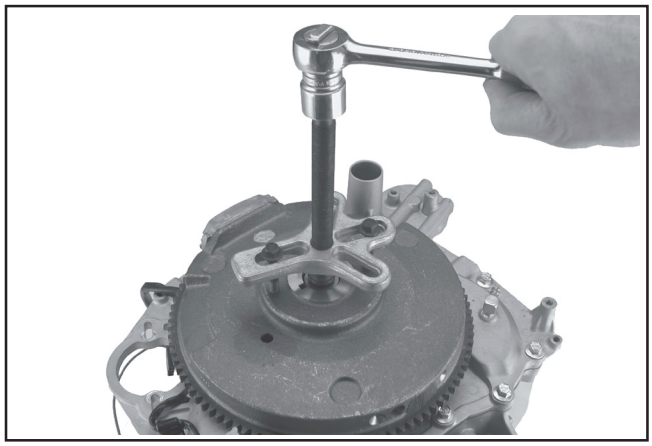


Figure 8-24. Removing Flywheel Using Puller.

5. Remove the flywheel key from the crankshaft.

Remove the Stator

1. Remove the two screws securing the stator to the closure plate bosses. See Figure 8-25.

NOTE: To disconnect the B+ or stator leads from the wiring harness connector, insert a small screwdriver, or similar narrow flat blade, and bend down the locking tang of the terminal(s). Gently pull the lead(s) out of the connector.

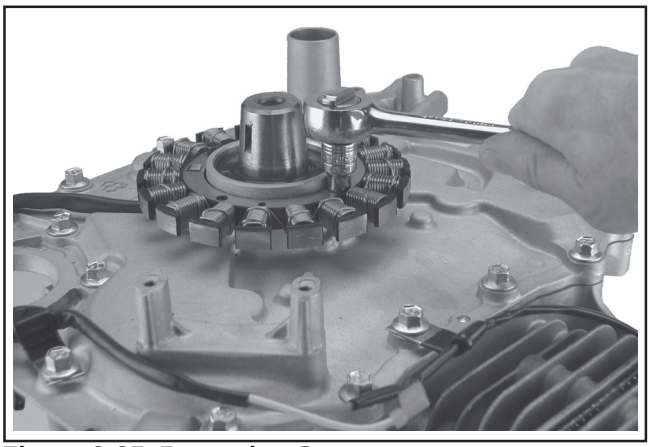


Figure 8-25. Removing Stator.

Remove Valve Cover and Cylinder Head

1. Remove the seven screws securing the valve cover and any attached brackets. See Figure 8-26.

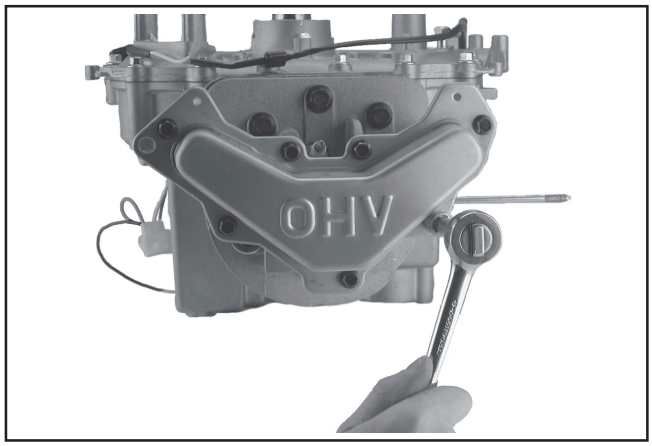


Figure 8-26. Removing Valve Cover Screws.

2. Remove the valve cover and gasket from the cylinder head. See Figure 8-27.

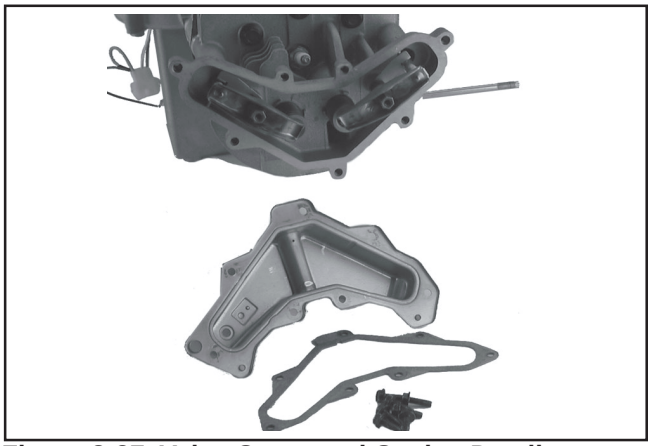


Figure 8-27. Valve Cover and Gasket Details.

3. Loosen the inner set screws (T15 TORX) and back off the rocker arm adjusting nuts. Remove the push rods and mark them, so they can be reinstalled in the same location. See Figure 8-28.

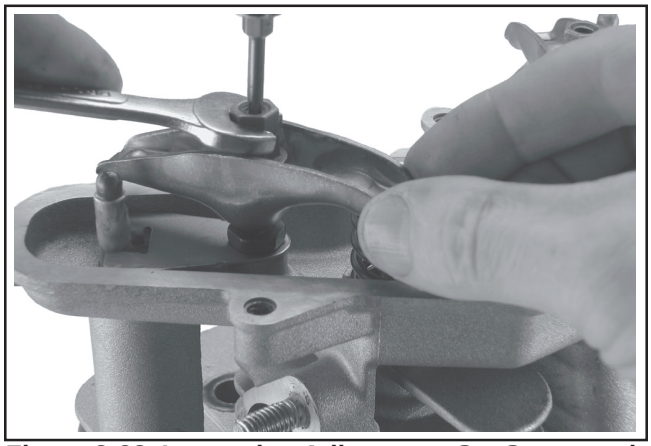


Figure 8-28. Loosening Adjustment Set Screw and Nut.

4. Remove the six hex. flange screws securing the cylinder head. Note the thick washer used on the screw closest to the exhaust port. See Figure 8-29.

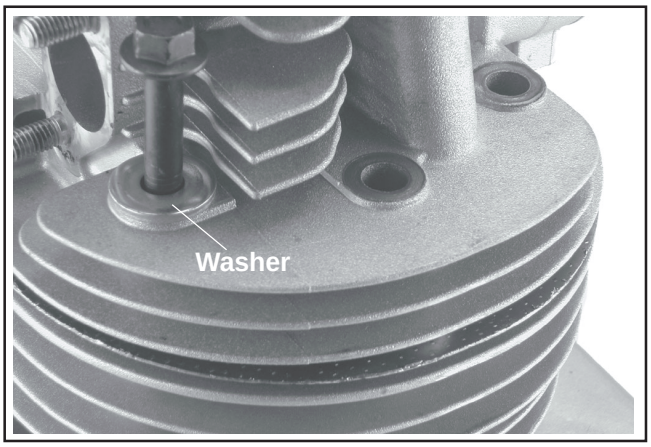


Figure 8-29. Removing Cylinder Head Bolts and Washer.

5. Remove the cylinder head and head gasket. See Figures 8-30.

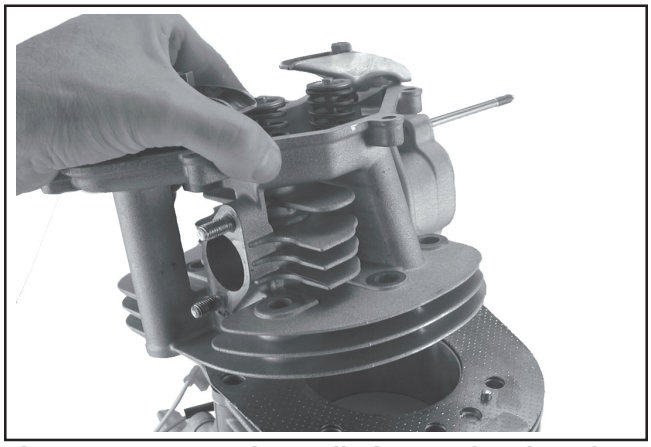


Figure 8-30. Removing Cylinder Head and Gasket.

6. Remove the drain back check ball from the keyhole slot in the crankcase. See Figure 8-31.

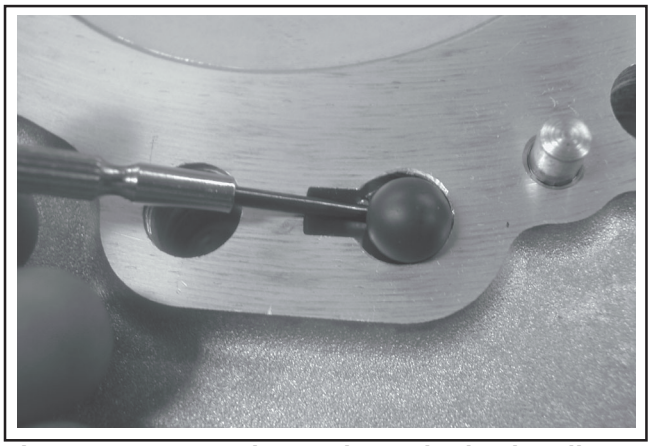


Figure 8-31. Removing Drain Back Check Ball from Crankcase.

Disassemble Cylinder Head

NOTE: Before disassembly, mark all valve train components that will be reused, to assure they are reassembled on the same side.

1. Remove the spark plug. See Figure 8-32.

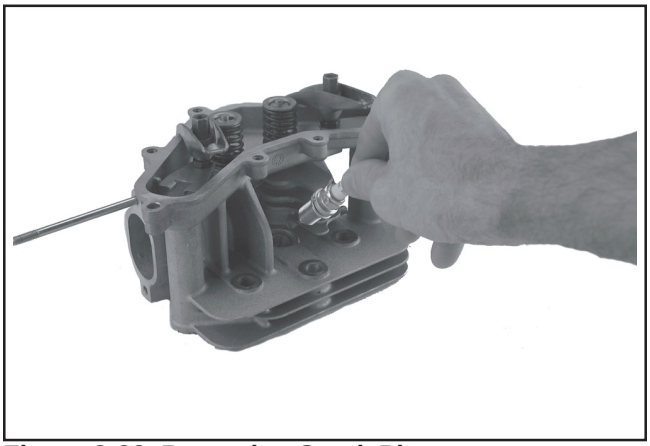


Figure 8-32. Removing Spark Plug.

2. Remove the adjustment nuts, pivots and rocker arms from the pivot studs.

3. Remove the rocker arm pivot studs and push rod guide plates. See Figure 8-33.

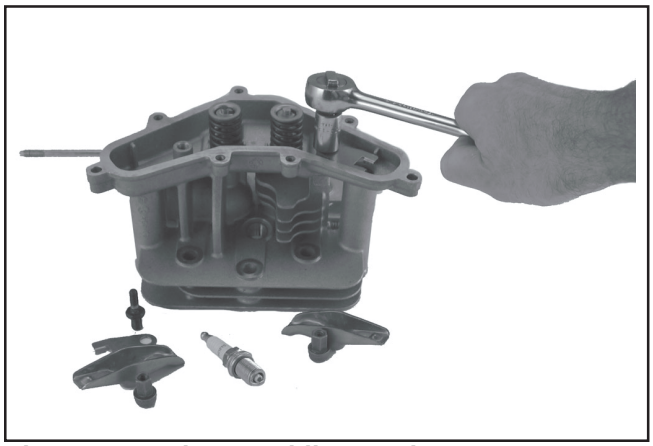


Figure 8-33. Disassembling Rocker Arm Components.

4. Remove the valves.

   a. Compress the valve springs using a valve spring compressor and remove the keepers. See Figure 8-34.

   b. Remove the compressor; then remove the valve spring caps, valve springs, and valves.

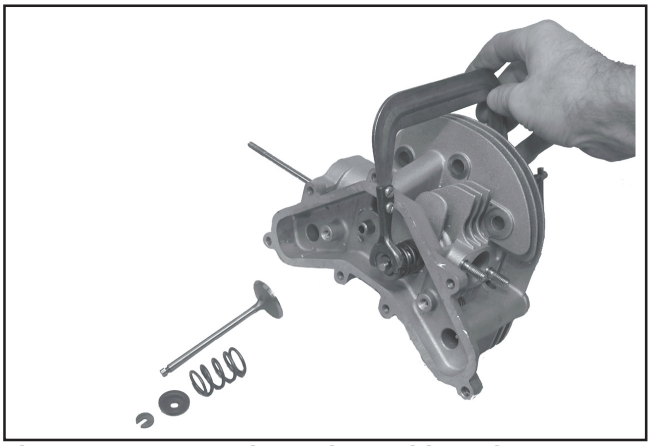


Figure 8-34. Removing Valves with Spring Compressor.

Remove Closure Plate

1. Remove the fourteen hex. flange screws securing the closure plate to the crankcase. See Figure 8-35. Note the location and position of any attached clips or clamps.

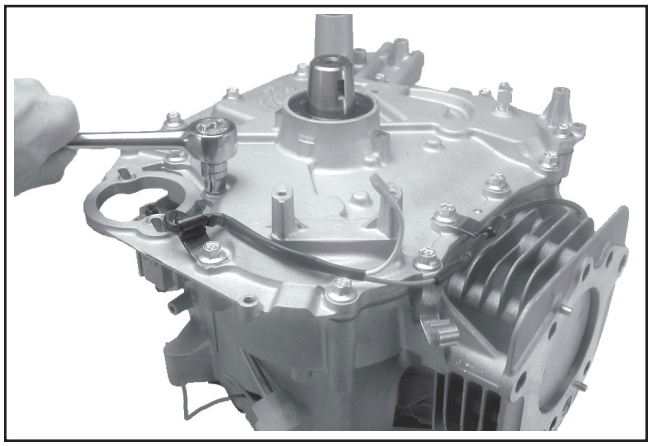


Figure 8-35. Removing Closure Plate Screws.

2. A gasket is used between the closure plate and crankcase. If necessary, carefully tap on the bosses for the starter or oil filter with a soft-faced mallet to loosen. Do not pry on the gasket surfaces of the crankcase or oil pan, as this can cause damage resulting in leaks.

3. Remove the closure plate assembly and gasket. See Figure 8-36.

4. If the wiring harness needs to be separated from the closure plate, pry open the clamps and pull out through the slot.

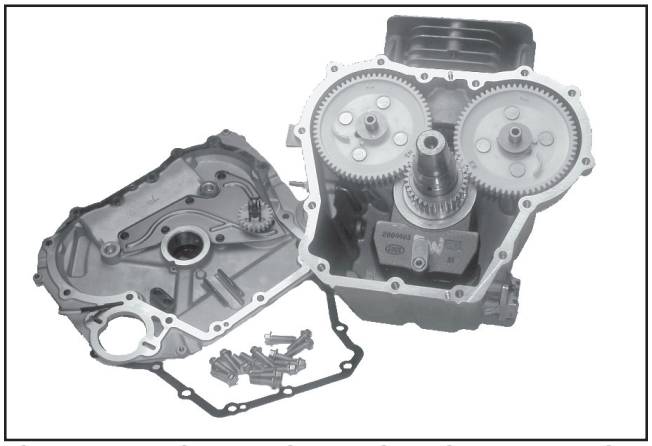


Figure 8-36. Closure Plate and Gasket Removed from Crankcase.

Disassemble Closure Plate

1. Remove the governor gear and regulating pin assembly. Gently pry upward using the blades of two small screwdrivers. See Figure 8-37.

NOTE: The governor gear is held onto the shaft by small molded tabs in the gear. When the gear is removed these tabs are destroyed and the gear must be replaced. Governor gear removal is required for closure plate disassembly and cleaning of the oil passages.

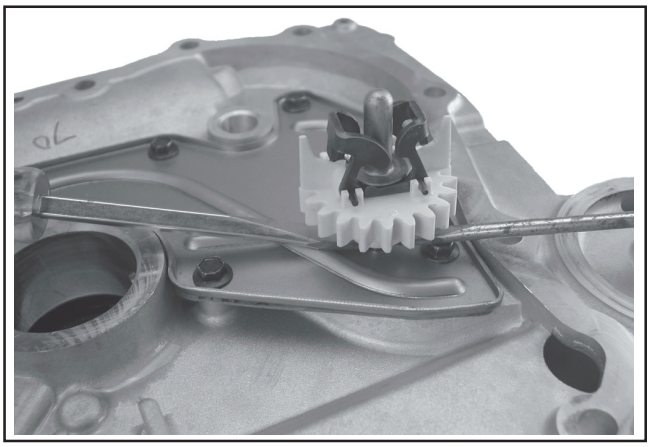


Figure 8-37. Removing Governor Gear.

2. Remove the six screws securing the oil passage cover to the closure plate. Remove the cover and gasket. See Figure 8-38.

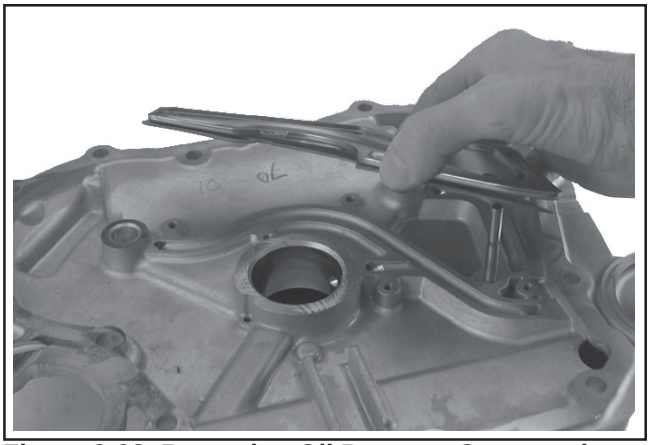


Figure 8-38. Removing Oil Passage Cover and Gasket.

Remove Cam Gears, Cam Shafts, and Oil Pump

1. Remove the thrust washers and cam gears from the cam shafts. See Figure 8-39.

NOTE: The ACR weight and spring normally captured by the thrust washer and installation of closure plate, will fall out if the exhaust cam gear is turned upside down.

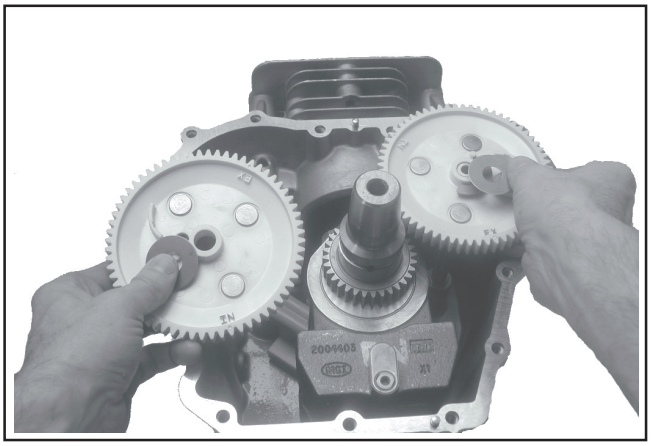


Figure 8-39. Removing Cam Gears.

2. Remove the screws securing the cam levers to the crankcase. See Figure 8-40. Mark the cam levers for proper reassembly.

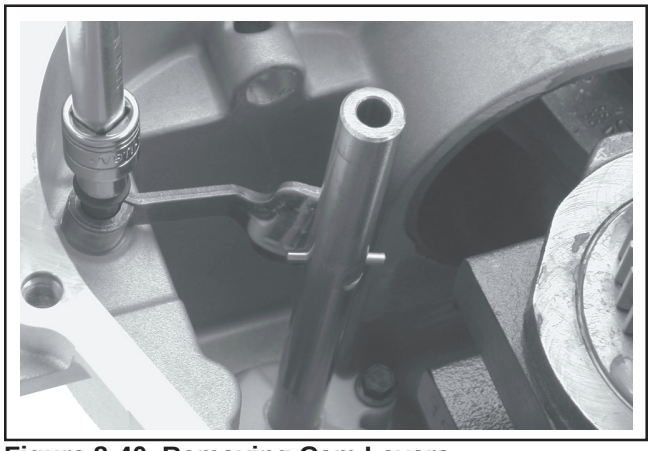


Figure 8-40. Removing Cam Levers.

3. Pull the exhaust side cam shaft and slotted thrust washer, out of the crankcase. See Figure 8-41.

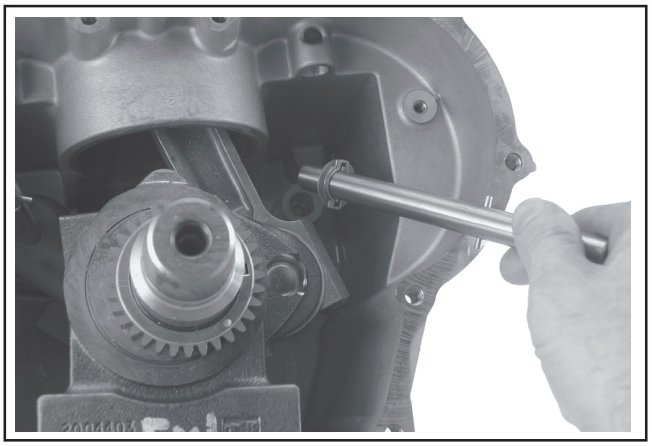


Figure 8-41. Removing Exhaust Side Cam Shaft and Slotted Thrust Washer.

4. Remove the two screws securing the oil pump and intake side cam shaft to the crankcase. Carefully pull upward on the cam shaft to remove the assembly from the crankcase cavity. A small rubber oil pump outlet seal* on the outlet of the oil pump may become dislodged during removal. Do not lose it. See Figure 8-42.

*NOTE: Most models use the outlet seal with the internal passage to feed oil to the lower main bearing. Some models use a solid seal, and the crankshaft is cross drilled to feed oil to the lower bearing. If the seal needs to be replaced, be sure the correct outlet seal is used.

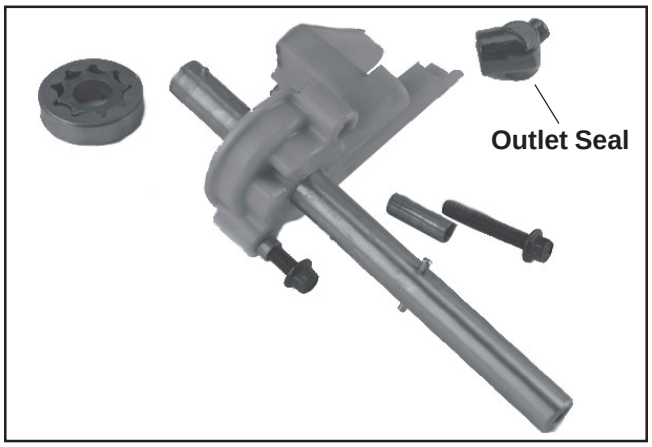


Figure 8-42. Intake Cam shaft and Oil Pump Assembly.

5. If necessary, the oil pump can be separated from the intake side cam shaft. Providing appropriate support for the shaft, drive out the lower pin. The oil pump assembly can then be removed from the cam shaft. See Figure 8-43.

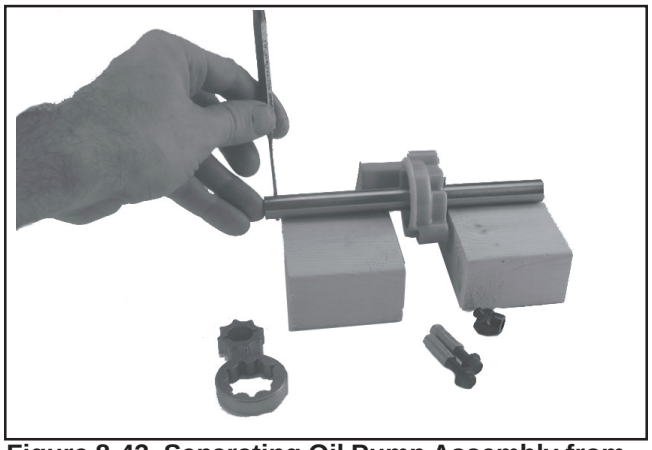


Figure 8-43. Separating Oil Pump Assembly from Intake Side Cam Shaft.

Remove Connecting Rod and Piston

1. Rotate the crankshaft so the rod journal is in the 9 o'clock position.

2. Remove the two hex. flange screws and the connecting rod cap. See Figures 8-44.

NOTE: If a carbon ridge is present at the top of the bore, use a ridge reamer to remove it before attempting to remove the piston.

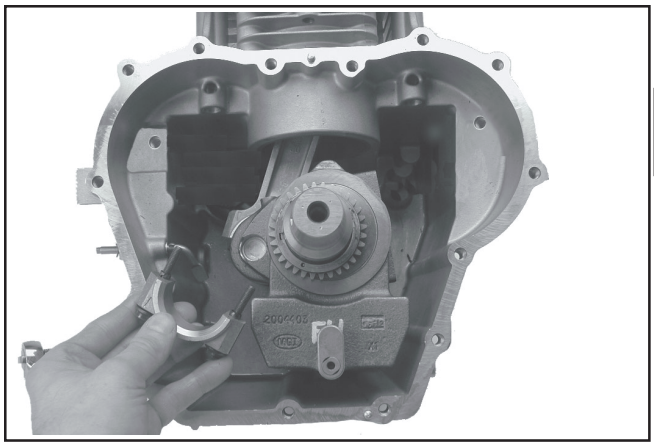


Figure 8-44. Removing Connecting Rod Cap.

3. Carefully push the connecting rod and the piston away from the crankshaft and out of the cylinder bore. See Figure 8-45.

8

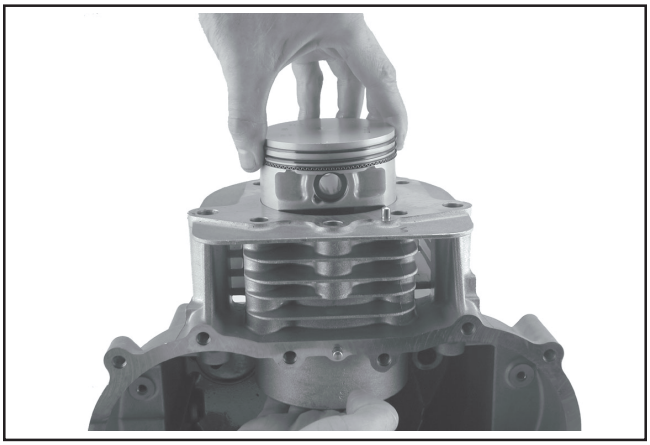


Figure 8-45. Removing Piston and Connecting Rod.

Remove Piston from Connecting Rod

1. Remove the wrist pin retainer and wrist pin. Separate the piston from the connecting rod. See Figure 8-46.

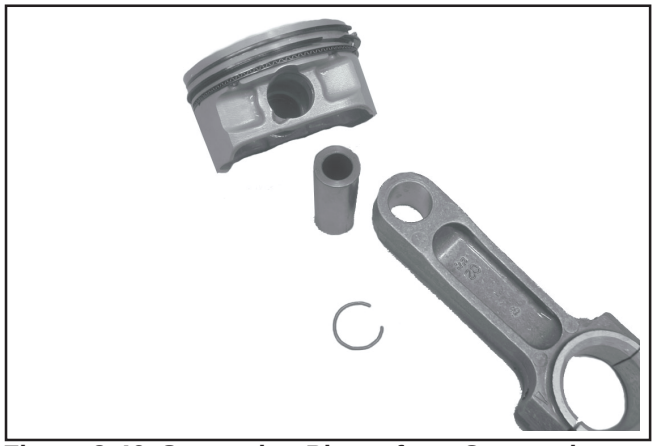


Figure 8-46. Separating Piston from Connecting Rod.

Remove Piston Rings

1. Remove the top and center compression rings using a ring expander. See Figure 8-47.

2. Remove the oil control ring rails, then remove the spacer.

Figure 8-47. Removing Piston Rings.

Remove Crankshaft and Balance Weight Assembly

1. Carefully lift the crankshaft and balance weight assembly out of the crankcase. See Figure 8-48.

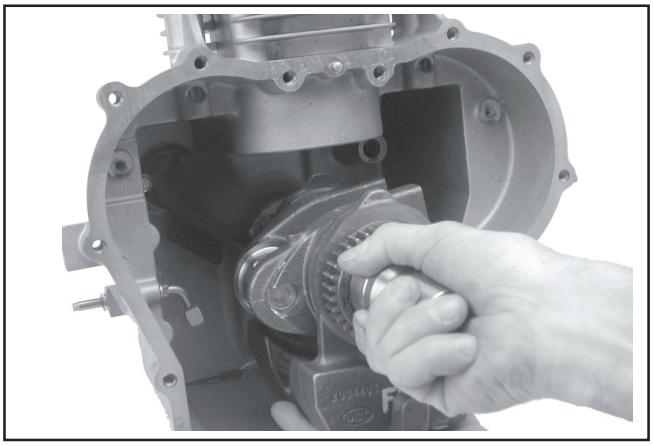


Figure 8-48. Removing Crankshaft and Balance Weight Assembly.

Balance Weight Disassembly

If necessary, the balance weight assembly can be separated from the crankshaft.

1. Remove the guide shoe from the guide pin on the flywheel side of the assembly.

2. Remove the crank gear from the crankshaft and carefully remove the key from the keyway. See Figure 8-49.

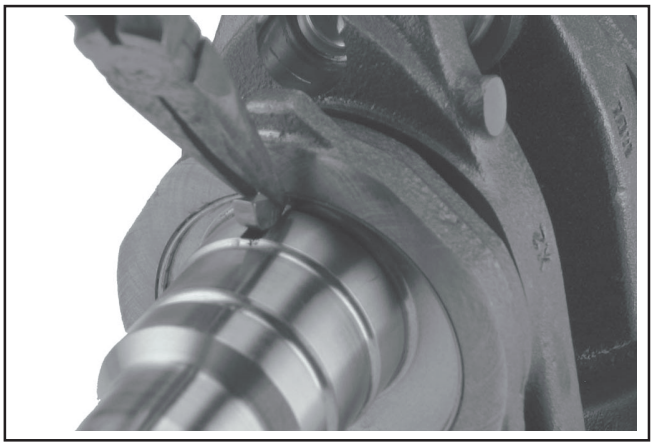


Figure 8-49. Removing Crank Gear Key.

3. Remove the long hex. flange screw securing the two balance weight halves together on the crankshaft. Hold the guide pin with a wrench (if required). See Figure 8-50.

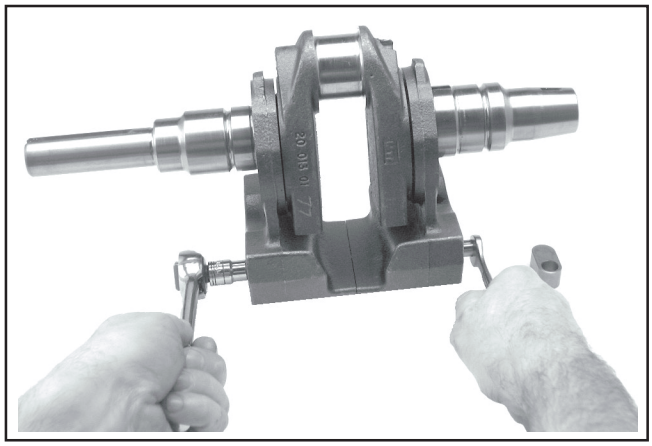


Figure 8-50. Removing Balance Weight Screw.

4. Mark the weights for proper reassembly and carefully slide the balance weights off the crankshaft eccentrics. See Figure 8-51.

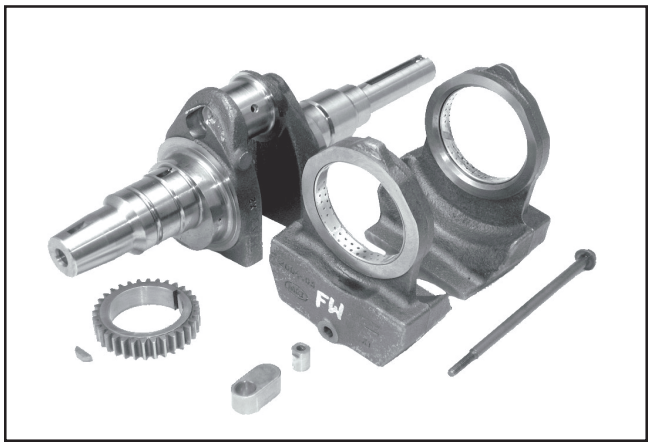


Figure 8-51. Disassembled Balance Weight.

Remove Governor Cross Shaft

1. Remove the hitch pin and washer located on the outside of the governor cross shaft. See Figure 8-52.

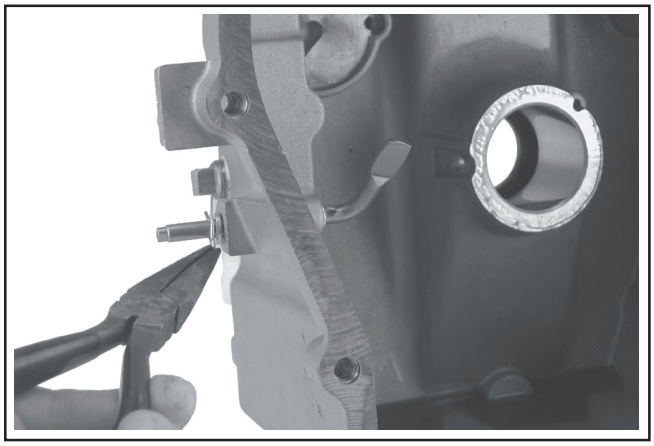


Figure 8-52. Removing Hitch Pin and Washer.

2. Slide the shaft inward and remove it through the inside of the crankcase. Be careful not to lose the small washer in the inside portion of the shaft. See Figure 8-53.

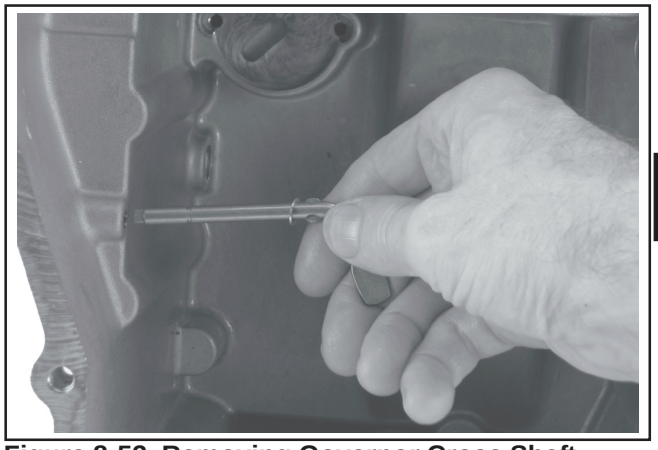


Figure 8-53. Removing Governor Cross Shaft.

8

Remove PTO and Flywheel Side Oil Seals

1. Use a seal puller to remove the PTO and flywheel side oil seals. See Figure 8-54.

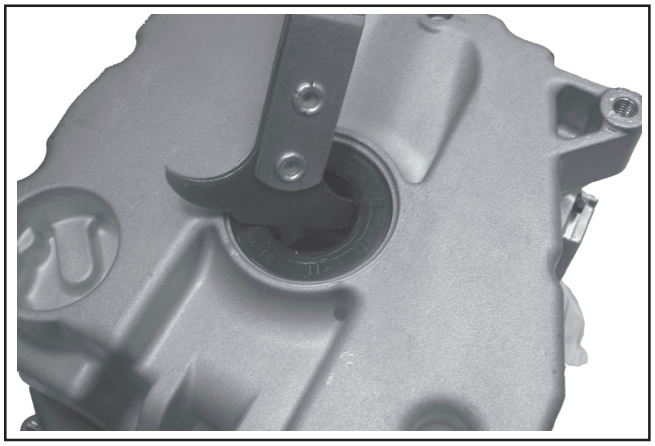


Figure 8-54. Removing Seal with a Seal Puller.

Section 9
Inspection and Reconditioning

This section covers the operation, inspection, and repair/reconditioning of major internal engine components. 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 7

Clean all parts thoroughly. 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. Use gasket remover to remove old material from the valve cover, cylinder head, crankcase, and oil pan. Do not scrape the gasket surfaces, as this could cause damage that results in leaks.

Make sure all traces of cleaning solvents 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.

Refer to A Guide to Engine Rebuilding (TP-2150) for additional information. Measurement Guide (TP-2159-A) and Engine Inspection Data Record (TP-2435) are also available; use these to record inspection results.

Automatic Compression Release (ACR)

This engine is equipped with an Automatic Compression Release (ACR) mechanism. The ACR lowers compression at cranking speeds to make starting easier.

Operation

The ACR mechanism consists of an actuating spring and a pivoting flyweight/control pin assembly, located in the exhaust side cam gear. A thrust washer and mounting of the closure plate hold the ACR in position. See Figure 9-1. At cranking speeds (700 RPM or lower), the spring holds the flyweight in and the "rounded" surface of the control pin protrudes above the exhaust cam lobe. This pushes the exhaust valve off its seat during the first part of the compression stroke. The compression is reduced to an effective ratio of about 2:1 during cranking.

After starting, when engine speed exceeds 700 RPM, centrifugal force overcomes the force of the flyweight spring. The flyweight moves outward, rotating the control pin to expose the "flat" surface, which is lower than the cam lobe. The control pin no longer has any effect on the exhaust valve, and the engine operates at full power.

When the engine is stopped, the spring returns the flyweight/control pin assembly to the compression release position, ready for the next start.

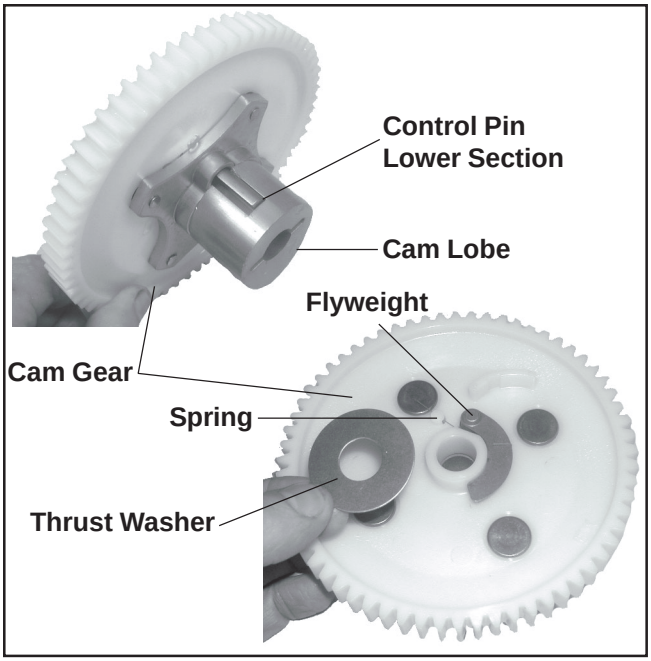


Figure 9-1. ACR Details.

Benefits
Reducing the compression at cranking speeds results in several important benefits.

1. The starter and battery can be smaller, more practical for the applications in which these engines are used.

2. ACR eliminates ‘‘kickback’’ during starting, so a spark retard/advance mechanism is no longer required.

3. The choke control setting is less critical with ACR. In the event of flooding, excess fuel is blown out the opened exhaust valve and does not hamper starting.

4. Engines with ACR start much faster in cold weather.

5. Engines with ACR can be started with spark plugs that are worn or fouled. Engines without ACR would be less likely to start with the same plugs.

Cam Gears

Inspection and Service
Inspect the gear teeth and cam lobes of the intake and exhaust cam gears. If the lobes exhibit excessive wear, or the teeth are worn, chipped or broken, replacement of the cam gear(s) will be necessary.

Crankshaft and Crank Gear

Inspection and Service
Inspect the teeth of the crank gear. If the teeth are badly worn, chipped, or some are missing, replacement of the crank gear will be necessary. Remove the gear by pulling it off the key and crankshaft.

Inspect the crankshaft bearing journal surfaces for wear, scoring, grooving, etc. If they show signs of damage or are out of running clearance specifications, the crankshaft must be replaced.

Inspect the crankshaft keyways. If worn or chipped, replacement of the crankshaft will be necessary.

Inspect the crankpin for wear, score marks or aluminum transfer. Slight score marks can be cleaned with crocus cloth soaked in oil. If wear limits are exceeded (see Section 1), it will be necessary to replace the crankshaft.

Crankcase

Inspection and Service
Check all gasket surfaces to make sure they are free of gasket fragments and deep scratches or nicks.

Check the cylinder wall for scoring. In severe cases, unburned fuel can wash the necessary lubricating oil off the piston and cylinder wall. The piston rings make metal to metal contact with the wall, causing scuffing and scoring. Scoring of the cylinder wall can also be caused by localized hot spots from blocked cooling fins or from inadequate or contaminated lubrication.

If the cylinder bore is scored, worn, tapered, or out-of-round, resizing may be possible. Use an inside micrometer or telescoping gauge to determine the amount of wear (refer to Section 1). If wear exceeds the published limits, a 0.08 mm (0.003 in.) oversize piston is available. If the cylinder will not clean up at 0.08 mm (0.003 in.) oversize, a short block or replacement engine will need to be considered.

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 counter bore. 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 the hone into the bore and, after centering, adjust it 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 the drill and honing process. Move the hone up and down while resizing to prevent the formation of cutting ridges. Check the size frequently. Make sure the bore is cool when measuring.

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 (refer to Figure 9-2).

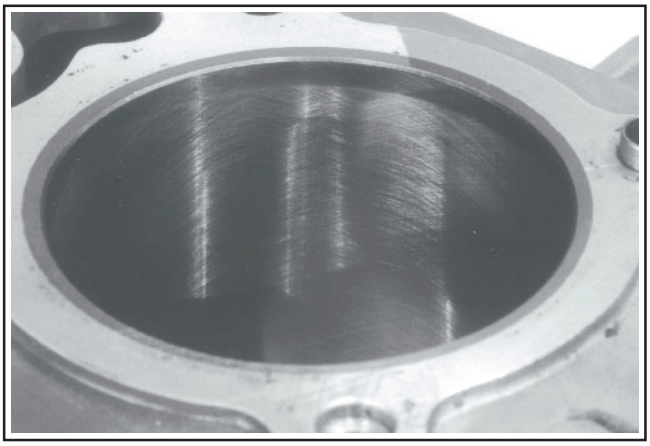


Figure 9-2. Cylinder Bore Crosshatch after Honing.

4. After honing, 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 honing is critical. 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 perpendicular to the piston pin, up **8 mm (0.314 in.)** from the bottom of the piston skirt as indicated in Figure 9-3.

Measure 8 mm (0.314 in.) Above the Bottom of Piston Skirt at Right Angles to Piston Pin.

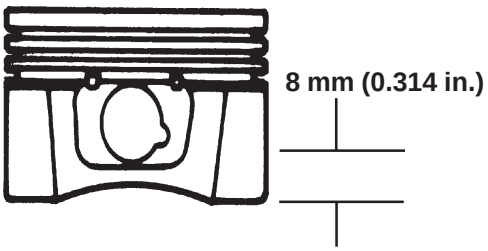


Figure 9-3. Measuring Piston Diameter.

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 piston diameter subtracted from the bore diameter (step 2 minus step 1).

Balance Weight Assembly

The balance weight assembly counterbalances the crankshaft weights and internal forces during operation to minimize vibration. Several key areas of the balance weight must be checked before installation and use. Additionally, the mating components (crankshaft eccentrics and closure plate guide channel) must also be inspected for wear or damage.

Use the following procedure to check the balance weight and matching components.

Balance Weight-to-Eccentric Clearance
Before the balance weight assembly is reassembled to the crankshaft, the running clearance to the crankshaft eccentrics must be accurately checked. Failure to maintain the required clearances will result in vibration or engine failure.

NOTE: Do not use a feeler gauge to measure balance weight-to-eccentric clearance.

Measuring Balance Weight to Crankshaft Eccentric Ring(s) Clearance

1. Use an inside micrometer, telescoping gauge, or bore gauge and measure the inside diameter of the balance weight bearing surface. Take two measurements 90° to each other on each weight. See Figure 9-4.

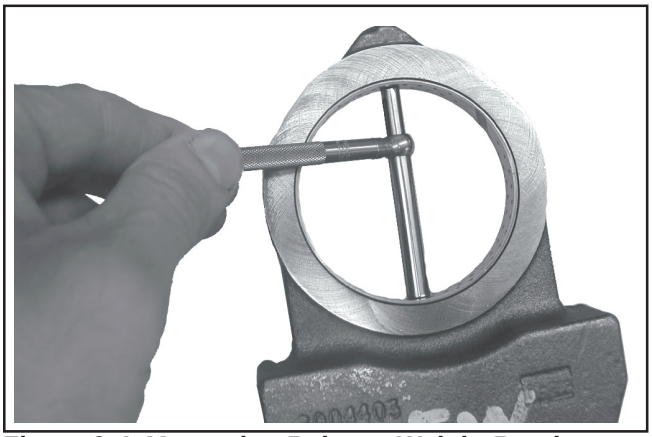


Figure 9-4. Measuring Balance Weight Bearing Surface.

2. Then use an outside micrometer and measure across each eccentric on the crankshaft. Again take two measurements 90° to each other. See Figure 9-5.

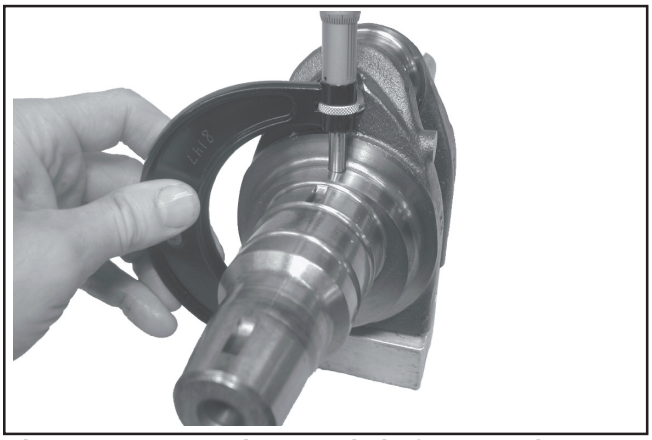


Figure 9-5. Measuring Crankshaft Eccentric.

3. The running clearance is the eccentric diameter subtracted from the balance weight bearing diameter (step 1 minus step 2). If the measurements are outside the maximum wear limits listed in Section 1, the affected component(s) must be replaced.

Measuring Balance Weight Guide Pin and Guide Shoe-to-Closure Plate Guide Channel Running Clearance

1. Use an outside micrometer and measure the outside width of the balance weight guide shoe. See Figure 9-6.

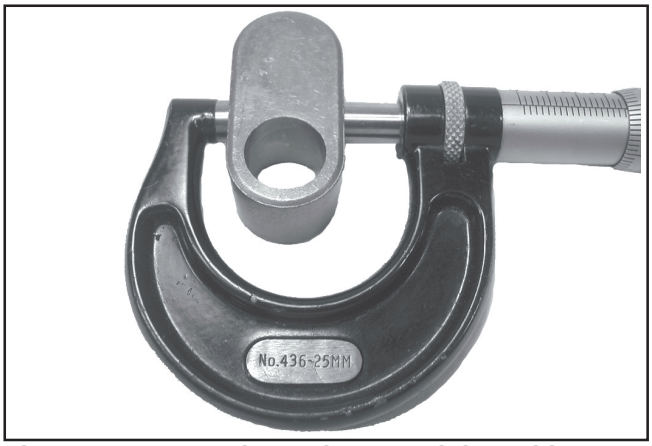


Figure 9-6. Measuring Balance Weight Guide Shoe.

2. Use an inside micrometer, telescoping gauge or similar tool and measure the width of the guide channel in the closure plate. See Figure 9-7. Record these dimensions.

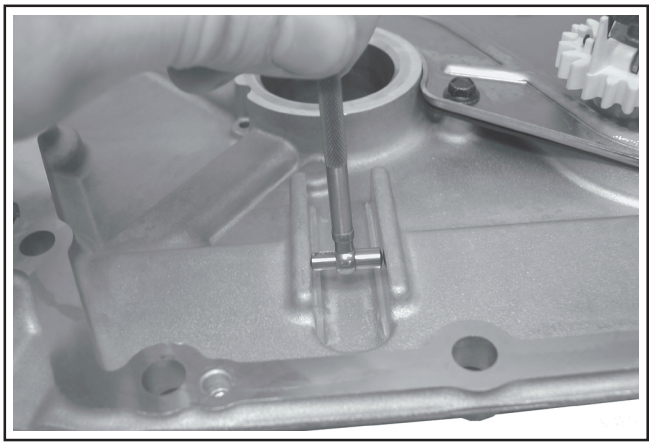


Figure 9-7. Measuring Guide Channel in Closure Plate.

3. Use an outside micrometer again and measure the O.D. of the balance weight guide pin. See Figure 9-8.

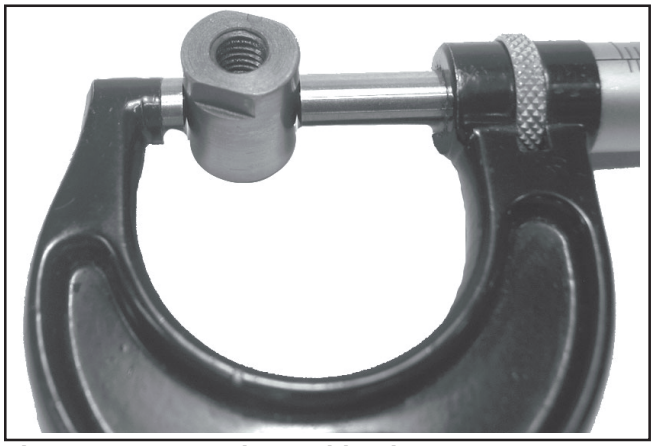


Figure 9-8. Measuring Guide Pin O.D.

4. Use a split ball gauge or dial calipers and measure the I.D. of the corresponding hole in the guide shoe. See Figure 9-9. Record these dimensions.

Figure 9-9. Measuring Guide Shoe Hole I.D.

If any of the measurements taken are outside the maximum wear limits listed in Section 1, the affected component(s) must be replaced.

Flywheel

Inspection

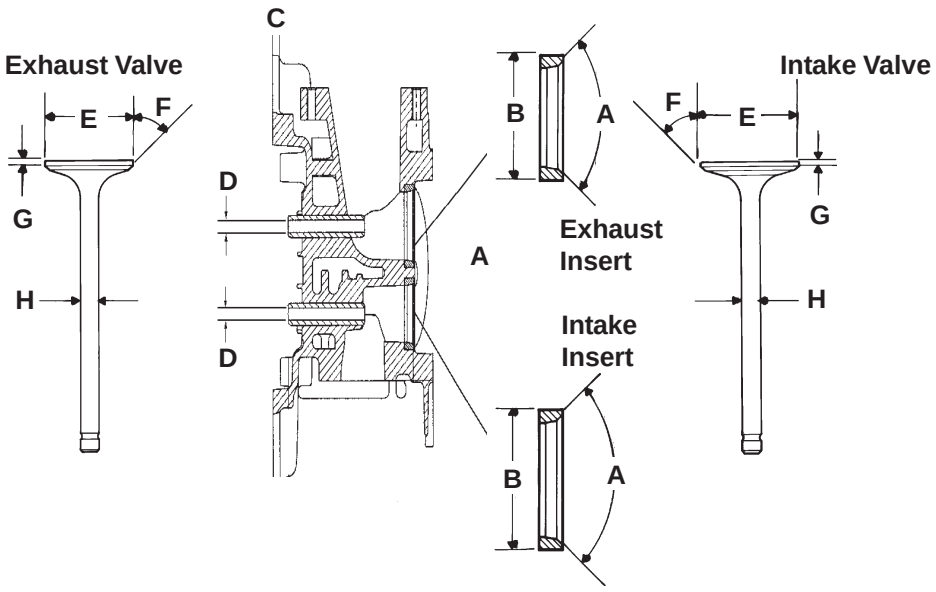
Inspect the flywheel for cracks and check the keyway for wear or damage. Replace the flywheel if cracked. If the flywheel key is sheared or the keyway is damaged, replace the crankshaft, flywheel, and key.

Inspect the ring gear for cracks or damage. Ring gears are not available separately. Replace the flywheel if the ring gear is damaged.

Cylinder Head and Valves

Inspection and Service

Carefully inspect the valve mechanism parts. Inspect the valve springs and related hardware for excessive wear or distortion. Check the valves and valve seats for evidence of deep pitting, cracks, or distortion. Check the running clearance between the valve stems and guides. See Figure 9-10 for valve details and specifications.



	Dimension	Intake	Exhaust
A	Seat Angle	89°	89°
B	Insert O.D.	41.737/41.783 mm	36.237/36.263 mm
C	Guide Depth	10.20 mm	10.20 mm
D	Guide I.D.	6.038/6.058 mm	6.038/6.058 mm
E	Valve Head Diameter	37.625/37.375 mm	32.125/32.375 mm
F	Valve Face Angle	45°	45°
G	Valve Margin (Min.)	1.5 mm	1.5 mm
H	Valve Stem Diameter	5.982/6.000 mm	5.970/5.988 mm

Figure 9-10. Valve Details.

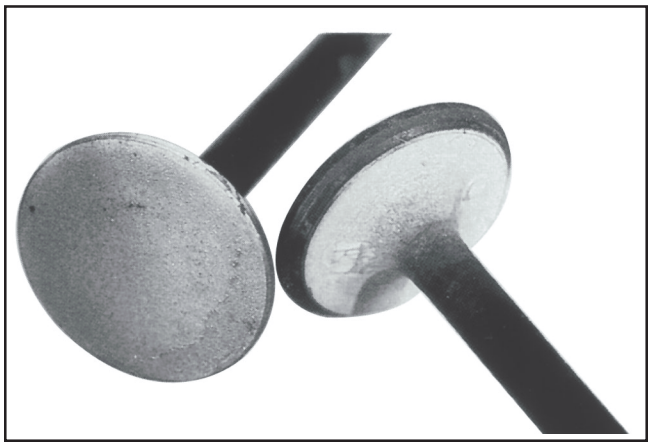
Hard starting, or loss of power accompanied by high fuel consumption, may be symptoms of faulty valves. Although these symptoms could also be attributed to worn rings, remove and check the valves first. After removal, clean the valve heads, faces, and stems with a power wire brush. Then, carefully inspect 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 a valve face or seat will allow leakage, resulting in a valve burned 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.

Coking: Coking is normal on intake valves and is not harmful. If the seat is good, the valve could be reused after cleaning.



Excessive Combustion Temperatures: The white deposits seen here indicate very high combustion temperatures, usually due to a lean fuel mixture.

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.

Gum: Gum deposits usually result from using stale gasoline. This condition is often noted in applications where fuel is not drained out of tank during the off season. 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.

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 burned 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 **6.135 mm (0.2415 in.)** while **6.160 mm (0.2425 in.)** is the maximum allowed on the exhaust guide. The guides are not removable. If the guides are within limits but the valve stems are worn beyond limits, replace the 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, but they can be reconditioned if not too badly pitted or distorted. If the seats are 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 9-11. The final cut should be made with an 89° cutter as specified for the valve seat angle in Figure 9-10. With the proper 45° valve face angle, 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 valve face and seat.

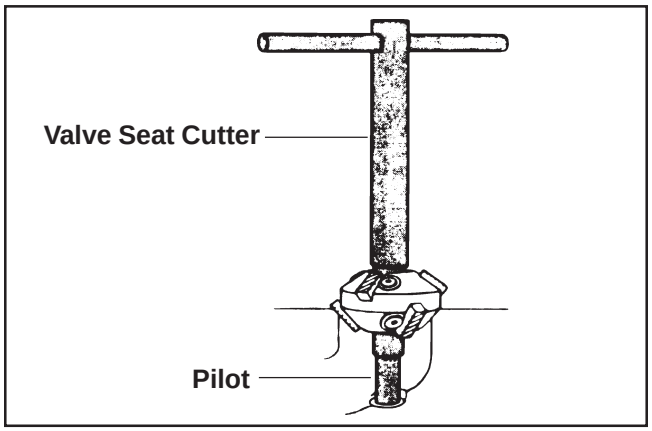


Figure 9-11. Typical Valve Seat Cutter.

Lapping Valves

Reground or new valves must be lapped in, to provide a good seal. 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 prevent rusting.

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 part of the piston assembly; if the pin boss or the 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 under this condition. 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 that meet and explode to create extreme hammering pressures on a specific area of the piston. Detonation generally occurs from using low octane fuels.

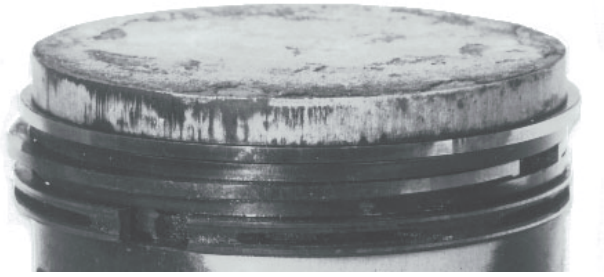
Preignition or ignition of the fuel charge before the timed spark can cause damage similar to detonation. Preignition damage is often more severe than detonation damage. Preignition is caused by a hot spot in the combustion chamber from sources such as glowing carbon deposits, blocked fins, improperly seated valve, or wrong spark plug. See Figure 9-12 for some common types of piston and ring damage.

Replacement pistons are available in STD and **0.08 mm (0.003 in.)** oversize, which include new rings and piston pins. Service replacement piston ring sets are also available separately. Always use new piston rings when installing pistons. **Never reuse old rings.**

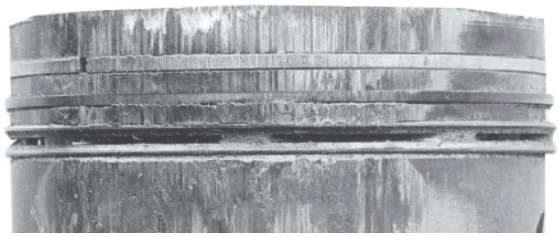
The cylinder bore must be deglazed before service ring sets are used.

Stuck, Broken Rings

Abrasive Scratched Rings



Overheated or Deteriorated Oil



Scored Piston and Rings

Figure 9-12. Common Types of Piston and Ring Damage.

Some important points to remember when servicing piston rings:

1. If the cylinder bore is within the wear limits (refer to Section 1) and the old piston is within wear limits, free of score or scuff marks, the old piston may be reused.

2. Remove old rings and clean up grooves. **Never reuse old rings.**

3. Before installing the rings on the piston, place each of the top two rings in its running area in the cylinder bore and check the end gap (see Figure 9-13). Compare to the listed specifications.

Top and Middle Compression Ring End Gap
New Bore
Top Ring ..... 0.15/0.40 mm (0.006/0.016 in.)
Middle Ring ..... 0.30/0.55 mm (0.012/0.022 in.)
Max. Used Bore ..... 0.77 mm (0.030 in.)

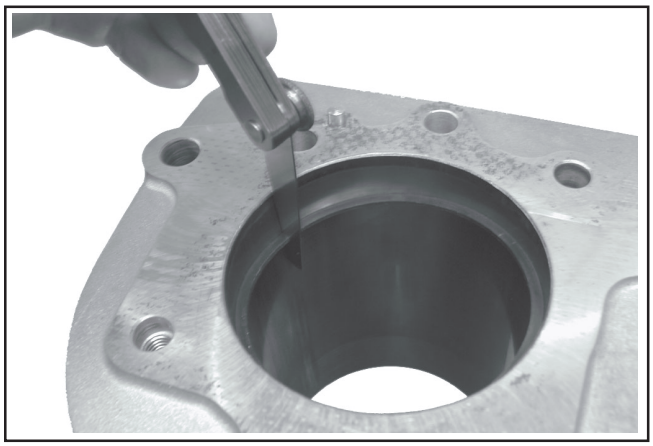


Figure 9-13. Measuring Piston Ring End Gap.

4. After installing the new compression (top and middle) rings on the piston, check piston-to-ring side clearance. The maximum recommended side clearance for each ring is **0.04 mm (0.0016 in.)**. If the side clearance is greater than specified, a new piston **must** be used. Refer to Figure 9-14.

Top Compression Ring-to-Groove
Side Clearance ..... 0.04 mm (0.0016 in.)

Middle Compression Ring-to-Groove
Side Clearance ..... 0.04 mm (0.0016 in.)

Figure 9-14. 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. Install the bottom (oil control) ring first and the top compression ring last. Refer to Figure 9-15.

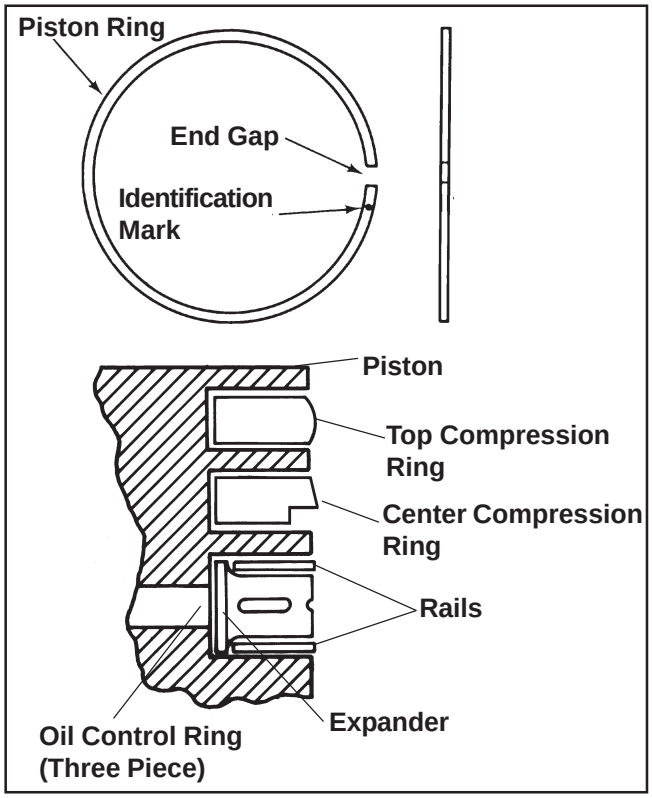


Figure 9-15. Piston Ring Installation.

1. Oil Control Ring (Bottom Groove): Install the expander and then the rails. Make sure the ends of the expander are not overlapped.

2. Compression Ring (Center Groove): Install the center ring using a piston ring installation tool. Make sure the identification mark is “up” when the ring is installed.

3. Compression Ring (Top Groove): Install the top ring using a piston ring installation tool. Make sure the identification mark is “up” when the ring is installed.

Connecting Rods

Inspection and Service
Check the bearing area (big end) for score marks and excessive wear (measure running and side clearances; refer to Section 1. Service replacement connecting rods are available in STD crankpin size.

Oil Pump Assembly and Pressure Relief Valve

Inspection and Service
The closure plate must be removed to inspect and service the oil pump. Refer to the “Disassembly” and “Reassembly” Sections (8 and 10) for removal and reinstallation procedures. Check the oil pump and gears for cracks, damage, wear, and smooth rotation. Replace the pump if any binding is noted or reuse is questionable in any way.

A pressure relief valve is built into the oil pump to limit maximum pressure. It is not serviceable. If a problem exists with the pressure relief valve, the oil pump assembly should be replaced.

Governor Gear and Shaft

Inspection
Inspect the governor gear teeth. Look for any evidence of worn, chipped, or cracked teeth. If one or more of these problems is noted, replace the governor gear.

The gear is held on the governor shaft by molded tabs, which are damaged when the gear is removed. Never reuse the gear once it has been pulled from the shaft. Replace the governor shaft only if it is damaged or worn.

Procedure to Remove Governor Shaft:

1. Remove the blower housing, flywheel, and cooling fan.

2. Remove the stator and crankshaft key.

3. Remove the closure plate screws and closure plate.

4. Rotate engine to top dead center aligning timing marks on the crankshaft and cam gears.

5. Remove the governor gear assembly and regulating pin from the closure plate with two small screwdrivers.

6. Locate the governor pin from flywheel side. With a small punch, drive the pin out of the closure plate. This could also be done with a press. **DO NOT** remove the governor pin with a vise grip or pliers, you may damage the closure plate.

7. Remove any old gasket material from the mating surfaces of the crankcase and closure plate. Use an aerosol gasket remover to help loosen any old gasket material. **Do not** scrape the surfaces, as any scratches, nicks, or burrs can result in leaks.

Procedure to Install Governor Shaft:

1. Install new pin by pressing or lightly tapping it into the closure plate. It must be installed so that it protrudes **44.50 mm (1.750 in.)**, plus or minus **0.101 mm (0.004 in.)** above the crankcase boss. See Figure 9-16.

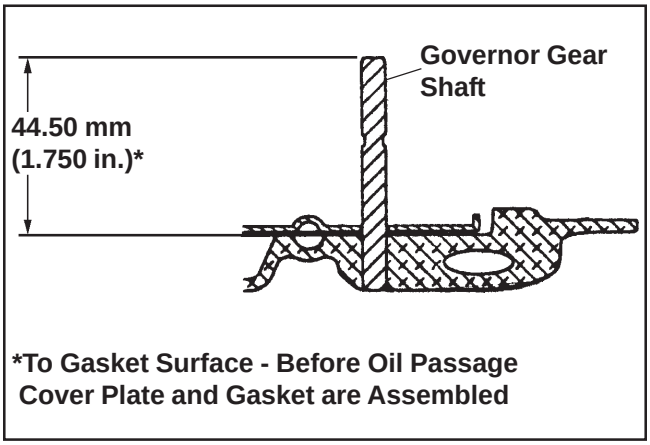


Figure 9-16. Governor Shaft Press Depth.

2. Install the new governor regulating pin and governor gear assembly.

3. Make sure governor gear assembly rotates freely.
4. Check that timing marks are still aligned.
5. Install a new closure plate gasket and install the closure plate. Refer to ‘‘Reassembly’’ Section 10 for proper torque sequence and specification.
6. Complete engine reassembly following “Reassembly” procedures.
7. When engine reassembly is completed, reset initial governor adjustment according to procedure in ‘‘Fuel System and Governor’’ Section 5.

Section 10
Reassembly

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. This procedure may be varied to accommodate options or special equipment.

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.

NOTE: Always use new gaskets.

NOTE: Make sure all components have been properly cleaned BEFORE reassembly.

Typical Reassembly Sequence

1. Install PTO side oil seal.
2. Install governor cross shaft.
3. Install oil pump and intake cam shaft assembly.
4. Install crankshaft and balance weight.
5. Install piston rings.
6. Install piston to connecting rod.
7. Install piston and rod to crankshaft.
8. Install cam levers.
9. Install exhaust cam shaft, cam gear and ACR.
10. Install intake cam gear.
11. Install oil seal into closure plate (flywheel side).
12. Install closure plate gasket, closure plate and wiring harness.
13. Assemble cylinder head.
14. Install cylinder head.
15. Install rocker arms and push rods.
16. Install valve cover.
17. Install stator and wiring harness.
18. Install flywheel and fan.
19. Install electric starter
20. Install ignition module.
21. Install spark plug.
22. Install heat deflector, carburetor, linkage, and air cleaner base.
23. Install and adjust governor lever, mounting speed control bracket.
24. Install fuel pump (some models).
25. Install rectifier-regulator.
26. Install blower housing and flywheel screen.
27. Install Oil Sentry™ switch or pipe plug.
28. Install air cleaner element, precleaner and air cleaner cover.
29. Install muffler.

Install PTO Side Oil Seal

1. Apply a small amount of oil to the outside diameter and lip of the PTO side oil seal before installing. Use a seal driver and install to a depth of **5.5 mm (0.216 in.)** into the crankcase. See Figures 10-1 and 10-2.

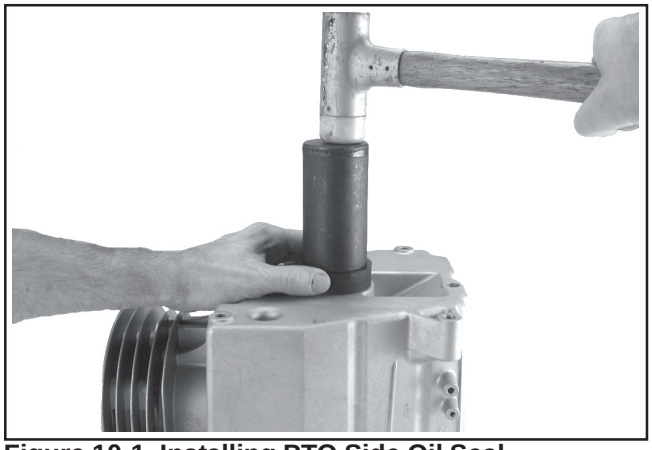


Figure 10-1. Installing PTO Side Oil Seal.

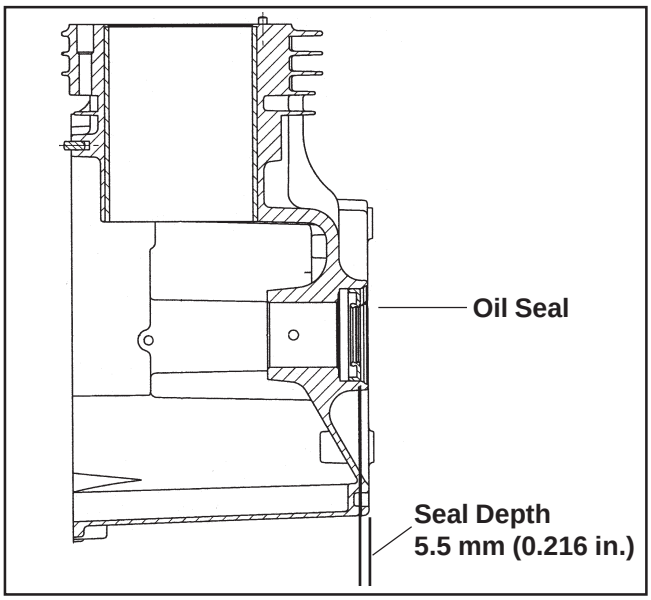


Figure 10-2. PTO Seal Depth Details.

Install Governor Cross Shaft

1. Place the thin thrust washer onto the governor cross shaft as far as it will go.

2. Lightly lubricate the shaft with oil, and install it from inside the crankcase. See Figure 10-3.

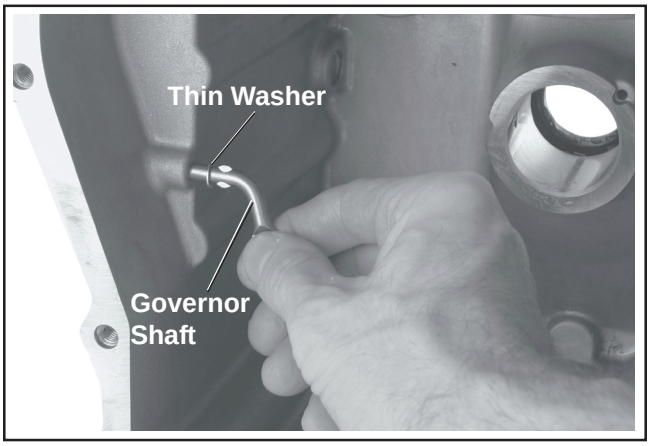


Figure 10-3. Installing Governor Cross Shaft.

3. Slide the thick thrust washer onto the shaft from the outside as far as it will go. Secure by inserting the hitch pin in the machined groove. See Figure 10-4.

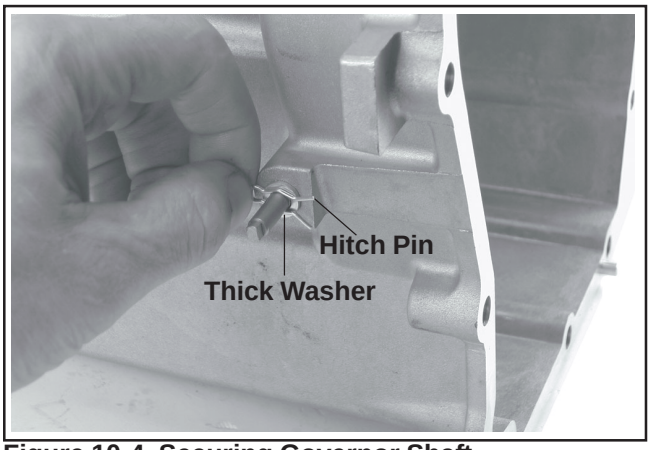


Figure 10-4. Securing Governor Shaft.

Install Oil Pump Assembly and Intake Cam Shaft

1. If the oil pump assembly was removed from the intake cam shaft, reassemble it onto the shaft. The drive pin holes are machined to be a clearance (slip) fit on one side and a press fit on the other. Support the cam shaft with the clearance holes up and install the shorter, **2.5 mm (0.098 in.)** diameter pin in the **outer** hole, closest to the bottom end. See Figure 10-5 and 10-6. Center the pin in the shaft.

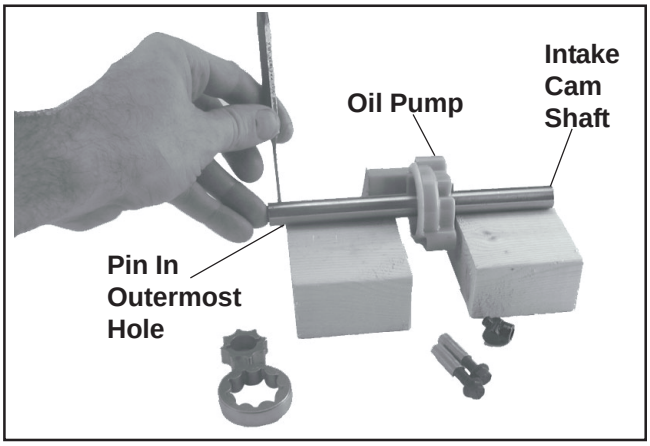


Figure 10-5. Installing Oil Pump and Lower Drive Pin on Intake Cam Shaft.

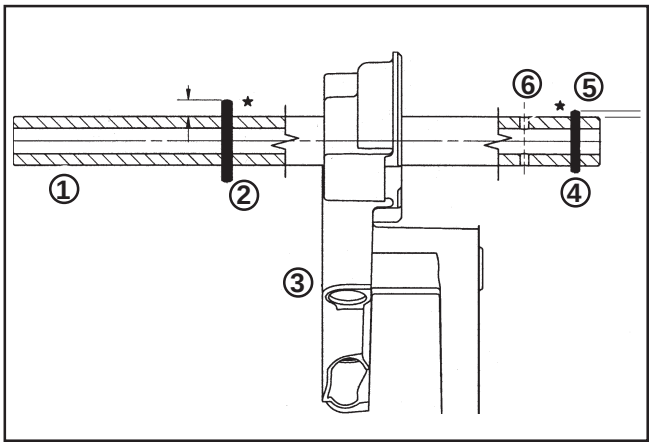


Figure 10-6. Assembled Intake Cam Shaft Details.

1. Intake Cam Shaft
2. 3 mm Diameter Pin
3. Oil Pump Assembly
4. 2.5 mm Diameter Pin
5. #1 Hole Location
6. #2 Hole Location

2. If it was removed, install and center the longer, **3 mm** diameter drive pin into the **upper** hole (See Figure 10-6).

3. Lightly grease the gerotor gears and install into the oil pump, with the short drive pin fitted into the slot of the inner gear. See Figure 10-7.

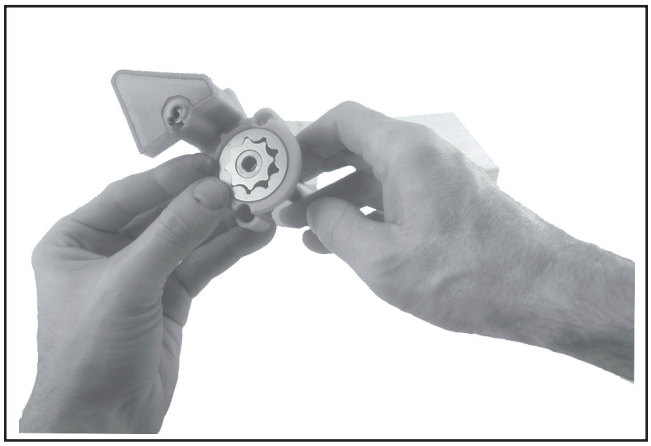


Figure 10-7. Gerotor Gears Installed in Oil Pump.

4. Lightly lubricate the ends of the oil pump outlet seal with oil and install it into the outlet of the oil pump. See Figure 10-8. Some models use a “solid” seal without an oil passage, and the crankshaft is cross drilled for lower bearing lubrication. Both styles of outlet seals are shown in Figure 10-9. If a new seal was ordered, make sure it is the right one for the engine.

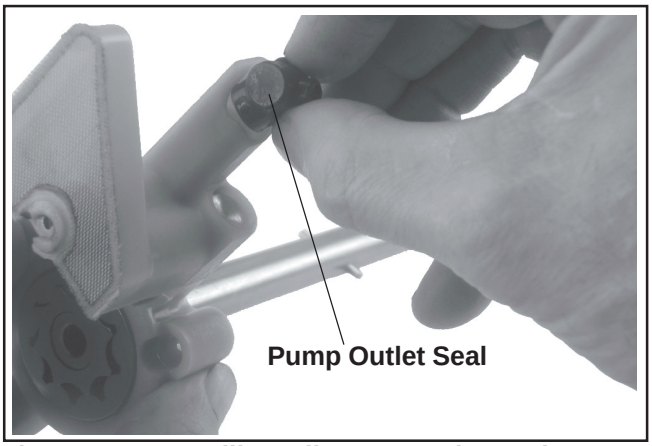


Figure 10-8. Installing Oil Pump Outlet Seal.

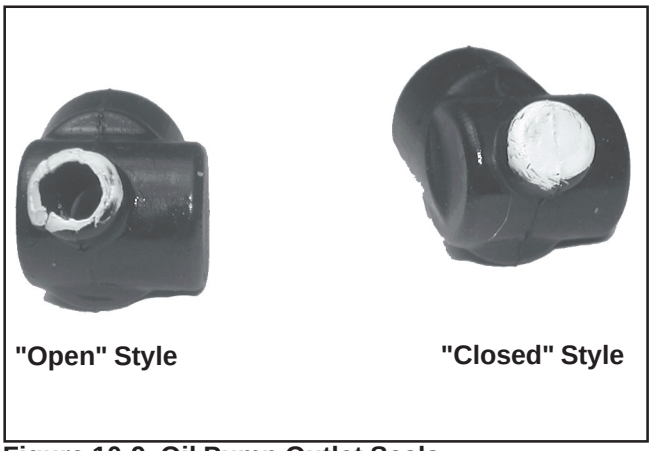


Figure 10-9. Oil Pump Outlet Seals.

5. Install the intake cam shaft down into the crankcase boss. Seat the rubber oil pump outlet seal into the machined pocket. If an “open” style outlet seal is used, check to make sure the small feed hole is open and aligned with the lower main bearing oil feed hole. Use a 3/32” allen wrench, or a light with a mirror. See Figure 10-10. Push the steel sleeves in the pump housing down until bottomed against the mounting surface. Install the two M5 mounting screws. Hold the pump outlet against the main bearing area and torque the screws to **4.0 N·m (35 in. lb.)**. See Figure 10-11.

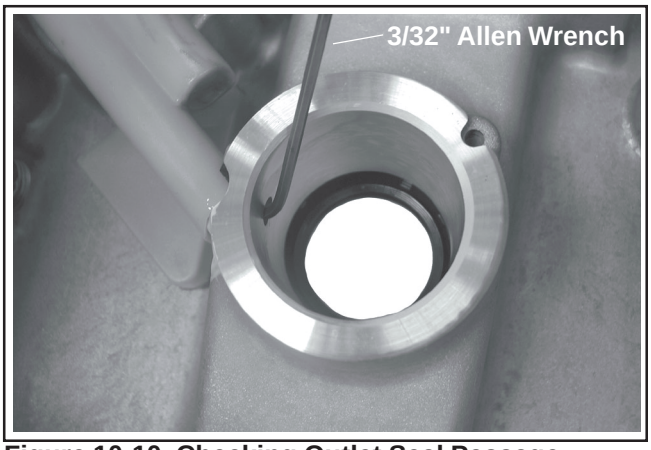


Figure 10-10. Checking Outlet Seal Passage Opening (Open Style).

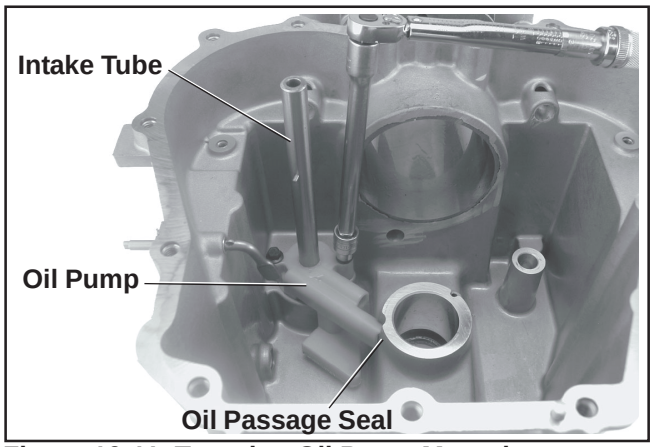


Figure 10-11. Torquing Oil Pump Mounting Screws.

Install Crankshaft and Balance Weight

1. Assemble the crankshaft balance weight if removed from the crankshaft.

   a. Lubricate the crankshaft eccentrics and the balance weight bearing surfaces with oil.

   b. Install the two balance weight halves onto the crankshaft eccentrics as marked or originally installed.

   c. Align the weights and install the balance weight screw, through the mounting holes, from the **PTO side**. Thread it into the guide pin outside the weight on the **flywheel side**. Hold the guide pin with a wrench, and torque the screw to **10 N·m (90 in. lb.)**. See Figure 10-12. **Do not** hold, or damage the outside diameter (O.D.) of the guide pin.

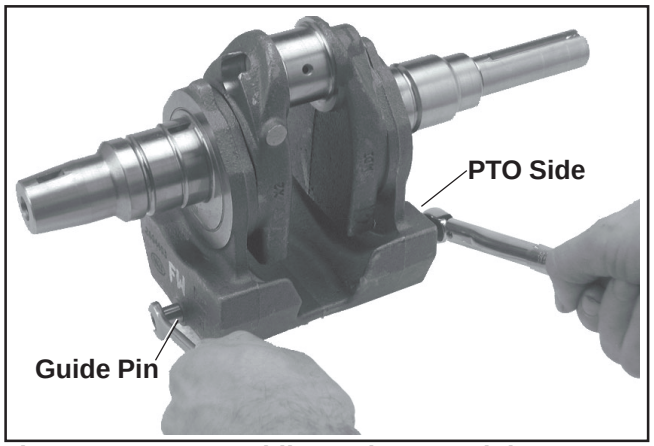


Figure 10-12. Assembling Balance Weight to Crankshaft.

   d. Carefully install crank gear key in keyway. See Figure 10-13.

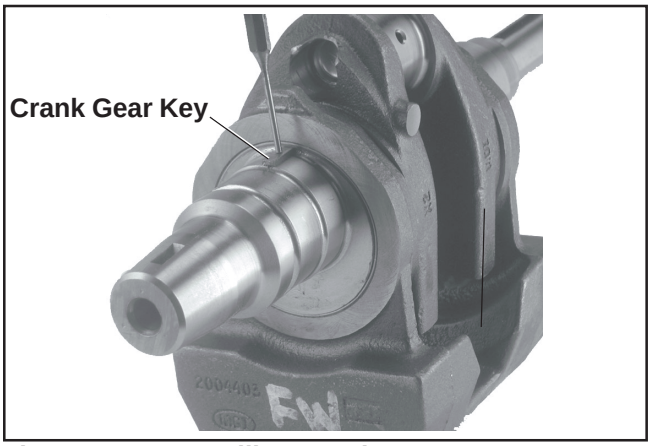


Figure 10-13. Installing Crank Gear Key.

2. Lubricate the PTO end bearing surfaces of the crankshaft and crankcase with oil. Apply a small amount of oil or grease to the lips of the PTO oil seal and to the guide shoe pin. Cover PTO keyway with tape to prevent cutting oil seal during installation.

3. Carefully install the crankshaft into the crankcase, through the PTO seal, and seat fully into place. Rotate the crankshaft so that the journal for the connecting rod is away from the cylinder. See Figure 10-14.

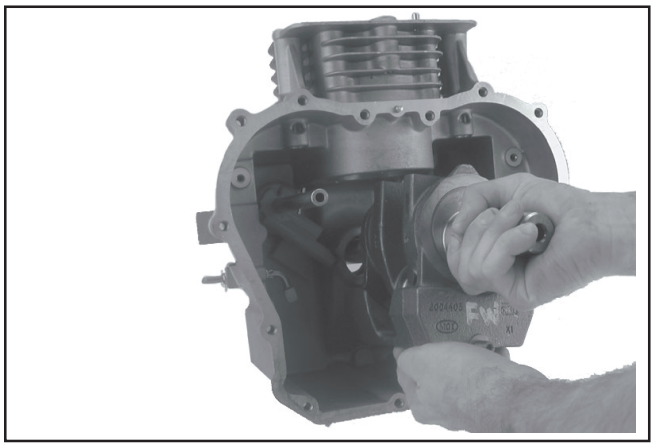


Figure 10-14. Installing Crankshaft Assembly.

4. Install the balance weight guide shoe onto the guide pin with the solid end toward the crankshaft. See Figure 10-15.

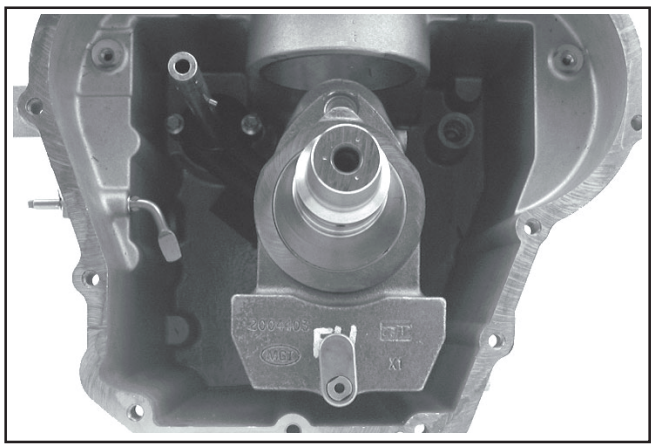


Figure 10-15. Installing Guide Shoe.

Install Piston Rings

NOTE: For detailed piston inspection procedures and piston ring installation refer to Section 9 “Inspection and Reconditioning.”

Install Piston to Connecting Rod

1. Assemble the piston, connecting rod, piston pin, and piston pin retainers. See Figure 10-16.

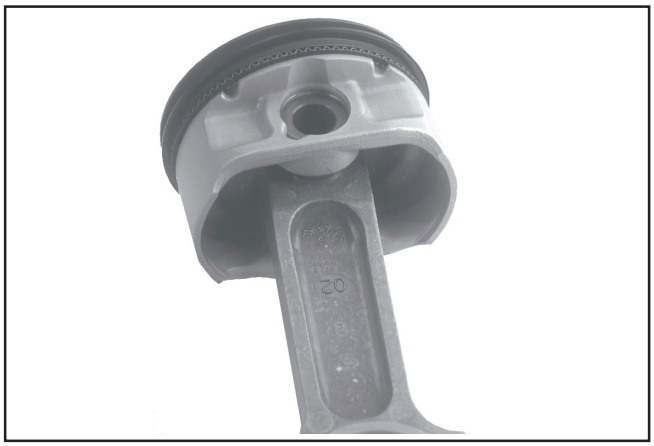


Figure 10-16. Assembled Piston and Connecting Rod.

Install Piston and Connecting Rod

NOTE: Proper orientation of the piston/connecting rod 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. Lubricate the cylinder bore, crankshaft journal, connecting rod journal, piston, and rings with engine oil.

2. Compress the piston rings using a piston ring compressor. Orient the “FLY” mark on the piston toward the flywheel side of the crankcase. See Figure 10-17. Place the ring compressor on the top surface of the crankcase and make certain it is seated down around the entire circumference. Use a soft, rubber grip hammer handle and tap the piston/connecting rod into the bore. See Figure 10-18. The first tap should be rather firm, so the oil ring moves from the compressor into the bore in one smooth, quick motion. Otherwise the oil ring rails may spring out and jam between the ring compressor and the top of the bore.

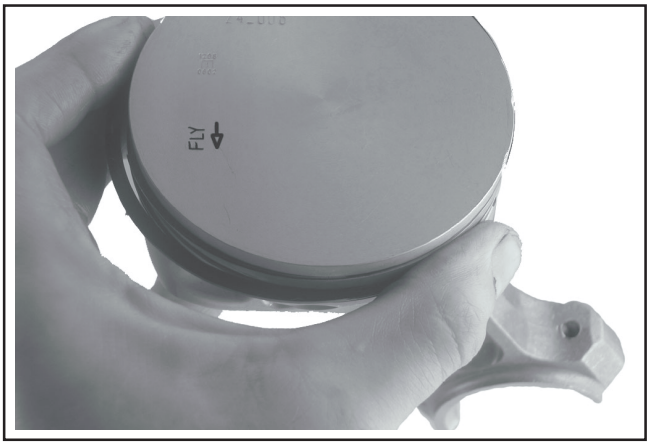


Figure 10-17. Direction Arrow on Piston.

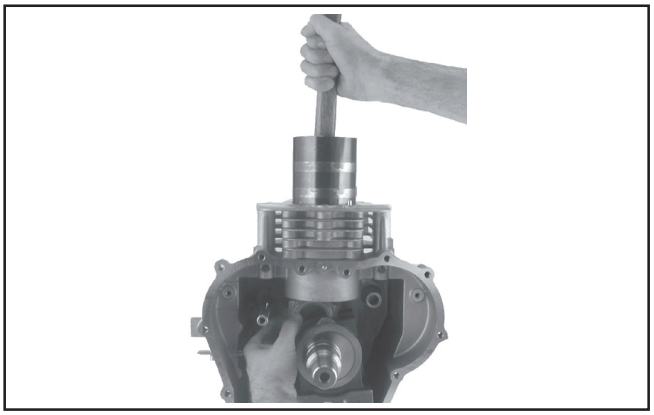


Figure 10-18. Installing Piston and Connecting Rod.

3. Guide the connecting rod down and rotate the crankshaft to mate the journals. Install the rod cap.

4. Install the hex. flange screws and torque in 2 increments, first to **5.5 N·m (50 in. lb.)**, finally to **11.5 N·m (100 in. lb.)**. See Figure 10-19.

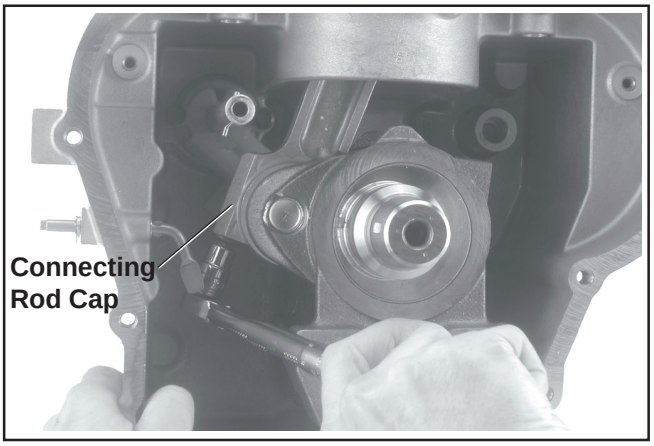


Figure 10-19. Torquing Connecting Rod Fasteners.

Install Cam Levers

1. Install the two cam levers as shown in Figure 10-20. The “dimple” for seating the push rod must face “up”. Secure each cam lever using an M6 hex. flange screw. Torque the screws to **7.5 N·m (65 in. lb.)**. Lubricate the dimple and bottom side of the cam lever with light grease or oil.

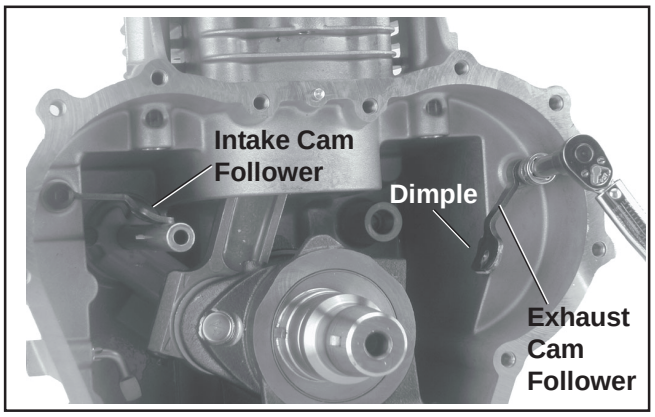


Figure 10-20. Installing Cam Levers.

Install the Exhaust Cam Shaft and Cam Gear

1. If the drive pins were removed from the exhaust cam shaft, follow the same procedure used earlier for the intake cam shaft and reinstall them. See Figure 10-21.

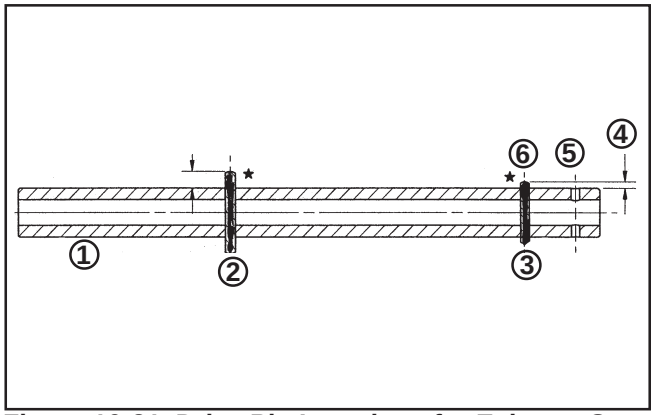


Figure 10-21. Drive Pin Locations for Exhaust Cam Shaft.

1. Exhaust Cam Shaft
2. 3 mm Diameter Pin
3. 2.5 mm Diameter Pin
4. 1.86 mm
5. #1 Hole Location
6. #2 Hole Location

2. Apply a dab of grease to the formed groove in the thrust washer. Slide the washer onto the cam shaft so the short drive pin is seated in the groove. The grease will hold the washer in position. Pivot the exhaust cam lever toward the push rod bore, then insert the cam shaft into the counterbore of the crankcase. Make sure the pin stays in the groove of the thrust washer. See Figure 10-22.

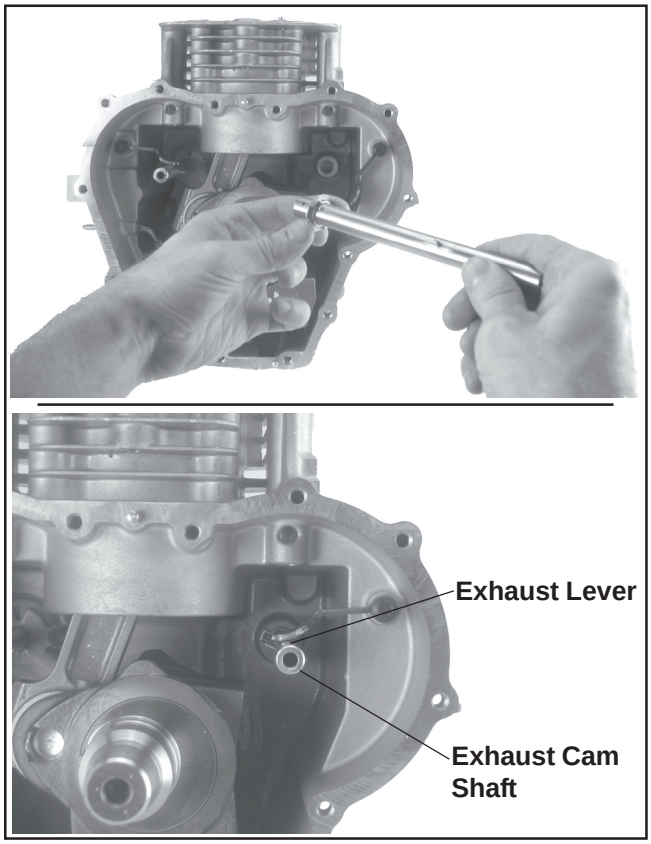


Figure 10-22. Exhaust Cam Shaft Installation.

3. Lubricate the cam surfaces of the cam gears with light grease or oil.

4. Assemble and install the ACR (automatic compression release) into the exhaust cam gear if removed for servicing.

   a. Install the spring onto the ACR weight with loop around post, and the formed upper leg hooked behind the upper section. See Figure 10-23.

   b. Install the ACR assembly into hole of exhaust cam gear and hook the long leg behind the notchedtab. See Figure 10-24.

Figure 10-23. Spring Installed on ACR Weight.

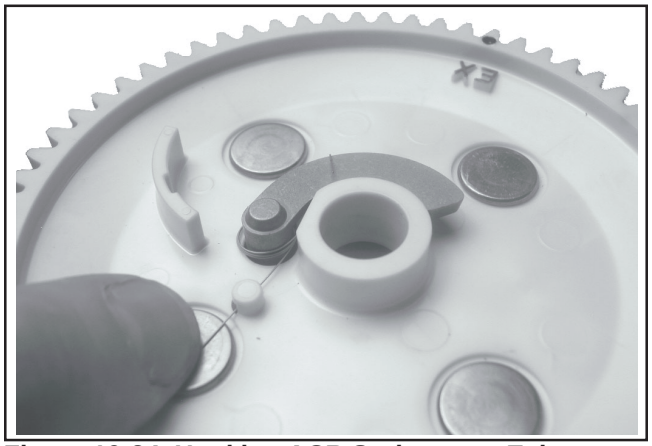


Figure 10-24. Hooking ACR Spring onto Exhaust Cam Gear.

5. Lift the exhaust cam lever and install the exhaust cam gear with assembled ACR onto the cam shaft, engaging the slot with the upper drive pin. Rotate the gear and shaft so the "**EX**" timing mark on the cam gear is in the 8 o'clock position. Install the thrust washer onto the cam shaft. See Figure 10-25.

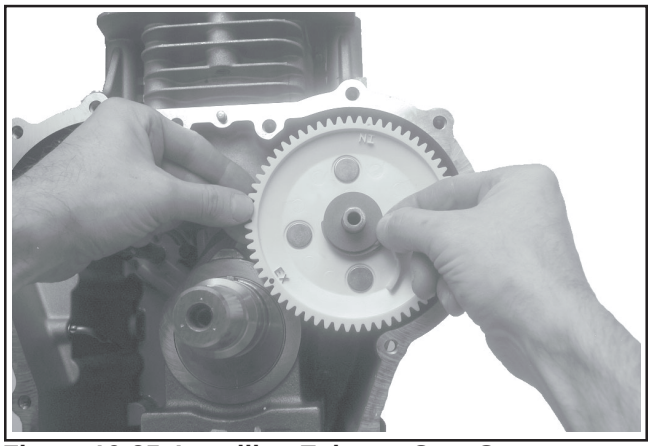


Figure 10-25. Installing Exhaust Cam Gear.

Install Intake Cam on Cam Shaft

1. Lift the intake cam lever and install the intake cam gear onto the intake cam shaft, engaging the slot with the upper drive pin. Rotate the gear and shaft so the "**IN**" timing mark on the cam gear is in the 4 o'clock position. Install the thrust washer onto the cam shaft. See Figure 10-26.

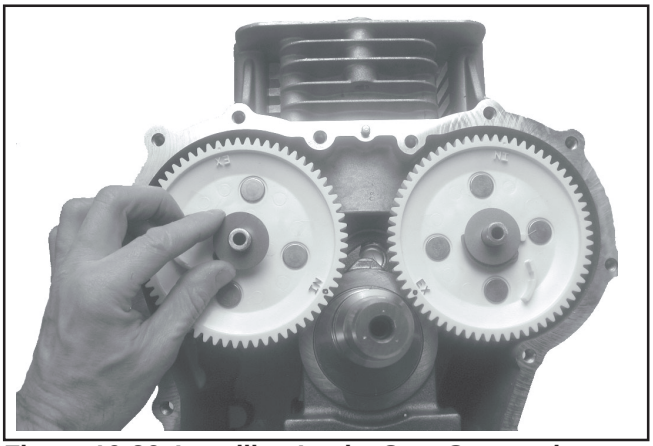


Figure 10-26. Installing Intake Cam Gear and Thrust Washer.

Install Crank Gear

1. Orient the crankshaft so the key is in the 12 o'clock position. Hold the crank gear with the timing marks visible and slide it onto the crankshaft and key, so the timing marks on the crank gear align with the timing marks on the cam gears. See Figure 10-27.

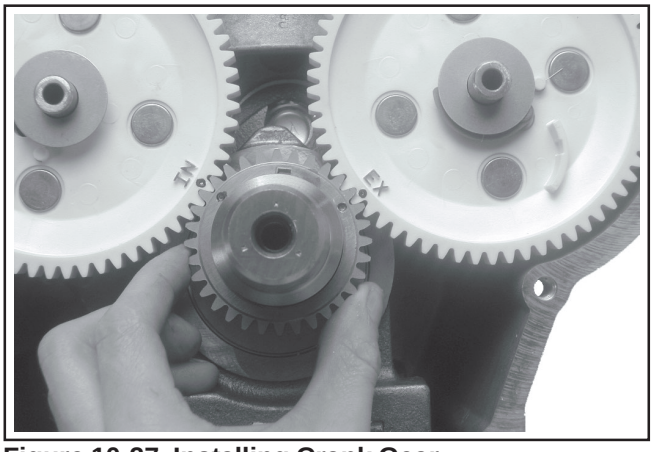


Figure 10-27. Installing Crank Gear.

Install Flywheel Side Oil Seal

1. Lubricate the outside diameter and lip of the flywheel end oil seal. Support the closure plate and install the oil seal. Using a seal driver, drive the seal to a depth of **5 mm (0.196 in.)** in the seal bore. See Figure 10-28.

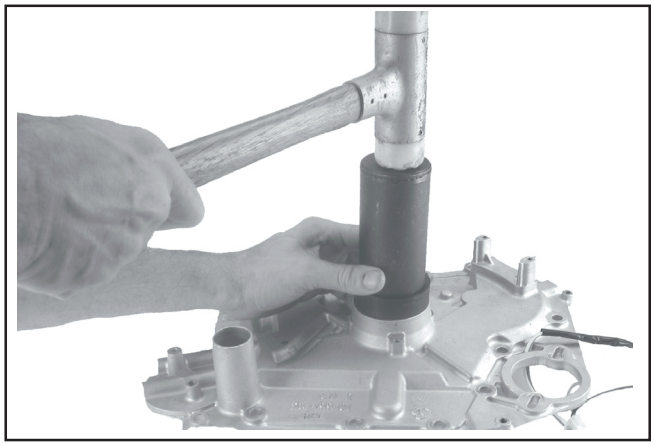


Figure 10-28. Installing Flywheel Side Oil Seal.

Install Closure Plate Gasket, Closure Plate, and Wiring Harness

NOTE: The special gasket used between the closure plate and crankcase controls crankshaft endplay, no shimming is required. **Do not** use RTV sealant in place of the gasket.

1. Make sure the sealing surfaces of crankcase and closure plate are clean, dry, and free of any nicks or burrs. Install a new closure plate gasket onto the crankcase.

Important!

2. Apply grease to the outside flat surfaces of the balance weight guide shoe. Position the guide shoe so the solid end is toward the crankshaft. See Figure 10-29. Make sure the guide shoe stays in this position during the next step.

3. Ensure the gasket, cover plate, and governor gear assembly, have been properly assembled to the closure plate (refer to Section 9). Start the closure plate onto the crankcase. Be sure the guide shoe is aligned with the guide channel in the closure plate, and the cam shafts and governor gear shaft are aligned with their mating bearing surfaces. See Figure 10-29. As the plate is lowered into final position, rotate the crankshaft slightly, if necessary, to help engage the governor gear.

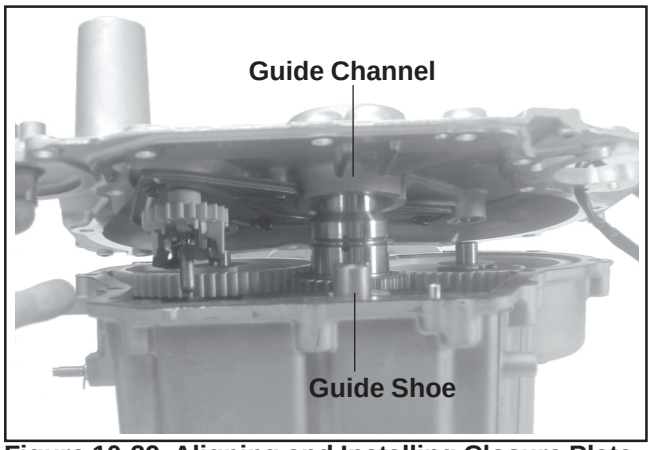


Figure 10-29. Aligning and Installing Closure Plate.

4. Install the fourteen hex. flange screws securing the closure plate to the crankcase, with any clamps for the wiring harness and the sheathed RFI suppression spark plug lead (#5 location, if so equipped), positioned as shown in Figure 10-30. If the wiring harness was separated from the closure plate, route the harness through the clamps and the slot in the closure plate. Close the clamps to retain the harness.

5. Torque the closure plate fasteners to **24.5 N·m (216 in. lb.)** using the sequence shown in Figure 10-31.

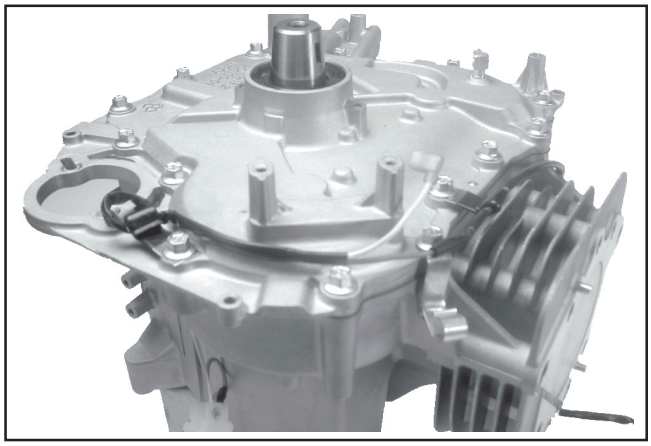


Figure 10-30. Closure Plate Installed.

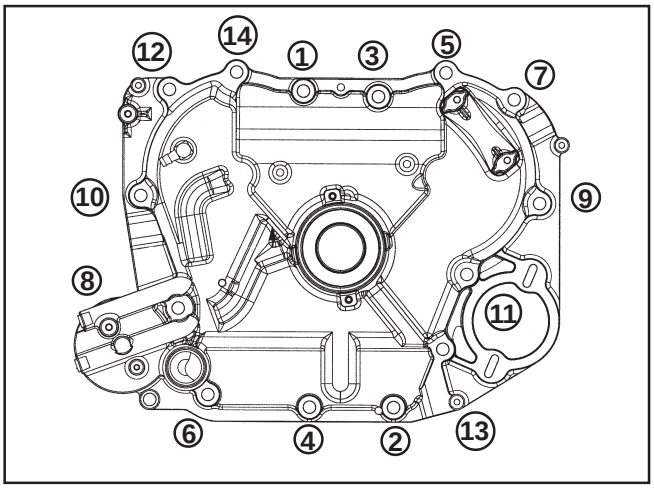


Figure 10-31. Closure Plate Fastener Torque Sequence.

Assemble Cylinder Head

Prior to assembly, lubricate all the components with engine oil, including the tips of the valve stems and valve guides. Using a valve spring compressor, install the following items in the order listed. See Figure 10-32.

- Intake and exhaust valves
- Valve spring caps
- Valve springs
- Valve spring retainers
- Valve spring keepers

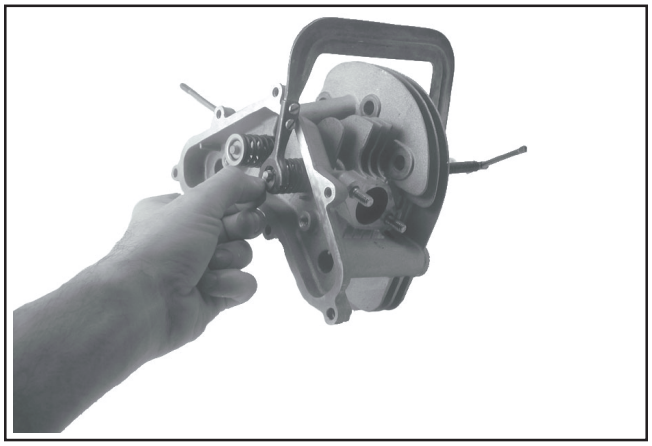


Figure 10-32. Assembling Cylinder Head.

Install Cylinder Head

NOTE: **Do not** reuse cylinder head screws or gasket, always replace with new parts.

1. Check to make sure there are no nicks or burrs on the sealing surfaces of the cylinder head or crankcase.

IMPORTANT-

2. **If the crankshaft has not been turned since the installation of the crank gear, turn it one (1) complete revolution. This will set the piston at top dead center (TDC) of the compression stroke, for proper valve lash adjustment later.**

3. Install the drain back check ball into the keyhole slot in the top of the crankcase. See Figure 10-33.

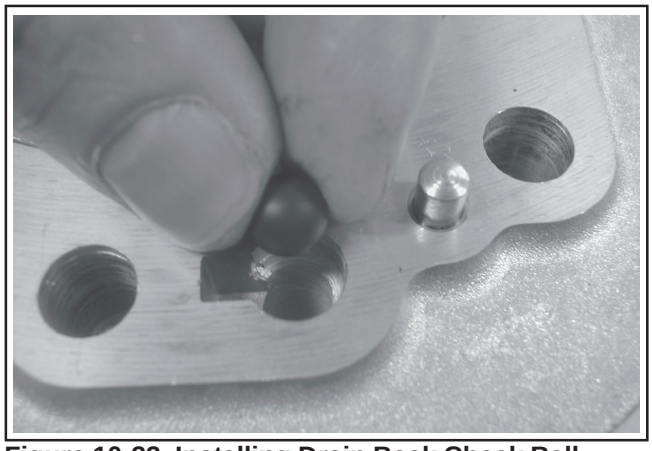


Figure 10-33. Installing Drain Back Check Ball.

4. Install a new cylinder head gasket. See Figure 10-34.

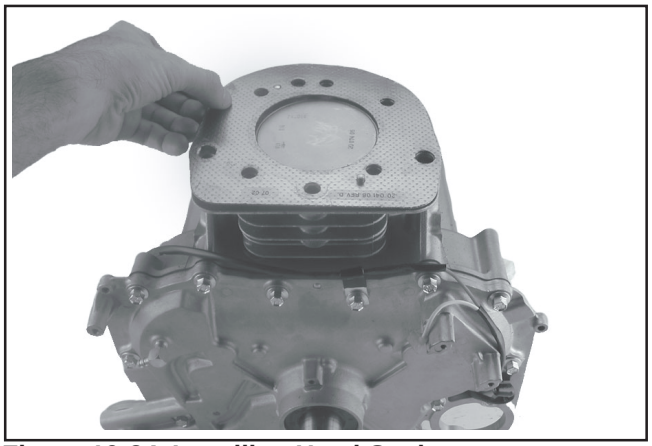


Figure 10-34. Installing Head Gasket.

5. Install the cylinder head and start the six hex. flange screws. Install the thick washer on the screw closest to the exhaust port. See Figure 10-35.

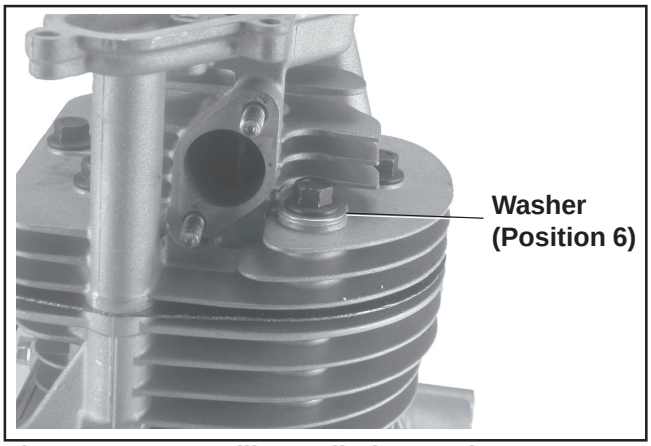


Figure 10-35. Installing Cylinder Head Fasteners.

6. Using the torque sequence shown in Figure 10-36, torque the cylinder head screws in two stages; initially to **20.5 N·m (180 in. lb.)**, and finally to **41.0 N·m (360 in. lb.)**.

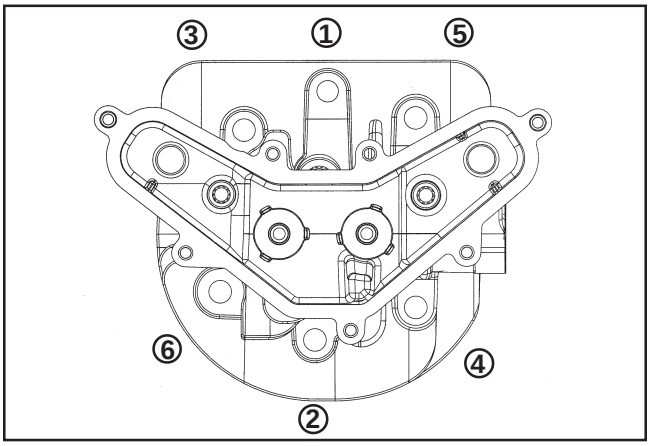


Figure 10-36. Cylinder Head Fastener Torque Sequence.

Install Rocker Arms and Push Rods

NOTE: Installation and seating of the push rods into the cam lever “recesses” during this sequence is critical. Position the engine with the cylinder head “up” if possible, to aid with proper installation of the push rods and rocker arms, and adjusting the valve lash.

1. Position the push rod guide plates on the cylinder head with the extruded edges “down” over the push rod bores. Secure by installing the rocker arm pivot studs. Torque the studs to **13.5 N·m (120 in. lb.)**. See Figure 10-37.

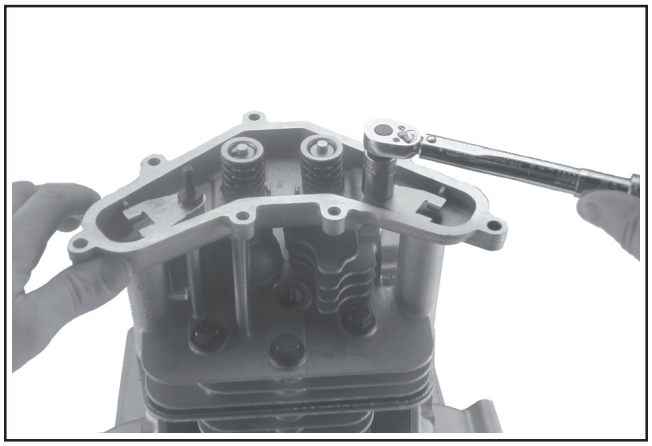


Figure 10-37. Installing Guide Plates and Rocker Arm Pivot Studs.

2. Apply grease to the contact surfaces of the rocker arms and adjusting nuts and install them onto the pivot studs.

NOTE: If being reused, push rods should always be installed in their original position.

3. Note the mark or tag identifying the push rod as either intake or exhaust. Apply grease to the ends of the push rods. Insert the push rods into the push rod bores and seat the lower end into the dimpled recess of the cam levers. It may be necessary to lift or shift the lower end of the push rod slightly, and "feel" that the rod seats into the recess. Once seated, hold it in place as you position the rocker arm. The push rod must stay in the recess while the rocker arms are positioned and adjusted. See Figure 10-38.

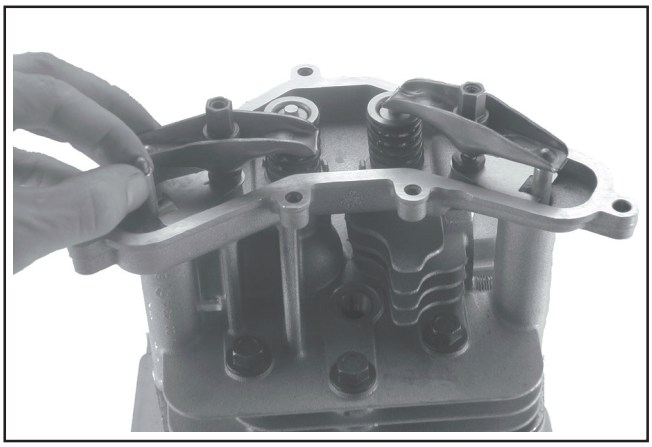


Figure 10-38. Installing Push Rods and Rocker Arm Assemblies.

4. With the engine at TDC of the compression stroke, insert a **0.076 mm (0.003 in.)** flat feeler gauge between one of the valve stems and the rocker arm. Tighten the adjustment nut with a wrench until a slight "drag" is felt on the feeler gauge. Hold the nut in that position and torque the set screw (T15 Torx drive) to **5.5 N·m (50 in. lb.)**. Perform the adjustment procedure on the other valve. Proper valve clearance is **0.076/0.127 mm (0.003/0.005 in.)**. See Figures 10-39 and 10-40.

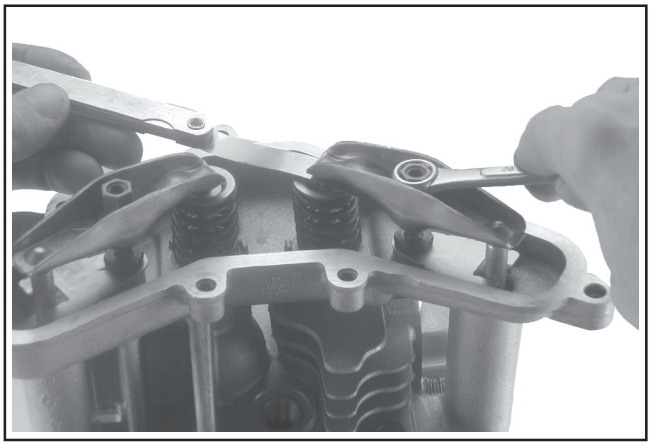


Figure 10-39. Adjusting Valve Clearance (Lash).

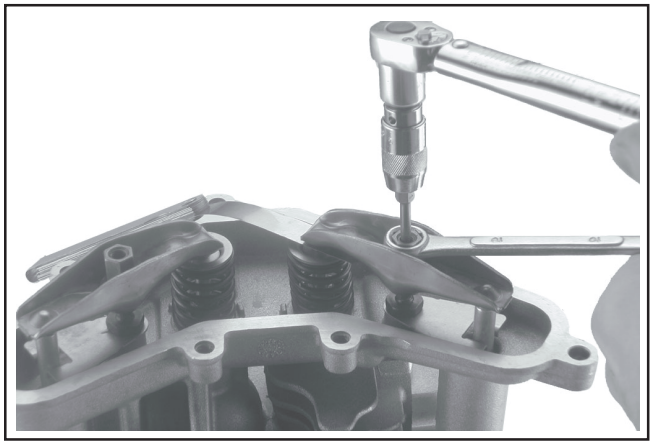


Figure 10-40. Locking Adjustment Nut Set Screw.

Install Valve Cover

1. Make sure the sealing surfaces of the valve cover and cylinder head are clean, and free of any nicks or burrs.

2. Install a new valve cover gasket, followed by the valve cover. Position any brackets that mount on the valve cover and start the seven mounting screws.

3. Torque the valve cover screws to **11.0 N·m (95 in. lb.) into new, as-cast holes,** or **7.5 N·m (65 in. lb.)** into used holes, using the sequence shown in Figure 10-41.

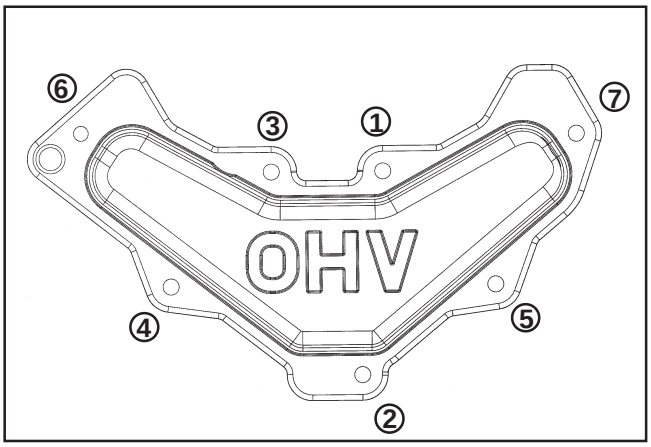


Figure 10-41. Valve Cover Torque Fastener Sequence.

Install Stator and Wiring Harness

Install Stator

1. Position the stator onto the mounting bosses so that the leads lay in the channel and recess of the closure plate. See Figure 10-42. They will become captured when the blower housing is installed.

2. Install the two hex. flange screws to secure the stator and torque to **6.0 N·m (55 in. lb.)**, into new, as-cast holes, or **4.0 N·m (35 in. lb.)**, into used holes.

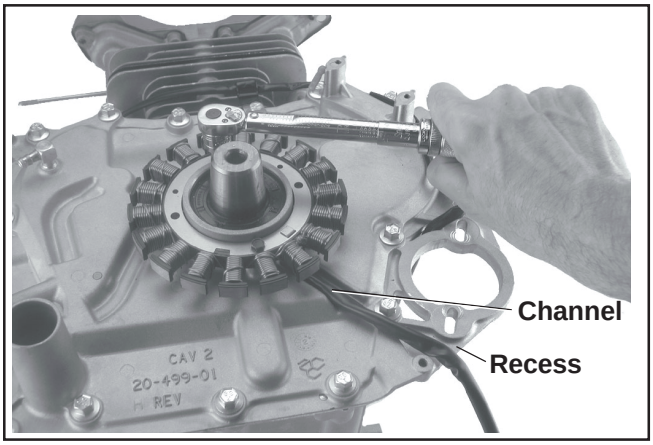


Figure 10-42. Installing Stator.

Install Wiring Harness

1. Check that the locking tang on the terminal of the violet B+ wiring harness lead is angled upward. Insert the terminal into the center location of the rectifier-regulator plug connector until it locks into place. If not already inserted, the two AC leads from the stator go in the outer locations. See Figure 10-43.

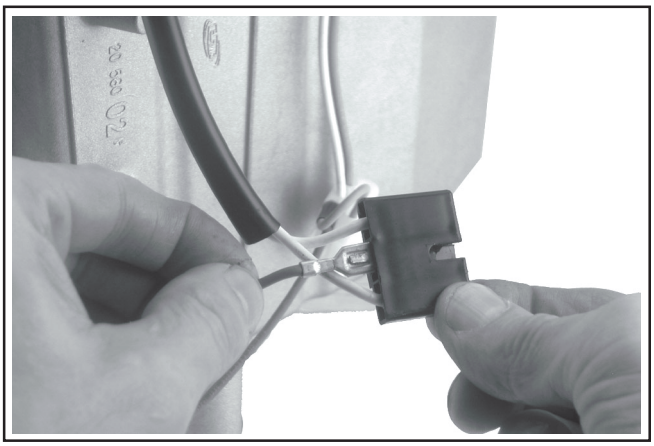


Figure 10-43. Installing B+ Lead into Connector.

Install Pipe Plug or Fitting and Pulse Line for Fuel Pump

1. Apply **pipe sealant with Teflon®** (Loctite® No. 59241 or equivalent), to the 1/8" pipe plug or 90° fitting (as equipped). Install and tighten into the tapped vacuum port of the closure plate. Torque the plug to **4.5-5.0 N·m (40-45 in. lb.)**. Turn the outlet of a fitting to the 8 o'clock position.

2. If a fitting is used, connect the fuel pump pulse line and secure with the clamp. See Figure 10-44.

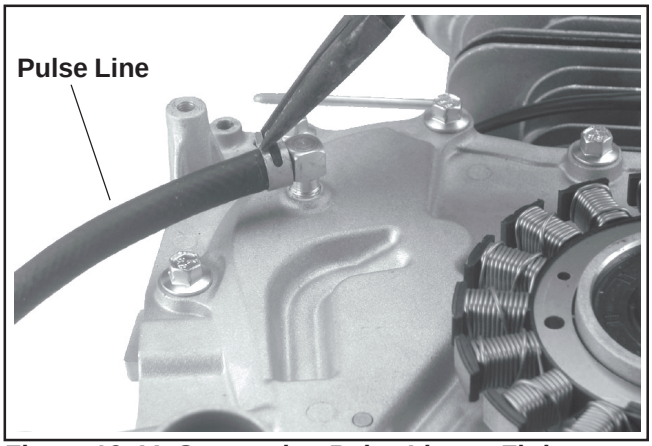


Figure 10-44. Connecting Pulse Line to Fitting.

Install Fan and 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 over stressed and damaged when the mounting screw is torqued to specification.

NOTE: Make sure the flywheel key is installed properly in the keyway. The flywheel can become cracked or damaged if the key is not properly installed.

NOTE: Always use a flywheel strap wrench or flywheel holding tool to hold the flywheel when tightening the flywheel fastener. Do not use any type of bar or wedge between the cooling fins or flywheel ring gear, as these parts could become cracked or damaged.

1. Install the woodruff key into the crankshaft keyway. Make sure that the key is fully seated and parallel with the shaft taper.

2. Install the flywheel onto the crankshaft aligning the keyway with the key. Be careful not to shift or unseat the key.

3. Position the fan onto the flywheel, so the locating pins drop into the corresponding recesses.

4. Install the fan mounting plate onto the fan, aligning the four cutouts, followed by the heavy flat washer and hex. flange screw. See Figure 10-45.

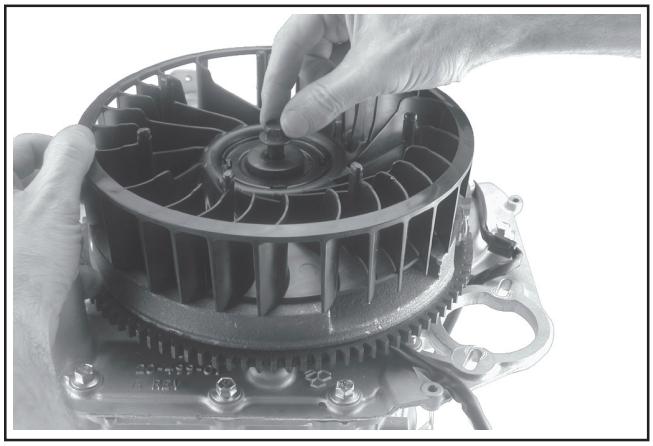


Figure 10-45. Installing Fan and Mounting Hardware to Flywheel.

5. Use a flywheel strap wrench or holding tool to hold the flywheel. Torque the hex. flange screw to **66.5 N·m (588 in. lb.)**. See Figure 10-46.

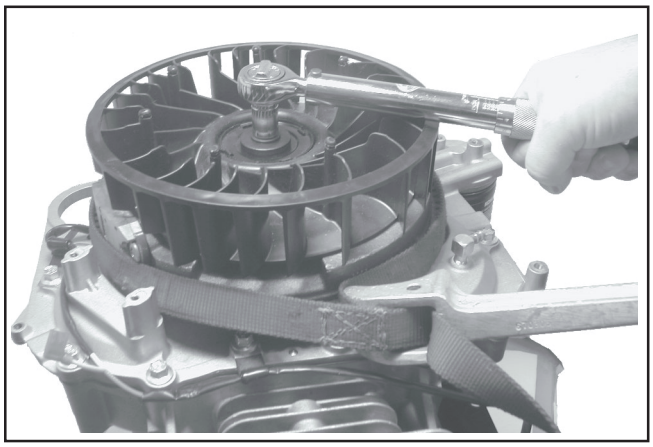


Figure 10-46. Torquing Flywheel.

Install Electric Starter

1. Install the electric starter to the closure plate and secure with the two #10-24 hex. nuts. Make sure the wires are clear of any moving parts and torque the hex. nuts to **3.6 N·m (32 in. lb.)**. See Figure 10-47.

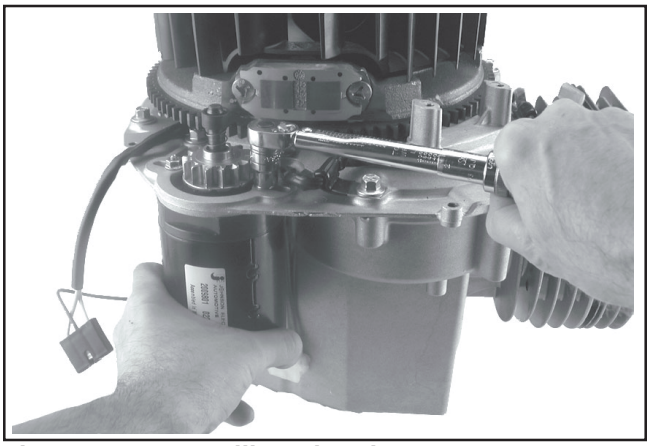


Figure 10-47. Installing Electric Starter.

Install Ignition Module

1. Rotate the flywheel so the magnet is away from the ignition module bosses. Using the hex. flange screws, install the ignition module to the crankcase bosses with the “kill” terminal “up”. Move the module as far from the flywheel as possible. Tighten the hex. flange screws sufficiently to keep the module in position. See Figure 10-48.

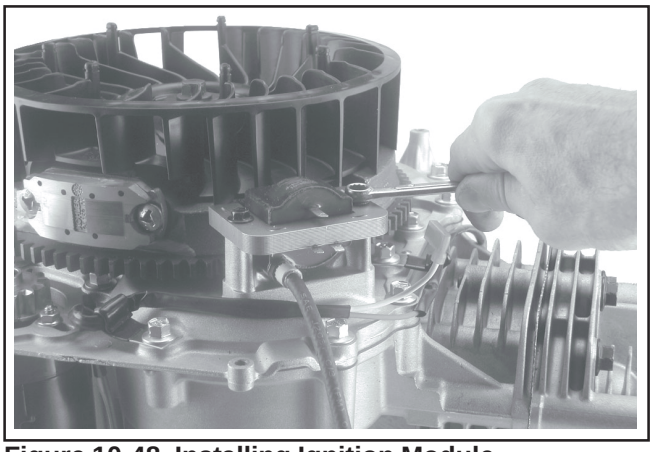


Figure 10-48. Installing Ignition Module.

2. Rotate the flywheel to align the magnet with the ignition module.

3. Insert a **0.25 mm (0.010 in.)** flat feeler gauge between the magnet and ignition module. See Figure 10-49. Loosen the screws so the magnet pulls the module against the feeler gauge.

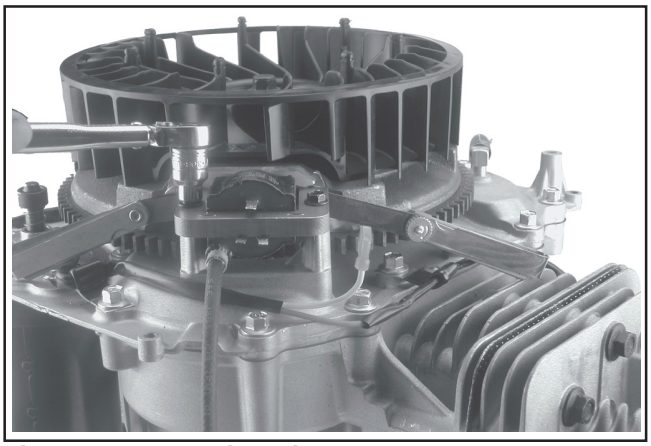


Figure 10-49. Setting Air Gap.

4. Torque the two screws to **6.0 N·m (55 in. lb.)**, into new, as-cast holes, or **4.0 N·m (35 in. lb.)**, into used holes.

5. Rotate the flywheel back and forth checking for clearance between the magnet and ignition module. Make sure the magnet does not strike the module. Recheck the air gap with a feeler gauge and readjust if necessary. Final Air Gap: **0.203/0.305 mm (0.008/0.012 in.)**.

6. Connect the kill lead to the tab terminal on the ignition module.

7. If equipped with a sheathed RFI suppression spark plug lead, place the lead in retaining clip so braided wires will be in direct contact with clip when closed. Carefully close the clip with a pliers until a **0.127 mm (0.005 in.)** gap exists between the ends. **Do not** pinch or flatten the clip. See Figure 10-50.

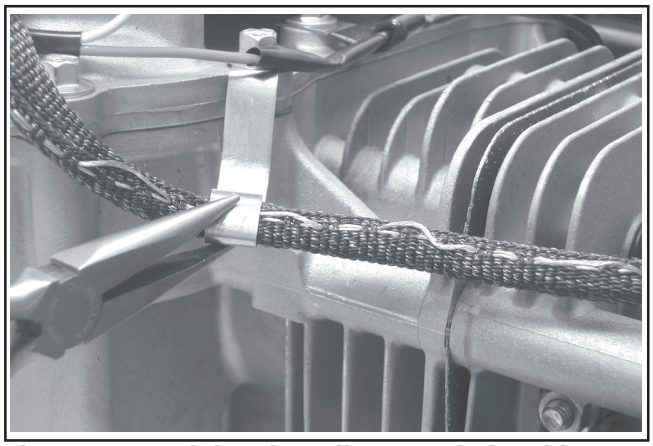


Figure 10-50. Tightening Clip around Sheathing.

Install New Spark Plug

1. Use a new Champion® RC12YC or QC12YC (or equivalent) spark plug.

2. Set the gap to **0.76 mm (0.030 in.)**.

3. Install the spark plug and torque it to **24-30 N·m (18-22 ft. lb.)**. See Figure 10-51.

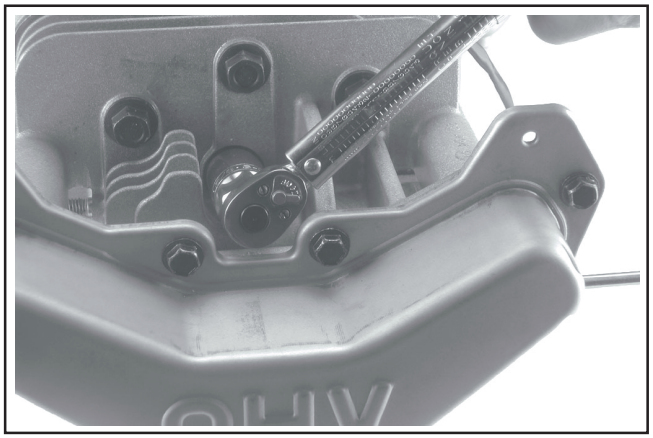


Figure 10-51. Installing Spark Plug.

4. Connect the spark plug lead.

Install Heat Deflector, Carburetor, Linkage and Air Cleaner Base

1. If the carburetor mounting stud was removed, reinstall it in the outer cylinder location (closest to head). Use an E5 Torx® socket or two hex. flange nuts tightened together, and turn the stud in until tight. See Figure 10-52.

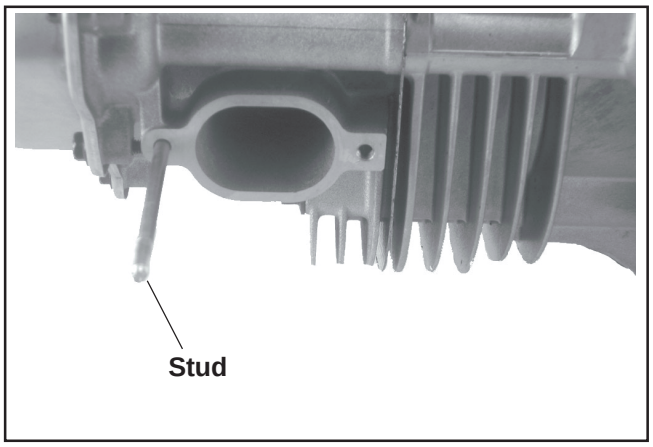


Figure 10-52. Mounting Stud Installed.

2. Make sure all the gasket surfaces are clean and free of any nicks or damage.

3. Install a new intake gasket onto the carburetor stud, then install the heat deflector. The curved section should be down, toward the engine, with the protruding point on the back inserted into the intake port. Be sure the protruding point goes through the large hole in the gasket, to keep it aligned. See Figure 10-53.

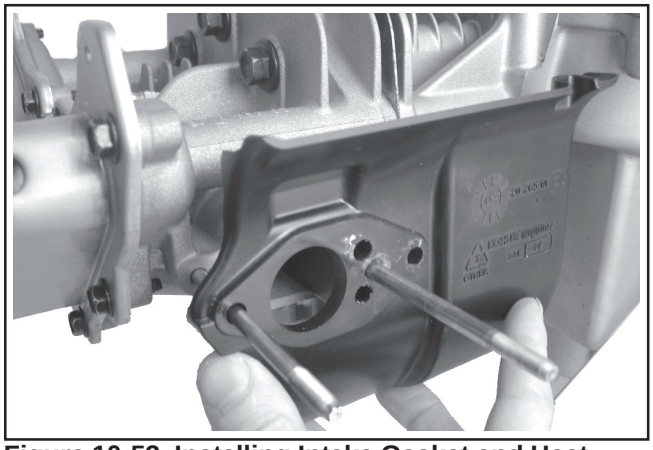


Figure 10-53. Installing Intake Gasket and Heat Deflector.

4. **Models with one screw and one mounting stud only:** Insert a 3/16” diameter rod, approximately 4” long, into the open mounting hole in the heat deflector to serve as a temporary alignment pin. See Figure 10-54. Be careful not to force the rod or damage the threads.

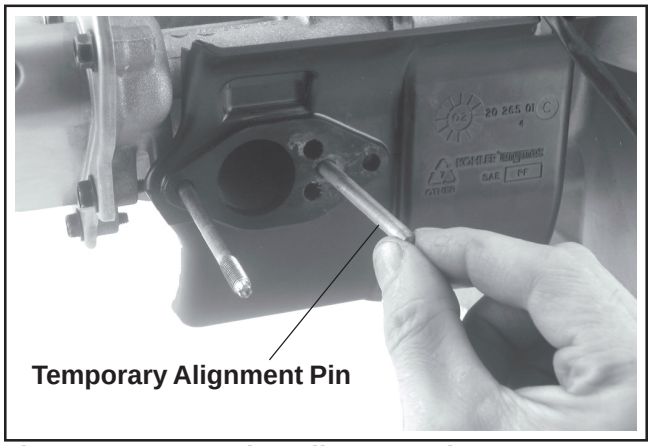


Figure 10-54. Inserting Alignment Pin.

5. Install a new carburetor gasket onto the mounting stud(s) and/or alignment pin.

6. Attach the choke and throttle linkages to the carburetor and install the carburetor assembly. See Figure 10-55. If the governor lever was not disconnected, slide it onto the governor shaft with the lever up.

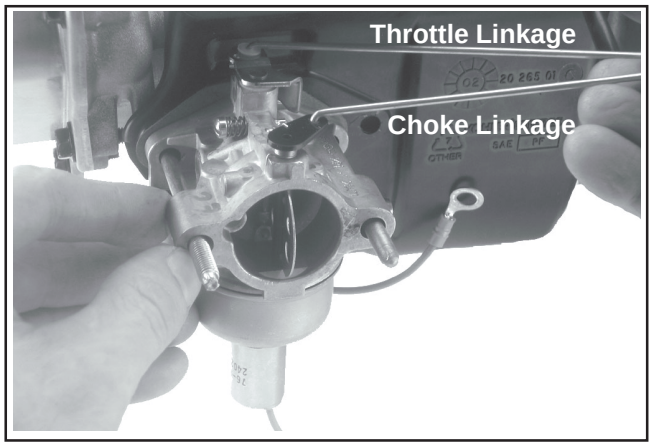


Figure 10-55. Installing Carburetor Assembly with Linkages.

7. If the carburetor has a fuel solenoid, fasten the ground lead to the crankcase boss, with the toothed washer between the eyelet terminal and the boss. See Figure 10-56. Torque the screw to **8.0 N·m (70 in. lb.)**. Connect the solenoid power lead to the wiring harness and secure with a tie strap. See Figure 10-57.

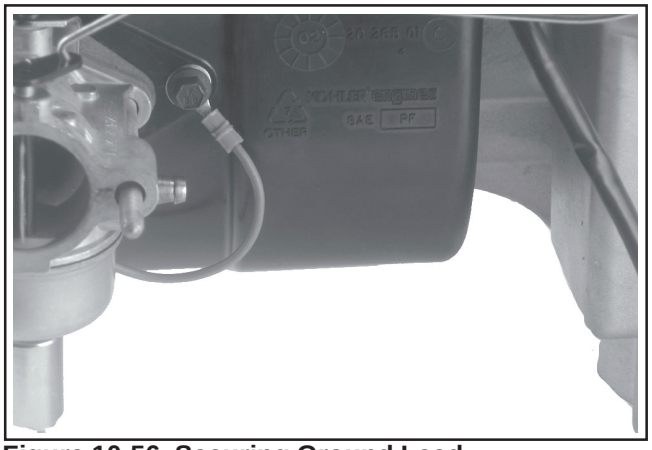


Figure 10-56. Securing Ground Lead.

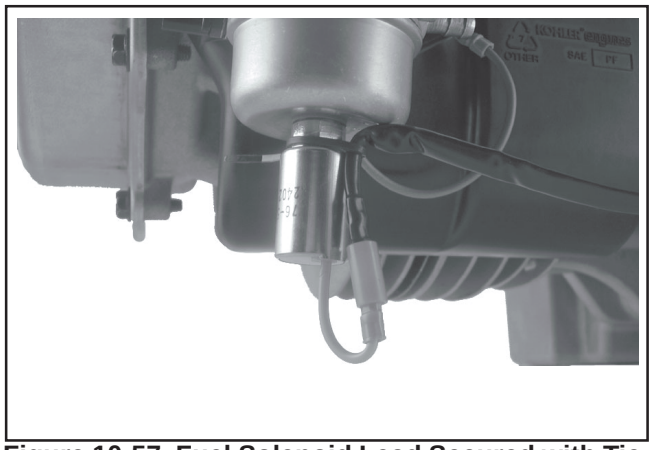


Figure 10-57. Fuel Solenoid Lead Secured with Tie Strap.

8. Connect the fuel line to the carburetor and secure with a hose clamp. See Figure 10-58.

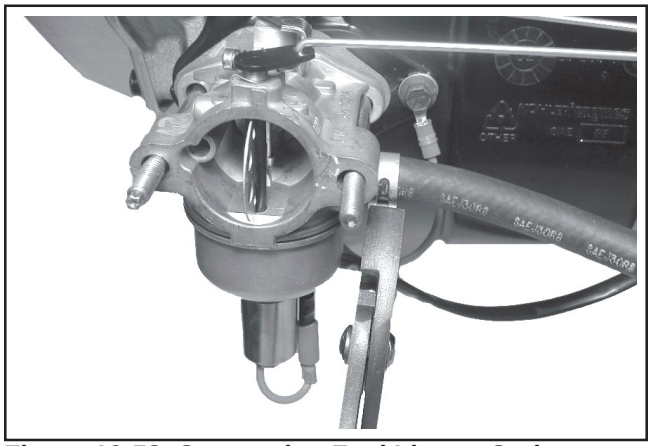


Figure 10-58. Connecting Fuel Line to Carburetor.

9. Install the air cleaner base.

   a. Install a new air cleaner base gasket. Check that the two metal spacers are in the air cleaner base mounting holes and install the base onto the stud(s), and or alignment pin. Make sure the upper mounting tab is positioned above the closure plate boss. See Figure 10-59. Install the hex. flange nut(s) and finger tighten See Figure 10-60.

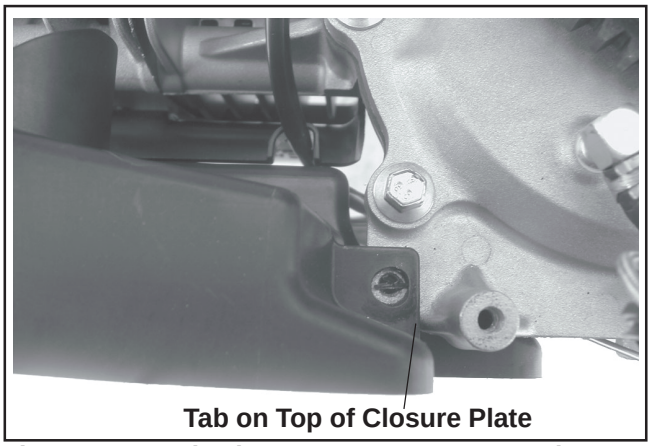


Figure 10-59. Air Cleaner Base Upper Mounting Tab Details.

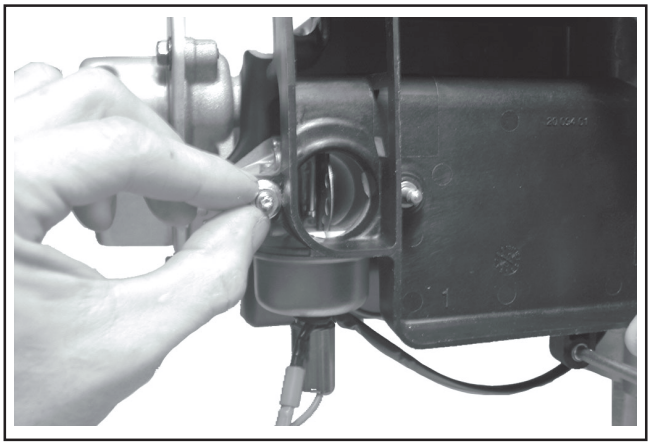


Figure 10-60. Installing Air Cleaner Base.

b. **Models with one screw and one mounting stud only:** Apply hand pressure to keep the parts from shifting, then carefully remove the alignment pin and install DRY the long M6 thread forming screw – DO NOT OIL. See Figure 10-61. Check to make sure all gaskets are still in proper position.

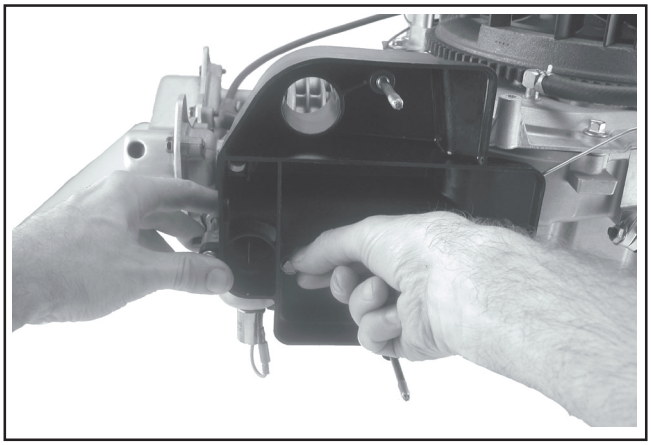


Figure 10-61. Installing Mounting Screw. (Models with one stud and one screw).

c. Torque the nut(s) to **5.5 N·m (48 in. lb.)**. Torque the screw to **8.0 N·m (70 in. lb.)** into a new hole, or **5.5 N·m (48 in. lb.)** into a used hole, **do not** over tighten. See Figure 10-62. The M6 screw for the upper tab will be installed when the blower housing is mounted.

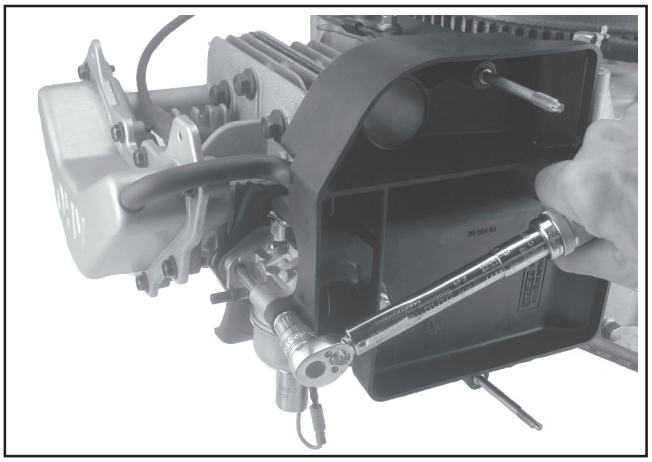


Figure 10-62. Torquing Air Cleaner Fasteners.

10. Attach the breather hose to the valve cover and air cleaner base.

Install and Adjust Governor Lever

1. Install the governor lever* onto the governor shaft with the lever section up. Connect the throttle linkage using the black linkage bushing. See Figure 10-63.

*NOTE: It is recommended that a new governor lever be installed whenever removal is performed.

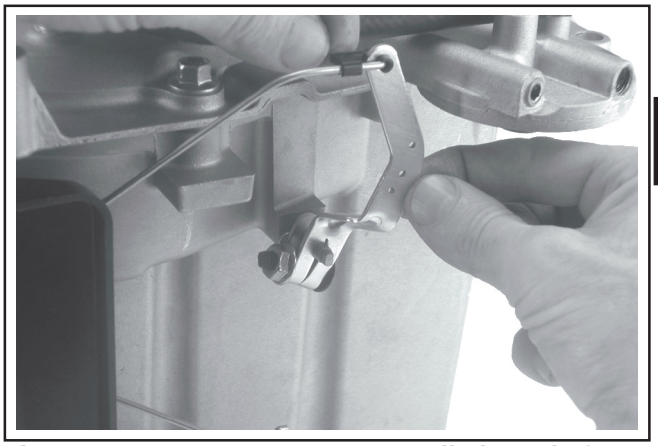


Figure 10-63. Governor Lever Installed on Shaft.

2. Move the governor lever toward the carburetor, to the limit of its travel (wide-open throttle) and hold in this position. Do not apply excessive pressure, flexing or distorting the linkage. Grasp the cross shaft with a pliers, and turn the shaft counterclockwise as far as it will go. See Figure 10-64. Torque the hex. nut to **7.0-8.5 N·m (60-75 in. lb.)**.

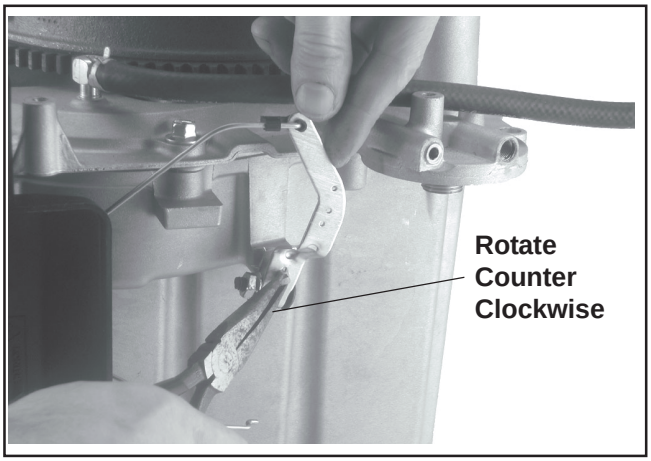


Figure 10-64. Adjusting Governor and Linkage.

Mounting Speed Control Bracket

1. Attach the governor spring to the governor lever and the throttle lever of the speed control bracket, in the original holes. If the holes were not marked during disassembly, refer to the chart in Section 5, Figure 5-23. Connect the choke linkage from the carburetor to the actuating lever of the speed control bracket. See Figure 10-65.

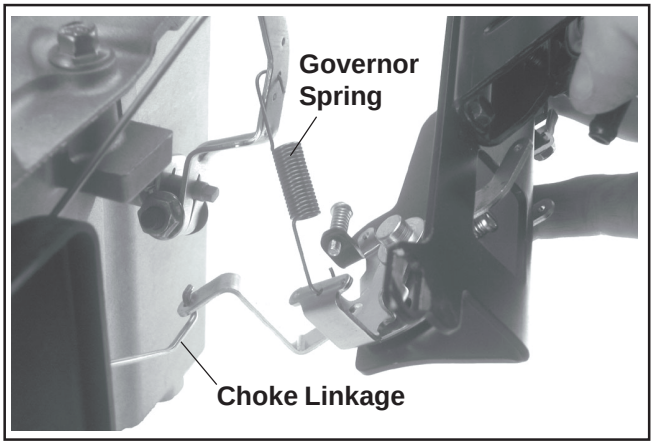


Figure 10-65. Connecting Choke Linkage and Governor Spring.

2. Attach the speed control bracket to the mounting locations on the engine with the M6 screws. Position the bracket as marked during disassembly. Torque the screws to **11.0 N·m (95 in. lb.)** into new, as-cast holes or **7.5 N·m (65 in. lb.)** into used holes. See Figure 10-66.

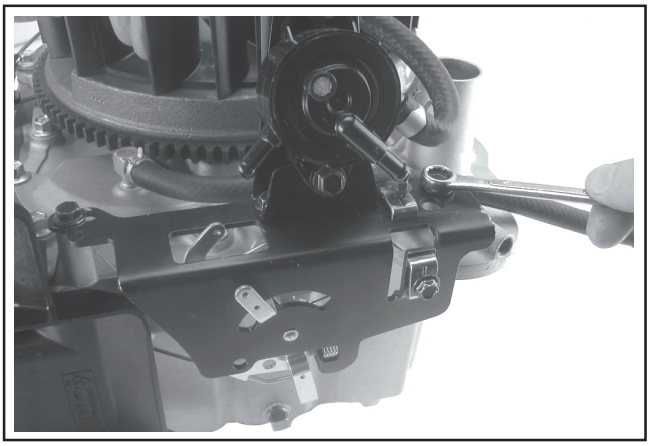


Figure 10-66. Attaching Speed Control Bracket.

Install Fuel Pump (if equipped)

1. Attach the fuel pump mounting bracket to the speed control bracket with the two M5 screws. Torque the screws to **6.5 N·m (55 in. lb.)** into new as-cast holes, or **4.0 N·m (35 in. lb.)** into used holes. See Figure 10-67.

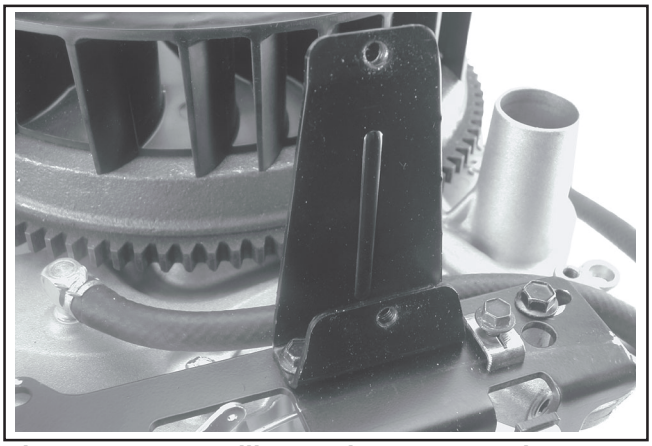


Figure 10-67. Installing Fuel Pump Mounting Bracket.

2. Attach the fuel pump to the bracket so the pulse fitting is oriented in the four o'clock position. Secure with the two M6 screws. Torque the screws to **5.9 N·m (52 in. lb.)**. **Do not** over tighten.

3. Connect the pulse and fuel lines to the fuel pump and secure with clamps. See Figure 10-68.

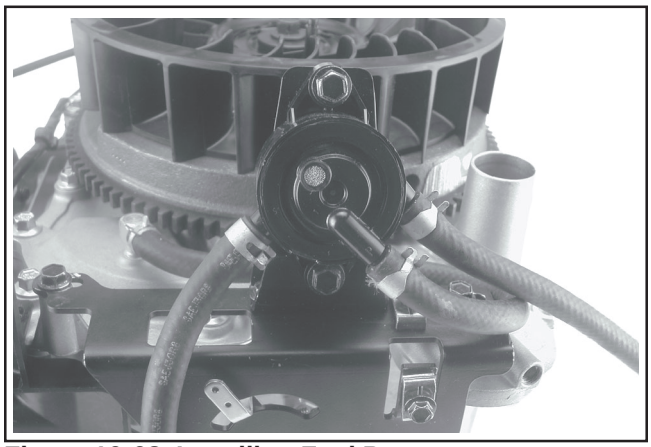


Figure 10-68. Installing Fuel Pump.

Install Rectifier-Regulator

1. Using the two M6 screws, mount the rectifier-regulator onto the crankcase bosses, with the cooling fins out. See Figure 10-69. Torque the screws to **6.0 N·m (55 in. lb.)** into new as-cast holes, or **4.0 N·m (35 in. lb.)** into used holes.

2. Attach the connector to the rectifier-regulator terminals.

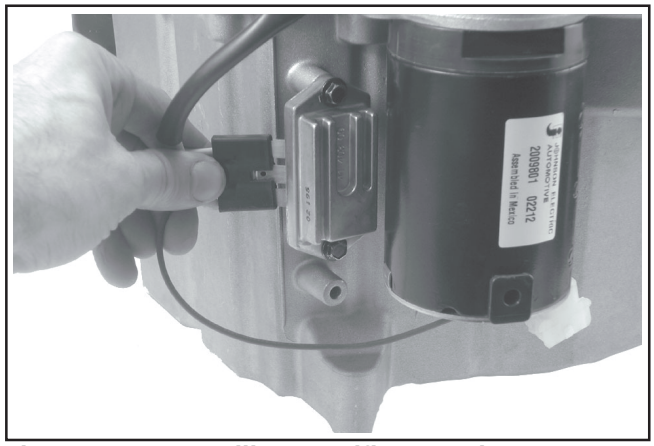


Figure 10-69. Installing Rectifier-Regulator.

Install Blower Housing and Flywheel Screen

1. Position the blower housing on the engine and route the spark plug lead through the underside slot. See Figure 10-70.

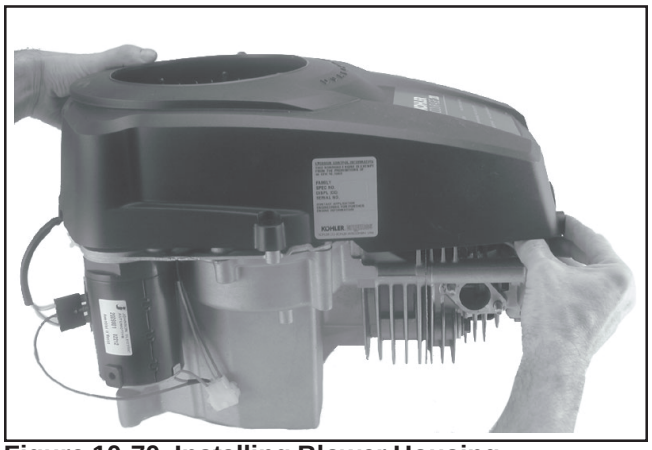


Figure 10-70. Installing Blower Housing.

2. Check that the stator leads are within the notch of the blower housing. Align the mounting locations, then install the four M6 shouldered mounting screws. If a flat washer was used under the head on one screw, install the screw in the location closest to oil fill/dipstick. Torque the screws to **11.0 N·m (95 in. lb.)** into new, as-cast holes, or **7.5 N·m (65 in. lb.)**, into used holes. See Figure 10-71.

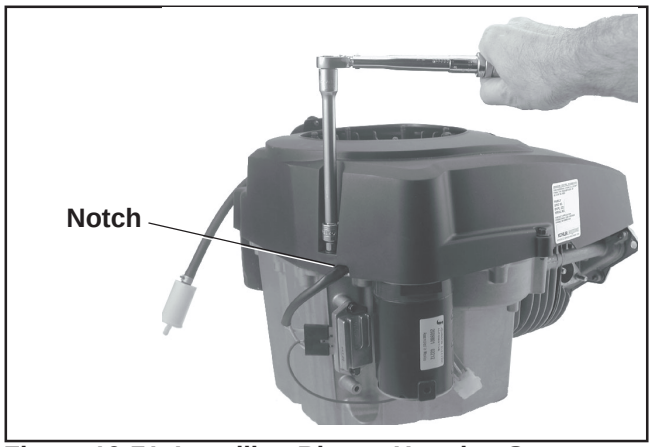


Figure 10-71. Installing Blower Housing Screws.

3. Snap the grass screen onto the cooling fan. See Figure 10-72.

Figure 10-72. Installing Grass Screen.

Install Oil Sentry™ or Pipe Plug

1. Apply **pipe sealant with Teflon®** (Loctite® No. 59241 or equivalent), to the threads of the 1/8" pipe plug or adapter. Install and tighten into the port on the closure plate. See Figure 10-73. Torque pipe plug to **4.5-5.0 N·m (40-45 in. lb.)**. If a switch was installed, apply sealant to the threads of the Oil Sentry™ switch and install into the adapter or center passage. Torque the switch to **4.5-5.0 N·m (40-45 in. lb.)**. Connect the green wiring harness lead to the terminal on the switch. See Figure 10-74.

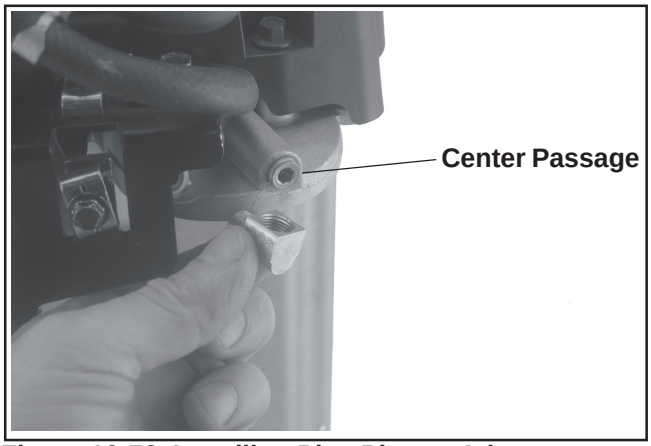


Figure 10-73. Installing Pipe Plug or Adapter.

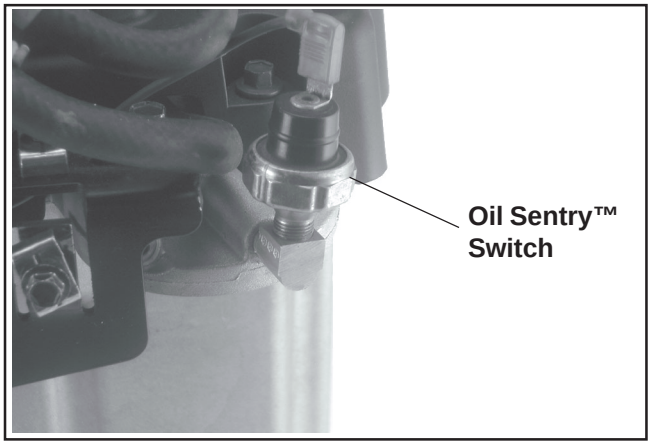


Figure 10-74. Installed Oil Sentry™ Switch.

Install Air Cleaner Element, Precleaner, and Air Cleaner Cover

1. Install the air cleaner element with the pleated side "out." Seat the rubber seal onto all the edges of the air cleaner base. See Figure 10-75.

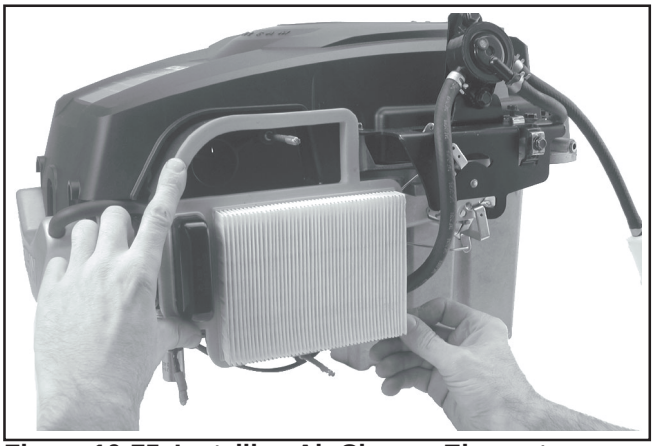


Figure 10-75. Installing Air Cleaner Element.

2. Install the precleaner (if so equipped), into the upper section of the air cleaner cover. See Figure 10-76.

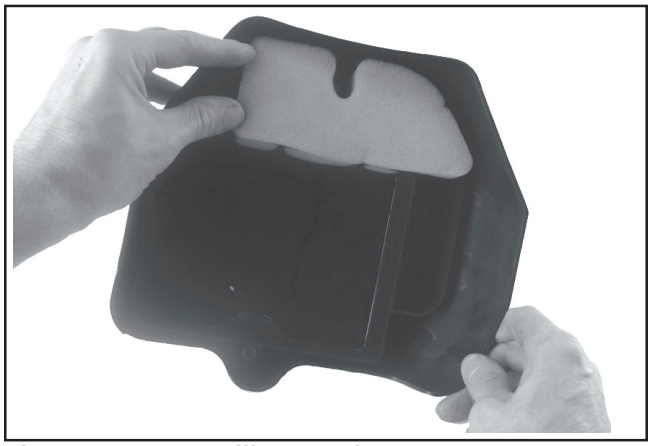


Figure 10-76. Installing Precleaner.

3. Install the air cleaner cover and secure with the two retaining knobs. See Figure 10-77.

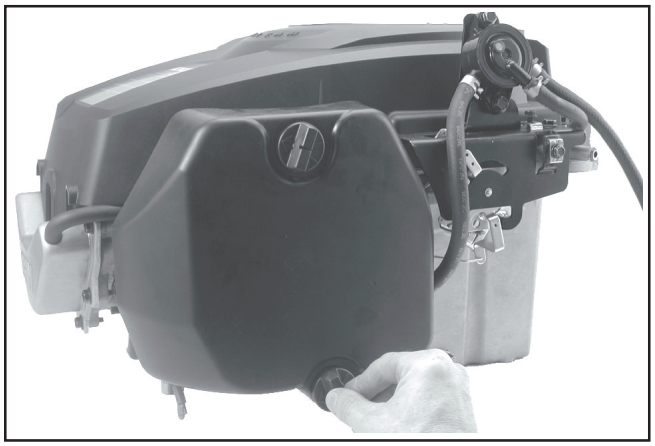


Figure 10-77. Installing Air Cleaner Cover.

Install Muffler

1. Install the gasket, muffler, and hex. flange nuts on the exhaust port studs. Leave the nuts slightly loose.

2. If an auxiliary muffler bracket is used, install the M6 hex. flange screw(s) into the bracket.

3. Torque the hex. flange nuts to **24.4 N·m (216 in. lb.)**. See Figure 10-78. Torque the screws to **7.5 N·m (65 in. lb.)**.

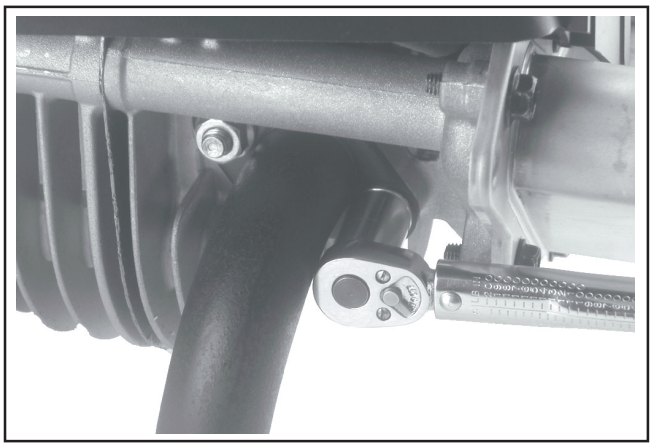


Figure 10-78. Torquing Exhaust Flange Nuts.

Install Drain Plug, Oil Filter, and Oil

1. Install the oil drain plug and torque to **14 N·m (125 in. lb.)**.

2. Place a new replacement 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.

3. Put a drop of oil on your fingertip and wipe it onto the rubber gasket. Thread the filter onto the engine until the rubber gasket contacts the surface, then tighten the filter an additional **2/3-1 turn**. See Figure 10-79. Fill the crankcase with new oil of the proper type, to the “F” mark on the dipstick.

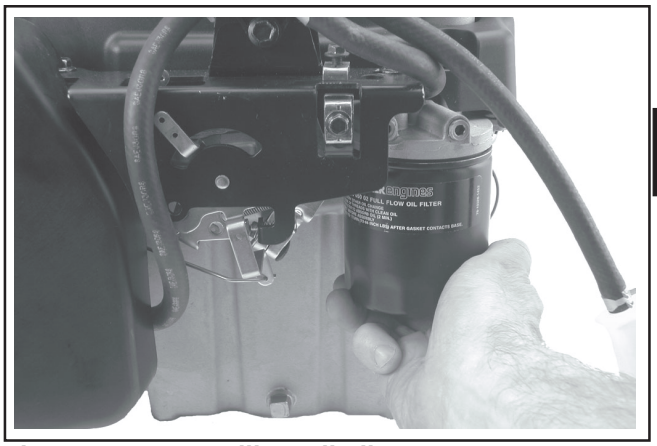


Figure 10-79. Installing Oil Filter.

Prepare the Engine for Operation

The engine is now completely reassembled. **Before** starting or operating the engine, be sure the following have been done.

1. All hardware is tightened securely.
2. The oil drain plug, Oil Sentry™ pressure switch (if so equipped), and a new oil filter are installed.
3. The crankcase is filled with the correct amount, weight, and type of oil.

Testing the Engine

It is recommended that the engine be operated on a test stand or bench prior to installation in the piece of equipment.

1. Set the engine up on a test stand. Install an oil pressure gauge. Start the engine and check to be certain that oil pressure (**5 psi** or more) is present.
2. Run the engine for 5-10 minutes between idle and mid-range. Adjust the throttle and choke controls and the high-speed setting as necessary. Make sure the maximum engine speed does not exceed **3300 RPM**. Adjust the carburetor idle fuel needle and/or idle speed screw as necessary. Refer to the “Fuel System and Governor” section.

KOHLER engines

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